Chapter Three Affected Environment and Consequences

Under the National Environmental Policy Act (NEPA), the analysis of environmental conditions is directly related to the expected environmental consequences of the proposed alternatives. NEPA requires that the analysis address those areas and the components of the environment with the potential to be affected by the proposed action; locations and resources with no potential to be affected need not be analyzed. The environment includes all areas and lands that might be affected, as well as the natural, cultural, and socioeconomic resources they contain or support. This chapter contains both the affected environment and environmental consequences analysis for all resources required by both NEPA and the Washington State Environmental Policy Act (SEPA). Chapter 3 answers two key environmental questions:

- What is the current condition of the project area?
- What effects will the proposed project have on the environment?

The relevant, affected environmental, social, and economic resources as they exist today are referred to as the "environmental baseline." Baseline conditions give the public and agency decisionmakers a meaningful point from which they can compare potential future environmental, social, and economic effects. Once baseline conditions are known (as presented in the *Affected Environment* sections), both the beneficial and adverse effects of the project can be predicted.

The *Environmental Consequences* section for each resource considers the direct and indirect effects of the No-Build Alternative, the Keechelus Lake Alignment Alternatives, and the Improvement Packages. Impacts of corridor-wide roadway improvements (such as wider medians, shoulders, etc.), not analyzed under the Keechelus Lake Alignment Alternatives, are assessed within the Improvement Packages.

Resources with biological and hydrological emphasis discuss consequences that are comprehensive for both the Keechelus Lake Alignment Alternatives and the Improvement Packages. For these resources, each Connectivity Enhancement Area (CEA) and option is presented, in addition to analysis on the effects of the Improvement Packages. For other resources, consequences related to the CEAs and Improvement Packages are minor and so they are summarized. Therefore, the presentation of consequences varies among resources.

This chapter presents a detailed comparison of the I-90 project area as it exists today, and the predicted future effects of all of the alternatives on the project area. This information will be used by the Washington State Department of Transportation (WSDOT) and Federal Highway Administration (FHWA) decisionmakers to weigh the benefits and adverse effects of each alternative as they consider a preferred alternative. Chapter 3 begins with an explanation of

ecological connectivity to give the reader additional context regarding this important issue. The discussion of ecological connectivity applies to the entire project area.

Ecological Connectivity Emphasis in United States Forest Service Land Management

The USFS is the primary land manager within the I-90 study area.

The majority of the 15-mile project corridor passes through lands managed by the United States Forest Service (USFS). Connectivity must be addressed by this project because it is one of five project needs, and it has been identified as a critical issue in USFS land management documents for the area, including the *1994 Northwest Forest Plan* (USFS and Bureau of Land Management [BLM] 1994). A key component of the *Northwest Forest Plan* is the Aquatic Conservation Strategy introduced in the Record of Decision (ROD).

The Aquatic Conservation Strategy was developed to improve and maintain the ecological health of watersheds and aquatic ecosystems contained within them on public lands. The strategy would protect salmon and steelhead habitat on federal lands managed by the USFS and BLM within the range of Pacific Ocean anadromous fish species. Goals of the Aquatic Conservation Strategy include striving toward maintaining and improving ecosystem health at watershed and landscape scales, protecting habitat for fish and other riparian-dependent species and resources, and restoring currently degraded habitats. "This approach seeks to prevent further degradation and restore habitat over broad landscapes, as opposed to individual projects or small watersheds. Because it is based on natural disturbance processes, it may take decades, possibly more than a century, to accomplish all of its objectives. Some improvements in aquatic ecosystems, however, can be expected in 10 to 20 years" (USFS and BLM 1994).

The *Northwest Forest Plan* also identified ten Adaptive Management Areas, including the Snoqualmie Pass Adaptive Management Area (SPAMA) (USFS and BLM 1994). These areas provide unique biologic challenges, private and public land ownerships problems, and differing natural resources goals. Adaptive Management Areas are "landscape units designated to encourage the development and testing of technical and social approaches" to economic, ecological, and other social objectives (USFS and BLM 1994).

The SPAMA contains 212,700 acres. The desired future condition of the SPAMA is to achieve the conscious integration of ecological processes, and social and economic values. The vegetative mosaic will include late-successional habitat in quantity and distribution that emphasizes opportunities over time for the north-south movement of wildlife through the Adaptive Management Area corridor, thus preventing their demographic or genetic

isolation, and providing for viable populations of species associated with late-successional habitat (USFS and BLM 1994).

The I-90 study area lies within the Snoqualmie Pass Adaptive Management Area.

One of the SPAMA's areas of emphasis is to create a comprehensive plan to provide for late-successional forest on "checkerboard"[1] lands. Because the land on both sides of the Interstate 90 (I-90) corridor is held in both private and public ownership, in 1998 the USFS completed the "Interstate 90 Land Exchange." This exchange resulted in the reduction of the checkerboard land ownership mosaic and allows for cohesive management of the consolidated exchange lands. Under USFS management, both the recently acquired exchange properties and existing USFS lands along the I-90 project corridor will eventually become late-successional forest.

The other area of emphasis acknowledges the SPAMA as a critical north-south link for species movement in the Cascade Range. WSDOT, the USFS, and other public agencies and organizations continue to cooperate to ensure that the design of I-90 and the adjacent habitat provide opportunities for movement of wildlife through the corridor, i.e., over and under I-90, thereby preventing the demographic or genetic isolation of terrestrial and aquatic species.

Connectivity Emphasis of the Project Design

Hydrologic and ecological connectivity were not incorporated into the original design of I-90 because these issues had not yet entered the environmental vocabulary. This, combined with the checkerboard land ownership in the corridor and the logging practices of private timber companies and the USFS, resulted in a fragmented landscape. Since the last major highway expansion was completed in the early 1970s, a great deal has been learned about ecological needs in general and the effects of roads on ecosystems in particular. WSDOT and FHWA recognized the need for improved hydrologic and ecological connectivity, and incorporated this objective into the Project Needs for the presently proposed action. Connectivity issues were identified for hydrology, fish, and aquatic habitat, including wetlands, and terrestrial species and habitats.

Hydrologic Connectivity. Hydrologic connectivity has been identified as a key component of the SPAMA. This connectivity is necessary both as a recharge mechanism for groundwater, and as a form of surface water movement that maintains and supports the function of wetlands, and the aquatic and riparian dependent species. In accordance with the objectives of the Aquatic

[1] Lands held in both public and private ownership in the Wenatchee, Mount Baker-Snoqualmie, and Gifford Pinchot National Forests makes the USFS's goal of maintaining unfragmented late-successional habitat and critical north/south wildlife connectivity corridors across National Forest System lands difficult to attain.

Conservation Strategy, WSDOT and its federal partners will make reasonable and prudent decisions on restoration opportunities. A few of the Aquatic Conservation Strategy objectives that will be considered by the USFS in their review of the project's consistency with the Wenatchee Forest Plan and the land transfer request are:

- to maintain and restore the physical integrity of the aquatic system;
- to maintain and restore water quality necessary to support healthy riparian, aquatic, and wetland ecosystems; and
- to maintain and restore in-stream flows sufficient to create and sustain riparian, aquatic, and wetland habits, and to retain patterns of sediment, nutrient, and wood routing.

The existing highway bisects some wetland systems, may have created wetlands in other instances, and interferes with natural surface and subsurface flow paths, which causes impacts to hydrologic systems, including:

- reduced groundwater recharge and base flows in streams;
- disrupted natural wetland hydrology;
- filled wetlands during or created as a result of road construction; and
- altered natural flow paths through soil compaction, berm construction, and direct excavation.

An objective of this project is to maintain or restore, where feasible, hydrologic function and connectivity across the highway, which will link and enhance aquatic resources on both sides of the highway.

Fish and Aquatic Habitat Connectivity. The Yakima River watershed supports federally listed bull trout, steelhead, and other salmonids that are the focus of significant management and recovery efforts. Federal, state, and tribal agencies have invested millions of dollars in salmon recovery efforts in the Yakima River Basin. The habitat adjacent to the project area is currently, and has been historically, used by these species. Streams within the project area directly support the quality of downstream habitat used by these species.

Highway and forest road stream crossings have altered the natural movement of water, sediment, wood, and organisms resulting in many different types of impacts. Construction of the highway caused the filling of stream floodplains, in turn reducing wetland and riparian habitats. Stream crossings have artificially locked stream channels in place, simplifying habitats, removing wood, and impeding sediment movement. Excavations have resulted in lowered flow levels and reduced water quality. Some road-crossing structures have become barriers

to fish migration, contributing to the reduction of aquatic species diversity, and limited wood and debris contribution.

These modifications affect the amount, quality, and connectivity of aquatic habitats, and can impact the species they support. An objective of this project is to provide stream crossings that enhance natural water, sediment, wood, and organism movement under the highway.

Terrestrial Connectivity. The Snoqualmie Pass area, where the east-west I-90 corridor is located, is part of a regionally important north-south corridor for wildlife in Washington. Even though major public and private land acquisition investments have been made for the purpose of improving and protecting the corridor, the highway presents a barrier to movement, preventing some species in the North Cascades from fully interacting with, and contributing to exchange among populations of, species in the South Cascades.

Successive landscape-level analyses have identified ecological problems associated with high road densities and timber harvest on federal lands, as well as development on private lands (Thomas et al. 1990, United States Fish and Wildlife Service [USFWS] 1992, USFS 1997, USFS 1999a). These disconnected tracts of terrestrial habitat have the potential to prevent species from maintaining their viability in a region (Garvey-Darda and Worthington 2003). Additionally, habitats adjacent to the highway can be degraded by the presence and operation of the highway (e.g., noise impacts, introduction and spread of noxious weeds, increased dust and litter). Finally, vehicle collisions are a source of wildlife mortality, as well as a public safety concern.

Effects on wildlife can include impacts on populations of rare and common species at the local and regional level. Local populations of low mobility species (LMS), such as amphibians, can be impacted by road mortality and habitat loss. Limiting wildlife movement can also affect the ability of wide-ranging species such as lynx, gray wolf, wolverine, fisher, and grizzly bear, by hampering their ability to access widely separated habitats or pursue patchily distributed prey. The highway can also slow or prevent animals from re-colonizing habitat that has been disturbed by natural events, such as forest fires, severe wind storms, or forested areas where insect infestations have occurred. Highways also cause behavioral modifications that may include shifts in home ranges, alteration in movement patterns, and changes in physiological responses to environmental stressors.

An objective of this project is to improve wildlife habitat connectivity by improving the ability of wildlife to move through the highway corridor safely. An essential component in attaining the full benefit of project connectivity investments includes the cooperation of USFS to minimize incompatible activities near connectivity structures, and to provide a reduction in USFS road densities in the project corridor. Another objective of this project is to protect

wildlife near the highway by improving the quality of habitats adjacent to the roadway crossing structures, without attracting wildlife onto the highway.

The environmental benefits and impacts (primarily construction-related) of the connectivity structures and features incorporated into the project alternatives are described in Sections 3.3 *Water Resources*, 3.4 *Wetlands*, 3.5 *Fish, Aquatic Habitat, and Threatened and Endangered Fish Species*, and 3.6 *Terrestrial Species*.

3.1 Geology and Soils

Denny Creek

This section was prepared based on the *Geology and Soils Discipline Report* (Washington State Department of Transportation [WSDOT] 2002a) (Appendix L). The purpose of the discipline report was to evaluate existing data on geology and soil conditions, and associated hazards in the project area such as landslides, avalanches, rock slope stability, loose or soft soil, faulting, seismicity, and groundwater. The investigations and analysis relied heavily on published information, databases and Geographic Information System information, previous mapped hazards, aerial photographs, and consultation with local, state, and federal agencies, including Kittitas County, United States Forest Service (USFS), Washington State Department of Natural Resources (WDNR), and various WSDOT groups and individuals.

The study area for geology and soils encompasses the regional geology, soils, and hazards that are near, underlie, or are located within the proposed footprint of the realigned and widened roadway of the 15-mile Interstate 90 (I-90) corridor.

3.1.1 Affected Environment

3.1.1.1 Regional Geology

The geology in the area of the proposed action is complex. In general, the alignment is underlain by a variety of glacial and alluvial deposits. These are underlain by rock units consisting of volcanic and terrestrial sedimentary strata. Local lacustrine deposits or peat soil underlies the project area adjacent to Keechelus Lake and Swamp Lake. Metamorphic rock units of the Cascade core, known as the Shuksan Greenschist, underlie the eastern portion of the project area. Major fault systems offset the geology as described further in this section.

In general, glacial materials dominate the surficial geology. The depth of the glacial materials varies along the project alignment. In areas along the valley bottom and stream channels, the glacial material may be very deep. Several feet of glacial drift are mapped on all but the steepest slopes outside the limits of the valley bottoms. The glacial materials and associated alluvium are thus the most important materials impacted by the proposed action.

Glacial Deposits

The existing project alignment lies on the east side of the Cascades crest within the area affected by alpine glaciation during the Quaternary period. The Kittitas Valley was occupied by a large valley glacier complex, which, at maximum, consisted of coalescent glaciers from Keechelus Lake, Kachess Lake, and Lake Cle Elum drainages. Deposits of at least three major glacial intervals have been mapped. These are the Thorp Drift (>700,000 years before present), the Kittitas Drift (120,000 years before present) and the Lakedale Drift (15,000 years before present). During Thorp and Kittitas times, the glaciers extended down the valley as far as the Teanaway River. The greatest advance of the glacier during the most recent glacial advance (the Fraser glaciation/Lakedale Drift) extended just east of the project limits.

Outwash materials were deposited downstream of the glacial termini. Each successive glaciation deposited outwash, which subsequently remained as terraces along the valley. The terraces of the Bullfrog and Ronald advances do not affect the present project. However, many portions of the I-90 alignment between Cabin Creek and Easton are built on outwash materials.

Landslide and Slope Deposits

During the Holocene era (i.e., the present era up to 11,000 years before present), the project area has been subject to active stream and hillslope processes along much of the alignment. Landslides, rock fall, and soil development have affected the mountain slopes. The mountain slopes skirting the project alignment are moderately sloped and support thick stands of trees. On all but the steepest slopes, colluvial soil has developed on glacial materials to average depths of about 3 feet (Plum Creek 1997). In local areas, the total soil depths can be as deep as 20 to 30 feet (Chadbourne and Moses 1994).

Faulting

The faults in the existing project alignment are considered inactive. One of the most prominent faults mapped in the area is the Straight Creek Fault, a right lateral strike-slip fault with at least 110 miles of maximum displacement (Tabor et al. 2000). This fault extends from Canada and possibly Alaska, southeast into the project area. The alignment of the Straight Creek Fault passes through Kachess Lake and the Easton area (Milepost [MP] 70.3) (Tabor et al. 2000). Recent work (Cheney 1999) suggests that the fault alignment through the project area may lie further to the west at MP 68, and in the Snoqualmie Quadrangle trends almost north-south. This mapping indicates the fault cuts across the project alignment just east of the top of Easton Hill (approximately MP 67.8).

The Olympic-Wallowa Lineament is another significant structure that intersects the project area. The Olympic-Wallowa Lineament is traced from the Olympic Mountains in the northwest to the Wallowa Mountains in the southeast. The

lineament lies south of and roughly parallels the I-90 alignment from North Bend to Ellensburg. In the project area, the lineament is interpreted as a poorly defined zone of faults and folds (Tabor et al. 2000). No specific structures have been tied directly to the lineament. However, the Olympic-Wallowa Lineament is mapped (Tabor et al. 2000) as lying eastward where it intersects the lineament and trends down the Kittitas Valley. The Olympic-Wallowa Lineament is also referred to as the Cle Elum-Wallula Lineament in the project area, and is described as a broad "linear zone of deformation and discontinuities" (Campbell 1988).

Several smaller faults have been mapped in the project area. Opinions vary concerning the locations, associations, displacements, and importance of these faults. One interpretation shows faults parallel to and associated with the Straight Creek Fault in the project area (Cheney 1999). Two faults trend generally along the Olympic-Wallowa Lineament (Cheney 1999). The Taneum Lake Fault is mapped with the down-dropped portions to the north. The Taneum Lake Fault is mapped as displacing the Columbia River Basalts (Campbell 1988).

Tabor et al. (2000) also shows three small, unnamed faults cutting across the I-90 alignment. The northernmost of these is inferred in the Gold Creek valley (MP 55.5). The second occurs on the east side of Keechelus Lake (MP 60.5). The third is on the north side of Amabilis Mountain near the Cabin Creek Interchange (MP 64.1).

3.1.1.2 SOILS

In general, soils are deep (5 to 30 feet in some areas), and typically well drained with moderate permeability (Plum Creek 1997). Soil conditions in the area are also discussed by WSDOT (Chadbourne and Moses 1994). Soil maps are maintained by Kittitas County in a Geographic Information System database. Further discussion on soils and their relationship to hydrological conditions may be found in Section 3.3.1.3.

3.1.1.3 GEOLOGIC AND SOIL RESOURCES

There is one road-surfacing stockpile and staging area located just south of Swamp Lake and north of I-90 (MP 63). There is also a small rock borrow source adjacent to I-90 at about MP 63.6 that appears to have been used as a limited source for rock ballast. WSDOT is phasing construction to maximize the use of existing cuts and fills, and to minimize the purchase of additional fill material. With the various tunneling alternatives for Slide Curve, the quantity of cut material generated exceeds the quantity of fill material. The Improvement Packages are relatively equal in terms of cut and fill material. However, the cut materials are not suitable for use as select wall backfill, as aggregate for the crushed surfacing base course, Asphalt Concrete Pavement (ACP), or in Portland Cement Concrete Pavement (PCCP). These materials would need to come from off-site sources (personal communication, Bell 2003). Excess cut materials determined unacceptable for incorporation into the project would be disposed of

at a waste site approved by WSDOT. The cut and fill quantities are shown in Table 3.1-1. Estimates for aggregate necessary for the Keechelus Lake Alignment Alternatives and Improvement Packages are presented in Table 3.1-2.

Table 3.1-1. Material Quantity Summary

	CUT/FILL QUANTITIES PRESENTED IN CUBIC YARDS						
	ALTERNATIVE				*IMPROVEMENT PACKAGE*		
Material Type	***1***	***2***	***3***	***4***	***A***	***B***	***C***
Roadway Excavation	362	842	847	451	2,077	2,085	2,218
Tunnel Excavation	1,907	615	307	0	0	0	0
Total Cut	**2,270**	**1,457**	**1,155**	**451**	**2,077**	**2,085**	**2,218**
Common Embankment	374	344	357	376	2,850	2,400	1,865
Select Wall Backfill	39	178	279	344	73	73	73
Total Fill	**412**	**522**	**636**	**721**	**2,923**	**2,473**	**1,938**
Net Cut/Fill	**1,858**	**935**	**519**	**(270)**	**(846)**	**(388)**	**280**

Table 3.1-2. Aggregate Needs[1]

	Slide Curve Alignment Alternatives[2]	***Other Areas, Including Improvement Packages[2]***
Crushed Surfacing Base Course	58,000	228,000
Asphalt Aggregate	28,000	90,000
PCCP Coarse Aggregate	43,000	80,000
PCCP Sand	15,000	46,000

Notes: 1. This table assumes that PCCP would be the pavement selected.
2. All quantities are cubic yards.

Several other rock sources were identified in the project area during a study for the Keechelus Dam (United States Bureau of Reclamation [USBR] 2001a). Descriptions of the sources closest to the proposed project are provided below:

- ***Fullerton-Pacific Site.*** This site is located adjacent to Crystal Springs Campground on the upstream side. The site is under consideration for private development by Fullerton-Pacific, and is estimated to contain more than 1 million cubic yards of gravel, silt, and sand material.

- ***Crystal Springs Borrow Area.*** This site is located along Stampede Pass Road (Forest Service Road [FSR] 54) near the Crystal Springs Campground and contains approximately 110,000 cubic yards of available material. The area is owned by the Washington State Parks and Recreation Commission (WSPRC) and used as a Sno-park. The site once served as a private sand and gravel pit covering about 50 acres.

- ***Telephone Creek Sand and Gravel Pit.*** Located along the Cabin Creek Road, this site is used by Ellensburg Cement Products, and contains about 35,000 cubic yards of fines, sand, and gravel.

- ***Easton Gravel Pit.*** Located adjacent to I-90 near Exit 71, this pit is owned by Ellensburg Cement Products. The Easton Gravel Pit contains at least one million cubic yards of gravel, with silt and sand.

Rock resources would be more specifically identified as the project design is completed. Several existing sources in the area, including those previously mentioned in this section, would be potentially available for the project. WSDOT would not develop additional sources on USFS lands.

3.1.1.4 GEOLOGIC HAZARD AREAS

The main geologic hazards along the existing project alignment include landslides, snow avalanches, rock slopes, soft or loose soil, and hazards related to seismic activity and faults. The potential hazards identified are only conceptual and require verification by future subsurface investigations.

Erosion Hazards

Soil erosion potential was inferred from soil and erosion hazard mapping. Soil mapping by Kittitas County Geographic Information System was used to identify areas of soft or loose soil conditions. The Plum Creek (1997) analysis identified erosion hazards with potential to deliver sediment to streams. From this information, areas of high erosion potential were identified.

Landslide Hazards

A recent inventory (Plum Creek 1997) identified 244 mass wasting features in the drainages surrounding the project alignment. Most of these features were classified as “shallow-rapid” events, defined as near-surface landslides consisting of soil and colluvial materials with little rock. These events were usually associated with large storms, particularly in areas of recent forest harvest activity. Landslides were found to be especially common in areas underlain by volcanic rocks of the Ohanapecosh Formation. No deep-seated landslides have been identified adjacent to the proposed alignment (Turner and Schuster 1996). The inner gorge areas of the steep tributary streams, such as Rocky Run (MP 56.8), are particularly vulnerable to shallow-rapid slides. Landslides in the inner gorge

areas are usually initiated by stream incision when the slopes are in excess of about 35 degrees. Construction activities such as road building can also create slide conditions. A major landslide occurred during past I-90 construction at Slide Curve.

Drainage and temporary road construction also appear to have some role in shallow debris slides along the alignment. A debris slide near MP 64.1 appears to be related to adverse grading on the native-surfaced road upslope of the slide and east of I-90. The grades on the upper road directed surface water runoff onto loose glacial deposits. It is possible that landsliding in this area is also related to weak soil materials or fault shear from a local fault.

Ancient, deep-seated landslides are associated exclusively with the altered volcanics of Huckleberry Mountain and the Naches Formations. These rocks contain planes of weakness along interbeds and faults. Most of these features exhibited only small, localized failures during the period of recent study (Plum Creek 1997).

Snow Avalanche

Avalanche chutes comprised 11 percent of the mass wasting features that have been mapped in the area (Plum Creek 1997). The steep slopes above Keechelus Lake are particularly prone to avalanches. Slopes that range between 30 and 45 degrees are most susceptible to initiation of avalanches (Chadbourne and Moses 1994). However, other factors, such as snow depth, elevation, deforestation, weather conditions, and temperature, are also important in determining areas susceptible to avalanche (Schaerer 2000).

Several avalanche tracks exist in the project area. The most significant tracks include five tracks near the snowshed (MP 58.2) and one at Slide Curve (about MP 59.1). Three of the avalanche tracks are the most notable hazards; these are designated East Snowshed Number 3, East Snowshed Number 4, and Slide Curve. The East Snowshed Number 4 track is considered an extreme hazard for the existing eastbound lanes (Schaerer 2000).

Rock Slopes: Cut Slopes and Portals

The highly jointed volcanic rocks along the alignment are vulnerable to rock fall where they would be intersected by cut slopes, or be subject to blasting or other activities during construction (Badger 1995). The vulnerability of these rock slopes is dependent on the material strength, groundwater conditions, and the orientation of the discontinuities in the rock mass (Hoek and Bray 1974).

Several areas of potential unstable slopes in rock have been identified along the alternative alignments (Badger 1995, Anderson 2000). Specific rock exposures are described by Chadbourne and Moses (1994).

The tunnel portals have the potential for rock fall, especially in the identified avalanche areas discussed above. Hatch Mott MacDonald (2001a) indicates that based on limited information, discontinuities at the tunnel portals are typically in good condition in fresh rock, and fair condition in weathered rock.

Rock Slopes: Tunnels

The long tunnel proposed in Alternative 1 starts on the east end with good rock conditions, traverses through an area of poor to fair rock conditions, and encounters fair to good rock quality through the rest of the excavation to the west portal. The construction for the short tunnel proposed in Alternative 2 would be mostly in good rock, possibly with some fair to poor rock immediately adjacent to the west portal (Hatch Mott MacDonald 2001b).

3.1.1.5 GEOMORPHIC CONDITIONS

The project area lies within the alpine zone on the east side of the Cascade Mountains. The general topography is one of mountainous ridges and peaks, with deep, glacially carved valleys. Most of the valleys exhibit geomorphology that is typically associated with glacial erosion. The most prominent mountain features surrounding the project alignment are Rampart Ridge, Keechelus Ridge, and Amabilis Mountain.

The highest elevations in the project area are generally less than 6,000 feet. Rampart Ridge, along the north end of the project alignment, reaches an elevation of 5,750 feet. Keechelus Ridge is just over 5,000 feet in elevation, while Amabilis Mountain is slightly higher than 4,500 feet. The road alignment is roughly at 2,500 feet in elevation through these areas, yielding a maximum relief of 2,000 to 3,000 feet.

Most of the slopes surrounding Keechelus Ridge and Mount Amabilis are generally 50 percent or less. Limited areas below Rampart Ridge surrounding Rocky Run Creek, between the snowshed and Slide Curve, exceed 100 percent (Plum Creek 1997).

The main river valley below Keechelus Lake is up to 1 mile wide; the average gradient is less than 10 percent. The valley bottom in the existing project alignment is generally broad with low gradients and has hummocky topography, especially in the areas below Keechelus Lake and around Swamp Lake. In other areas, the valley sides show a series of relatively level, successively lower terraces. These terraces are remnants of the outwash of the successive glacial episodes.

Unique physiographic features in the project area include Keechelus, Kachess, and Cle Elum lakes. These water bodies formed when glacial moraines impounded the waters of melting ice at the end of the most recent glaciation.

Dams have raised the lake levels by 97 feet in Keechelus Lake (Carter 1989) and by 59 feet in Kachess Lake (Lockhart 1989).

Several broad low gaps or passes between the drainages of the three lake basins are less prominent features of the project area. These passes include Copper Pass, between the Cle Elum and Kachess drainage basins, and the gap between Keechelus Ridge and Amabilis Mountain.

3.1.2 Environmental Consequences

This section identifies potential project impacts in terms of the geologic hazards discussed above. These impacts have been analyzed considering potential relative hazards and potential relative consequence. The potential relative hazard is mainly based on judgments made during the investigations and mapping presented in the *Geology and Soils Discipline Report* (WSDOT 2002a). The relative potential consequence is based on the proximity of the potential hazard to the project elements for each alignment alternative and Improvement Package.

3.1.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, avalanche hazards would continue, especially in vulnerable areas at the East Snowshed and Slide Curve. Because the No-Build Alternative does not change the areas of this hazard, the long-term impacts would remain the same. Because the existing alignment traverses areas of faulting, where cut slopes intersect fault gouge and loose (sheared) soil materials, the potential for continued slope degradation would continue to be a hazard. The No-Build Alternative involves no tunneling or added lanes. Impacts to soft and loose soil conditions from maintenance activities that currently exist along the existing alignment would be expected to continue.

3.1.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

Alternative 1: Long Tunnels

Borings from the existing westbound bridge at Gold Creek show up to 60 feet of loose to dense sand and gravel. Construction of the proposed multi-span bridges over the Gold Creek floodplain would require pile foundations or drilled caissons.

Cut slopes may increase landslide hazards during construction of the long tunnel, especially where they intersect weak rock, and loose or marginally stable slopes. These areas include the rock slopes at MPs 57.7, and 58.2 to 59.1. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide areas or areas of high erosion hazard, although the long tunnel alternative does not create new cut slopes in this area. There are landslide hazards in this reach of the project (MP 59 to MP 59.5).

Table 3.1-3. High Avalanche Hazard Areas

Avalanche Chute Designation	*MP Number*
ES-1	58
ES-2	58.05
ES-3	58.1
ES-4	58.15
ES-5	58.18
Slide Curve	59.0

Construction activities, such as blasting, fill placement, excavation, and rock slope improvement, could increase avalanche hazards depending on the time of year the work is performed. High avalanche hazard areas in this section of the project are identified in Table 3.1-3.

Tunnel excavation could disturb nearby weak or marginally stable rock. Groundwater drainage from tunnel excavations could also impact high-erosion hazard areas. Hazards associated with rock stability during tunneling would depend on site-specific engineering design and construction techniques, as well as on the inherent site conditions. Increases in these potential hazards are difficult to quantify at this stage in project design.

Construction could increase erosion, especially in areas where soft and loose soil conditions exist. Erosion could also occur in areas such as where grades direct surface water to vulnerable areas, fill embankments are constructed near soft or loose soil, and where construction occurs in Keechelus Lake (Jenkins 2000a, 2000b). Areas most susceptible to erosion occur mainly along Keechelus Lake.

Construction of Alternative 1 would result in 50 acres of total disturbed footprint and 38 acres of abandoned roadway reclaimed.

WSDOT would implement Best Management Practices (BMPs) to minimize soil compaction outside the roadway prism (i.e., construction areas).

Alternative 2: Short Tunnels

This alternative includes tunnels that are substantially shorter than that proposed in Alternative 1 and would construct short bridges over Keechelus Lake near the snowshed. West of the snowshed, the road would cut into the hillside to

straighten out the "S" curve between Rocky Run Creek and the snowshed. Cut slopes may increase landslide hazards, especially where they intersect weak rock, and loose or marginally stable slopes. These areas include the rock slopes at MPs 57.7, 58.2 to 59.1, and 60.28 to 60.41. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide areas or areas of high erosion hazard. There are landslide hazards in this reach of the project (MP 59 to MP 59.5).

Construction activities would be the same as described in Alternative 1. Tunnel excavation could disturb nearby weak or marginally stable rock. Groundwater drainage from tunnel excavations could also impact high-erosion hazard areas. Hazards associated with rock stability during tunneling would depend on site-specific engineering design and construction techniques, as well as on the inherent site conditions. Increases in these potential hazards are difficult to quantify at this stage in project design. These hazards would be less than those for Alternative 1 since the tunneling activities are shorter in length and duration.

Cut slopes may increase landslide hazards, especially where they intersect weak rock, and loose or marginally stable slopes. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide areas or areas of high erosion hazard.

Construction could increase erosion, especially in areas where soft and loose soil conditions exist. Erosion could also occur in areas where grades direct surface water to vulnerable areas, where fill embankments are constructed near soft or loose soil, and where construction occurs in Keechelus Lake (Jenkins 2000a, 2000b). Areas most susceptible to erosion occur mainly along Keechelus Lake.

Construction of Alternative 2 would result in 82 acres of total disturbed footprint and 21 acres of abandoned roadway reclaimed.

WSDOT would implement BMPs to minimize soil compaction outside the roadway prism (i.e., construction areas).

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

This alternative is similar to Alternative 2, although the short tunnel is only for the westbound lanes (i.e., it is narrower), and the eastbound lanes travel on the existing Slide Curve alignment. Similar to Alternative 2, this alternative also includes a cut into the hillside west of the snowshed to straighten the "S" curve between Rocky Run Creek and the snowshed, in addition to a single eastbound bridge west of Slide Curve. It includes bridges over Keechelus Lake near the snowshed. Cut slopes may increase landslide hazards, especially where they intersect weak rock, and loose or marginally stable slopes. These areas include the rock slopes at MPs 57.7, 58.2 to 59.1, and 60.28 to 60.41. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide

areas or areas of high erosion hazard. There are landslide hazards in this reach of the project (MP 59 to MP 59.5).

Construction activities would be the same as described in Alternative 1. Tunnel excavation could disturb nearby weak or marginally stable rock. Groundwater drainage from tunnel excavations could also impact high-erosion hazard areas. Hazards associated with rock stability during tunneling would depend on site-specific engineering design and construction techniques as well as on the inherent site conditions. Increases in these potential hazards are difficult to quantify at this stage in project design. These hazards would be less than those for Alternative 1 because the tunneling activities are shorter in length and duration. The hazards should be similar to Alternative 2, because the single tunnel is approximately the same length as the dual tunnels of Alternative 2.

Alternative 3 may increase landslide hazards on unstable slopes in vulnerable areas at Slide Curve. Cut slopes may increase landslide hazards, especially where they intersect weak rock, and loose or marginally stable slopes. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide areas or areas of high erosion hazard. This is particularly applicable for the cut slope at the snowshed.

Construction could increase erosion, especially in areas where soft and loose soil conditions exist. Erosion could also occur in areas such as where grades direct surface water to vulnerable areas, fill embankments are constructed near soft or loose soil, and where construction occurs in Keechelus Lake (Jenkins 2000a, 2000b).

Fill placement may increase erosion through the following mechanisms:

- Creation of temporary grades that direct surface water runoff to sensitive areas.
- Rapid loading, leading to bearing failure.
- Loading of landslide areas, thus increasing the potential for movement.

Several areas of soft soil conditions exist along Alternative 3. Slide Curve (MP 58.6 to about MP 59.6) is the most significant of these areas.

Construction of deep foundations that may be needed for the elevated roadway over Keechelus Lake could cause soil settling and mobilization.

Construction of Alternative 3 would result in 99 acres of total disturbed footprint and 13 acres of abandoned roadway reclaimed.

WSDOT would implement BMPs to minimize soil compaction outside the roadway prism (i.e., construction areas).

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

This alignment would construct both directions of traffic around Slide Curve. West of the existing snowshed, the road would cut into the hillside to straighten out the "S" curve between Rocky Run Creek and the snowshed and includes bridges over Keechelus Lake near the snowshed. An eastbound bridge would be required at the west end of Slide Curve. Cut slopes may increase landslide hazards, especially where they intersect weak rock, and loose or marginally stable slopes. These areas include the rock slopes at MPs 57.7, and 58.2 to 59.1. Cut slopes may also increase landslide hazards by redirecting surface water runoff onto landslide areas or areas of high erosion hazard. There are landslide hazards in this reach of the project (MP 59 to MP 59.5).

All impacts of this alternative are similar to Alternative 3, except no tunneling is involved. As discussed in Chapter 2, this alignment results in a roadway with a design speed that is less than desirable and, as in Alternative 3, leaves the current unstable soils at Slide Curve as part of the alignment.

Construction of Alternative 4 would result in 94 acres of total disturbed footprint and 5 acres of abandoned roadway reclaimed.

WSDOT would implement BMPs to minimize soil compaction outside the roadway prism (i.e., construction areas).

3.1.2.3 IMPROVEMENT PACKAGES

This section presents impacts to geology and soils from the three Improvement Packages and corridor-wide roadway improvements outside the Keechelus Lake Alignment Alternatives.

A fault line occurs at MP 64.2 between Toll Creek and Cedar Creek. Potential failures could occur in areas of faulting where cut slopes intersect fault lines and loose (sheared) soil materials. This could lead to increased slope degradation. Cut and fill activities are planned for the Cabin Creek Interchange.

Rock slopes with a high potential for rock falls exist at several locations between Cedar Creek and the West Easton Interchange, and near Townsend Creek between MP 60.28 and 60.41.

Construction of Improvement Package A would result in 377 acres of total disturbed footprint, and 29 acres of abandoned roadway would be reclaimed. With Improvement Package B, the total disturbed footprint would be 405 acres, with 16 acres of abandoned roadway reclaimed. Improvement Package C results in 405 acres of total disturbed footprint with 7 acres of abandoned roadway reclaimed.

3.1.3 Construction and Operation Best Management Practices

To minimize the potential for failure of geologic elements due to weather or other natural or man-made factors, the following measures may be utilized during construction.

Temporary slopes may require such BMPs as the following:

- Perimeter ditching or other erosion control measures.
- Plastic sheeting in severe weather to protect subgrades or fill materials.
- Staged fill placement or surcharges.
- Temporary walls.
- Temporary crushed rock armoring of exposed soil.
- Rock ballast for buttressing in landslide areas.
- Temporary containment fences for rock fall and avalanches.
- Replacement of soft or unsuitable foundation materials.

Depending on timing of construction, some method of slope monitoring (e.g., optical and physical stationing) could be needed to monitor and track expected movements or settlements.

Foundation construction would involve techniques similar to those described above for temporary slopes. In addition, foundation construction could include use of special types of equipment, and include the following:

- Additional core sampling to understand underlying material and geology.
- Barges and large drilling equipment for lake shore placement of drilled caissons in soft or loose conditions.
- Placement of compacted soil/rock to span poor subgrade areas, and to more evenly distribute loads or settlement.

Tunnel construction may require the use of special excavating equipment to minimize impacts to soft ground and loose soil. Temporary shoring may be necessary in areas where cuts are less stable (e.g., portals and fault lines). Temporary erosion control may be needed at the portals or where excess water is directed. Containment fencing may be required on slopes near the tunnel excavation to control rock fall and snow avalanche hazards.

Operation techniques would vary depending on the type of feature and location where the impact occurs. Current techniques for minimizing avalanche hazards include passive measures or active control of avalanches. Examples of passive

measures include avoidance, snowshed construction, walls, berms, or containment fencing. Active control consists of using explosives to cause avalanches. Active control minimizes avalanche impacts by controlling the size and timing of the avalanche.

3.2 Air Quality

Emissions from transportation projects are produced by vehicles operating on roadways.

The following presentation is based on the *Air Quality Discipline Report* (Washington State Department of Transportation [WSDOT] 2003a) (Appendix F). The purpose of the report was to identify key air pollutants, conduct appropriate dispersion modeling, document the air quality status in the project vicinity including attainment status, identify carbon monoxide (CO) impacts at sensitive receptors and air quality impacts during construction, and provide recommendations for emission controls. CO emissions emitted as vehicle exhaust are the primary pollutant of concern because of their potential to cause CO hotspots. Consequently, CO is the primary focus of the analysis and the only pollutant for which predictive modeling was performed using the CAL3QHC dispersion model.

The study area for air quality is both regional and project specific depending on the pollutant. For nitrogen oxides and volatile organic compounds, the study area is Kittitas County, encompassing the Alpine Lakes Wilderness Area north of Interstate 90 (I-90). This is because nitrogen oxides and volatile organic compounds are precursors to ozone, and their effect on ozone levels usually occurs several hours after they are emitted and many miles from the source. CO is the pollutant of greatest concern for transportation sources on a localized basis. Therefore, the study area for CO is the 15-mile project area from Hyak to Easton. Existing and future CO concentrations were modeled at various sensitive receptors within 500 feet of I-90 throughout the project area. The impact of fugitive dust and particulate matter less than 10 microns in diameter (PM_{10}) due to construction activities usually occurs adjacent to construction areas. Therefore, the study area for these emissions is in proximity to proposed construction areas.

Emissions from transportation projects occur from vehicles operating within roadway systems. For the I-90 project, CO emissions emitted as vehicle exhaust are the primary pollutant of concern because of their potential to cause CO hotspots. Ozone precursors (reactive organic compounds and nitrogen oxides) are also emitted by vehicles, but are not expected to produce substantial localized or regional air pollution impacts. PM_{10} is also emitted in vehicle exhaust, and released by tire and brake wear. However, due to the rural nature of the project and the minor amount of PM_{10} released by mobile sources, PM_{10} emissions associated with the I-90 project are not expected to result in substantial

environmental effects. Sulfur oxides and nitrogen oxides are also emitted by motor vehicles, but the impact of these pollutants near roadways is generally low.

3.2.1 Affected Environment

AMBIENT AIR QUALITY STANDARDS

The Washington Department of Ecology's (WDOE) Central Regional Office in Yakima enforces air regulations in Kittitas County. The United States Environmental Protection Agency (USEPA) and WDOE establish regulations designed to limit emissions from air pollution sources, and to minimize concentrations of pollutants in the outdoor air. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state has adopted more stringent standards, USEPA's National Ambient Air Quality Standards (NAAQS) apply. The NAAQS consist of primary standards designed to protect public health and secondary standards designed to protect public welfare (e.g., preventing air pollution damage to vegetation). Washington has established additional state ambient standards for total suspended particulates and sulfur dioxide standards that are more stringent than the federal requirements.

Toxic air pollutants (TAPs) include pollutants that generally have no established ambient standards, but are known or suspected to cause some level of acute or chronic health risk (cancer or non-cancer effects) to the general public. Since the proposed construction action and resulting operational scenarios include a variety of mobile emission sources that would emit TAPs, this Environmental Impact Statement (EIS) includes an analysis of the impact of proposed TAPs emissions to public health.

REGIONAL AIR QUALITY

WDOE maintains a network of criteria air pollutant monitoring stations throughout the state. These stations are placed in areas where there may be air quality problems, usually in or near urban areas or close to large air pollution sources. A limited number of additional stations are located in remote areas to provide an indication of regional background air pollution levels. Based on monitoring information collected over a period of years, the state and federal agencies designate regions as being "attainment," "nonattainment," or "unclassifiable" areas for regulated air pollutants. "Attainment" status indicates that air quality in an area meets the federal health-based ambient air quality standards; "nonattainment" status indicates that air quality in an area does not meet those standards. "Unclassifiable" status indicates that there are no relevant monitoring data for the area, in which case the area has the same regulatory status as "attainment." There is one criteria air pollutant monitoring station in Kittitas County at Ellensburg that measures PM_{10}. There is also a monitoring station at the top of the Snoqualmie Pass Ski Area that measures air quality

values as part of the national network of the Interagency Monitoring of Protected Visual Environments program.

For purposes of modeling ambient CO impacts for this project, it was assumed that the background CO concentrations are 3.0 parts per million (ppm) (1-hour average) and 2.1 ppm (8-hour average).

The project area is an attainment area for ozone, and there are no significant local or regional sources of ozone precursors. The proposed I-90 improvement is included in the Transportation Improvement Plan. Therefore, the project is not subject to Air Quality Conformity for ozone, and no quantitative analysis of photochemical ozone was developed for this analysis.

PREVENTION OF SIGNIFICANT DETERIORATION

Alpine Lakes

The Clean Air Act Section 162 established the goal of prevention of significant deterioration (PSD) of air quality in all international parks; national parks that exceeded 6,000 acres; and national wilderness areas that exceeded 5,000 acres, if these areas were in existence on August 7, 1977. These areas were defined as mandatory Class I areas, while all other attainment or unclassifiable areas were defined as Class II areas. Under the Clean Air Act Section 164, states or tribal nations, in addition to the federal government, have the authority to redesignate certain areas as (non-mandatory) PSD Class I areas, that is, a National Park or national wilderness area established after August 7, 1977, that exceeds 10,000 acres. PSD Class I areas are areas where any appreciable deterioration of air quality is considered significant, while all other areas are defined as Class II areas, where moderate, well-controlled growth could be permitted. The Clean Air Act Section 169A established the additional goal of prevention of further visibility impairment in the PSD Class I areas. Visibility impairment is defined as a reduction in the visual range and atmospheric discoloration. Due to the proximity of federal Class I areas to the project site, the proposed action has the potential to impact air quality in these pristine areas. The Clean Air Act allows almost no degradation of air quality in Class I areas from proposed emission sources. The Regional Haze Regulation promulgated by the USEPA in 1999 also directs states to achieve “natural” visibility conditions in Class I areas within the next 60 years. The closest Class I area to the project site is the Alpine Lakes National Wilderness Area, whose nearest border is about 1 mile northeast of I-90.

3.2.2 Environmental Consequences

The following discussion of air quality environmental consequences applies to all the Keechelus Lake Alignment Alternatives.

3.2.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, existing facilities would not be expanded. However, periodic resurfacing of the roadway would occur. Best Management

Practices (BMPs) in regard to air quality would be followed during the resurfacing procedures. Therefore, no impact to air quality is expected.

3.2.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

Alternative 1: Long Tunnels

Carbon Monoxide Impacts at Sensitive Receptors

The CO modeling analysis was conducted in accordance with the requirements of Washington Administrative Code 173-420 and USEPA guidelines. The air quality dispersion model recommended by the USEPA and WSDOT for estimating CO concentrations is called CAL3QHC. Version 2.0 of this model was used to calculate peak 1-hour and 8-hour CO concentrations near the I-90 roadway. Because there are no stop-controlled intersections in the I-90 corridor, only "free-flow" links were used in the CO modeling analysis. Traffic volumes and travel speeds for existing conditions in 2001 and 2020 were provided by WSDOT.

Vehicle emission factors generated by the USEPA MOBILE5A mobile source emissions model were used to calculate the amount of CO (in grams per mile of travel) emitted by traffic on I-90. Because the modeled link is assumed to be a free-flow link, emission factors for a vehicle speed of 65 miles per hour (mph) were selected for the various conditions. The modeled CO emission factors used for this project were as follows:

- Year 2010 (65 mph) – 32.5 grams per vehicle mile
- Year 2020 (65 mph) – 15.9 grams per vehicle mile

The CAL3QHC dispersion model was used to estimate the worst-case peak-hour CO concentrations for sensitive receptor locations at varying distances from the highway. Modeling output reports are found in the *Air Quality Discipline Report* (WSDOT 2003a). Critical assumptions and configuration parameters used in the worst-case CAL3QHC modeling were based on USEPA guidance (USEPA 1992).

Table 3.2-1 lists the modeled 1-hour CO concentrations at various distances from the highway, including the sensitive receptors identified along the project corridor. Table 3.2-1 also shows the modeled 8-hour average concentrations at each receptor location. The modeled concentrations include the assumed background concentrations. For the existing conditions and the future conditions, the modeled CO concentrations at all receptors within 500 feet of the highway were much lower than the NAAQS. The concentrations at the worst-case receptor at the edge of the right-of-way (ROW) were less than the NAAQS limits.

Table 3.2-1. Modeled 1-Hour and 8-Hour Carbon Monoxide Concentrations

Receptor Distance from Nearest Highway Lane (feet)	*Existing Conditions (ppm)*		*Build Year 2005 (ppm)*		*Horizon Year 2030 (ppm)*	
	1-Hour	*8-Hour*	*1-Hour*	*8-Hour*	*1-Hour*	*8-Hour*
General Receptors at Varying Distances from Highway						
100 feet from roadway (assumed edge of right-of-way [ROW])	5.4	3.8	4.6	3.2	3.7	2.6
200 feet from roadway	4.0	2.8	3.4	2.4	2.8	2.0
300 feet from roadway	3.4	2.4	3.0	2.1	2.4	1.7
400 feet from roadway	2.9	2.0	2.6	1.8	2.2	1.5
500 feet from roadway	2.7	1.9	2.4	1.7	2.0	1.4
Specific Receptors Based on Site Reconnaissance						
White castle cabin at Hyak (150 feet from highway)	4.7	3.3	3.9	2.7	3.3	2.3
Cabins at Wolfe Creek (150 feet from highway)	4.7	3.3	3.9	2.7	3.3	2.3
Cabins at Resort Creek (400 feet from highway)	2.9	2.0	2.6	1.8	2.2	1.5
Crystal Springs Campground (300 feet from highway)	3.4	2.4	3.0	2.1	2.4	1.7
Lake Easton State Park (250 feet from highway	3.7	2.6	3.2	2.2	2.6	1.8
Cabins near Lake Easton Airport (250 feet from highway)	3.7	2.6	3.2	2.2	2.6	1.8

Notes: The 1-hour state and federal CO standard is 35 ppm.
Assumed 1-hour CO background value = 1 ppm
The 8-hour state and federal CO standard is 9 ppm.
Assumed 8-hour CO background value = 0.7 ppm
Source: WSDOT 2003a.

Since the CAL3QHC modeling was performed using a combination of worst-case assumptions, it is concluded that none of the development options would cause any adverse air quality impacts at any sensitive receptor. Moreover, the results of the CO modeling analysis show that air quality impacts from the project would decrease in future years, because a decrease in emissions from the future vehicle fleet due to the implementation of USEPA vehicle emission standards would offset the increase in future traffic volumes along I-90. It is expected that the CO concentrations under any of the build alternatives would be lower than under the No-Build Alternative because of the projected reduction in traffic congestion. As a result, the proposed action would not produce any adverse air quality impacts within the project area.

Toxic Air Pollutant Impacts From Future Vehicular Traffic

Combustive emissions due to the operation of vehicles within the I-90 roadway affected by the proposed action would contain TAPs that have the potential to produce acute or chronic public health effects, especially to sensitive receptors. Due to the mobile nature of these sources and their relatively low TAPs emission rates, emissions of TAPs from the project roadway would produce minimal pollutant impacts in a localized area. Similar to what was determined in the CAL3QHC modeling analysis for CO, TAPs impacts from the project would decrease in future years, because a decrease in emissions from the future vehicle fleet due to the implementation of USEPA vehicle emission standards would offset the increase in future traffic volumes along I-90. As a result, TAPs emissions from the operation of vehicles within the project roadway would not produce any adverse air quality impacts to public receptors within the project area.

Air Quality Impacts During Construction

Fugitive Dust

Construction activities would produce fugitive dust emissions due to wind erosion and the operation of construction equipment on exposed earth surfaces. Fugitive dust releases generally constitute the largest source of PM_{10} during construction. Dust emissions depend upon soil types and moisture. Most of the dust particles would settle out adjacent to construction areas, while a small fraction would be transported further downwind and would contribute to the regional ambient PM_{10} level. Air quality impacts caused by construction equipment emissions are short-term and would cease upon completion of construction activities. Implementation of the BMPs described in Section 3.2.3 would minimize fugitive dust emissions from construction and would not produce any adverse air quality impacts.

Slash Disposal

It is possible that some wood debris generated during construction might be burned for disposal. If so, burn permits would be obtained from WDOE and the Washington Department of Natural Resources (WDNR). The burn permit would allow burning only during favorable weather conditions with good air ventilation, thus ensuring that debris burning would not produce any adverse air quality impacts.

Odors

Short-term, localized odors might be generated by exhaust from construction equipment, asphalt paving, and line painting. Based on the rural nature of the project area and the relatively large distances to sensitive receptors, the temporary odor emissions would not produce any adverse impacts.

Combustive Emissions from Construction Equipment

Mobile construction equipment and portable stationary engines would emit combustive air pollutants, including nitrogen oxides, CO, PM_{10}, and TAPs. Due to their temporary and intermittent nature, the ambient concentrations produced by these emissions within the project region would be substantially less then those identified in any ambient air quality standard. As a result, combustive emissions from project construction equipment would not produce any adverse air quality impacts within the project area. Implementation of the BMPs described in Section 3.2.3 would minimize combustive emissions from construction.

Emissions from Temporary Stationary Sources

Highway construction could require the operation of temporary asphalt plants, concrete batch plants, and gravel borrow pits. These operations would be subject to permitting by the local air quality regulatory agency. Emission controls would be required in accordance with Best Available Control Technology. Use of these emission controls would ensure that the temporary sources would not cause ambient air pollutant concentrations exceeding the NAAQS limits.

Project Air Quality Impacts to Class I Areas

The project site is in close proximity to the Alpine Lakes National Wilderness Area, a pristine Class I area. Due to the reduction in emissions from the future I-90 project corridor, project emissions would produce minimal air quality impacts within this Class I area.

Alternative 2: Short Tunnels

The air quality environmental consequences under this alternative are the same as those identified for Alternative 1. Refer to that alternative for the discussion of air quality impacts.

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

The air quality environmental consequences under this alternative are the same as those identified for Alternative 1. Refer to that alternative for the discussion of air quality impacts.

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

The air quality environmental consequences under this alternative are the same as those identified for Alternative 1. Refer to that alternative for the discussion of air quality impacts.

3.2.2.3 IMPROVEMENT PACKAGES

Impacts as a result of the implementation of the Improvement Packages would focus on those associated with construction. Fugitive dust or PM_{10} impacts produce from the project would be short-term and would cease upon completion of construction activities. With the implementation of the construction measures listed below, construction emissions would produce minimal air quality impacts.

3.2.3 Construction Best Management Practices

FUGITIVE DUST CONTROLS

Impacts from fugitive dust, odors, and particulate matter during construction are expected to be short-term. Implementation of the following BMPs would reduce adverse air quality related construction impacts and would comply with Washington State regulations to minimize fugitive dust emissions:

- Water all active construction areas as required to control dust.
- Cover all trucks hauling soil, sand, and other loose materials, or require all trucks to maintain at least 2 feet of freeboard.
- Pave, apply water regularly, or apply (nontoxic) soil stabilizers on all unpaved access roads, parking areas, and staging areas at construction sites.
- Sweep, as required to control dust (with water sweepers), all paved access roads, parking areas, and staging areas at construction sites.
- Limit traffic speeds on unpaved access roads to 15 mph.
- Install erosion control measures to prevent silt runoff to public roadways.
- Monitor conditions, and apply an adaptive management philosophy.

3.3 Water Resources

Kachess Dam and Reservoir

This section was prepared based on the *Final Discipline Report for Interstate 90 Snoqualmie Pass East: Hydrologic Systems, Water Quality, and Floodplains* (Washington State Department of Transportation [WSDOT] 2002b) (Appendix N), *Interstate 90 – Snoqualmie Pass East Water Resources Discipline Report Supplement* (WSDOT 2004e) (Appendix X), *Interstate 90 Snoqualmie Pass East Mitigation Development Team: Draft Recommendation Package* (MDT 2004), and field observations. The purpose of the reports was to evaluate the existing conditions, potential impacts, and mitigation measures for these three separate discipline areas as they relate to potentially affected waterways in the project area.

The attributes of water resources addressed in this section include groundwater, floodplains, stream geomorphology, water quality, and Riparian Reserves. Groundwater characteristics such as aquifer recharge areas, roadfill interception, and connectivity are addressed for areas where groundwater features were identified. Floodplain characteristics addressed in the analysis include confinement (i.e., natural confinement, artificial confinement, and unconfined), connectivity to stream channel, soil compaction, and encroachment. Stream geomorphology refers to stream channel characteristics such as connectivity to floodplains, channel migration/confinement, capacity for bed load and sediment transport, and flow regime (i.e., base and peak flows). Water quality parameters used to characterize the water resources within the project area include water temperature, sediment, dissolved oxygen levels, metals concentration, and fecal coliform.

Riparian Reserve is a United States Forest Service (USFS) land allocation classification, established in the Aquatic Conservation Strategy of the Northwest Forest Plan, and refers to the area located within an established buffer distance away from water bodies and wetlands. Within Riparian Reserves, particular emphasis is placed on riparian-related resources by the USFS, and special standards and guidelines were developed to manage these areas to achieve specific objectives. These objectives, in conjunction with the riparian reserves and the standards and guidelines, are the core of the Aquatic Conservation Strategy, and are intended to maintain and restore the ecological health of watersheds and aquatic ecosystems within the Northwest Forest Plan area.

The study area for water resources is defined as the Upper Yakima River Sub-basin watershed, which consists of three watersheds (USFS and Bureau of Land Management [BLM] 1994). The three watersheds are Kachess Lake, Keechelus Lake, and Lake Easton. The existing highway alignment runs along the shoreline of Keechelus Lake for approximately half the reach, and then along the left bank of the Yakima River (looking downstream) for the remainder of the project.

Within the study area, there are 14 major tributaries that cross the highway and drain into Keechelus Lake or the Yakima River, and 3 reservoirs. A detailed listing of the tributaries and description of the study area is presented in Section 3.3.1.1, *Watersheds*.

The dominant water quality deficiencies identified in the study area are excessive temperature caused from lack of vegetative stream cover and sediment deposition caused by streambed erosion. Sedimentation, partially attributed to traction sand in runoff from the existing Interstate 90 (I-90) roadbed, was also identified as a problem. Performance standards relating to hydrologic connectivity, stream crossings, and water quality are specifically addressed at each stream section directly affected by the proposed action.

3.3.1 Affected Environment

This section describes the existing condition of water resources within the project corridor (Figure 1-2). Groundwater, surface water, and floodplains are addressed in this section, while wetlands and aquatic habitat are described separately in Sections 3.4 and 3.5, respectively. Unless cited, this affected environment section is referenced from the *Final Discipline Report for Interstate 90 Snoqualmie Pass East: Hydrologic Systems, Water Quality, and Floodplains* (WSDOT 2002b) (Appendix N).

3.3.1.1 WATERSHEDS

The entire project area is located within the 6,000-square-mile Yakima River Basin, which is designated as Water Resource Inventory Area 39 by the Washington Department of Ecology (WDOE). The majority of the project is located within the 2,100-square-mile Upper Yakima River Sub-basin. There are 14 tributaries draining an area greater than 300 acres each that cross the existing roadway or may be directly affected by the project. These tributaries are listed in Table 3.3-1. There are three United States Bureau of Reclamation (USBR)-operated reservoirs located in the vicinity of the project. Two of the reservoirs, Keechelus Lake and Lake Easton, are located within the project area. The third reservoir, Kachess Lake, is located to the east just outside of the project area. Keechelus Lake and Lake Easton are located on the Yakima River, and have capacities of 158,000 acre-feet and 4,000 acre-feet, respectively. Kachess Lake is located on the Kachess River and has a capacity of 239,000 acre-feet.

Table 3.3-1. Yakima River Tributaries

Tributary Name	*Stream Type*	*Existing I-90 Crossing*	*Drainage Area (acres)*	*Floodplain Type*
Coal Creek	Perennial	50 foot bridge	3,616	Artificially confined (Mitigation Development Team [MDT] 2004)
Gold Creek	Perennial	150 foot bridge	8,937	Artificially confined (MDT 2004)
Rocky Run Creek	Perennial	100 foot bridge eastbound / double 6 foot pipe culverts westbound	1,416	Naturally confined
Wolfe Creek	Perennial	6 foot pipe culvert	486	Naturally confined
Resort Creek	Perennial	6 foot pipe culvert	1,815	Alluvial fan – artificially confined (MDT 2004)
Townsend Creek	Perennial	6 foot pipe culvert	798	Naturally confined
Price Creek	Perennial	10 foot box culvert	377	Artificially confined (MDT 2004)
Noble Creek	Perennial	4 foot pipe culvert	311	Artificially confined (MDT 2004)
Bonnie Creek	intermittent	6 foot box culvert	800	Artificially confined (MDT 2004)
Swamp Creek	Perennial	8 foot double box culvert	2,570	Artificially confined (MDT 2004)
Toll Creek	Intermittent	4 foot pipe culvert	419	Alluvial fan – artificially confined (MDT 2004)
Cedar Creek	Intermittent	4 foot box culvert	346	Transition confined/unconfined
Telephone Creek	Intermittent	4 foot box culvert	701	Naturally confined
Hudson Creek	Intermittent	2 foot pipe culvert	903	Artificially confined (MDT 2004)
Kachess River	Perennial	100 foot bridge	40,632	Artificially confined (MDT 2004)

The Yakima River begins at Keechelus Dam at an elevation of 2,480 feet and descends at a 0.35 percent gradient to its confluence with the Cle Elum River (downstream of the project area). Near Kennewick, the Yakima River drains into the Columbia River, which then empties into the Pacific Ocean. Yakima River streamflow is heavily dependent upon the controlled releases from Keechelus Lake and Kachess Lake by the USBR. Irrigation releases from Keechelus Dam generally occur between June and continue until October. At other times of the year, target flows, mandated by Federal law, must be met at the Sunnyside Diversion Dam and Prosser Diversion Dam from April through the end of the irrigation season. Winter flow releases below several of the reservoirs, including Keechelus, are set annually at the discretion of the USBR Yakima Field Office Manager (personal communication, Kaumheimer 2005). Releases from Lake Easton do not impact flows in the Yakima River within most of the project area, as the lake is located at the downstream end of the project area.

3.3.1.2 WATER QUALITY

Waters of the Upper Yakima River Sub-basin upstream of the Cle Elum River mouth are classified as AA (Extraordinary) by the State of Washington. Beneficial uses for the Upper Yakima River Sub-basin include, but are not limited to, domestic water supply, salmonid spawning, and primary contact recreation.

In accordance with Section 303(d) of the federal Clean Water Act, every 4 years each state must identify its water bodies that do not meet beneficial uses and water quality standards, and submit this list to the United States Environmental Protection Agency (USEPA). These are water quality-limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next 4 years.

A total of 16 waterbody segments near the project area are included on the most recently published 303(d) list (1998), with 15 of those on the Yakima River. Only one of these Yakima River segments is located within the project area, immediately downstream of Lake Easton (T. 20 N., R. 13 E., Section 10). This segment of the Yakima River is listed for exceeding temperature standards. The remaining 14 segments are located as far downstream from the project area as Ellensburg.

Gold Creek is the only tributary to the Yakima River within the project area that is listed on the 303(d) list. The listed location is well upstream of the project area and is unlikely to be affected by project activities. Many water body segments within the project area have not been sampled, and their status for water quality is unknown.

Baseline water quality monitoring was performed in 2001 to determine background water quality conditions of the creeks within the project vicinity (WSDOT 2002b). This program involved both continuous water temperature

monitoring and event-based water quality sampling. Baseline water quality sampling was conducted during representative events including snowmelt, fall rainfall runoff, winter rainfall runoff, and typical summer low flow conditions.

The baseline water quality monitoring conducted in 2001 showed that most streams crossing the existing I-90 alignment do not have substantial levels of contamination. The state standards were exceeded for some parameters in a few streams. Exceedances of State standards are summarized in Table 3.3-2. Monitored water quality parameters of concern included temperature, turbidity, fecal coliform, dissolved oxygen, lead, arsenic, chromium, pH, and specific conductivity.

Table 3.3-2. Water Quality and Functional Status of Water Bodies

Creek	***Water Quality Parameters Exceeding State Standards***[1]	***Functional Status***[2]
Coal Creek	Temperature, Turbidity, Fecal Coliform, Dissolved Oxygen, Heavy Metals[3]	Not Properly Functioning (NPF)
Gold Creek	Temperature, Dissolved Oxygen	NPF
Rocky Run Creek	Temperature, Dissolved Oxygen, Heavy Metals[3]	NPF
Wolfe Creek		Properly Functioning (PF)
Resort Creek	Temperature, Dissolved Oxygen	PF
Townsend Creek		NPF
Price Creek		PF
Noble Creek		At Risk
Bonnie Creek	Limited Information	Not Identified
Swamp Creek	Temperature, Turbidity, Fecal Coliform, Dissolved Oxygen, Heavy Metals[3]	NPF
Toll Creek	Turbidity, Fecal Coliform, Dissolved Oxygen, Heavy Metals[3]	NPF
Cedar Creek	Dissolved Oxygen	At Risk
Telephone Creek	Temperature, Dissolved Oxygen	NPF
Hudson Creek	Temperature	NPF
Kachess River/Lake Easton	Temperature, Turbidity, Dissolved Oxygen, Heavy Metals[3]	NPF

Notes: 1. From WSDOT 2002b
2. From MDT 2004 (Functional Status ratings discussed later in this section.)
3. Indicates heavy metals were detected but did not exceed state standards. Summarized in WSDOT 2002b.

In general, temperature exceedances of state water quality standards can be attributed to poor riparian vegetative cover, the disruption of groundwater flow, and shallow water depth. Groundwater flow can be disrupted by roads and drainage structures, which force subsurface flow to the surface. Shallow water depth can result from excessive sediment deposition, which may occur as a result of increased bank erosion. Stream channels that are artificially confined by the highway and by stream crossing structures are prevented from migrating naturally across their floodplain.

Increased sediment deposits can also result from the application of traction sand on the highway, which enters waterways in stormwater runoff. Traction sand and bank erosion may also influence turbidity levels in streams. Dissolved oxygen concentrations that are below water quality standards may result from the presence of animal waste, decaying organic matter, or automobile spills such as fuels or lubricants. Low dissolved oxygen levels are also related to elevated water temperatures. Detectable quantities of heavy metals result from automobiles.

Water quality for each water body within the project area was assessed by the MDT (2004), based on its ability to meet water quality standards for aquatic species and human beneficial uses. The water quality for each waterbody in the project area is described as being properly functioning, not properly functioning, or at risk. Streams that met all water quality standards were identified as "properly functioning." Streams that failed to meet standards for one or more parameters were identified as "not properly functioning." Streams that could potentially fail standards if not restored were rated as "at risk."

All water quality standards have been met for each stream at the I-90 crossing unless identified in Table 3.3-2. It should be noted that although the 2001 monitoring (WSDOT 2002b) determined that Resort Creek exceeded state standards for temperature and dissolved oxygen, the creek was still identified as being properly functioning by the MDT (2004). As stated in the MDT (2004) report, continuous temperature monitoring in Resort Creek was incomplete, missing the warmest part of the summer. The temperatures that were recorded during this monitoring never exceeded state standards. However, temperature did violate the applicable standards during sampling of summer low flows in 2001, as did dissolved oxygen.

For Townsend Creek, none of the aforementioned water quality parameters of concern exceeded state standards during 2001 sampling (WSDOT 2002b). However, the MDT (2004) did describe the creek as not properly functioning due to sediment. The MDT (2004) also described the water quality of Noble Creek as at risk due to sediment from the interstate, although no standards were violated during 2001 sampling.

3.3.1.3 GROUNDWATER

The Upper Yakima River Sub-basin consists of two hydrostratigraphic provinces, the Columbia Plateau aquifer system, and pre-Miocene rock units with Quaternary volcanics. The most prevalent aquifer system within the project area is composed of the pre-Miocene rocks. Porosity and hydraulic conductivity for this aquifer system are expected to be very low, resulting in limited groundwater storage and well yield, but conclusive data have not been collected. The Yakima River may recharge the aquifer during periods of high flow and then receive groundwater (i.e., gaining river) during low flow. There are no sole source aquifers within the project area.

Based on interviews conducted with local, state, and federal agency staff, it appears that groundwater quality monitoring is not occurring on a regional basis within the Yakima River Basin. All of the federally regulated drinking water systems (systems serving more than 15 customers or 25 people) are currently meeting state and federal standards. Typical sources of groundwater degradation that could be expected in this area include naturally occurring dissolved salts and minerals, septic systems, leaking underground storage tanks, point source contamination at the wellhead, areas with fertilizer or pesticide application, chemical spills, and leaching from landfills (Economics and Engineering Services, Inc. 2001). Due to the relatively undeveloped mountainous characteristic of the project area, groundwater quality is expected to be very good.

Groundwater use in 2000 for the entire Upper Yakima River Sub-basin, including Ellensburg, was 36,371 acre-feet, of which 19,556 acre-feet was used for agriculture, 9,933 acre-feet for public water systems and 5,652 acre-feet for individual household wells (Economics and Engineering Services, Inc. 2001).

Localized groundwater conditions were assessed on the ability of the site to perform groundwater flow and recharge functions. The presence of important groundwater features were identified, including outwash soils that provide groundwater recharge, till/outwash soils that indicate groundwater/surface water interactions, and groundwater flow that supports wetland and riparian habitat. Impairments to groundwater flow were identified, including obstruction by the road prism and compaction of soils by human activities.

In the project area, the highway generally occurs on terraces of glacial outwash and older alluvium. Flow, recharge, and connectivity of the shallow unconfined aquifers that are present in these terraces are impacted by cut slopes, fill, and drainage systems associated with the highway. Baseflow of the Yakima River and recharge of the wetlands located within the Yakima River floodplain are reduced due to the highway, which interferes with groundwater flow between the upslope terraces and the alluvial aquifer within the river floodplain.

Outwash soil and an aquifer recharge area were identified at Coal Creek. The USFS has also potentially identified an unconfined aquifer in the area of Milepost (MP) 54.5, which exists at a depth of 80 to 150 feet beneath the ground surface. Interception and accelerated runoff of this groundwater has resulted from previous highway construction.

The glacial terraces within the Gold Creek valley contain shallow unconfined aquifers. Highway fill, cut slopes, and drainage structures impact recharge and connectivity of these aquifers. Hyporheic flow was identified at Gold Creek. The interaction between surface water and groundwater may be contributing to dewatering of Gold Creek upstream of I-90. Groundwater was identified at Townsend Creek, although no impacts were identified.

An area of unconfined streams, perched wetlands, and groundwater emergence is located west of Price Creek for approximately 800 feet along the north side of I-90 toward Keechelus Dam. This hydrologically active area was cut off from landforms to the south during past highway construction and placement of road fill materials. These features were important in storing both surface and groundwater, and releasing it slowly downslope toward the Yakima River, sustaining streamflow, water temperature regimes, and aquatic habitat in the Yakima River. Roadfill in the area of Noble Creek intercepts and reroutes groundwater flow to Noble Creek, which causes groundwater to emerge on the east side of Noble Creek.

At Bonnie Creek, roadfill intercepts and reroutes groundwater flow to the east and west of the interstate for about 500 and 300 feet, respectively. Groundwater occurs east and west of the Stampede Pass interchange near Swamp Creek. Surface and groundwater hydrologic continuity is high in this area, although I-90 fill, Forest Service Road (FSR) 54, and the dam constructed upstream of I-90 are partial barriers to hydrologic continuity.

Groundwater flow east of the Cabin Creek interchange near Toll Creek has been affected by I-90 fill, although specific impacts are not identified. A groundwater emergent zone near Cedar Creek and a groundwater recharge area below I-90 near Telephone Creek were identified, but impacts are not identified. Highway fill near Hudson Creek covers a terrace that once provided groundwater recharge and connectivity to wetlands below. Cut slopes east of Hudson Creek intercept and divert seepage into the highway drainage system, reducing recharge of groundwater in the downslope terrace.

Groundwater features were not identified at Rocky Run, Wolfe Creek, or Resort Creek.

3.3.1.4 FLOODPLAINS AND STREAM GEOMORPHOLOGY

The existing I-90 roadway is located primarily outside of the 100-year floodplain (as delineated by the Federal Emergency Management Agency) except at several

localized stream crossings (Figure 3.3-1). Within the project area is approximately 900 acres of the Yakima River floodplain. In general, the existing hydrology of the Yakima River in the project area is governed by reservoir operations. In some locations, highway fill has cut off historical flow paths. Culverts and bridges restrict meander and artificially increase the stream slope. Some direct highway runoff enters the tributaries. However, because the roadway currently has no stormwater facility, highway runoff is generally discharged through storm culverts to the south slope of the highway fill. There it either infiltrates or travels as overland flow to the tributaries, lakes, or rivers in the project area. Existing highway crossings may present fish passage barriers as a result of high velocities, low depths, or discontinuities in the stream slope (perched culverts).

Three types of stream systems occur in the project corridor: naturally confined channels, artificially confined channels, and alluvial fans. The stream system type for each creek within the project area is summarized in Table 3.3-1. Naturally confined channels are incised into colluvial deposits on steeper hillsides. Flow is confined within the channel banks, and there is no distinct floodplain. These systems do not actively migrate and can therefore be accommodated by crossing structures that are sufficient to provide fish passage, and convey water and debris. Rocky Run Creek, Wolfe Creek, and Telephone Creek have naturally confined channels. Townsend Creek has a natural, moderately confined channel (MDT 2004).

The artificially confined channel type is characterized by restricted lateral migration, resulting in decreased channel complexity, bank erosion, and modified sediment transport regimes. Undersized culverts result in decreased natural flow, debris, and fish movement. Natural channel migration is currently limited on ten tributaries to the Yakima River: Coal Creek, Gold Creek, Resort Creek, Price Creek, Noble Creek, Bonnie Creek, Swamp Creek, Toll Creek, Hudson Creek, Cedar Creek, and the Kachess River (MDT 2004).

Alluvial fans form in the project area where creeks transition from steep hillsides onto glacial terraces. As they emerge from the upslope canyons, the creeks carry a high sediment load that is then deposited onto the terrace, forming a fan of alluvial debris. Channel migration on alluvial fans is episodic in nature, as opposed to the more gradual migration that occurs in meandering or braided floodplain systems. Resort Creek is an example of an alluvial fan system within the project area. During construction of I-90, Resort Creek was confined to a single channel at the highway crossing. Upstream of I-90, a well-developed alluvial fan still exists (MDT 2004).

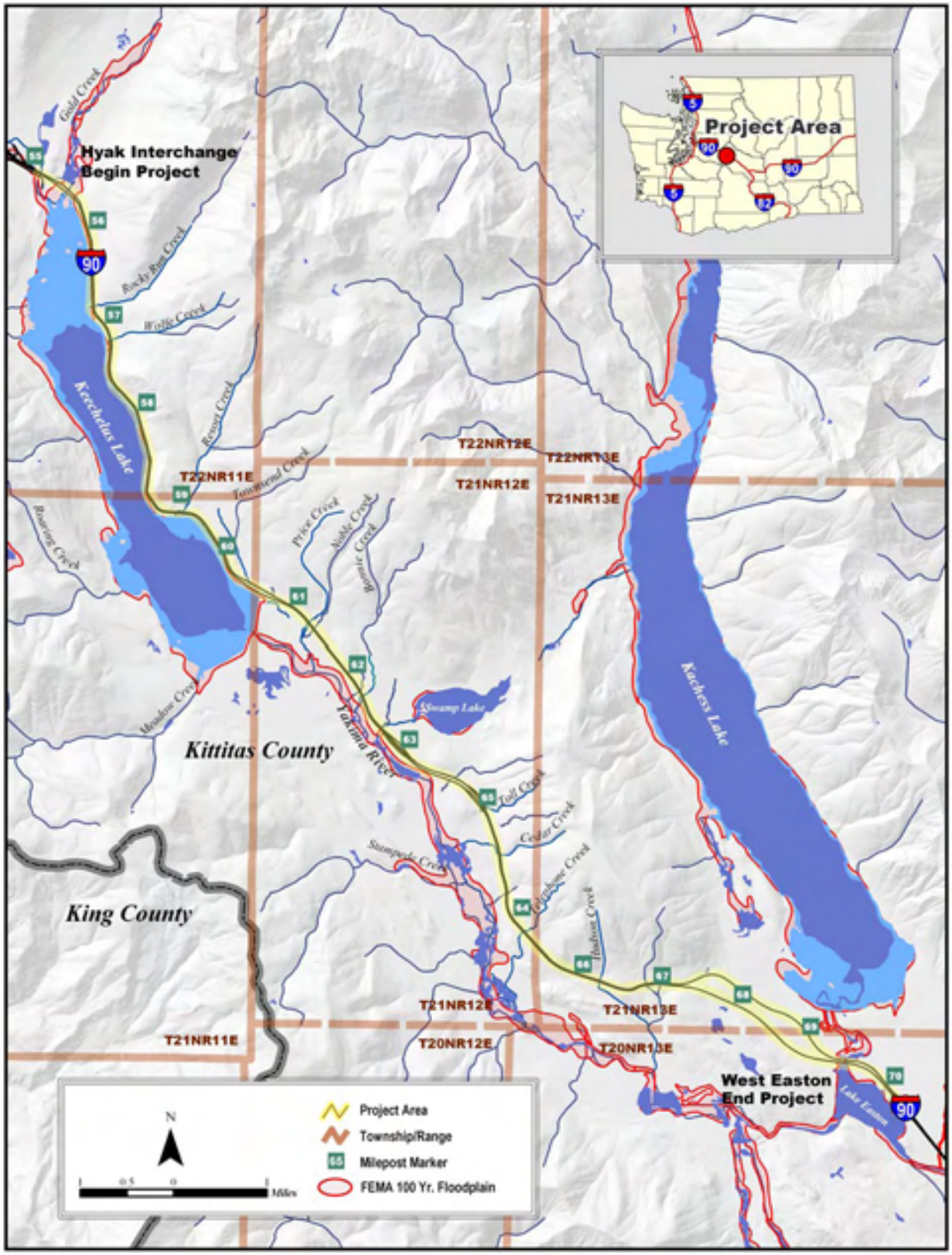


Figure 3.3-1. Existing 100-year Federal Emergency Management Agency Floodplain Delineation

3.3.2 Environmental Consequences

3.3.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, the existing four-lane roadway would be maintained and rehabilitated as needed, but no new construction on the highway would occur. Under this alternative, existing impacts to water resources within the project area resulting from highway operation and maintenance would persist. This alternative would result in the continuing environmental degradation associated with stream instability and poor road condition.

Several culverts are currently being undercut as a result of bed scour at the existing roadway, and this would continue without remedial action. Channel degradation would still occur downstream of perched culverts. Stream migration would remain constrained by the existing culverts and short bridges. Higher stream velocities, stream channel instability, and stream bank erosion associated with channel confinement would persist. Streams can be expected to continue to downcut, resulting in incised stream channels losing connectivity with the floodplain. There are no known existing impacts to underlying aquifer water quality.

Continuing bank erosion would contribute sediment to the Yakima River, which may impact salmonid spawning grounds, cause greater turbidity, and elevate the already high level of suspended solids in the river and reservoirs. Bank protection will be required to reduce this erosion. It is anticipated that there would be a 3.5 percent annual increase in traffic on this highway, and it is expected that there would be a corresponding increase in pollutants entering waterways in highway runoff under the No-Build Alternative. Due to the substandard design condition in relation to speed limits, there is also an increased potential for accidents, spills, and consequential contamination of surface and groundwaters associated with the expected increase in traffic.

3.3.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

The environmental consequences related to water resources of each of the Keechelus Lake Alignment Alternatives are discussed in this section. The Alignment Alternatives only concern water resources located between MP 56.6 and MP 59.9 (Appendix B). The affected water resources therefore include Rocky Run, Wolfe, and Resort creeks as well as Keechelus Lake. Temporary impacts relating to construction activities are addressed first, followed by a discussion of anticipated beneficial effects and adverse operational (as-built) impacts associated with each alignment alternative. In general, the effects of temporary impacts are confined to the period of time in which construction activities take place, whereas operational impacts persist as a function of the as-built design.

The types of temporary construction impacts are, in general, similar for all of the creeks and lakes in the project area, so these impacts are addressed in a project-wide context. These include impacts to hydrology, water quality, groundwater, channel function, floodplains, and Riparian Reserves. The severity of the

impacts depends on the intensity of the construction activity associated with each alternative. Temporary impacts to water resources may result from construction activities that occur during highway realignment and widening, crossing structure replacement, and tunnel construction.

Within the localized area of each stream, construction activity associated with the Keechelus Lake Alignment Alternatives is generally most intense under Alternative 1, followed by Alternatives 2, 3, and 4. Construction activity is the same for Rocky Run Creek for all alternatives. Regarding impacts to Keechelus Lake, construction activity is most severe with Alternative 4 and least severe with Alternative 1. Table 3.3-3 describes the construction activity for each of these alternatives and the severity of the impacts from that activity, relative to the impacts resulting from Alternative 1. Impacts associated with these construction activities are assumed to be directly related to the intensity of the construction activity. Therefore, construction for Alternative 1 is expected to have the greatest impact on water resources at each of the creeks. Alternative 4 is expected to have the greatest impact on the water resources of Keechelus Lake. Best Management Practices (BMPs) and MDT performance standards shall be selected, installed, and maintained in accordance with WSDOT's 2004 Highway Runoff Manual to address potential impacts resulting from construction activity. In addition, all stream crossing structures will be constructed using Washington Department of Fish and Wildlife (WDFW) Stream Simulation Guidelines to allow for passage of aquatic species, passage of 100-year storm discharge, and associated bedloads and woody debris.

Temporary construction impacts that potentially affect hydrology within the project area include flow alterations and increased peak flows resulting from increases in runoff. In general, these flow alterations are expected to be minor. Increases in runoff may result from soil compaction and decreased cover in temporary staging areas. Runoff is also expected to be influenced by drainage pattern alterations.

Water quality may be negatively affected by construction activities in the project area, primarily through sediment and pollutants in runoff from construction and staging areas. Organic pollutants and chemicals from construction equipment and construction-related activities may enter adjacent waterbodies. Erosion of cleared areas and temporary roads as well as sediment from highway construction and fill removal may enter streams and lakes in runoff. Temporary Erosion Sedimentation Control and Spill Prevention, Control, and Countermeasure Plans (SPCCPs) will be designed and implemented in accordance with the 2004 Highway Runoff Manual (HRM) to address the above impacts. Water temperatures may increase in areas where vegetation has been cleared.

Channel function may be negatively impacted during construction by temporary cofferdams and diversions that impair natural channel form and function. Levees may also be used, separating the channel from its floodplain. Construction activity may also directly impact channels during stream crossing structure replacement, disturbing banks and the channel bed.

Table 3.3-3. Keechelus Lake Alignment Alternatives Construction Comparison

Creek	*Construction Activity*[1]	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternative 4*
Rocky Run Creek	**Description of Construction**	Slight realignment, widening, profile slightly raised, replacement of bridge/culvert with another bridge.	Same as Alternative 1.		
	Impact from Construction Relative to Alternative 1	N/A	No change from Alternative 1.		
Wolfe Creek	**Description of Construction**	Major realignment, widening, profile slightly raised, replacement of culvert with large culvert, tunnel construction in close proximity to creek.	Same as Alternative 1, but less severe realignment and no tunnel construction in close proximity to creek.		
	Impact from Construction Relative to Alternative 1	N/A	Less overall impact from construction than Alternative 1.		
Resort Creek	**Description of Construction**	Major realignment, widening, replacement of existing culvert with bridge at new crossing, removal of existing roadway and fill, tunnel construction in close proximity to creek.	Same as Alternative 1.	Major realignment, widening, replacement of existing culvert with large culverts at existing crossing, bridge construction at new crossing, single tunnel construction in close proximity to creek.	Minor realignment, widening, replacement of existing culvert with large culverts at existing crossing.
	Impact from Construction Relative to Alternative 1	N/A	No change from Alternative 1.	Less overall impact from construction than Alternatives 1 and 2.	Less overall impact from construction than Alternatives 1, 2, and 3.
Keechelus Lake	**Description of Construction**	Major realignment, widening, long tunnel construction, removal of existing roadway and fill.	Major realignment, widening of more roadway, shorter tunnel construction, bridge construction, removal of less roadway and fill compared with Alternative 1.	Same as Alternative 2, but widening of more roadway, single tunnel construction, no removal of roadway or fill, and construction of an additional bridge.	Same as Alternative 3, but no tunnel construction.
	Impact from Construction Relative to Alternative 1	N/A	Greater overall impact from construction than Alternative 1.	Greater overall impact from construction than Alternatives 1 and 2.	Greater overall impact from construction than Alternatives 1, 2, and 3.

Note: 1. Information derived from the most current WSDOT design plans (4-16-04) and from the *Interstate 90 Snoqualmie Pass East MDT: Draft Recommendation Package* (MDT 2004).

Both regulatory (Keechelus Lake) and tributary floodplains will likely be disturbed during stream crossing replacement, highway fill removal, and during highway widening and realignment. Bridge construction and roadway realignment along Keechelus Lake would involve in-water construction and would encroach into the lake. However, even under the alternative with the highest potential fill/embankment impact (Alternative 4), the impact to Keechelus Lake storage capacity would be substantially less than 1 percent (loss of 147 acre-feet of storage volume). Any loss of lake storage capacity resulting from this construction is expected to be offset by an increase in lake capacity elsewhere.

Floodplain encroachment may occur through the use of temporary cofferdams. Floodplain soils may be compacted by equipment, impairing shallow groundwater flow and recharge. Riparian Reserves may be impacted by construction activities, with possible vegetation clearing for staging areas, and during highway widening and crossing structure replacement.

Some temporary construction impacts only apply to specific creeks and Keechelus Lake. Construction of the tunnel through Slide Curve will most likely affect only Wolfe Creek (Alternative 1), Resort Creek (Alternatives 1, 2, and 3), and Keechelus Lake (Alternatives 1, 2, and 3). Tunnel construction may temporarily affect stream hydrology through drainage pattern and groundwater alterations. Both groundwater flow and quality may be affected by tunnel construction if tunneling passes through subsurface aquifers. Water quality degradation in Wolfe and Resort Creeks may occur as a result of localized tunnel activity. Although tunnel construction would occur outside the regulatory floodplain of Keechelus Lake, water inflows into the lake may be artificially increased; groundwater intercepted during tunnel construction would be treated before being discharged into Keechelus Lake. BMPs shall be selected, installed, and maintained in accordance with WSDOT's 2004 HRM to address potential impacts resulting from construction activity.

Table 3.3-4 examines expected beneficial effects and operational impacts for all of the Alignment Alternatives. Table 3.3-5 summarizes the impacts to Riparian Reserves for all Alignment Alternatives.

Alternative 1: Long Tunnels

Under Alternative 1, twin three-lane 1.9-mile-long tunnels would be constructed through Slide Curve. These tunnels would decrease the exposed impervious surface between MP 56.6 to MP 59.9 from the existing 30.6 acres (No-Build Alternative) to 22 acres. With Alternative 1, the total disturbed footprint would be 50 acres, while 38 acres of abandoned roadway would be reclaimed. The total disturbed footprint includes the existing and proposed area that would be disturbed during construction from cut/fill line to cut/fill line plus a 10-foot buffer zone on each end.

At Rocky Run Creek, Alternative 1 involves constructing a single span bridge (minimum vertical clearance of 8 feet westbound and 10 feet eastbound) over the creek in both directions, replacing the existing 120-foot bridge and 7-foot culverts. The constructed bridge would provide for improved hydrologic connectivity, flow conveyance, as well as fish and debris passage. Replacing the culverts with a bridge would improve channel migration potential, floodplain and channel connectivity, and groundwater flow and recharge. For Wolfe Creek, Alternative 1 involves replacing the existing 6-foot diameter culvert with a larger culvert. This larger culvert would be either three-sided or bottomless, and would improve hydrologic connectivity and debris passage.

When referring to the large replacement culverts in the Keechelus Lake Alignment Alternatives, the term "large culvert" is used to indicate the installation of either a three-sided or bottomless culvert. These large culverts would be designed to provide for passage under I-90 of fish, 100-year storm discharge, and bedload and woody debris. Alternative 1 would also involve constructing single span bridges over the active channel migration zone of Resort Creek in both directions of I-90, upstream of the existing crossing. These bridges would replace the existing 6-foot diameter culvert. The existing roadway and embankment fill that occurs within the Keechelus Lake floodplain near Resort Creek would be removed. Construction of the bridges would provide for active channel migration across the entire alluvial fan present at the I-90 crossing, as well as year-round fish passage. Hydrologic connectivity, floodplain function, and groundwater recharge would also be greatly impaired.

Alternative 1 would substantially improve hydrologic connectivity for Rocky Run, Wolfe, and Resort creeks relative to existing conditions. Realignment of the highway along Keechelus Lake would result in the filling of 12 acres of aquatic and shoreline habitat. However, due to removal of roadway and fill along the lake, lake storage capacity is expected to increase by 20 acre-feet. For a more detailed examination of the expected beneficial effects and operational impacts under Alternative 1, see Table 3.3-4.

Table 3.3-6 depicts an estimate of annual pollutant loads from highway surfaces, by alternative.

The design of Alternative 1 is expected to impact a total of about 30 acres of Riparian Reserves in the project area between MP 56.6 and MP 59.9. Although Alternative 1 has substantial construction associated disturbance, the effects on Riparian Reserves are less than the other alternatives because of the tunnel. A Riparian Reserve is a USFS land allocation classification that refers to the area located within an established buffer distance away from water bodies and wetlands. Table 3.3-5 summarizes the impacts to Riparian Reserves by habitat classification.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 1 of 7)

Rocky Run Creek[1]	Baseline Condition	**Alternative 1** New alignment slightly differs from existing, curve east of creek is straightened out. Existing bridge/culvert replaced with another slightly longer bridge.[3]		**Alternative 2** Same as Alternative 1.		**Alternative 3** Same as Alternative 1.		**Alternative 4** Same as Alternative 1	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Culvert constricts flow and increases velocity.[2]	Improved hydrologic connectivity, flow conveyance, lower stream velocities.[2]	Increased runoff may slightly alter peak flows.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Runoff	Runoff enters creek from highway.	None	Drainage patterns altered. Impervious area and runoff may increase.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Debris / Sediment Transport	Culvert can not convey high bedload and debris.[2]	Improved bedload and debris passage.[2]	Sediment from traction sand runoff.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Channel Function	PF[6], but steep gradient downstream I-90 to Lake Keechelus.[2]	Improved potential for channel migration and decreased gradient.	Depth may be decreased; new channel may develop to lake.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Floodplain	Naturally confined, so limited floodplain connectivity.[2]	High level of floodplain restoration will occur upon culvert removal.	None.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Groundwater	N/A[2]	Improved recharge and groundwater flow.	None.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Surface Water Quality	NPF[7] – metals in runoff, large daily water temperature changes (lack of vegetation).[2]	Reduced sedimentation and temperature, but still problem with lack of adequate shade. Reduced accidents and pollutant releases into the creek.	Increased pollutants from traffic and traction sand from lane widening.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 2 of 7)

Wolfe Creek[1]	Baseline Condition	**Alternative 1** New alignment quite different from existing alignment. New lanes straightened and located south of existing roadway. Existing culvert replaced with large culvert.[3]		**Alternative 2** Same as Alternative 1, but less severe realignment. Westbound lane between existing lanes, eastbound lane south of existing roadway.[3]		**Alternative 3** Same as Alternative 2.		**Alternative 4** Same as Alternative 2.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Culvert may be undersized for peak flow conveyance.	Improved hydrologic connectivity, reduced velocities, better peak flow conveyance. Lower peak flows.	Increased flow from construction and operation of tunnel. Base flow may be altered by tunnel.	Same as Alternative 1.	Increased peak flows from impervious area runoff.	Same as Alternative 1.	Same as Alternative 2.	Same as Alternative 1.	Same as Alternative 2.
Runoff	Runoff enters creek from highway.	Impervious area will likely decrease, causing a decrease in storm runoff.	Drainage patterns would be altered due to tunnel and lane modifications.	Depends on highway drainage design.	Drainage patterns not as altered. Increased runoff from increase in impervious area.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.
Debris / Sediment Transport	Adequate transport but culvert may be plugged by debris.	Improved sediment and debris passage.	Sediment from fill and traction sand runoff.	Same as Alternative 1.	Same as Alternative 1, but less sediment from fill.	Same as Alternative 1.	Same as Alternative 2.	Same as Alternative 1.	Same as Alternative 2.
Channel Function	PF[2]	Slight improvement in potential for channel migration and decreased gradient.	Depth may be decreased; new channel may develop to lake.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Floodplain	Naturally confined, so floodplain connectivity is limited.[2]	Low floodplain restoration due to large culvert installation.	Floodplain encroachment similar to existing conditions.	Same as Alternative 1.	Floodplain encroachment probably same as Alternative 1.	Same as Alternative 1.	Same as Alternative 2.	Same as Alternative 1.	Same as Alternative 2.
Groundwater	N/A[2]	Low restoration of groundwater recharge and flow.	Tunnel could pass through aquifers, but minimal impact on groundwater.	Same as Alternative 1.	Same as Alternative 1, but less potential impacts to groundwater.	Same as Alternative 1.	Same as Alternative 2.	Same as Alternative 1, and no impact from tunnel.	Little potential impacts to groundwater.
Surface Water Quality	PF[2]	Reduced sedimentation and temperature. Reduced accidents and pollutant releases into the creek.	Contaminants may increase with traffic and tunnel, sediment from erosion of fill and traction sand.	Same as Alternative 1.	Same as Alternative 1, but potential erosion of fill not as severe.	Same as Alternative 1.	Same as Alternative 2.	Same as Alternative 1.	Same as Alternative 2.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 3 of 7)

Resort Creek[1]	**Baseline Condition**	**Alternative 1** New alignment will cross creek in a new location, upstream of the existing crossing. Culvert at existing crossing will be removed, as will the existing roadway and highway fill. Tunnel will be built just west of creek crossing. Long bridges will be built over floodplain (active channel migration zone) of the creek.[3]		**Alternative 2** Same as Alternative 1, but tunnel will be shorter.[3]		**Alternative 3** Westbound alignment crosses creek in a new location over a new bridge, short westbound tunnel built just west of creek. Eastbound lanes and fill will remain around Slide Curve, but existing culvert will be replaced with a series of large culverts.[3]		**Alternative 4** Both the westbound and eastbound lanes will be widened but new alignment appears to closely follow the existing highway footprint around Slide Curve. A series of large culverts will be installed at the current creek crossing.[3]	
		Beneficial Effects	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]
Hydrology	Culvert may be undersized for peak flow conveyance.	Improved hydrologic connectivity, better flow conveyance and lower velocities. Lower peak flows.	Increased flow from construction and operation of tunnel. Base flow may be altered by tunnel.	Same as Alternative 1.	Same as Alternative 1.	Peak flows reduced CTEC[5], but less than Alternative 1 due to increased runoff. Eastbound conveyance better CTEC, but likely less compared to Alternative 1.	Increased flow from impervious area runoff relative to Alternative 1, but less flow effects from tunnel.	Flow conveyance better CTEC, but likely less than other alternatives.	Peak flows less than other alternatives and CTEC due to impervious area runoff, but no flow from tunnel.
Runoff	Runoff enters creek from highway.	Impervious area and runoff should decrease. Drainage patterns returned to a more natural pattern.	Depends on highway drainage design, but none expected.	Same as Alternative 1.	Same as Alternative 1.	Runoff and impervious area should decrease CTEC, but less than Alternative 1. Drainage more natural CTEC, but less than Alternative 1.	Drainage less natural than Alternative 1. Impervious area and runoff should increase compared to Alternative 1.	Depends on highway drainage design.	Drainage less natural than other alternatives. Impervious area and runoff increased CTEC and other alternatives.
Debris / Sediment Transport	Adequate transport but possibility of culvert being plugged by debris.	Improved sediment and debris passage, reducing excessive sedimentation.	Sediment from traction sand runoff.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1, but possibly not as great eastbound due to culverts instead of bridge.	Same as Alternative 1, but sediment also from fill around culverts.	Same as Alternative 3.	Same as Alternative 3, but more sediment from fill.
Channel Function	PF, but steep drop occurs downstream of existing culvert at low lake levels.[2]	Substantial improvement in potential for channel migration and decreased gradient.	Depth may be decreased; new channel may develop to lake.	Same as Alternative 1.	Same as Alternative 1.	Channel migration potential limited compared to Alternative 1, but much better CTEC.	Same as Alternative 1.	Channel migration potential limited compared to other alternatives, but better CTEC.	Same as Alternative 1.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 4 of 7)

Resort Creek[1]	**Baseline Condition**	**Alternative 1** New alignment will cross creek in a new location, upstream of the existing crossing. Culvert at existing crossing will be removed, as will the existing roadway and highway fill. Tunnel will be built just west of creek crossing. Long bridges will be built over floodplain (active channel migration zone) of the creek.[3]		**Alternative 2** Same as Alternative 1, but tunnel will be shorter.[3]		**Alternative 3** Westbound alignment crosses creek in a new location over a new bridge, short westbound tunnel built just west of creek. Eastbound lanes and fill will remain around Slide Curve, but existing culvert will be replaced with a series of large culverts.[3]		**Alternative 4** Both the westbound and eastbound lanes will be widened but new alignment appears to closely follow the existing highway footprint around Slide Curve. A series of large culverts will be installed at the current creek crossing.[3]	
		Beneficial Effects	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]
Floodplain	Artificially confined.[2]	Increase in floodplain area and high restoration of floodplain function. Encroachment much less than existing conditions.	None	Same as Alternative 1.	Same as Alternative 1.	Increase in floodplain area and restoration of floodplain function not as great as Alternative 1, but better CTEC.	Floodplain encroachment greater than Alternative 1 but likely less CTEC, depending on fill required for lane widening.	Depending on fill required for lane widening, a minor increase in floodplain area and function is expected CTEC, but less than other alternatives.	Floodplain encroachment likely greater than other alternatives and possibly CTEC, depending on fill required for lane widening.
Groundwater	N/A[2]	High restoration of groundwater recharge and flow.	Tunnel could pass through aquifers, but minimal impact on groundwater flow and quality.	Same as Alternative 1, but less potential impacts from shortened tunnel.	Same as Alternative 1, but impacts may be reduced due to shortened tunnel.	Restoration of recharge and flow less than Alternative 1 but greater CTEC. Less potential impacts from shortened tunnel than Alternative 1.	Same as Alternative 2, but less potential impacts to localized groundwater flow and quality.	Restoration of recharge and flow less than other alternatives, but greater CTEC. No potential impacts from tunnel.	The potential impacts to localized groundwater flow and quality will be substantially less due to no tunnel.
Surface Water Quality	PF[2]	Reduced sedimentation and temperature. Reduced accidents and pollutant releases into the creek.	Pollutant loading may increase with traffic and tunnel, greater sediment from added traction sand.	Same as Alternative 1.	Same as Alternative 1.	Sedimentation and temperature reduced CTEC, but not as much as with Alternative 1. Less impact to water quality from shortened tunnel than Alternative 1.	Same as Alternative 1 but erosion of fill for eastbound alignment and lane widening may contribute more sediment into creek.	Likely little improvement in sedimentation and temperature CTEC. No impact to water quality from tunnel.	Same as Alternative 3 but erosion of additional fill and sediment input into creek may be greater. No tunnel impacts.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 5 of 7)

Keechelus Lake[1]	**Baseline Condition**	**Alternative 1** New alignment straightened and located south of existing roadway between Rocky Run and Wolfe Creeks. Long tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 2** New alignment located slightly south of existing lanes between Rocky Run and Wolfe Creeks. Between Wolfe Creek and Slide Curve, new alignment cuts into hillside and passes over Lake on bridges at location of snowshed. Short tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 3** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, single westbound tunnel passes through Slide Curve. Eastbound lanes located around Slide Curve, approximately following existing highway footprint except near Resort Creek. Near creek, eastbound lanes located south of existing roadway and westbound lanes straightened and located north of existing roadway[3]		**Alternative 4** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, both westbound and eastbound lanes located around Slide Curve, slightly south of existing footprint. New, wider lanes occupy a larger footprint than the existing lanes. At Resort Creek, new alignment wider and located south of existing roadway.[3]	
		Beneficial Effects	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]
Hydrology	N/A	Drainage patterns and hydrologic connectivity more natural. Lower peak flows to lake.	Increased flow from construction and operation of tunnel. Base flow into lake may be altered by tunnel.	Drainage patterns and hydrologic connectivity more natural CTEC due to bridges at snowshed, but < Alternative 1.	Runoff and peak flows to lake should increase CTEC as compared to Alternative 1. Less flow effects from tunnel compared to Alternative 1.	Drainage patterns more natural CTEC, but less than Alternatives 1 and 2.	Same as Alternative 2, but flows into lake increased more. Less flow effects from tunnel compared to Alternatives 1 and 2.	Drainage patterns more natural CTEC, but less than other alternatives.	Same as Alternative 3, but flows into lake increased more. No flow effects from tunnel.
Runoff	Runoff currently enters the lake.	Impervious area and runoff should decrease CTEC. Drainage patterns more natural.	Depends on highway drainage design, but none expected.	Drainage patterns more natural CTEC, but < Alternative 1.	Impervious area and runoff should increase CTEC as compared to Alternative 1.	Drainage patterns more natural CTEC, but less than Alternatives 1 and 2.	Impervious area and runoff should increase CTEC as compared to Alternatives 1 and 2.	Drainage patterns more natural CTEC, but less than other alternatives.	Impervious area and runoff should increase CTEC as compared to other alternatives.
Debris / Sediment Transport	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Channel Function	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 6 of 7)

Keechelus Lake[1]	**Baseline Condition**	**Alternative 1** New alignment straightened and located south of existing roadway between Rocky Run and Wolfe Creeks. Long tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 2** New alignment located slightly south of existing lanes between Rocky Run and Wolfe Creeks. Between Wolfe Creek and Slide Curve, new alignment cuts into hillside and passes over Lake on bridges at location of snowshed. Short tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 3** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, single westbound tunnel passes through Slide Curve. Eastbound lanes located around Slide Curve, approximately following existing highway footprint except near Resort Creek. Near creek, eastbound lanes located south of existing roadway and westbound lanes straightened and located north of existing roadway[3]		**Alternative 4** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, both westbound and eastbound lanes located around Slide Curve, slightly south of existing footprint. New, wider lanes occupy a larger footprint than the existing lanes. At Resort Creek, new alignment wider and located south of existing roadway.[3]	
		Beneficial Effects	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]	**Beneficial Effects**	**Operational Impacts**[4]
Floodplain	Current alignment encroaches on lake floodplain.	Possible increase in lake floodplain area with less encroachment between Wolfe and Resort Creeks due to removal of roadway and fill. No impact from tunnel construction.	Possible encroachment between Rocky Run and Wolfe Creeks greater than existing conditions. 11.7 acres of total shoreline filled along lake.	Increase in lake floodplain area less than Alternative 1 but is greater than existing conditions around Slide Curve due to removal of roadway and fill. No impact from short tunnel.	Same as Alternative 1, but widened lanes and new bridges also encroach on floodplain area. 16.2 acres of total shoreline filled along lake.	Increase in lake floodplain area less than Alternatives 1 and 2, similar to existing conditions around Slide Curve, depending on fill required. No impact from tunnel.	Same as Alternative 2 except more encroachment from eastbound lane location around Slide Curve. 21.1 acres of total shoreline filled along lake.	Depending on fill required for widening, no beneficial effects may exist due to greater encroachment CTEC.	Same as Alternative 3 except encroachment from westbound and eastbound lanes around Slide Curve. 17.6 acres of total shoreline filled along lake.
Groundwater	N/A	None	Tunnel could pass through aquifers, but minimal impact on groundwater flow and quality.	Impacts lessened compared to Alternative 1 due to shortened tunnel.	Same as Alternative 1, but impacts may be reduced due to shortened tunnel.	Impacts lessened compared to Alternatives 1 and 2 due to single tunnel.	Same as Alternative 2, but less potential impacts to groundwater flow and quality.	None due to increased impervious area..	The potential impacts to groundwater flow and quality will be lessened due to no tunnel but will be increased due to greater impervious area.

Table 3.3-4. Keechelus Lake Alignment Alternatives Consequences
(Page 7 of 7)

Keechelus Lake[1]	**Baseline Condition**	**Alternative 1** New alignment straightened and located south of existing roadway between Rocky Run and Wolfe Creeks. Long tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 2** New alignment located slightly south of existing lanes between Rocky Run and Wolfe Creeks. Between Wolfe Creek and Slide Curve, new alignment cuts into hillside and passes over Lake on bridges at location of snowshed. Short tunnel passes through Slide Curve. New alignment straightened and located north of existing roadway near Resort Creek.[3]		**Alternative 3** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, single westbound tunnel passes through Slide Curve. Eastbound lanes located around Slide Curve, approximately following existing highway footprint except near Resort Creek. Near creek, eastbound lanes located south of existing roadway and westbound lanes straightened and located north of existing roadway[3]		**Alternative 4** New alignment west of Slide Curve same as Alternative 2. At Slide Curve, both westbound and eastbound lanes located around Slide Curve, slightly south of existing footprint. New, wider lanes occupy a larger footprint than the existing lanes. At Resort Creek, new alignment wider and located south of existing roadway.[3]	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Surface Water Quality	State Standards have been exceeded for fecal coliform bacteria.	Reduced accidents and pollutant releases into the lake.	Pollutant loading may increase with traffic and tunnel, greater sediment from fill and added traction sand.	Reduction in pollutant releases less than with Alternative 1 due to greater risk of accidents.	More severe than with Alternative 1, due to increased erosion of highway fill which will increase sediment input into lake and due to increased runoff.	Reduction in pollutant releases less than with Alternative 2 due to greater risk of accidents.	More severe than Alternative 2, due to increased erosion of eastbound highway fill which will increase sediment input into lake and due to increased runoff.	Reduction in pollutant releases less than with Alternative 3 due to greater risk of accidents.	More severe than Alternative 3, due to greater erosion of fill which will increase sediment input into lake and due to increased runoff.

Notes:
1. Unless otherwise noted, information derived from the *Final Discipline Report for Interstate 90 Snoqualmie Pass East: Hydrologic Systems, Water Quality, and Floodplains* (WSDOT 2002b)
2. Information derived from *Interstate 90 Snoqualmie Pass East MDT: Draft Recommendation Package (MDT 2004)*
3. Information derived from current WSDOT design plans (04-16-04)
4. BMPs such as biofiltration swales and detention ponds can be used to minimize water quantity and quality impacts from operation
5. CTEC stands for “compared to existing conditions”
6. PF stands for “properly functioning” as defined by the MDT (2004).
7. NPF stands for “not properly functioning” as defined by the MDT (2004)

Table 3.3-5. Riparian Reserve Impacts for Keechelus Lake Alignment Alternatives

Habitat Classification[1]	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternative 4*
Forest older than 80 yrs.	0.8 acre	0.9 acre	0.8 acre	2.0 acres
Forest younger than 80 yrs.	3.5 acres	4.3 acres	3.1 acres	4.1 acres
Other vegetated areas	13.1 acres	20.3 acres	24.4 acres	34.5 acres
Roadways and gravel areas	8.4 acres	18.5 acres	26.8 acres	33.4 acres
Other non-vegetated areas	2.3 acres	3.8 acres	4.9 acres	7.4 acres
Lakes	1.8 acres	4.0 acres	4.6 acres	13.0 acres
Total	29.9 acres	51.8 acres	64.6 acres	80.8 acres

Notes: 1. Within the Riparian Reserve land allocation, these were the actual habitat types found by WSDOT biologists.

Table 3.3-6. Estimated Annual Pollutant Loads from Highway Surfaces

	No-Build/ Existing	*Alternative 1*	*Alternative 2*	*Alternative 3*	*Alternative 4*
Roadway Treated (acres)	0.0	47.3	48.3	49.8	51.5
Roadway Untreated (acres)	30.6	0.0	0.0	0.0	0.0
Total Roadway (acres)	30.6	47.3	48.3	49.8	51.5
Annual load of total suspended solids	26,867 lbs/yr	1,939 lbs/yr	1,980 lbs/yr	2,042 lbs/yr	2,112 lbs/yr
Annual load of total phosphorus	39.8 lbs/yr	14.2 lbs/yr	14.5 lbs/yr	14.9 lbs/yr	15.5 lbs/yr
Annual load of total copper	6.1 lbs/yr	2.4 lbs/yr	2.4 lbs/yr	2.5 lbs/yr	2.6 lbs/yr
Annual load of total zinc	33.7 lbs/yr	12.3 lbs/yr	12.6 lbs/yr	12.9 lbs/yr	13.4 lbs/yr

Note: Calculations based on mean pollutant loads from high average daily traffic volume highways (90,000-160,000) in Western Washington (WSDOT 2004 National Pollutant Discharge Elimination System Annual Progress Report). Includes impervious surface within tunnels.

Alternative 2: Short Tunnels

Under Alternative 2, twin three-lane, 0.6-mile-long tunnels would be constructed through Slide Curve. Near the existing snowshed, bridges would be constructed over Keechelus Lake to allow avalanches to pass underneath the roadway. For all of the creeks, Alternative 2 is essentially the same design as Alternative 1. With Alternative 2, the amount of exposed impervious surface is 40 acres, an increase compared to Alternative 1 (22 acres) and existing conditions (No-Build Alternative, 30.6 acres). With this alternative the total disturbed footprint would be 82 acres, while 21 acres of abandoned roadway would be reclaimed.

Beneficial effects of the Alternative 2 design on water quality, channel function, and floodplain properties are similar to those identified for Alternative 1 for Rocky Run, Wolfe, and Resort creeks. Alternative 2 would substantially improve hydrologic connectivity for Rocky Run, Wolfe, and Resort creeks relative to existing conditions. For Wolfe Creek, the absence of a tunnel in close proximity would result in greater impervious area and higher runoff, but likely less impacts to groundwater compared to Alternative 1. Construction of the bridges at Resort Creek would provide for active channel migration across the alluvial fan present at the I-90 crossing, as well as year-round fish passage. Realignment of the highway along Keechelus Lake and the construction of bridges at the existing snowshed would result in the filling of 16 acres of aquatic and shoreline habitat. Removal of roadway and fill along the lake is expected to increase lake storage capacity by 5 acre-feet. For a more detailed examination of the expected beneficial effects and operational impacts under Alternative 2, see Table 3.3-4.

The design of Alternative 2 is expected to impact a total of about 52 acres of Riparian Reserves in the project area between MP 56.6 and MP 59.9. Although Alternative 2 has associated construction disturbance, the effects on Riparian Reserves are somewhat less because of the tunnels. Table 3.3-6 summarizes the impacts to Riparian Reserves by habitat classification.

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

Alternative 3 involves constructing a three-lane, 0.6-mile-long tunnel through Slide Curve for the westbound lanes. The eastbound lanes would remain along the shoreline of Keechelus Lake around Slide Curve. Between the existing snowshed and Rocky Run Creek, the road would be realigned and straightened. Near the existing snowshed, bridges would be built over Keechelus Lake, allowing avalanches to pass under the roadway. A small bridge would also be constructed at the west end of Slide Curve for the eastbound lanes only. Under this alternative, the westbound lanes would meet the standards for a 70 miles per hour (mph) design speed while the eastbound lanes would meet the standards for a 60 mph design speed. With Alternative 3, the amount of exposed impervious surface is 46 acres, an increase compared to Alternatives 1 and 2 and the existing 30.6 acres (No-Build Alternative). With Alternative 3, the total disturbed footprint would be 99 acres, while 13 acres of abandoned roadway would be reclaimed.

For Rocky Run Creek, Alternative 3 is the same design as Alternatives 1 and 2. For Wolfe Creek, Alternatives 2 and 3 are the same design. For Resort Creek, the design for Alternative 3 would involve constructing a single span bridge over the active channel migration zone of Resort Creek in only the westbound direction of I-90. The bridge would have an approximate length of 120 feet and a minimum vertical clearance of 12 feet. Construction of the bridge would provide for active channel migration across the alluvial fan present at the westbound I-90 crossing, as well as year-around fish passage. Under the eastbound lane, a series of large culverts (12 feet high by 25 feet wide) would be constructed throughout

the active migration zone of Resort Creek. These large culverts would allow for fish passage and improve channel migration, but would provide less opportunity for channel migration than the bridges used in Alternatives 1 and 2. The bridge and series of culverts would replace the existing 6-foot diameter culvert located at the Resort Creek crossing.

The effects of Alternative 3 on Rocky Run Creek are the same as with Alternatives 1 and 2, since the design is the same for all three alternatives. For Wolfe Creek, the beneficial effects are essentially the same as with Alternatives 1 and 2, although the design differs compared with Alternative 1. Alternative 3 would substantially improve hydrologic connectivity for Rocky Run and Wolfe Creeks relative to existing conditions. Resort Creek would not be as improved in this alternative as compared to Alternative 1 and 2. Realignment of the highway along Keechelus Lake and the construction of bridges would result in the filling of 21 acres of aquatic and shoreline habitat. Lake storage capacity is expected to decrease by 61 acre-feet. Any loss of storage capacity is expected to be offset by increases in lake capacity elsewhere. For a more detailed examination of the expected beneficial effects and operational impacts under Alternative 3, see Table 3.3-4.

The design of Alternative 3 is expected to impact a total of about 65 acres of Riparian Reserves in the project area between MP 56.6 and MP 59.9. Table 3.3-6 summarizes the impacts to Riparian Reserves by habitat classification.

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

The design for Alternative 4 involves both the westbound and eastbound lanes remaining along the shoreline of Keechelus Lake around Slide Curve. This design would meet the standards for a 60 mph design speed. Between Rocky Run Creek and the existing snowshed, the roadway would be realigned and straightened. Near the existing snowshed, bridges would be built over Keechelus Lake as with Alternatives 2 and 3, allowing avalanches to pass under the roadway. At the west end of Slide Curve, an eastbound bridge approximately 800 feet long would be constructed. With Alternative 4, the amount of exposed impervious surface is 52 acres, an increase compared to the other alternatives and the existing 30.6 acres (No-Build Alternative). With Alternative 4, the total disturbed footprint would be 94 acres, while 5 acres of abandoned roadway would be reclaimed.

For Rocky Run Creek, Alternative 4 is the same design as Alternatives 1, 2, and 3. For Wolfe Creek, Alternative 4 has the same design as Alternatives 2 and 3. For Resort Creek, the design for Alternative 4 would involve replacing the existing 6-foot diameter culvert with a series of large culverts (12 feet high by 25 feet wide) under both the westbound and the eastbound directions of I-90. The series of culverts would be constructed throughout the active migration zone of Resort Creek. These large culverts would allow for fish passage and improve channel migration within the denuded reservoir drawdown zone. This alternative would avoid removal of Riparian Reserve vegetation and soil disturbances along

the properly functioning channel of Resort Creek. Environmental consequences would therefore be less than under Alternatives 1, 2, and 3.

The effects of Alternative 4 on Rocky Run and Wolfe creeks are the same as with the other three Alternatives, since the design is essentially the same for all four alternatives (with the exception of the tunnel near Wolfe Creek in Alternative 1). Alternative 4 would substantially improve hydrologic connectivity and debris passage for Rocky Run and Wolfe creeks relative to existing conditions. Realignment of the highway along Keechelus Lake and the construction of bridges would result in the filling of 18 acres of aquatic and shoreline habitat. Lake storage capacity is expected to decrease by 147 acre-feet. Any loss of storage capacity is expected to be offset by increases in capacity elsewhere. For a more detailed examination of the expected beneficial effects and operational impacts under Alternative 4, see Table 3.3-4.

The design of Alternative 4 is expected to impact a total of about 64 acres of Riparian Reserves in the project area between MP 56.6 and MP 59.9. Table 3.3-6 summarizes the impacts to Riparian Reserves by habitat classification.

3.3.2.3 IMPROVEMENT PACKAGES

This section presents the environmental consequences related to water resources of each of the Improvement Packages and the corridor-wide roadway improvements (outside the Keechelus Lake Alignment Alternatives). Temporary impacts relating to construction activities are addressed first, followed by a discussion of anticipated beneficial effects and adverse operational (as-built) impacts associated with each Improvement Package option.

In general, the types of construction impacts are similar for all of the creeks and lakes in the project area, so these impacts are addressed in a broader context. The severity of the impacts depends on the intensity of the construction activity associated with each of the Improvement Packages. Temporary impacts to water resources will result from construction activities that occur during highway realignment and widening and crossing structure replacement. For a detailed description of the types of temporary impacts to water resources in the project area, see Section 3.3.2.2. Construction activity involved with the Improvement Packages is generally most intense with Package A, followed by Packages B and C. Table 3.3-7 describes the construction activity for each of these Packages and the severity of the impacts from that activity, relative to the impacts resulting from Package A. Because the impacts associated with this construction activity are assumed to be directly related to the intensity of the activity, impacts are expected to be most severe with Package A, followed by Packages B and C. BMPs shall be selected, installed, and maintained in accordance with WSDOT's 2004 HRM to address potential impacts resulting from construction activity.

Similar to the Keechelus Lake Alignment Alternatives, potential fill/embankment impacts to reservoirs will be negligible. Under any Improvement Package, no loss of storage capacity is expected for Keechelus Lake.

Table 3.3-7. Improvement Packages Construction Comparison Table[1]
(Page 1 of 3)

Creek	*Construction Activity[1]*	*Package A*	*Package B*	*Package C*
Gold Creek	**Description of Construction**	Minor realignment, widening, profile moderately raised, replacement of existing bridge with longer bridge, bridge built west of creek.	Same as Package A, but no bridge built west of creek.	Same as Package A, but profile slightly raised, existing bridge replaced with shorter bridge than in Package A and Package B.
	Impact from Construction Relative to Package A	N/A	Overall impact from construction similar to Package A, but no impact west of creek.	Overall impact from construction less than Package A and Package B.
Townsend Creek	**Description of Construction**	Very minor realignment, widening, replacement of existing culvert with large culvert.	Same as Package A.	Same as Package A.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	No change from Package A.
Price/Noble Creeks	**Description of Construction**	Very minor realignment, widening, profile substantially raised, replacement of existing culverts in creeks with bridge over both creeks, existing culvert west of creeks replaced with bridge, existing culverts east of creeks replaced with bridge, Sno-park pavement removed and restored.	Same as Package A, but east of creeks existing culverts replaced with a series of large culverts.	Same as Package B, but profile slightly raised, two separate shorter bridges built over creeks and Sno-park pavement structure not removed.
	Impact from Construction Relative to Package A	N/A	Overall impact from construction similar to Package A for creeks, but less impact east of creeks.	Overall impact from construction less than Package A and Package B.
Bonnie Creek	**Description of Construction**	Widening, profile substantially raised, replacement of existing culvert in creek and west fork with bridge over both.	Same as Package A, but existing culvert in creek replaced with a shorter bridge and culvert in west fork replaced with a large culvert.	Same as Package B, but culvert in creek replaced with a large culvert.
	Impact from Construction Relative to Package A	N/A	Overall impact from construction less than Package A.	Overall impact from construction less than Package A and Package B.

Table 3.3-7. Improvement Packages Construction Comparison Table[1]
(Page 2 of 3)

Creek	*Construction Activity*[1]	*Package A*	*Package B*	*Package C*
Swamp Creek	**Description of Construction**	Widening, profile substantially raised, replacement of existing culvert in creek with a bridge, culvert east of creek replaced with a bridge, Stampede Pass Interchange rebuilt to an overcrossing.	Same as Package A, but profile only slightly raised, existing culvert in creek replaced with a shorter bridge, Stampede Pass Interchange would remain an undercrossing.	Same as Package B, but existing culvert east of creek replaced with a large culvert.
	Impact from Construction Relative to Package A	N/A	Overall impact from construction less than Package A.	Overall impact from construction less than Package A and Package B.
Toll Creek	**Description of Construction**	Widening, replacement of existing culvert in creek with a large culvert, existing culvert west of creek replaced with a bridge.	Same as Package A.	Same as Package A, but culvert west of creek replaced with a large culvert.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	Overall impact from construction less than Package A and Package B.
Cedar Creek	**Description of Construction**	Major realignment, widening, replacement of existing culvert with a large culvert.	Same as Package A.	Same as Package A.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	No change from Package A.
Telephone Creek	**Description of Construction**	Minor realignment, widening, replacement of existing culvert with a larger culvert.	Same as Package A.	Same as Package A.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	No change from Package A.
Hudson Creek	**Description of Construction**	Major realignment, widening, replacement of existing culvert in middle fork with a bridge, culverts in west and east forks replaced with larger culverts.	Same as Package A, but existing culvert in middle fork replaced with a shorter bridge.	Same as Package B, but existing culvert in middle fork replaced with a larger culvert.
	Impact from Construction Relative to Package A	N/A	Overall impact from construction less than Package A.	Overall impact from construction less than Package A and Package B.

Table 3.3-7. Improvement Packages Construction Comparison Table[1]
(Page 3 of 3)

Creek	*Construction Activity*[1]	*Package A*	*Package B*	*Package C*
Kachess River	**Description of Construction**	Widening of highway and existing bridge.	Same as Package A.	Same as Package A.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	No change from Package A.
Lake Easton	**Description of Construction**	Widening of highway and existing bridge over Kachess River.	Same as Package A.	Same as Package A.
	Impact from Construction Relative to Package A	N/A	No change from Package A.	No change from Package A.

Note: 1. Information derived from the most current WSDOT design plans (4-16-04) and from the *Interstate 90 Snoqualmie Pass East MDT Draft Recommendation Package* (MDT 2004).

In order to minimize adverse water quantity and quality impacts from highway construction and operation, stormwater BMPs would be utilized, including the construction of detention ponds. These ponds would be constructed throughout the project area, and their locations do not differ by Improvement Package. No detention basins are currently planned for the Slide Curve area. For a detailed description of the ponds, see Section 3.3.3. Where these ponds are located may adversely impact water resources, specifically hydrologic connectivity zones and Riparian Reserves. Based on the most current design plans (Appendix B), water resources including hydrologic connectivity zones and creeks were avoided during the siting of these ponds. Only one of the detention ponds is to be located near a hydrologic connectivity zone. This pond is designed to be a maximum of 100 feet by 300 feet, and is to be located in the Price/Noble Creeks Connectivity Enhancement Area (CEA), west of Price Creek. The impacts from this pond would be minimal.

Improvement Package A

Improvement Package A provides the greatest improvement in aquatic, riparian, and terrestrial connectivity within the project area. Proper functioning of hydrologic processes, including hydrologic connectivity, is intrinsic to satisfying ecological connectivity objectives. Environmental consequences, including both beneficial effects and operational impacts, are discussed in Table 3.3-9 at the end of Section 3.3. Table 3.3-10 shows that there is an insignificant difference in estimated annual pollutant loads from highway surfaces by Improvement Package. It should be noted that when referring to the large replacement culverts in the Improvement Packages, the term “large culvert” is used. “Large culvert” means that either a three-sided or bottomless culvert would be used.

With Improvement Package A, the amount of exposed impervious surface would be 170 acres. The total disturbed footprint would be 377 acres, while 29 acres of abandoned roadway would be reclaimed. Reclaimed asphalted areas would also include the Price Creek Sno-park. The roadway changes under Package A would result in the filling of 6 acres of Keechelus Lake aquatic and shoreline habitat, and 0.6 acre of Lake Easton aquatic and shoreline habitat. The storage capacity of Keechelus Lake is expected to increase by 80 acre-feet.

The design of Package A is expected to impact a total of about 81 acres of Riparian Reserves in the project area (excluding the area between MP 56.6 and MP 59.9). Table 3.3-8 summarizes the impacts to Riparian Reserves by habitat classification.

Table 3.3-8. Riparian Reserve Impacts for Improvement Packages

Habitat Classification[1]	*Improvement Package A*	*Improvement Package B*	*Improvement Package C*
Forest older than 80 yrs.	3.3 acres	2.5 acres	2.7 acres
Forest younger than 80 yrs.	7.4 acres	7.1 acres	6.8 acres
Other vegetated areas	28.6 acres	28.1 acres	27 acres
Roadways and gravel areas	28 acres	27.9 acres	27.9 acres
Other non-vegetated areas	11.4 acres	11 acres	11.2 acres
Lakes	2.1 acres	1.9 acres	1.6 acres
Total	80.6 acres	78.5 acres	77.2 acres

Notes: 1. Within the Riparian Reserve land allocation, these are the actual habitat types found by WSDOT biologists.

Improvement Package B

The potential benefits to hydrologic systems in Improvement Package B may be slightly reduced from those of Improvement Package A at some locations. By using large culverts in place of elevated roadways (bridges), the amount of floodplain area available for channel migration may be lower, although site-specific designs of culverts can provide equal benefits to hydrological systems. A notable exception occurs at the Swamp Creek CEA, where under Package B, an additional bridge would be built in a hydrologic connectivity zone west of Swamp Creek (MP 62.5). Improvement Package B represents a high level of connectivity at a lower cost than Improvement Package A. Substantial changes in environmental consequences as compared to Improvement Package A are identified in Table 3.3-9. The same design option would be built for all three Improvement Packages at Townsend Creek, Cedar Creek, Telephone Creek, and Kachess River/Lake Easton. Therefore, discussion of environmental consequences at these areas is only included under Improvement Package A.

The amount of exposed impervious surface under Improvement Package B would be the same as that under Package A, 170 acres. With Improvement Package B, the total disturbed footprint would be 405 acres, while 16 acres of abandoned roadway would be reclaimed. Reclaimed asphalted areas would also include the Price Creek Sno-park. The roadway changes under Package B would result in the filling of 5 acres of Keechelus Lake aquatic and shoreline habitat, and 0.6 acre of Lake Easton aquatic and shoreline habitat. The storage capacity of Keechelus Lake is expected to increase by 73 acre-feet.

The design of Package B is expected to impact a total of about 79 acres of Riparian Reserves in the project area (excluding the area between MP 56.6 and MP 59.9). Table 3.3-8 summarizes the impacts to Riparian Reserves by habitat classification.

Improvement Package C

Improvement Package C replaces some sections of bridges proposed in Improvement Package B with culverts, which reduces the potential for channel migration and natural channel morphology, but still offers hydrologic improvements in comparison to the existing road. The same design option would be built for all three improvement packages at Townsend Creek, Cedar Creek, Telephone Creek, and Kachess River/Lake Easton. Therefore, discussion of environmental consequences at these areas is only included under Improvement Package A. Environmental consequences are discussed in Table 3.3-9.

With Improvement Package C, the amount of exposed impervious surface would be 170 acres, the same as for Packages A and B. With Improvement Package C, the total disturbed footprint would be 405 acres, while 7 acres of abandoned roadway would be reclaimed. No asphalt would be removed at the Price Creek Sno-park. The roadway changes under Package C would result in the filling of 4 acres of Keechelus Lake aquatic and shoreline habitat, and 0.6 acre of Lake Easton aquatic and shoreline habitat. The storage capacity of Keechelus Lake is expected to increase by 47 acre-feet.

The design of Package C is expected to impact a total of about 77 acres of Riparian Reserves in the project area (excluding the area between MP 56.6 and MP 59.9). Table 3.3-8 summarizes the impacts to Riparian Reserves by habitat classification.

3.3.3 Construction and Operation Best Management Practices

The mitigation and enhancement proposed is based on preliminary design. The type and location of mitigation will be dependant on findings from field surveys and other fieldwork to complete final design of the project. All stormwater BMPs will be designed, constructed, and maintained in accordance with WSDOT's 2004 HRM in order to minimize water quantity and quality impacts from freeway construction and operation.

Construction and as-built impacts can both be addressed through BMPs. A National Pollutant Discharge Elimination System Permit is required for construction for any disturbance of 1 acre or more to ensure discharge limits and water quality standards are met. Such a permit would require erosion and sediment control plans, and BMPs to minimize or eliminate adverse impacts on water resources. Any loss of riparian and wetland habitat as a result of an alternative could be compensated for by the creation of new habitat or enhancing existing habitat (see Section 3.5 for more detail). BMPs will be selected in accordance with the 2004 HRM to meet or exceed water treatment requirements under WDOE standards and USEPA Clean Water Act requirements.

Temporary construction impacts on hydrologic systems can be minimized somewhat through the timing of construction activities and locating staging areas

away from watercourses. Once construction is complete, it is necessary to mitigate increased runoff rates resulting from increased impervious surface to ensure that peak flows and runoff pollutant loadings are not increased. Temporary construction impacts on water quality can be mitigated somewhat by performing construction during seasonally dry periods to allow for spill containment and to minimize erosion. A number of BMPs are available to control and treat stormwater runoff both during and after construction.

Stormwater management on this project may consist of BMPs such as biofiltration swales, drainage inlets, detention ponds, and natural or engineered dispersion. These elements will be designed in accordance with the HRM and the Hydraulics Manual in a manner that prevents runoff from entering any stream without the necessary flow control and runoff (quality) treatment. All water entering drainage features would be routed either to a BMP feature, or as appropriate, Keechelus Lake. According to the HRM, Keechelus Lake is exempt from flow control (water quantity) requirements. Therefore, there are no BMPs for flow control along the lake. The stormwater management system designed for this project would provide an upgrade over the existing highway drainage system. Therefore, even though impervious area would generally increase throughout the project area, the proper application of BMPs should result in less pollutants entering waterways in runoff, decreased peak flows, and less erosion relative to existing conditions.

Along Keechelus Lake (MP 55.10 to MP 60.65) biofiltration swales are used to provide for runoff treatment, and have been designed to accommodate 6-month storm events. These grassy swales range from 4 to 10 feet in width, on grades ranging from 1 percent to 5 percent, and allow flows greater than the 6-month storm to be routed to Keechelus Lake. Within these swales are raised inlets and check dams placed at intervals. These raised inlets provide for a small amount of retained water, and promotion of infiltration. The check dams retain sediment, and are designed to overtop during extreme storm events. All swales within the project limits would be designed in this manner to meet runoff treatment requirements.

From the south end of Keechelus Lake to the top of Easton Hill (MP 60.80 to MP 67.40), flow control and runoff treatment will be required. Biofiltration swales (with raised inlets) would continue to be used to meet water quality issues. For flow control issues, BMPs such as detention ponds and natural dispersion would be utilized as the terrain dictates, with natural or engineered dispersion as the preferred treatment. Detention ponds would be used in areas where the terrain does not lend itself to dispersion (see Appendix B). These pond designs have been based upon the 6-month, 10-year, 50-year, and 100-year storm events, and not only meet flow control requirements, but also provide extra sediment control.

Stormwater detention basins are currently planned within the project area (see Appendix B). The mitigation proposed is based on preliminary design. The type and location of mitigation will be dependant on findings from field surveys and

other fieldwork to complete final design of the project. All stormwater BMPs will be designed, constructed, and maintained in accordance with WSDOT's 2004 HRM in order to minimize water quantity and quality impacts from freeway construction and operation. A detention basin (100 feet by 300 feet maximum) would be located near MP 61, west of Price Creek (Price/Noble Creeks CEA). Two detention basins (100 feet by 400 feet maximum) would be located within the Swamp Creek CEA (MP 62.70 to MP 63.20), one west of Swamp Creek and the other east of the Stampede Pass Interchange. Between the Toll Creek CEA and the Cedar Creek CEA at MP 64.30, a detention basin (100 feet by 300 feet maximum) is located. Another detention pond (100 feet by 300 feet maximum) is planned near MP 66.20, between Telephone Creek and Hudson Creek. No detention basins are currently planned for the Slide Curve area.

From the top of Easton Hill, to the end of the project (MP 67.40 to MP 70.30), natural or engineered dispersion would be the primary BMP, although detention basins may be required if conditions needed for dispersion cannot be achieved. Biofiltration swales would also be used to collect stormwater and treat it to meet quality issues.

Stormwater not treatable by the BMPs mentioned above would be discharged outside of the roadway prism for treatment. Other BMPs would have to be adopted if pipelines, other infrastructure, or public drinking water supplies are encountered.

Wider stream crossings may result in decreased water depths. In order to minimize the decrease in water depth, the creek beds may be actively shaped, through geomorphic design, to maintain adequate depths for fish passage through wider, self-maintaining crossings.

Larger culverts may be needed to reduce flow alteration and promote stream stability. Implementing mitigation to protect and enhance fisheries habitat, as described in Section 3.5 *Aquatic Habitat*, should also promote hydraulic stability for improved water quality.

Spill prevention, material management, and spill response is addressed in a site-specific SPCCP as required by WSDOT. The SPCCP identifies the minimum required spill response equipment necessary to keep on site. Spill prevention and planning is critical to minimize contamination of water resources. Secondary containment equipment such as spill pads/pallets, portable berms, drum trays, drain seals, and patch kits should be available for incidental spills. Spill prevention measures including containment areas for heavy equipment storage and fueling should also be utilized.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 1 of 12)

Gold Creek[1]	Baseline Condition	Package A Eastbound alignment closely follows existing alignment. Westbound alignment located slightly south of existing alignment. Existing bridge over creek replaced with longer bridge. Bridge built west of creek.[3]		Package B Similar to Package A, but no bridge built west of creek.		Package C Similar to Package A, but existing bridge over creek replaced with a shorter bridge than that in Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2]	Same as Package A.	Same as Package A.	Improvements CTEC[7], but likely less improvement compared to Package A due to shorter bridge.	Same flow alteration as Package A from runoff.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Limited bedload transport	Improved capacity for sediment/debris transport.	Sediment from traction sand.[2]	Same as Package A.	Same as Package A.	Smaller improvement in bedload capacity compared to Package A, but better CTEC.	Similar to Package A but erosion of fill may contribute sediment during high flows.
Channel Function	NPF[9] – limited migration	High improvement in channel migration.[5]	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Small improvement in channel migration.[5]	Same as Package A.
Floodplain	Artificially confined	Increase in area and high restoration of floodplain function.[5]	None	Same as Package A.	Same as Package A.	Smaller increase in area and low function restoration relative to Package A, but better CTEC.	More fill required for shorter bridge compared to Package A, but less than existing.
Groundwater	Hyporheic flow under bridge	High restoration of groundwater flow and recharge.	None	Same as Package A.	Same as Package A.	Low restoration of groundwater flow and recharge	Minor compaction effects, less than existing.
Surface Water Quality	NPF – temperature (lack of vegetation), sediment, DO[11]	Reduced sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and traction sand from lane widening.	Same as Package A.	Same as Package A.	Sediment and temperature likely reduced CTEC, but less reduction than with Package A.	Similar to Package A, but likely more sediment from erosion of fill from around bridge.
Riparian Reserves	N/A	N/A	13 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	12 acres of riparian reserves would be impacted.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 2 of 12)

Townsend Creek[1]	Baseline Condition	Package A At creek crossing, new alignment very similar to existing alignment. West of the creek, new alignment cuts into the hillside to straighten existing curve and does not appear to enter the Keechelus Lake floodplain. Existing culvert at creek replaced with a large culvert.[3]		Package B Same as Package A.		Package C Same as Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Excessive sediment deposition	Improved capacity for sediment/debris transport.	Sediment from fill and traction sand.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Channel Function	PF[8], steep drop downstream of culvert	Slight increase in migration potential and slope reduction.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Floodplain	Naturally confined	Minor increase in area and low restoration of floodplain function.	Some fill required for lane widening, encroachment likely similar to existing.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Groundwater	Flow and recharge occurs	Low restoration of groundwater flow and recharge.	None	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Surface Water Quality	NPF – sediment	Reduced sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and traction sand from lane widening. Sediment from fill.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 3 of 12)

Price Creek[1]	Baseline Condition	Package A New alignment very similar to existing alignment. Highway raised above existing grade. Culvert replaced with long bridge. Bridges built east and west of creek.[3]		Package B Similar to Package A, but bridge east of creek replaced by a series of culverts.		Package C Similar to Package A, but highway not raised as much and existing culvert replaced with a shorter bridge over creek. Series of culverts installed east of creek.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Similar to Package A for creek, but less improvement east of creek, still improved CTEC.	Same flow alteration as Package A.	Similar to Package A, but less improvement in creek and east of creek. Still improved CTEC.	Same flow alteration as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase. Profile raising may impact drainage.	Same as Package A.	Same as Package A.	Same as Package A.	Similar to Package A, but profile not raised as much so less impact on drainage.
Debris / Sediment Transport	Sediment from highway	Improved capacity for sediment/debris transport.	Sediment from fill from profile raising and traction sand.[2]	Same as Package A.	Same as Package A.	Similar to Package A, but slightly smaller improvement. Still improved CTEC.	Similar to Package A, but more fill added at creek crossing.
Channel Function	NPF – channel entrenched	Reduced entrenchment, high improvement in migration potential.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Less improvement in migration and entrenchment than Package A, still improved CTEC.	Same as Package A.
Floodplain	Artificially confined by highway fill and culvert	Major increase in area and high restoration of floodplain function.	None	Same as Package A.	Same as Package A.	Minor increase in area and lower restoration of floodplain function compared to Package A.	More fill required than Package A at crossing, less than existing.
Groundwater	Loss of recharge by compaction	High restoration of groundwater flow and recharge.	Minor compaction effects, less than existing.	Less restoration in area east of creek than Package A, still better CTEC.	Same as Package A.	Less restoration in creek area and east of creek than Package A, still improved CTEC.	Similar to Package A, but possibly increased impacts from fill at crossing.
Surface Water Quality	PF – sediment from highway	Minor reduction in sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and traction sand from lane widening.	Same as Package A	Same as Package A.	Sediment and temperature likely reduced CTEC, but less reduction than with Package A due to shorter bridge over creek.	Similar to Package A, but likely more sediment from erosion of fill from around bridge and from profile raising.
Riparian Reserves	N/A	N/A	4 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 4 of 12)

Noble Creek[1]	Baseline Condition	Package A At creek crossing, new alignment very similar to existing alignment. Culvert replaced with long bridge. Bridges built west of creek and east of creek.[3]		Package B Similar to Package A, but bridge east of creek replaced by a series of culverts.		Package C Similar to Package A, but highway not raised as much and existing culvert replaced with shorter bridge over creek. Series of culverts installed east of creek.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Similar to Package A, but less improvement east of creek, but still improved CTEC.	Same flow alteration as Package A.	Similar to Package A, but less improvement in creek and east of creek. Still improved CTEC.	Same flow alteration as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase. Profile raising may impact drainage.	Same as Package A.	Same as Package A.	Same as Package A.	Similar to Package A, but profile not raised as much so less impact on drainage.
Debris / Sediment Transport	Sediment from highway	Improved capacity for sediment/debris transport.	Sediment from fill from profile raising and traction sand.[2]	Same as Package A.	Same as Package A.	Similar to Package A, but slightly smaller improvement. Still improved CTEC.	Similar to Package A, but more fill added at creek crossing.
Channel Function	NPF – channel confined and moved	Reduced entrenchment.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Less improvement in entrenchment than Package A, still improved CTEC.	Same as Package A.
Floodplain	Artificially confined, channel not connected to floodplain	Major increase in floodplain area.	None	Same as Package A.	None	Minor increase in floodplain area compared to Package A, still improved CTEC.	More fill required than Package A at crossing, less than existing.
Groundwater	Routed to creek by fill	High restoration of groundwater flow and recharge.	Flow may be modified by alteration of fill.	Less restoration in area east of creek than Package A, but still improved CTEC.	Same as Package A.	Less restoration in creek area and east of creek than Package A, still improved CTEC.	Effects on flow may be less than Package A due to less fill removal.
Surface Water Quality	AR[10] – sediment from highway	Minor reduction in sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and traction sand from lane widening.	Same as Package A.	Same as Package A.	Sediment and temperature likely reduced CTEC, but less reduction than with Package A due to shorter bridge over creek.	Similar to Package A, but likely more sediment from erosion of fill from around bridge and from profile raising.
Riparian Reserves	N/A	N/A	4 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 5 of 12)

Bonnie Creek[1]	Baseline Condition	Package A New alignment appears to be very similar to the existing alignment but profile substantially raised. Culvert replaced with single long bridge over creek and west fork.[3]		Package B Similar to Package A, but shorter bridge built over creek and culvert installed in west fork.		Package C Similar to Package A, but profile not raised as much and existing culvert replaced with a large culvert. Culvert installed in west fork.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Similar to Package A, but less improvement due to smaller structures. Still improved CTEC.	Same flow alteration as Package A.	Similar to Package A, but less improvement in creek and east of creek. Still improved CTEC.	Same flow alteration as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase. Profile raising may impact drainage.	Same as Package A.	Same as Package A.	Same as Package A.	Similar to Package A, but profile not raised as much so less impact on drainage.
Debris / Sediment Transport	Sand from highway	Improved capacity for sediment/debris transport.	Sediment from fill from profile raising and traction sand.[2]	Similar to Package A, but less capacity, especially in west fork. Improved CTEC.	Similar to Package A, but more sediment from fill in creek and west fork.	Similar to Package A, but less capacity in creek and west fork. Improved CTEC.	Similar to Package A, but more fill added in creek and west fork.
Channel Function	NPF – migration restricted.	High improvement in migration potential.	Depth may decrease; new channel may form.[2]	Less migration potential, especially the west fork compared to Package A.	Same as Package A.	Less migration potential in creek compared to Package A. Improved CTEC.	Same as Package A.
Floodplain	Artificially confined, floodplain occupied by highway	Major increase in floodplain area and high restoration of floodplain function.	None	Moderate increase in floodplain area and moderate restoration of floodplain function.	More fill required in creek and west fork, but less than existing.	No floodplain restoration.	More fill required than Package A and Package B, encroachment likely equal to existing.
Groundwater	Flow routed by highway roadfill	High restoration of groundwater flow and recharge under bridge.	Groundwater flow may be modified by alteration of highway fill.	Moderate restoration under bridge, less under culvert in fork.	Similar to Package A, but may be more modified due to additional fill.	Low restoration in creek and fork due to culverts. Improved CTEC.	Effects on flow may be greater than Package A due to more fill added in floodplain.
Surface Water Quality	Not Rated – sediment from highway a concern	Minor reduction in sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and traction sand from lane widening.	Sediment and temperature likely reduced CTEC, but less reduction than with Package A due to smaller structures.	Similar to Package A, but likely more sediment from erosion of fill from around culvert and from profile raising.	No reduction in sediment and temperature expected.	Similar to Package A, but likely more sediment from erosion of fill from around culverts. Sediment from culvert maintenance.
Riparian Reserves	N/A	N/A	3 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 6 of 12)

Swamp Creek[1]	Baseline Condition	Package A New alignment very similar to existing alignment. The highway profile raised, and Stampede Pass Interchange rebuilt to an overcrossing. Long bridge over creek, bridge built east of creek.[3]		Package B Similar to Package A, but the highway profile would not be raised as much and the existing Interchange undercrossing structure would be replaced. Shorter bridge over creek, same bridge built east of creek. Additional bridge built west of creek near MP 62.5.		Package C Similar to Package B, but culvert installed east of creek and no bridge built west of creek.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity at creek, improved flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows. Hydrologic connectivity degraded at new Interchange.	Similar to Package A, but less improvement at creek due to shorter bridge but more improvement west of creek due to additional bridge. Improved CTEC.	Same flow alteration as Package A. Interchange not rebuilt, so no extra degradation of connectivity.	Similar to Package B, but less improvement east of creek and no improvement west of creek. Overall improvement CTEC.	Same as Package B.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from highway	Improved capacity for sediment/debris transport.	Sediment from fill and traction sand.[2]	Similar to Package A, but less capacity at creek but more west of creek. Improved CTEC.	Less sediment from fill from profile raising. Fill from shorter bridge over creek.	Similar to Package B, but less improvement east of creek and none west. Improved CTEC.	Similar to Package B, but more fill added at creek crossing.
Channel Function	NPF – confined at culvert	High restoration of channel function but limited natural migration.[6]	Depth may decrease; new channel may form.[2]	Similar to Package A, but only moderate restoration of channel function.[6] High restoration west of creek.	Same as Package A.	Similar to Package B, but less improvement east of creek and none west of creek. Improved CTEC.	Same as Package A.
Floodplain	Artificially confined, floodplain compacted by highway	Major increase in floodplain area and high restoration of floodplain function.[6]	None	Moderate increase in floodplain area and restoration of floodplain function.[6] Major improvement west of creek.	Less fill required for Interchange, but more for shorter bridge compared to Package A. Encroachment < CTEC	Similar to Package B, but less improvement east of creek and none west of creek. Improved CTEC.	More fill required than Package B due to culverts, encroachment likely less than existing depending on fill.
Groundwater	High continuity	High restoration of flow and recharge under bridge.	Flow intercepted by Interchange ramps.	Moderate restoration under shorter bridge. High restoration west of creek.	Less impact on flow from Interchange than Package A.	Similar to Package B, but less improvement east of creek and none west of creek.	Similar to Package B, but flow restricted east of creek from culvert.
Surface Water Quality	NPF – temperature, sediment, dissolved oxygen, fecal coliform, lead	Minor reduction in sediment and temperature. Reduced accidents and pollutant releases into creek.	Increased organics from traffic and sediment from lane widening and fill for profile raising.	Sediment and temperature likely reduced CTEC, but less reduction than with Package A due to smaller structures.	Similar to Package A, but likely less sediment from erosion of fill.	Similar to Package B, but no reduction expected east of creek.	Similar to Package B, but likely more sediment from erosion of fill from around culvert east of creek.
Riparian Reserves	N/A	N/A	6 acres of riparian reserves would be impacted.	N/A	5 acres of riparian reserves would be impacted.	N/A	Same as Package B.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 7 of 12)

Toll Creek[1]	Baseline Condition	Package A New alignment very similar to existing alignment. Bridge built over unnamed creek west of Toll Creek. Existing culvert in Toll Creek would be replaced by a larger culvert.[3]		Package B Same as Package A.		Package C Similar to Package A, but large culvert installed in unnamed creek.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Same as Package A.	Same as Package A.	Similar to Package A, but less improvement in unnamed creek. Improved CTEC.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from highway	Improved capacity for sediment/debris transport.	Sediment from fill and traction sand.[2]	Same as Package A.	Same as Package A.	Similar to Package A, but less improvement in unnamed creek. Improved CTEC.	Similar to Package A, but more fill added.
Channel Function	NPF – confined at culvert	High restoration of migration potential for unnamed creek. No change for Toll Creek.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Similar to Package A, but moderate restoration of migration potential.	Same as Package A.
Floodplain	Artificially confined, channel disconnect, loss of recharge	Major increase in floodplain area and function for unnamed creek, no change for Toll Creek.	None	Same as Package A.	Same as Package A.	Similar to Package A, but very small increase in floodplain area and low restoration of floodplain function.	More fill required than Package A, encroachment same as existing.
Groundwater	Highway fill impacts flow	High restoration of flow and recharge under bridge in unnamed creek.	None	Same as Package A.	Same as Package A.	Very small restoration of flow and recharge in unnamed creek.	Minor compaction effects, likely less effects than existing.
Surface Water Quality	NPF – temperature, traction sand, dissolved oxygen, metals	Minor reduction in sediment and temperature. Reduced accidents and pollutants into creek.	Increased organics from traffic and sediment from lane widening and fill.	Same as Package A.	Same as Package A.	No change expected for unnamed creek or Toll Creek.	Similar to Package A, but likely more sediment from erosion of fill from around culvert.
Riparian Reserves	N/A	N/A	2 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 8 of 12)

Cedar Creek[1]	Baseline Condition	Package A New westbound lane located between existing lanes. Eastbound lane location is new, located south of existing roadway. Existing culvert replaced with a larger culvert.[3]		Package B Same as Package A.		Package C Same as Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from I-90, high risk of debris flow	Improved capacity for sediment/debris transport.	Sediment from added fill and traction sand.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Channel Function	NPF – confined at culvert	No restoration of migration, but creek naturally limited.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Floodplain	Transition – naturally confined upstream of I-90	No increase in floodplain area and function.	Encroachment likely similar to existing.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Groundwater	Emergent zone	No restoration of flow and recharge.	Minor effects from fill and compaction.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Surface Water Quality	AR – sediment from highway	Reduced accidents and pollutant releases into creek.	Increased organics from traffic and sediment from lane widening and fill.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 9 of 12)

Telephone Creek[1]	Baseline Condition	Package A New alignment appears to be similar to existing alignment, but may be located slightly south of the existing roadway. Existing culvert replaced with a larger culvert.[3]		Package B Same as Package A.		Package C Same as Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, increased velocity	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from I-90, high risk of debris flow	Improved capacity for sediment/debris transport.	Sediment from added fill and traction sand.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Channel Function	AR – confined at culvert	No restoration of migration, but creek naturally limited.	Depth may decrease; new channel may form.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Floodplain	Transition – naturally confined upstream of I-90	No increase in floodplain area and function.	Encroachment similar to existing.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Groundwater	Recharge area	No restoration of flow and recharge.	Minor effects from fill and compaction.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Surface Water Quality	NPF – temp, sediment from highway	Reduced accidents and pollutant releases into creek.	Increased organics from traffic and sediment from lane widening and fill.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 10 of 12)

Hudson Creek[1]	Baseline Condition	Package A New alignment appears to be located slightly south of the existing alignment. Bridge built over middle fork, culvert installed in the west fork.[3]		Package B Similar to Package A, but smaller bridge built over middle fork and no culvert replacement in west fork.		Package C Similar to Package B, but culvert installed in middle fork.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, high peak flows	Better hydrologic connectivity, flow conveyance; lower stream velocities	Increased runoff may slightly alter peak flows.[2] Extra lanes covering recharge soils may alter base flows.	Less improvement in middle fork compared to Package A, but improved CTEC. No change in west fork.	Same flow alteration as Package A.	Less improvement in middle fork compared to Package B, but improved CTEC. No change in west fork.	Same flow alteration as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from I-90, disturbed areas	Improved capacity for sediment/debris transport.	Sediment from added fill and traction sand.[2]	Less improvement in middle fork compared to Package A, but improved CTEC. No change in west fork.	Similar to Package A, but more fill added in middle fork.	Less improvement in middle fork compared to Package B, but improved CTEC. No change in west fork.	Similar to Package B, but more fill added in middle fork.
Channel Function	NPF – confined at culverts	High restoration of migration potential for middle fork. No change in west fork.	Depth may decrease; new channel may form.[2]	Moderate restoration in middle fork. No change in west fork.	Same as Package A.	No change for middle and west forks.	Same as Package A.
Floodplain	Artificially confined	Major increase in floodplain area and function for middle fork, no change for west fork.	None	Moderate increase in floodplain area and function for middle fork, no change for west fork.	More fill required than Package A, encroachment may be greater than existing for west fork.	No increase in floodplain area and no restoration of floodplain function in middle and west forks.	More fill required than Package B in middle fork, encroachment likely same as existing.
Groundwater	Recharge reduced	High restoration of flow and recharge under bridge.	None	Moderate restoration in middle fork, no change in west fork.	Same as Package A.	Minor restoration in middle fork, no change in west fork.	Minor compaction effects, less than existing.
Surface Water Quality	NPF – temp (lack of vegetation), sediment from I-90	Minor reduction in sediment and temperature. Reduced accidents and pollutants into creek.	Increased organics from traffic and sediment from lane widening and fill.	Less improvement in middle fork compared to Package A, but improved CTEC. No change in west fork.	Similar to Package A, but more sediment from fill in middle fork.	No change for middle and west forks.	Similar to Package B, but likely more sediment from erosion of fill from around culvert in middle fork.
Riparian Reserves	N/A	N/A	5 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	6 acres of riparian reserves would be impacted.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 11 of 12)

Kachess River[1]	Baseline Condition	Package A New alignment very similar to existing alignment. Existing bridge to be widened.[3]		Package B Same as Package A.		Package C Same as Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow constricted, controlled by dam	None	Increased runoff may slightly alter peak flows.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Debris / Sediment Transport	Sediment from lake and I-90	None	Sediment from added fill and traction sand.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Channel Function	NPF – influenced by dam	None	Channel may be more restricted by bridge and highway widening.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Floodplain	Artificially confined – encroached upon by highway	None	Floodplain may be confined more by bridge widening and additional fill for highway widening.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Groundwater	Recharge area	None	Minimal compaction effects	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Surface Water Quality	NPF – temp (lake effects, lack of veg), sediment from highway	Reduced accidents and pollutant releases into creek.	Increased organics from traffic and sediment from lane widening and fill.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Riparian Reserves	N/A	N/A	5 acres of riparian reserves would be impacted.	N/A	Same as Package A.	N/A	Same as Package A.

Table 3.3-9. Improvement Package Consequences for Water Resources
(Page 12 of 12)

Lake Easton[1]	Baseline Condition	Package A New alignment very similar to existing alignment. Existing river bridge widened.[3]		Package B Same as Package A.		Package C Same as Package A.	
		Beneficial Effects	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**	**Beneficial Effects**	**Operational Impacts[4]**
Hydrology	Flow into lake controlled by dam	None	Increased runoff may alter peak and low flows into lake.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Runoff	Runoff from highway	Depends on highway drainage design.	Impervious area and runoff increase.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Sediment Transport	Sediment from I-90	None	Sediment from added fill and traction sand.[2]	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Channel Function	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Floodplain	Minor encroachment from highway	None	No additional lake floodplain encroachment expected.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.
Groundwater	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Surface Water Quality	NPF – temperature, sediment from highway	Reduced accidents and pollutant releases into lake.	More organics from traffic and sediment from widening and fill.	Same as Package A.	Same as Package A.	Same as Package A.	Same as Package A.

Notes:
1. Unless otherwise noted, information derived from the *Interstate 90 Snoqualmie Pass East MDT Draft Recommendation Package* (MDT 2004)
2. Information derived from the *Final Discipline Report for Interstate 90 Snoqualmie Pass East: Hydrologic Systems, Water Quality, and Floodplains* (WSDOT 2002b)
3. Information derived from current WSDOT design plans (04-16-04)
4. BMPs such as biofiltration swales and detention ponds can be used to decrease runoff into creeks and minimize water quantity and quality impacts from operation
5. Improvements in channel function and floodplain restoration dependent upon replacing the FSR 4832 bridge with a crossing that will accommodate channel migration and floodplain function.
6. Improvements in hydrologic connectivity and floodplain function dependent upon relocating FSR 54.
7. CTEC stands for “compared to existing conditions
8. PF stands for “properly functioning” as defined by the MDT (2004)
9. NPF stands for “not properly functioning” as defined by the MDT (2004)
10. AR stands for “at risk” as defined by the MDT (2004)

Table 3.3-10. Estimated Annual Pollutant Loads from Highway Surfaces

	No-Build/ Existing	*Package A*	*Package B*	*Package C*
Roadway Treated (acres)	0.0	169.6	169.6	169.9
Roadway Untreated (acres)	135.1	0.0	0.0	0.0
Total Roadway (acres)	135.1	169.6	169.6	169.9
Annual load of total suspended solids	118,618 pounds/year	6,954 pounds/year	6,954 pounds/year	6,966 pounds/year
Annual load of total phosphorus	175.6 pounds/year	50.9 pounds/year	50.9 pounds/year	51.0 pounds/year
Annual load of total copper	27.0 pounds/year	8.5 pounds/year	8.5 pounds/year	8.5 pounds/year
Annual load of total zinc	148.6 pounds/year	44.1 pounds/year	44.1 pounds/year	44.2 pounds/year

Notes: Calculations based on mean pollutant loads from high average daily traffic volume highways (90,000-160,000) in Western Washington (WSDOT 2004 National Pollutant Discharge Elimination System Annual Progress Report).

3.4 Wetlands

Gold Creek

This section was prepared based on the *Wetland/Biology Report* for the Interstate 90 (I-90) Snoqualmie Pass East Project (Washington State Department of Transportation [WSDOT] 2004f) (Appendix Y). Wetlands were identified using aerial photography, National Wetland Inventory maps, soil survey information, and preliminary wetland inventories previously completed during planning for the I-90 upgrade project. Wetlands were classified according to the United States Fish and Wildlife Service (USFWS) classification system (Cowardin et al. 1979), and the hydrogeomorphic classification system (WSDOT 2000).

After an office review of National Wetland Inventory maps and aerial photographs for the project area, WSDOT biologists conducted an on-site wetland inventory in fall 1998. Wetland delineations began four years later in fall 2002, and were completed in late summer 2003. The wetland determinations were made using observable vegetation, hydrology, and soils as set forth in the new Washington State Wetlands Identification and Delineation Manual (Washington Department of Ecology [WDOE] 1997). Sequentially numbered flags delineated the boundaries of all jurisdictional wetlands occurring within this 600-foot swath. A soil survey for Kittitas County has not been published, so the only information on soils in this report comes from what was encountered in the various wetlands. Site visits were made in September and October 2004, to re-flag wetlands for additional surveying work. The study area for wetlands includes the 15-mile I-90 corridor and wetlands that occur downstream of the highway to the Yakima River. Figure 3.4-1 shows wetlands along the entire project route. The graphics in Section 2.4.3 and 2.4.6 show wetlands for each of the Keechelus Lake Alignment Alternatives and Connectivity Enhancement Areas (CEAs).

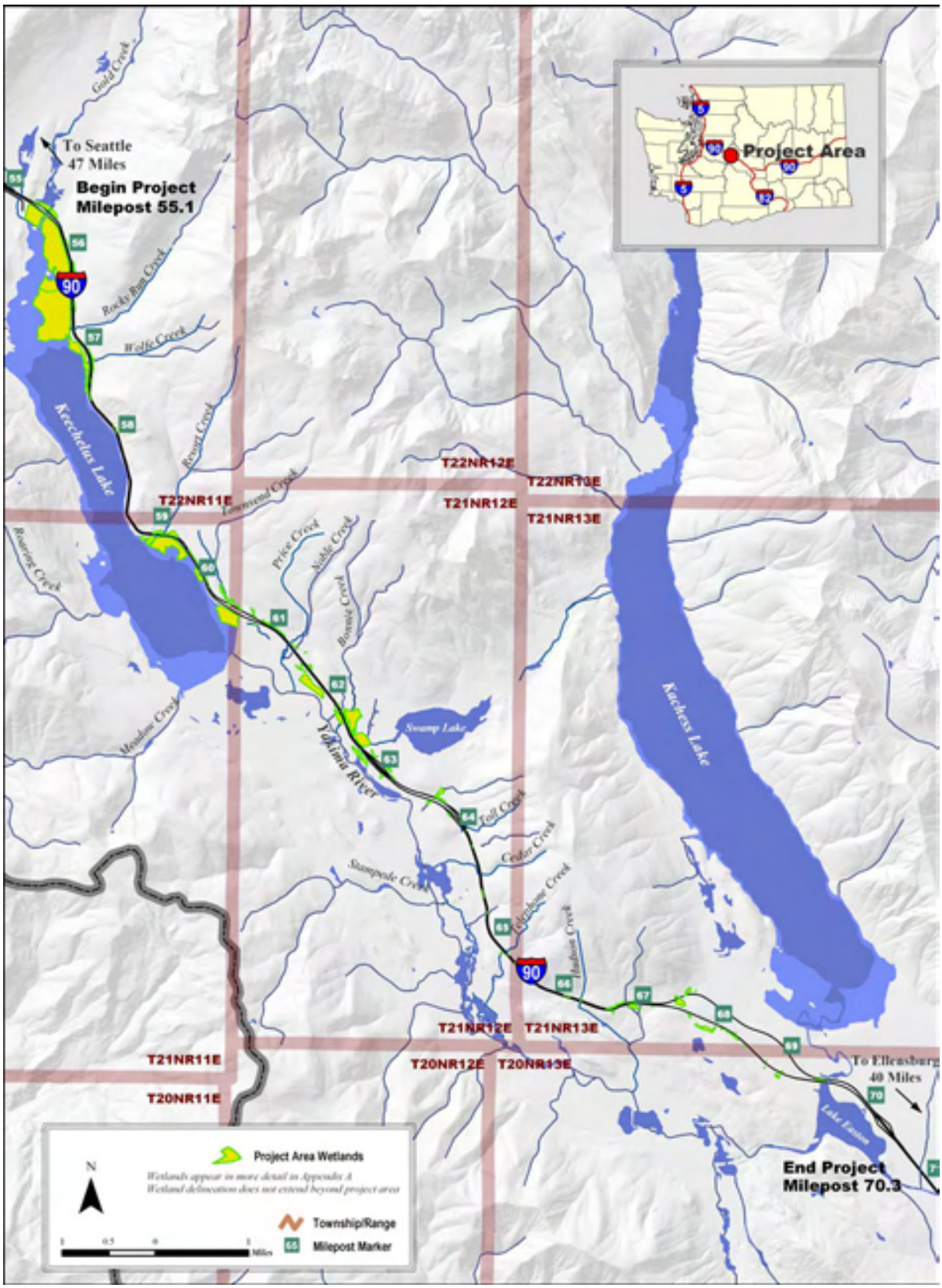


Figure 3.4-1. Project Area Wetlands

3.4.1 Affected Environment

The project area lies immediately on the east side of the Cascade crest, at the border between the Northern Cascades and Southern Washington Cascades physiographic provinces (Franklin and Dyrness 1988). From Snoqualmie Pass at 3,022 feet, elevation within the project area decreases steadily to about 2,150 feet near Easton. North of the project area, Keechelus Ridge and Amabilis Mountain rise to over 4,500 feet. Prominent water bodies within the project area include Keechelus Lake, Kachess Lake, Lake Easton, and the Yakima River. Named tributaries to Keechelus Lake and the Yakima River include (moving from west to east) the following:

- Coal and Gold creeks flowing into the head of Keechelus Lake.
- Rocky Run, Wolfe, Resort, and Townsend creeks flowing into the east side of Keechelus Lake.
- Cold, Mill, Roaring, and Meadow creeks flowing into the west side of Keechelus Lake.
- Price Creek (left bank tributary), Swamp Creek (left bank tributary), Mosquito Creek (right bank tributary), Stampede Creek (right bank tributary), Cedar Creek (left bank tributary), Telephone Creek (left bank tributary), Hudson Creek (left bank tributary), Cabin Creek (right bank tributary), Kachess River (left bank tributary), and Silver Creek (left bank tributary), flow into the Yakima River and Lake Easton.

The glacial and alluvial geology in the valleys within the project area help determine, to a large extent, the location and type of wetlands that occur there. For example, the Swamp Lake area is distinguished by organic soils formed by deposition at the bottom of a lake, which formed behind a lateral moraine. The geology leads directly to the formation of hydric soils, a high water table, and a dominance of hydrophytic vegetation in a large wetland complex.

Areas near the Cascade crest receive up to 100 inches of precipitation annually, much of it falling as snow during the winter. Near Easton, annual precipitation is about 50 inches (USFS 1997). The generous precipitation and snow pack in the high mountain areas supply water to Keechelus Lake and the Yakima River. Aquatic types found in the project area include small mountain streams, a large reservoir with substantial seasonal fluctuation, and the Yakima River. Water quality is generally very good or exceptional, as distinguished by low nutrient and contaminant levels, and cold temperature. Exceptions include Gold Creek, which exhibits high fine sediment levels and is listed on the state 303(d) list as water temperature-impaired, and Cabin Creek, which also has fine sediment levels higher than 15 percent by volume (United States Forest Service [USFS] 1997). The hydrologic cycle of the aquatic systems displays seasonal trends

defined by heavy winter snowfall, followed by runoff of the spring melt, and a dry late summer and early fall.

Wetlands found within the project area include forested, scrub-shrub, and emergent vegetation, which, like the other aquatic systems, are driven by the seasonal hydrologic cycle. The wetlands help moderate high spring runoff by storing water that, later in the summer, supports base flows in streams and rivers. The headwater location of the project area increases the relative importance of the water storage/base flow support function of the wetlands. The wetlands in the project area also provide critical migration and forage habitat for a variety of wildlife species. Mountain wetland systems generate substantial quantities of organic matter. Since the lakes and streams in sub-alpine areas are typically oligotrophic, organic input from wetlands helps drive and sustain the aquatic food web.

The varied climatology and landscapes in the project area provide a correspondingly diverse assemblage of habitats for an estimated 394 species of fish and wildlife in the Wenatchee National Forest (WNF) (USFS 1990). Many of these species are highly migratory, moving into high elevation areas during the short growing season, then back down to lower elevation valleys during the winter.

3.4.1.1 GOLD CREEK

Gold Creek

An extensive complex of emergent and scrub-shrub wetlands stretches from the north end of Keechelus Lake north to the Gold Creek valley, and across the boundary of the project area. The physical barrier of I-90 and the dam at Keechelus Lake has changed some of the historic characteristics of the complex. Currently, wetlands on the south side of the existing I-90 alignment are supported by both flow in Gold Creek and backflooding from Keechelus Lake, whereas wetlands north of I-90 are supported by backflooding from Keechelus Lake, creek flow, and runoff from the surrounding mountains. Prior to the construction of the roadway and the dam, the lake likely had less influence on the complex (limited to the delta area with the natural lake and Gold Creek), and Gold Creek had more influence. The floodplain of Gold Creek was unrestricted, and supported a more diverse wetland and riparian structure that extended to a delta on the historic lake shoreline.

The highway and Forest Service Road (FSR) embankment also likely interrupts some of the surface and subsurface water flow toward Keechelus Lake. During much of the year, the lake's edge is located well south of I-90 where Gold Creek crosses under the highway. During the summers of low water years, the Gold Creek delta is exposed as an undulating plain extending south about 1.5 miles, almost to the mouth of Mill Creek (along the western shore of Keechelus Lake).

Logging, highway and road development have affected conditions in the Gold Creek watershed, including the wetlands within the project area. I-90 cuts

transversely through the floodplain wetland complex, and interrupts the hydrologic and ecological connectivity of the system. A road system runs north from FSR 4832, likely constructed to access a historic gravel pit just north of the project boundary. The gravel pit itself has converted a portion of the scrub-shrub and emergent wetland into a small lake.

Using the wetland hydrogeomorphic classification system outlined by Brinson (1993), the Gold Creek wetlands are a mix of riverine and depressional wetland areas, forming a complex matrix. Functions likely provided by the riverine and depressional wetlands in the Gold Creek system include sediment and nutrient removal, peak flow reduction, base flow support, shoreline stabilization, primary production and organic export, fish and wildlife habitat, and native plant richness.

Near the southern edge of the wetland complex, the wetlands are associated more with Keechelus Lake than Gold Creek and are classified as lacustrine fringe wetlands (Brinson 1993). With the exception of peak flow reduction and base flow support, the lacustrine fringe wetlands perform essentially the same functions as the other Gold Creek wetlands (WSDOT 2000).

3.4.1.2 KEECHELUS LAKE

Keechelus Lake

Wetland inventories indicate a fringe of unconsolidated shore, emergent, and scrub-shrub wetlands associated with the shoreline of Keechelus Lake (Appendix Y). The sources of hydrology for these fringe systems are somewhat complex, and can be driven by seasonal fluctuations of the level of Keechelus Lake, upland runoff, groundwater seepage, or all three. In wetter years, many of these fringe wetland areas are inundated during the early growing season and through a good share of the summer. In dry years, these wetlands may be inundated or saturated for a limited period, if at all, but may persist due to overland flow and groundwater seepage. The source of hydrology may be seasonal streams and seeps that can support fringe wetlands throughout the drier summer months when the pool is lowered.

The most extensive wetland complexes along the lakeshore occur where tributary streams enter the lake. These alluvial deltas are mapped as an intricate mix of unconsolidated shore, emergent, and scrub-shrub wetlands and riparian areas. For example, the delta of Meadow Creek, at the southwestern corner of the lake, supports a complex of riparian areas and wetlands in the triangular delta at the lake's edge. Delta wetland complexes in the vicinity of the existing route of I-90 include those associated with Rocky Run, Wolfe, Resort, and Townsend creeks.

The wetlands around Keechelus Lake can be best classified as lacustrine fringe systems (Brinson 1993). The pattern and magnitude of seasonal water fluctuations heavily influence the functions provided by the different elevation zones within the wetlands. The influence of the hydrologic cycle on the

functions derives from the vegetation communities at the shoreline that are dependent, in large part, on the hydrologic cycle. In general, functions provided include sediment, nutrient and contaminant removal, shoreline stabilization, fish and wildlife habitat, and primary production and organic export.

Functional levels of shoreline stabilization, fish and wildlife habitat, and organic export are influenced by the lake level, and the resulting shoreline characteristics that occur during the year. However, Keechelus Lake is a controlled reservoir that fluctuates annually between high and low water surface elevations.

3.4.1.3 YAKIMA RIVER

From the dam outlet, the Yakima River flows roughly towards the southeast, to the south of the existing I-90 alignment. A variety of small scrub-shrub and forested wetlands occur along the river channel between the dam outlet and where the river channel exits the project area. Like the wetland system associated with the dam's drainage channel, these wetlands occur within the valley bottom of the Yakima River. The wetlands are situated within a forested riparian corridor adjacent to the river channel. Generally, the wetlands and riparian areas are confined within a zone of soils mapped as fluvaquents, a hydric soil that is typically associated with floodplains and alluvium (Natural Resources Conservation Service 1996).

Being associated with the river channel, these wetlands fall within the riverine classification (Brinson 1993). However, wetland areas that lie in relict channel scars that are not directly associated with the present channel are more appropriately classed as depressional systems. All of these wetlands provide sediment and nutrient removal and retention, peak flow reduction, base flow support, fish and wildlife habitat, primary production, and organic export.

3.4.1.4 SWAMP LAKE

Northeast of the highway near the Stampede Pass Interchange, Swamp Lake encompasses a large scrub-shrub and forested wetland with a small emergent component. The Swamp Lake wetlands extend north beyond the project boundary. As with the large wetland complex immediately downstream of the dam, the Swamp Lake wetland soils are mapped as organic soils. The large Swamp Lake wetland drains to the Yakima River via Swamp Creek, which flows through a narrow wetland panhandle that is contiguous with the main body of the Swamp Creek wetland. The wetland complex now associated with Bonnie Creek was historically part of the Swamp Lake complex. However, the cedar bog portion of this wetland has since been logged, with a portion of this wetland complex classified as a Category I remnant cedar bog. The wetland is bracketed by forest roads following the contours of the surrounding hillsides. The Swamp Lake watershed receives runoff from an area defined by the east end of Keechelus Ridge (to the west of the main wetland), the west end of Amabilis

Mountain (to the east of the main wetland), and a small area extending up to a low pass leading to the Lodge Creek watershed and Kachess Lake.

The Swamp Lake wetland is a classic depressional outflow system. Water collects in the wetland and flows out through Swamp Creek. Key functions provided by the Swamp Lake system include sediment and nutrient removal, peak flow reduction (which helps prevent downstream shoreline erosion), base flow support, primary production, organic export, groundwater recharge, and fish and wildlife habitat.

3.4.1.5 EASTON HILL AND LAKE EASTON

A variety of small forested and scrub-shrub wetland pockets, most likely associated with streams draining higher elevations, occur within the project corridor between the top of Easton Hill and the eastern project boundary. If associated with a stream, the wetlands would be classed as riverine; otherwise, they are depressional or slope systems. These wetlands provide valuable habitat diversity, and provide peak flow reduction and baseflow support for small streams and creeks and the Yakima River.

Near Lake Easton, two larger scrub-shrub wetlands occupy pockets of a region that appear to be a glacial moraine. The project corridor includes only the extreme northern portions of both these wetlands. The soils in these pockets are mapped as organic soils and, along with landscape location, indicate that these wetlands are depressional. They provide sediment and nutrient retention and removal, peak flow reduction, base flow support, primary production, organic export, groundwater recharge, and wildlife habitat functions.

The existing I-90 alignment crosses the mouth of the Kachess River. The lake itself is a reservoir with steeply sloped shorelines that support little if any wetland fringe. The existing highway crosses the narrow lake panhandle on a bridge. Two fill causeways on either side of the bridges narrowly constrict the lake and almost completely cut off a small portion of the lake area north of the highway.

3.4.2 Environmental Consequences

Unlike some of the other resources, this section does not include a description of the generic types of impacts that could result from the project. However, the Impact Mechanisms sections under *Fish and Aquatic Habitat* (Section 3.5) and *Terrestrial Species* (Section 3.6) provide a good overview of the types of physical effects the project is expected to have on aquatic habitat, including wetlands. For the purpose of understanding impacts to wetland hydrology, culverts installed for the proposed project would be bottomless or three-sided culverts. Appendix B, the Design Appendix, presents mapped wetlands and location of alternative improvements.

The impacts of the project on wetlands are quantified in the following sections according to wetland category as defined by the Washington State Wetland Rating System (Hruby 2004). This rating system categorizes wetlands based on rarity, sensitivity to disturbance, our ability to replace them, and the functions they provide.

CATEGORY I

Category I wetlands are generally unique and rare wetlands, undisturbed, sensitive to disturbance, difficult to replace, or provide a high level of functions.

Specifically, Category I wetlands are:

- Alkali wetlands
- Wetlands that are identified by the Washington Natural Heritage Program/WDNR as high quality wetlands
- Bogs
- Mature and old-growth forested wetlands with slow growing trees
- Forests with stands of aspen
- Wetlands that perform many functions well

CATEGORY II

Category II wetlands are more common than Category I wetlands, but still provide high levels of some function. They may be difficult, but not impossible, to replace.

Specifically, Category II wetlands are:

- Forested wetlands in the floodplains of rivers
- Mature and old-growth forested wetlands with fast growing trees
- Vernal pools
- Wetlands that perform functions well

CATEGORY III

Category III wetlands are generally less diverse and more isolated from other natural resources than Category II wetlands. Specifically, Category III wetlands are:

- Wetlands with a moderate level of functions
- Isolated vernal pools

CATEGORY IV

Category IV wetlands have the lowest levels of functions and are often heavily disturbed. These wetlands can usually be replaced or improved.

At this time, the project is at approximately 30 percent design, and wetland impacts are approximations only, based on field reviews and aerial photographs. Prior to permitting, wetland impacts would be field verified and actual impacts determined. The following impacts are considered estimates only and may change during final design.

3.4.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, none of the build alternatives for the Slide Curve area, nor any of the Improvement Package actions for the other portions of the route, would be implemented. Therefore, none of the benefits of improved hydrological connections and resulting restoration of wetlands as described below for the four build alternatives and three Improvement Packages would be achieved. However, the loss of wetlands as well as the short-term adverse impacts resulting from construction, as described in Sections 3.4.2.2 and 3.4.2.3, would also not occur. There would be no loss of wetlands at the south end of the potential tunnels, near Resort Creek (Alternatives 1-3), nor at locations along the lake where the roadway would be straightened (Alternatives 1-4). This alternative would not realize the potential wetland habitat restoration benefits of removing highway and/or fill that would occur under Alternatives 1-3 and the Improvement Packages (greatest with Improvement Package A and least with Improvement Package C).

3.4.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

Alternative 1: Long Tunnels

Wetlands are limited in the Slide Curve area, and consist of small lake fringe wetlands and small delta wetlands at the mouths of Rocky Run and Wolfe creeks, and at Resort Creek. Enlarging the culverts at Rocky Run Creek and Wolfe Creek would benefit wetlands at these sites. Removal of highway along the shoreline of Keechelus Lake in the Slide Curve area may result in some improvement or recovery of lakeshore vegetation and habitat in that area (fringe wetlands). A total of 38 acres of abandoned roadway would be removed under this alternative, with the potential for wetlands or other aquatic (lakeshore) habitat to be created in at least part of this area. This effect would be greater than for the other Keechelus Lake Alignment Alternatives, where a shorter length of

the highway would be removed or the highway would be built out into the lake on bridges.

Straightening of the highway alignment would result in filling of 12 acres of aquatic and shoreline habitat, some of which currently supports wetlands. Wetlands would also be lost at the south end of the tunnel at Resort Creek, due to construction of the roadway from the portal to the existing alignment of the highway to the southeast. A total of 5.6 acres of primarily Category II wetlands would be lost under this alternative. These impacts would be mitigated by creation or enhancement of wetlands at this or another site (Section 4.2.1). Further downstream, installing a bridge at the Resort Creek crossing of I-90 would allow more natural channel migration and hydrology in the alluvial fan at this site, with beneficial impacts on the existing wetlands habitat.

Operation of the tunnel would have little impact on wetlands, assuming measures to minimize impacts to water quality are implemented as discussed in Section 3.3.2. This alternative would result in less exposed impervious surface than the other alternatives. The stormwater control measures discussed in Section 3.3.2 are expected to reduce the resulting water quality impacts to less than current levels.

Alternative 2: Short Tunnels

Improvement in lakeshore fringe wetland habitat due to highway removal would be less than under Alternative 1, because less abandoned roadway would be removed (21 acres vs. 38 acres). Construction of new bridges over Keechelus Lake at the site of the existing snowshed could result in disturbance or long-term displacement of lakeshore fringe wetlands. These bridges could also result in long-term shading of lakeshore fringe wetlands. Enlarging the culverts at Rocky Run Creek and Wolfe Creek would benefit wetlands at these sites.

Straightening of the highway alignment, in addition to the construction of new bridges at the existing snowshed, would result in the filling of 16 acres of aquatic and shoreline habitat, some of which currently support wetlands. At the south end of the tunnel, the loss of wetlands near Resort Creek would be the same as under Alternative 1. A total of 5.2 acres of primarily Category II wetlands would be lost under this alternative. These impacts would be mitigated by creation or enhancement of wetlands at this or another site (Section 4.2.1). The beneficial effects of installing a bridge at the Resort Creek crossing would be the same as under Alternative 1. As with Alternative 1, operation of the tunnel and highway would have little impact on wetlands, assuming measures to minimize impacts to water quality are implemented as discussed in Section 3.3.2.

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

This alternative would have minimal beneficial impacts on wetlands because the eastbound lanes of I-90 would not be removed in the Slide Curve area. Removal

of 13 acres of abandoned roadway (westbound lanes) would make area available for potential habitat restoration. New bridges would be built at the site of the existing snowshed and at the west end of Slide Curve. Construction of these bridges and realignment of the eastbound lanes could result in short-term, construction-related disturbance and/or long-term displacement of lakeshore fringe wetlands. Enlarging the culverts at Rocky Run Creek and Wolfe Creek would benefit wetlands at these sites.

Straightening of the highway alignment and construction of bridges would result in filling of 19 acres of aquatic and shoreline habitat, some of which currently support wetlands, including at Resort Creek. At the south end of the tunnel, a smaller area of wetlands would be lost than under Alternatives 1 or 2. A total of 8.3 acres of primarily Category II wetlands would be lost under this alternative. These impacts would be mitigated by creation or enhancement of wetlands at this or another site (Section 4.2.1). The beneficial effects of installing a bridge at the Resort Creek crossing would be the same as under Alternatives 1 and 2. As with Alternatives 1 and 2, operation of the tunnel and the eastbound highway would have little impact on wetlands, assuming measures to minimize impacts to water quality are implemented as discussed in Section 3.3.2.

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

This alternative does not include the benefit of removing major sections of highway from the lakeshore (a total of 5 acres of abandoned roadway would be removed). However, it also would not result in loss of wetlands at the south end of the tunnel, as would occur with Alternatives 1-3. Realignment of the highway in the Slide Curve area and construction of a new bridge at the west end of Slide Curve would result in temporary disturbance and long-term displacement of lakeshore fringe wetlands. A total of 18 acres of aquatic and shoreline habitat would be filled, some of which currently support wetlands. A total of 4.9 acres of primarily Category II wetlands would be lost under this alternative. These impacts would be mitigated by creation or enhancement of wetlands at this or another site (Section 4.2.1). Enlarging the culverts at Rocky Run Creek and Wolfe Creek would benefit wetlands at these sites. The installation of a series of culverts at Resort Creek is expected to have beneficial effects. Despite the wider highway, the stormwater management measures discussed in Section 3.3.2 are expected to control operational water quality impacts to less than current levels.

3.4.2.3 IMPROVEMENT PACKAGES

The three Improvement Packages have been developed to provide three levels of improved (from existing conditions) hydrologic, habitat, and species movement connectivity along the I-90 corridor and to assess the effects of the roadway improvements. These changes would improve hydrologic conditions for wetlands, connections between wetlands on opposite sides of the highway, and movement of wetland species. Overall, Improvement Package A provides the greatest improvement in connectivity, while Improvement Package C provides

the least improvement. All three Improvement Packages would improve hydrologic conditions in the vicinity of I-90, which would help to restore wetlands and other aquatic habitat, reduce habitat disconnection, and facilitate movement of wildlife across the highway (beneficial effects). In the following pages, wetlands impacts are described for each Improvement Package as a whole for the project route outside the Keechelus Lake Alignment Alternatives. Table 3.4-1 (found at the end of this section) summarizes wetlands impacts for each CEA under the three Improvement Packages.

Improvement Package A

As mentioned above, Improvement Package A would result in the greatest improvement in hydrologic and ecological connectivity in the project area, resulting in the greatest benefit to wetlands among the Improvement Packages. Under Improvement Package A, bridges of various lengths would be installed at selected stream crossings, with culverts installed at some of the smaller crossings, allowing for free water flow, channel migration, and movement of aquatic species under the highway. These changes would improve water supply to wetlands downstream of the highway. Removal of highway fill at the bridge sites would allow wetlands to develop in the right-of-way (ROW) at many of these sites and would promote connection between wetlands on opposite sides of the highway. Removal of the Price Creek Sno-park would also enhance wetlands and a small, unnamed creek on both sides of the highway. Functions that these wetlands are likely to support include sediment and nutrient removal, peak flow reduction, base flow support, shoreline stabilization, primary production and organic export, fish and wildlife habitat, and native plant richness.

At the Swamp Creek CEA, at the Stampede Pass interchange, the I-90 profile would be raised and reconstructed to an overcrossing. Culverts would be installed within the interchange area to help restore the surface hydrologic connectivity across I-90. Aside from this site, this Improvement Package would improve hydrologic connectivity and wetland habitat in the project area (Appendix A). Table 3.4-1 summarizes the wetland impacts for the individual CEAs under the three Improvement Packages.

Overall, there would be a major improvement in hydrologic connectivity and conditions for wetland habitat in the vicinity of I-90 and the affected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and wetland connectivity in the region.

A total of 8.6 acres of wetlands would be lost due to highway construction, including construction at the CEAs and in the sections of the route between CEAs:

- Category I Wetlands: 0.8 acre
- Category II Wetlands: 5.5 acres

- Category III Wetlands: 2.3 acres

The I-90 Wetlands Report (Appendix Y) identifies impacts to wetlands in more detail. As discussed in Section 4.2.1, wetland habitat lost as a result of the project would be mitigated by creation or enhancement of wetlands (some of which would occur at sites where highway fill is removed as part of the proposed action) so that there would be no net loss of wetlands.

Improvement Package B

The connectivity structures that would be installed under Improvement Package B are similar to those under Improvement Package A, except that shorter bridges or culverts would be installed at Price/Noble Creeks, Bonnie Creek, and Hudson Creek, and an animal overcrossing would be installed at Easton Hill instead of a short bridge. As a result, there would be slightly less benefit to wetlands and wetland functions than under Improvement Package A. Wetlands would benefit from improved water supply, channel migration, and movement of aquatic species across the highway. Where fill would be removed for bridge installation, wetlands could be created or enhanced in the ROW, and connection between wetlands on opposite sides of the highway would be promoted. Removal of the Price Creek Sno-park would also enhance wetlands and a small, unnamed creek on both sides of the highway. Overall, there would be a major improvement in hydrologic connectivity and conditions for wetland habitat in the vicinity of I-90, and the affected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and wetland connectivity in the region. Table 3.4-1 summarizes wetland impacts for each CEA for the three Improvement Packages.

A total of 7.4 acres of wetlands would be lost due to highway construction, including construction at the CEAs and in the sections of the route between CEAs:

- Category I Wetlands: 0.6 acre
- Category II Wetlands: 4.7 acres
- Category III Wetlands: 2.1 acres

The I-90 Wetlands Report (Appendix Y) identifies impacts to wetlands in more detail. As discussed in Section 4.2.1, wetland habitat lost as a result of the project would be mitigated by creation or enhancement of wetlands (some of which would occur at sites where highway fill would be removed as part of the proposed action), so that there would be no net loss of wetlands. The beneficial effects of the project on wetlands and wildlife are considered more important than the loss of wetlands from construction.

Improvement Package C

Compared to Improvement Package B, under this Improvement Package, shorter bridges would be installed instead of longer bridges, or culverts would be installed instead of bridges at seven CEAs. The resulting benefits to hydrologic connectivity and wetland habitat conditions would be substantially less than under Improvement Packages A and B. Connectivity would probably not be improved substantially for lower mobility aquatic species. However, this Improvement Package still represents substantial improvement over existing conditions in terms of hydrologic connectivity and benefits to wetlands. Bridges would be installed at four major CEAs: Gold Creek/Gold Creek West, Price/Noble Creeks, Swamp Creek, and Easton Hill. Large culverts would be installed at four additional CEAs: Townsend Creek, Bonnie Creek, Swamp Creek East, and Toll Creek West. These structures would allow for considerable water flow, channel migration, and movement of aquatic species, and the resulting benefits to wetlands. Overall, there would be substantial improvement in hydrologic connectivity and conditions for wetland habitat in the vicinity of I-90, and the affected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and wetland connectivity in the region. Table 3.4-1 summarizes wetland impacts for each of the CEAs for the three Improvement Packages.

A total of 7.2 acres of wetlands would be lost due to highway construction, including construction at the CEAs and in the sections of the route between CEAs:

- Category I Wetlands: 1.0 acre
- Category II Wetlands: 4.1 acres
- Category III Wetlands: 2.1 acres

The I-90 Wetlands Report (Appendix Y) identifies impacts to wetlands in more detail. As discussed in Section 4.2.1, wetland habitat lost as a result of the project would be mitigated by creation or enhancement of wetlands (some of which would occur at sites where highway fill is removed as part of the proposed action) so that there would be no net loss of wetlands.

Table 3.4-1. Wetlands Impacts of the Improvement Packages (Page 1 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Gold Creek		
A	Hydrological connectivity, channel migration, and movement of aquatic and terrestrial species would be improved substantially by removal of embankment and installation of long bridge. This would lead to improvement in and expansion of wetlands and other aquatic habitats, including more diverse wetland and riparian habitat structure. There is a potential for wetlands to be created/enhanced in the ROW.	Temporary disturbance of wetlands at the site during construction. Loss of 2.3 acres of wetlands due to highway construction. Such losses would be mitigated for in consultation with regulatory agencies to achieve no net loss of wetlands, including wetland restoration that occurs as a beneficial effect of the project.
B	Impacts would be similar to Package A.	Temporary disturbance of wetlands at this site during construction. Loss of 1.7 acres of wetlands due to highway construction. Such losses would be mitigated for in consultation with regulatory agencies to achieve no net loss of wetlands, including wetland restoration that occurs as a beneficial effect of the project.
C	Types of impacts would be similar to Packages A and B, but substantially less beneficial. There is a smaller potential for wetlands to be created/enhanced in the ROW than under the other packages.	Temporary disturbance of wetlands at this site during construction. Loss of 1.0 acre of wetlands due to highway construction. Such losses would be mitigated for in consultation with regulatory agencies to achieve no net loss of wetlands, including wetland restoration that occurs as a beneficial effect of the project.
Townsend Creek		
A, B, and C	Replacing the existing culvert with larger culvert would allow more natural channel migration and hydrology, which may benefit the high quality wetlands at the site.	Short-term construction-related impacts.
Price/Noble Creeks		
A	Replacement of culverts with bridges would improve surface and subsurface hydrological connections that should improve and expand wetlands, especially downstream of the highway. These benefits depend on restoration of water flow patterns and wetlands along Sunset Highway north of I-90. East of Noble Creek, bridge installation would allow wetlands to be created/enhanced. Removal of the Sno-park would restore wetlands on both sides of the highway and on a small, unnamed stream.	Temporary disturbance of wetlands at the site during construction. Loss of 0.7 acre of wetlands due to highway construction.
B	The bridges over Price and Noble Creeks would restore hydrological connectivity of wetlands upslope of the highway to historic forested wetlands downslope. The effectiveness of these beneficial effects is dependent on restoration of wetlands and water flow paths along Sunset Highway upslope of I-90. East of Noble Creek, the connectivity structures would restore wetland hydrology up and downslope of the project, but would not create/enhance wetlands within the existing highway ROW as Package A would do. Removal of the Sno-park would enhance wetlands on both sides of the highway and a small, unnamed stream.	Same as Package A.
C	Hydrologic connectivity structures will provide minimal benefit because wetlands within the Sno-park would not be restored.	Same as Package A.

Table 3.4-1. Wetlands Impacts of the Improvement Packages (Page 2 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Bonnie Creek		
A	Installation of the 600-foot-long bridge over the creek and branches, and of the culverts east of Bonnie Creek would restore the hydrologic connection between wetlands upslope of I-90 to the historic forested wetlands south of the highway. Removal of existing fill at the bridge site would potentially allow creation/enhancement of a 600-foot span of wetlands at the immediate highway site, and wetland hydrology up and down slope. Improving hydrologic connectivity should also alleviate the sediment retention problem at this site.	Temporary disturbance of wetlands at the site during construction. Loss of 0.2 acre of wetlands due to highway construction.
B	Permeability structures throughout the Bonnie Creek area would restore hydrologic connectivity between wetlands upslope of the highway to historic forested wetlands south. The shorter bridge span at Bonnie Creek would create/enhance a shorter (250 feet vs. 600 feet) segment of wetlands filled by the highway, and wetland hydrology up and downslope, but would not create or enhance wetlands near the west fork. This package represents a improvement over existing conditions for wetlands.	Temporary disturbance of wetlands at the site during construction. Loss of 0.1 acre of wetlands due to highway construction.
C	Minimal improvement in hydrologic connectivity for wetlands at either fork of Bonnie Creek.	Temporary disturbance of wetlands at the site during construction. Loss of 0.5 acre of wetlands due to highway construction.
Swamp Creek		
A	Installation of the bridge at Swamp Creek, another east of the Stampede Pass Interchange, and several large culverts will improve hydrologic connectivity, and improve surface and groundwater movement. This, along with removal of fill as part of bridge installation, will help to restore hydrologic connectivity between wetlands on either side of the highway. The bridge span at Swamp Creek will also help to create a 250-foot segment of wetlands in an area currently filled by the highway.	Temporary disturbance of wetlands at the site during construction. Loss of 0.9 acre of wetlands due to highway construction.
B	Wetlands would be created in a shorter segment (120 feet vs. 250 feet) of the ROW. Otherwise, the improvement to hydrologic connectivity and reduction in wetland disconnection would be similar to that under Package A.	Temporary disturbance of wetlands at the site during construction. Loss of 0.5 acre of wetlands due to highway construction.
C	This package would achieve only part of the hydrologic connections of disconnected wetlands that would occur under the other packages.	Temporary disturbance of wetlands at the site during construction. Loss of 0.3 acre of wetlands due to highway construction.

Table 3.4-1. Wetlands Impacts of the Improvement Packages (Page 3 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Toll Creek		
A	Installation of bridge and culvert would restore hydrologic connectivity between wetlands upslope and downslope of the highway. Removal of fill would provide an opportunity to create wetlands in a 120-foot segment of the highway. Benefits to wetlands are likely to be less than at other locations, such as Swamp Creek and Price/Noble Creeks.	Temporary disturbance of wetlands at the site during construction. Loss of 0.3 acre of wetlands due to highway construction.
B	Same impacts as Package A.	Same as Package A.
C	Installing a culvert rather than a bridge would provide restoration of hydrologic function of wetlands upslope and downslope, but to a lesser degree than the other packages.	Same as Package A.
Cedar Creek		
A, B, and C	Replacing the existing culvert with a larger culvert would improve hydraulic capacity and contribute to improvements in high quality wetlands downstream of the highway.	Short-term construction-related impacts.
Telephone Creek		
A, B, and C	Replacing the existing culvert with a larger culvert would improve hydraulic capacity and contribute to improvements in wetlands downstream of the highway.	Short-term construction-related impacts.
Hudson Creek		
A	The proposed installation of two bridges would restore some of the surface and groundwater connections in this area, improving hydrologic conditions for downstream wetlands, which should result in long-term improvement to wetlands habitat. The bridge span will provide an opportunity to restore filled wetlands in a 120-foot segment of the highway.	Temporary disturbance of wetlands at the site during construction. Loss of 2.6 acres of wetlands due to highway construction.
B	Fewer surface water and groundwater connections would be established compared to Package A, and benefits to wetlands would be somewhat less. Conditions would still be improved over existing conditions, however.	Temporary disturbance of wetlands at the site during construction. Loss of 2.5 acres of wetlands due to highway construction.
C	The restoration of surface and groundwater connections would be minimal, as would the resulting benefit to downstream wetlands.	Temporary disturbance of wetlands at the site during construction. Loss of 2.7 acres of wetlands due to highway construction.
Easton Hill		
A	The wildlife structure provides hydrologic connectivity up and downslope of the highway, and so may benefit wetlands downslope.	Temporary disturbance of wetlands at the site during construction. Loss of 0.5 acre of wetlands due to highway construction.
B	"Hydrologic connectivity zone" would improve connectivity, and benefit wetlands between the eastbound and westbound lanes, and downstream of the highway.	Temporary disturbance of wetlands at the site during construction. Loss of 0.3 acre of wetlands due to highway construction.
C	Same impacts as Package B.	Same as Package A.
Kachess River/Lake Easton		
A	No impact.	Temporary disturbance of wetlands at the site during construction. Loss of 0.3 acre of wetlands due to highway construction.
B	No impact.	Same as Package A.
C	No impact.	Same as Package A.

3.5 Fish, Aquatic Habitat, and Threatened and Endangered Fish Species

Yakima River near Crystal Springs Campground

This section was prepared based on the *Aquatic Species Discipline Report* (Washington State Department of Transportation [WSDOT] 2002c) (Appendix G) and its supplement (Appendix H), the *Draft Aquatic Species Biological Assessment* (WSDOT 2002d), and the *MDT Draft Recommendation Package* (Appendix A), which are incorporated into this document by reference. The purpose of these reports was to evaluate the existing conditions of aquatic species and habitats, the impact mechanisms, range of adverse and beneficial impacts from the construction of multiple bridges and culverts (3-sided box culverts and bottomless culverts) throughout the project corridor, and potential mitigation. The investigations and analysis utilized published information, consultation with local experts and surveys, sampling and analysis of streams, lakes, and wetlands for fish habitat, fish species distribution, amphibian habitat, and aquatic macroinvertebrate conditions. In addition, the primary purpose of the Draft Biological Assessment was to evaluate the presence and potential impact to two fish species listed as threatened under the federal Endangered Species Act (ESA): the bull trout, and middle Columbia steelhead trout. Habitat was also evaluated for other species, such as the Westslope cutthroat trout, within the Biological Assessment.

The study area comprises streams, lakes, ponds, and wetlands along the Interstate 90 (I-90) 15-mile corridor, encompassing amphibians, fish, and aquatic macroinvertebrate habitat. Between Milepost (MP) 55.1 and MP 57.0, aquatic habitats are located in Keechelus Lake, Coal Creek, Gold Creek, Rocky Run Creek, and three major wetland complexes. Between MP 57.0 and MP 60.6, habitat consists of Wolfe Creek, Resort Creek and wetlands, and Townsend Creek. Between MP 60.6 and MP 64.8, habitat occurs in Yakima River Side Channel, Price Creek, Noble Creek, Bonnie Creek, Swamp Creek, Toll Creek, and Cedar Creek and associated wetlands. Between MP 64.8 and MP 67.0, habitat is found in ponds, and in Telephone Creek and Hudson Creek. Between MP 67.0 and MP 70.3, habitat occurs in Easton Hill's wetlands, and Lake Easton/Kachess River below Kachess Dam.

3.5.1 Affected Environment

3.5.1.1 AQUATIC HABITAT/AQUATIC INVERTEBRATES

Aquatic Invertebrate Evaluation

Aquatic macroinvertebrates are an integral component of stream ecosystems. Invertebrates are an important link in the food web, feeding on algae and detritus, and, in turn, being eaten by predators, including other invertebrates, fish, and

amphibians. Because of their low mobility, aquatic invertebrates typically cannot escape the effects of reduced water quality, substrate alteration, and hydrologic fluctuations. The life span of some aquatic macroinvertebrate species can be over a year in length, and different macroinvertebrate species have different environmental tolerances. The composition of the aquatic invertebrate community can, therefore, yield an indication of environmental stress that is integrated over time. In a system with episodic water quality problems, the composition and abundance of the invertebrate community can indicate alterations in water quality that could easily be missed during water quality sampling.

Five of nine streams consistently scored high with regard to B-IBI. Two of nine streams (Gold and Price Creeks) received one moderate rating among otherwise high ratings.

Aquatic macroinvertebrates were collected from sites upstream and downstream of I-90 on nine project area streams (the Yakima River, and Coal, Gold, Price, Noble, Swamp, Telephone, Cedar, and Hudson creeks). The Yakima River does not cross the project but receives flow from several tributaries that cross the project.

Invertebrate taxonomic data were analyzed using the benthic index of biotic integrity (B-IBI) method of Karr and Chu (1997). A high B-IBI score indicates a healthy stream condition, and a lower score indicates stream degradation. B-IBI scoring summaries reflect the condition of four sampled locations on each stream, including riffles and pools, and whether the feature was upstream or downstream of I-90 (Table 3.5-1). Five of nine streams consistently scored high with regard to B-IBI. Two of nine streams (Gold and Price Creeks) received one moderate rating among otherwise high ratings. Two of nine streams (Coal and Swamp Creeks) received predominately moderate scores. Only Coal Creek showed a decline in B-IBI total score downstream of I-90. A comparison of B-IBI scores is shown in Table 3.5-1. The data indicate that aquatic macroinvertebrate communities in creeks in the project area are generally in good condition, and that communities below I-90 are, in some cases, in better condition than communities above I-90.

3.5.1.2 AMPHIBIANS

This section describes aquatic amphibian habitat and distribution in the I-90 corridor. Wetlands and streams within approximately 0.5 mile of the I-90 route were assessed for amphibian habitat. Amphibian habitat and species occurrence along the corridor were identified from Priority Habitat Species data, interviews with local biologists (Garvey-Darda et al. 2002), existing literature, and observations made during fish distribution and habitat surveys conducted in 2001.

Table 3.5-1. Benthic Index of Biotic Integrity Total Ratings[1] in Project Area Streams by Riffle and Pool Habitats, and Location Relative to I-90

	STREAMS[2]								
	Coal	*Gold*	*Price*	*Noble*	*Swamp*	*Cedar*	*Telephone*	*Hudson*	*Yakima*
Riffles									
Upstream of I-90	40 H	40 H	48 H	50 H	36 M	48 H	50 H	42 H	44 H
Downstream of I-90	36 M	40 H	50 H	48 H	42 H	50 H	50 H	48 H	48 H
Pools									
Upstream of I-90	30 M	34 M	34 M	48 H	32 M	48 H	50 H	n/d[3]	n/d[3]
Downstream of I-90	26 M	40 H	40 H	48 H	34 M	46 H	48 H	50 H	40 H

Notes: 1. Stream health ratings under this classification are; L = Low (<25 B-IBI), M = Moderate (25-39 B-IBI), H = High.(>39 B-IBI)
2. In order of occurrence from west to east.
3. n/d = no data

Source: WSDOT 2002c

Available Habitat and Species Distribution

The I-90 corridor (MP 55.1 to MP 70.3) traverses forestlands of the eastern Cascades between the headwaters of Keechelus Lake and the Lake Easton Interchange. Historically, wetlands and ponds from the headwaters of Gold Creek and Coal Creek downstream through the Yakima River valley and Swamp Creek provided breeding and upland dispersal habitat for aquatic amphibians. Currently, suitable amphibian habitat is present in wetlands and ponds in the project area, but amphibian communities are likely influenced by the interstate highway system, operation of the Keechelus Dam, and logging operations.

Pacific tree frog

The project area is within the range of eight species of aquatic amphibians (Corkran and Thoms 1996). Six of these are pond-breeding amphibians that inhabit marshes, ponds, and stream margins. These include the Western toad (*Bufo boreas*), Cascade frog (*Rana cascadae*), Pacific tree frog (*Hyla regila*), long-toed salamander (*Ambystoma macrodactylum*), Northwestern salamander (*Ambystoma gracile*), and rough-skinned newt (*Taricha granulosa*). Habitat occurs in the project area for these species. These species may occur in marshes and wetlands in the summer, but typically disperse to forested upland habitats for the remainder of the year. Because of this behavior, available habitat for amphibians consists of breeding habitat, dispersal habitat, and overwintering habitat. In the project area, the highway embankment and Keechelus Lake interrupt dispersal of amphibians.

Forested streams in the project area support another group of amphibians. These include the Pacific giant salamander (*Dicamptodon tenebrosus*) and the tailed frog (*Ascaphus truei*), which inhabit cool, permanent forested streams. Both of these species can disperse from streams as adults but generally are found in close association with fast moving streams (Blaustein et al. 1995). A neotenic form of the Pacific giant salamanders may live its entire life in the stream.

Threatened, endangered, and species of concern that are known or expected to occur in the project area are described in Table 3.6-1. Four species are considered species of concern by the United States Fish and Wildlife Service (USFWS), but no amphibian species in the project area are listed as threatened or endangered under the ESA.

The following sections describe available habitat and species distribution by project area segment.

Coal Creek to Wolfe Creek

Between MP 55.1 and MP 57.0, the I-90 corridor passes along the northern boundary of Keechelus Lake. Historically, over 1.5 miles of wetland and river complexes occurred from the Coal and Gold creek valleys downstream to the Keechelus Lake shoreline prior to United States Bureau of Reclamation (USBR) inundation, or post USBR, but prior to roadway fill. The complex array of wetlands, open water, and forested uplands would have supported large populations of native amphibians.

Currently, aquatic habitat for amphibians occurs on both sides of I-90. Marshes occur upstream of I-90 in the Coal and Gold creek drainages. Upland forested habitat connects these two marshes. Ponds occurring downstream of I-90 may attract amphibians, but these lack connectivity to high quality marshes north of I-90 or to upland dispersal sites. Currently, amphibian habitats along the shoreline and floodplain of Keechelus Lake downstream of I-90 are of limited quality. However, Western toads may opportunistically use seasonal wetlands and pools formed in the large delta exposed during the summer low pool. Within this section of the highway, aquatic habitats consist of Keechelus Lake, Coal Creek, Gold Creek, Rocky Run Creek, and three major wetland complexes.

Wolfe Creek to Keechelus Dam

Between MP 57.0 and MP 60.6, the I-90 corridor crosses several moderate gradient streams as it parallels the north side of Keechelus Lake. Wolfe Creek, Resort Creek, and Townsend Creek are moderate to high gradient streams that flow through a forested riparian zone. Most amphibian habitat in these streams occurs upstream (north) of I-90. Downstream of I-90, the streams lack overhead vegetation and pool habitat needed by Pacific giant salamanders. A wetland near the mouth of Resort Creek provides habitat for Western toads, Cascade frogs, and other pond-breeding amphibians. The water level in this wetland is influenced

by both inflows from Resort Creek and inundation during Keechelus Lake high pool. Upland habitat (forests and meadows) for species breeding in these ponds occurs upstream or north of I-90. Neither tailed frogs nor Pacific giant salamander habitat occurs in Keechelus Lake.

Keechelus Dam to Cedar Creek

From Keechelus Dam (MP 60.6) through Cedar Creek (MP 64.8), the I-90 corridor passes through a strip of older forest bisected by several stream and wetland complexes. The high quality emergent wetlands and streams occurring in this area support populations of Western toads, Cascade frogs, Pacific giant salamanders, tailed frogs, and other amphibians.

Historically, riverine wetlands and forests associated with the Yakima River were connected to Kachess Lake through the Swamp Creek wetland complexes. Upland habitat corridors for amphibian migrations occurred between the Yakima River valley wetlands and wetlands situated along Kachess Lake to the north. Currently, wetland complexes along the Yakima River floodplain are isolated from the Swamp Creek drainage by the I-90 embankment and a dam on Swamp Creek upstream of I-90. Populations of pond breeding amphibians still occur in the upper Swamp Creek and the Yakima River valley wetlands. However, the I-90 embankment impedes successful dispersal and migration to overwintering habitat for Western toads and other amphibians between these two areas.

Yakima River valley wetlands occur along the lower reaches of Price Creek, Noble Creek, and lower Swamp Creek. Western toads, Cascade frogs, tailed frogs, and Pacific giant salamanders were observed in these reaches. The upstream portions of Price Creek, Noble Creek, and Bonnie Creek are higher gradient streams with cobble substrate that support Pacific giant salamanders and tailed frogs.

The Swamp Creek wetland complexes occur primarily north of I-90. Water collects in the wetland at Swamp Lake and flows out through the creek. This large scrub-shrub and emergent wetland is shallow, and provides abundant spawning and rearing habitat for pond amphibians. Beaver dams impound the lower portion of West Fork Swamp Creek. A 50/50 mix of emergent and scrub-shrub areas in this wetland complex provide spawning and rearing habitat for pond breeding amphibians. Amphibians detected in Swamp Lake include Western toad and Northwestern salamanders.

Cedar Creek to Easton Hill

Between Cedar Creek (MP 64.8) and the top of Easton Hill near MP 67.0, the I-90 corridor passes through a forested landscape that is traversed by several small streams. Most habitat types in this area are most suitable for the stream-breeding amphibians, the tailed frog and Pacific giant salamander. Telephone Creek and Hudson Creek are low to moderate gradient streams that flow through

a forested riparian zone. Pacific giant salamanders and tailed frogs were detected both upstream and downstream of I-90 in both streams. Ponds near the mouth of Telephone Creek may support pond-breeding amphibians. A variety of small forested and scrub-shrub wetland pockets associated with these streams may support a few long-toed salamanders, Pacific tree frogs, and Western toads.

Easton Hill to Easton Interchange

From the Top of Easton Hill (MP 67.4) to the West Easton Interchange (MP 70.3), I-90 passes through an upland forested area with few streams or emergent wetlands. Near Lake Easton, two large scrub-shrub wetlands occur on the north side of I-90. Forested upland occurs on the north side of these wetlands. Pond breeding amphibians could find suitable spawning and rearing habitat in these wetlands. The existing I-90 alignment crosses the northern arm of Lake Easton. The lake itself is a reservoir with steeply sloping shorelines with little emergent vegetation, and is inhabited by trout and other fishes. Because of the lack of emergent vegetation and abundant trout, amphibian habitat is limited in Lake Easton.

3.5.1.3 FISH

Fish Species Distribution

Anadromous salmon, steelhead, and over 30 resident fish species inhabit the Yakima River system. Historically, this river supported runs of hundreds of thousands of salmon (Haring 2001). Salmon and steelhead populations in the Upper Yakima system are greatly diminished from their original numbers. Declines in these runs are attributed largely to the dams that block or reduce passage, and alter flow regimes in the river. Other factors contributing to declines in anadromous fish stock include logging, increases in water temperature, fishing, irrigation (e.g., entrainment in unscreened diversions and in-stream flow depletions), channel straightening, declines of invertebrate populations, reductions in beaver and large woody debris, and related pond formation.

Resident fish found throughout the Upper Yakima River system include rainbow (*Oncorhynchus mykiss*), cutthroat (*Onorhynchus clarkia*), and bull trout (*Salvelinus confluentus*), whitefish (*Prosopium* spp.), and several species of dace, sculpins, and suckers. The most prominent introduced species is the Eastern brook trout (*Salvelinus fontinalis*). Less common introduced species are predominantly warm water species: largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieu*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and yellow perch (*Perca flavescens*). Resident fish present in Keechelus Lake and the other large oligotrophic reservoirs in the basin include rainbow, cutthroat, and bull trout, kokanee

(*Oncorhynchus nerka*), whitefish, burbot (*Lota lota*), and several species of dace and suckers (Economics and Engineering Services, Inc. 2001).

Detailed life history information on some of the important fish species in the project area is presented in *Aquatic Species Discipline Report* (WSDOT 2002c).

Bull Trout (Federal Threatened Species)

Bull trout

Nine bull trout stocks occur in the Yakima River basin (Washington Department of Fish and Wildlife [WDFW] 1998). The project vicinity contains the Yakima River and Keechelus Lake (isolated above the dam) sub-populations. This inventory recognizes three bull trout life history forms: adfluvial, fluvial, and resident. Isolated adfluvial stocks occur in Kachess Lake and Keechelus Lake, and a fluvial stock occurs in Lake Easton and the mainstem of the Yakima River.

Keechelus Lake Stock

Construction of the Keechelus Dam between 1913 and 1917 isolated the Keechelus Lake stock. Currently, the only known population in Keechelus Lake spawns in Gold Creek. A single juvenile bull trout was reported in Rocky Run Creek in 1983 (Brown 1992). However, natural and manmade barriers to passage exist on the lower reaches of Rocky Run Creek that would prevent upstream migration from Keechelus Lake. Jones & Stokes conducted night snorkel surveys of streams crossing the project (Coal, Gold, Rocky Run, Resort, and Townsend creeks) in 2001 and detected bull trout only in Gold Creek (WSDOT 2002c). No bull trout were found in any other streams in the project area. Generally, visibility was high, and gradient was low in all streams. The probability of detecting bull trout in these surveys, assuming they were present and their density was not less than one in 164 feet of stream, was between 96 and 99 percent (WSDOT 2002c).

Upstream migration of adult bull trout in Gold Creek occurs from July to mid-August (WDFW 1998). Spawning occurs from late September through early October. In 1996, most redds were found in a spring-fed channel near river mile 4.1 and near the mouth of Silver Creek (Wissmar and Craig 1997). Spawning has also been observed in the outlet channel from Gold Creek Pond and in the main channel between the pond and the FSR 4832 bridge (WSDOT 2002c). Craig (1997) estimated an incubation time of 200 days in Gold Creek with emergence occurring in May. Juveniles likely remain in Gold Creek for 1 to 3 years. Outmigration may occur throughout the year.

Adult bull trout in Keechelus Lake are probably primarily piscivorous. Likely prey species available to adult bull trout in Keechelus Lake include kokanee, whitefish, redside shiner, rainbow trout, and brook trout. Redds in Gold Creek have varied from two in 1984 and 1985, to 51 in 1996, and 20 in 2004 (Haring 2001, personal communication, Anderson 2005). The Gold Creek stock is

considered critical, primarily because of its chronically low redd counts and its isolation from other stocks (WDFW 1998).

Yakima River Stock

Yakima River stock is recognized as a distinct stock by WDFW (1998). These bull trout are assumed to be fluvial fish that inhabit the mainstem and spawn in tributaries (WDFW 1998). Although bull trout are present in the Yakima River, they are likely to occur in very low densities. Eight years of sampling the Yakima River below Easton Diversion Dam resulted in the detection of only four bull trout (USBR 2001a). During September 2001, two bull trout were detected near redds in the braided area near Crystal Springs (Anderson 2001, as cited in WSDOT 2002d). In October 2001, two bull trout were observed tending a redd near the end of Cabin Creek Road (Forest Service Road [FSR] 4823) (WSDOT 2002d). Regulation of the Yakima River flow for irrigation has resulted in reduced rearing habitat during high summer flows, and reduced spawning and rearing habitat during the low flows of fall and winter (USBR 2001a).

The primary limiting factors in the upper Yakima fluvial stocks of bull trout appear to be: a) brook trout hybridization/competition; b) loss of prey base for juvenile salmon; c) an extremely altered river flow regime to deliver irrigation water; d) barriers, and e) water quality.

Summer Steelhead (Federal Threatened Species)

Historically, steelhead had access to most reaches within the Upper Yakima Watershed, including the pre-dam Keechelus Lake watershed. Passage to Keechelus Lake was blocked in 1901 by construction of the first Keechelus Dam (Wissmar and Craig 1997). Downstream, the Easton Diversion Dam has a fish ladder that generally allows passage in the winter and spring when steelhead would be migrating into the Easton to Keechelus Reach (Haring 2001). Between 1941 and 1990, steelhead passage was impaired at the Roza Dam, although returning fish are trapped at the dam and returned to the river upstream (Economics and Engineering Services, Inc. 2000). Good quality spawning and rearing habitat is located downstream of the Keechelus Dam, but returning numbers to the Upper Yakima River are small. Estimated returns of the Yakima River stock of summer steelhead between 1985 and 2000 ranged from 212 in 1988 to 15 in 1993 to (Haring 2001); 234 returned in 2004 (Yakima Subbasin Fish and Wildlife Planning Board 2004a). In time, steelhead may re-colonize more of the upper Yakima Watershed. If this occurs, tributary streams (including those crossing the project) may provide spawning and rearing habitat for steelhead. At this time, it does not appear that significant numbers of steelhead use any of these tributaries.

The Phase I report of the Storage Dam Fish Passage Feasibility Study concluded that passage at Keechelus Dam would be technically feasible and that habitat, potentially useable by steelhead, would be made available. The study has now

moved into its second phase, which is a feasibility study of the potential for providing upstream and downstream fish passage at Cle Elum and Bumping Lake dams. Interim fish passage facilities are also being constructed at Cle Elum Dam at this time and will be operational in the spring 2005. There is potential that during the life of the proposed project, fish passage may be restored to Keechelus Lake, potentially allowing steelhead to recolonize the upper Yakima Watershed and Keechelus Lake tributaries (including Coal, Gold, Resort, and Townsend creeks, and possibly Rocky Run Creek).

Westslope Cutthroat Trout

Cutthroat trout are distributed throughout the project area (WSDOT 2002c). High numbers of cutthroat trout were found in Coal, Gold, Rocky Run, Resort, Bonnie, and Hudson creeks (WSDOT 2002c). A comparison of cutthroat fish densities can be found in the *Aquatics Discipline Report* (WSDOT 2002c). Several of these cutthroat trout populations cannot move out of lakes and rivers into streams, because culvert barriers along the current I-90 facility block access to Keechelus Lake or the Yakima River. In addition, on some of the tributaries, there are barriers above or below I-90 that also impede fish passage. Although abundance was relatively high in some streams, isolation of populations by barriers and the presence of brook trout pose threats to the persistence of the cutthroat trout metapopulation above Keechelus Dam.

3.5.1.4 WATERSHED CONDITION

Several planning documents (Economics and Engineering Services, Inc. 2001, Cupp 1997, USFS 1997, Haring 2001, Yakima Subbasin Fish and Wildlife Planning Board 2004b) have been prepared that describe watershed-scale conditions in the Upper Yakima River watershed, including the project area. Specific concerns that have been identified for the watershed include the following:

- Highly regulated instream flows in mainstem of Yakima and tributaries.
- Upstream and downstream passage.
- Degraded riparian and instream habitat.
- Disruption of natural hydrologic conditions.
- Altered sediment regime.
- Altered channel conditions and substrate.
- Modification of the original land cover due to agriculture, grazing, urban development, and timber harvest.
- Modification of the floodplain due to construction of permanent roadways, railroads, gravel pits, and other features.

3.5.2 Environmental Consequences

The following sections describe the general environmental consequences for fish and aquatic habitats due to construction procedures and project elements common to all of the alternatives. Most of these impacts result from construction activities. The impacts specific to each of the alternatives are discussed in Sections 3.5.2.1 through 3.5.2.3. In the construction and operation of the project, WSDOT would implement Best Management Practices (BMPs) to avoid or minimize adverse environmental effects.

GROUND DISTURBANCE

Excessive turbidity can cause direct injury, avoidance behavior, reduced feeding success, and reduced prey base in aquatic species. Excessive fine sediment in spawning areas can cause filling of intergravel interstices and reduce intergravel dissolved oxygen, affecting the survival of incubating eggs and newly hatched alevins.

The degree to which excavation and grading cause adverse sediment effects depends upon the successful implementation of erosion and sediment control BMPs (http://www.wsdot.wa.gov/FASC/EngineeringPublications/library.htm). The *WSDOT Highway Runoff Manual* (HRM) (2004h) and the WSDOT/Washington Department of Ecology (WDOE) Implementing Agreement require, at a minimum, that adjacent properties and all water bodies be protected from sediment migration and deposition, increased peak flow, and duration of flow. Ground disturbance may cause direct mortality of amphibians inhabiting burrows in the soil and may alter vegetation communities near wetlands.

CONSTRUCTION OF NEW IMPERVIOUS SURFACES

New impervious surfaces have the potential to alter the timing and duration of flows in the streams draining the project area and can influence the timing and fluctuations of adjoining wetlands. The quantity of new impervious surface area varies by alternative.

Although a portion of the roadway would drain directly to Keechelus Lake with limited stormwater control, the flow regime of the Upper Yakima River is controlled by operation of the Keechelus, Kachess, and Cle Elum dams.

In compliance with Minimum Requirement 2 of the HRM (WSDOT 2004h), the project would be designed to use the best available design practices to maintain hydrologic function and drainage patterns based on site geology, hydrology, topography, and practicability. Although a portion of the roadway (under Alternatives 3 and 4 in the Slide Curve area) would drain directly to Keechelus Lake with limited flow control, the flow regime of the Upper Yakima River is controlled by operation of the Keechelus, Kachess, and Cle Elum dams, and, therefore, would be unaffected by the project. Water quality BMPs would be implemented for all impervious surfaces, prior to discharge, resulting in net improvements to water quality.

Stormwater collection and infiltration features would be used throughout the remainder of the project to maintain local hydrology as much as possible. Thus, wetlands adjoining the highway would not experience increases in water level fluctuations as a result of this project. Stormwater strategies for the corridor are outlined in Table 3.5-2.

Table 3.5-2. Stormwater Management Strategies

Location (MP)	*Strategy*	*Downstream Receiving WaterBody*
55.6 to 57.3	Biofiltration in median	Keechelus Lake
57.3 to 58.6 (Alternatives 2, 3, and 4)	Limited biofiltration in median	Keechelus Lake
57.3 to 59.6 (Alternative 1)	Oil/water separator	Keechelus Lake
58.6 to 59.6 (Alternative 2)	Oil/water separator	Keechelus Lake
58.6 to 59.6 (Alternatives 3 and 4)	Limited biofiltration	Keechelus Lake
59.6 to 60.8	Biofiltration in median	Keechelus Lake
60.8 to 67.4	Natural dispersion where possible, biofiltration swales outside of roadway and in median, check dams where needed, possibly dry ponds	Yakima River
67.4 to 70.3	Natural dispersion where possible, biofiltration swales, infiltration ditches/ponds, and dry ponds	Kachess River/ Lake Easton

BLASTING

When blasting occurs in close proximity to fish, they may be disturbed by the sound or physical shock of the blast. The potential for effects is reduced with distance from streams and with reduced size of the blasting charge (Wright and Hopky 1998). An acoustic shock of 100 kilo Pascals can cause injury to fish or fish eggs (Wright and Hopky 1998).

Generally, blasting would take place far enough from fish-bearing waters that there would be no effect. Charge size would be based on rock density and distance to known fish-bearing streams. In no case would a charge exceeding 100 kilo Pascals be used near fish habitat. At this distance, assuming that the substrate is solid rock between the blasting and the lake, a 229-kilogram charge would be required to cause a 100 kilo Pascals acoustic shock based on the equations published by Wright and Hopky (1998). The most extensive blasting would be used in tunnel construction. However, with the exception of the west entrance, the tunnel is generally much further from fish habitat than the lakeside roadway segments.

Blasting would not be used in the construction of roadway foundations across the bed of Keechelus Lake. No blasting is proposed in the vicinity of the Yakima

River or its tributaries. BMPs would be used to minimize blasting effects on aquatic species. No injury to bull trout or other aquatic species is expected as a result of acoustic shock caused by blasting.

REMOVAL OF RIPARIAN VEGETATION

Riparian vegetation provides several important functions including shade, maintaining bank stability, and recruitment of woody debris and other organic material to the streams. Loss of shade can cause increased water temperatures downstream. Loss of riparian vegetation can also affect bank stability if banks are not protected where vegetation is removed.

Woody debris from riparian trees is crucial to maintaining habitat complexity, forming pools, and protecting banks. Amphibians use woody debris in riparian zones as overwintering sites. However, habitat adjoining the highway has limited amphibian habitat potential. Fine organic material from riparian vegetation (leaves, needles, bark, small wood) provides nutrients for the aquatic food web. Removal of riparian vegetation would be necessary at locations where new roadways would cross riparian corridors, including the streams crossing the project and seasonally inundated portions of Keechelus Lake.

Where the roadway crosses streams, bridges and culverts would be installed. In these locations, the loss of shade due to removal of vegetation would be minimized by the fact that these structures provide shade. The area of impact would include the removal of the existing bridge structure, which would have little to no riparian vegetation. The area of impact would be the additional two lanes, shoulders, and right-of-way (ROW), or approximately 30 feet of clearing on each side of the existing roadway. As per Table 2-5, there is a permanent loss of riparian habitat in each of the alternatives and Improvement Packages. Clearing limits can be clearly defined with construction fencing and need not extend beyond the bridge "footprint." With appropriate BMPs, vegetation clearing can be limited, and some material can be incorporated into habitat elements under the bridge structures. WSDOT has not actively managed for vegetation under bridges; however, those bridges that are at the right aspect and high enough to provide for sunlight do have substantial vegetation growth. Overall, the loss of shade would not be a significant impact on aquatic species. In reviewing bridge replacement projects that have included fish removal, pools directly under bridges provide relatively good habitat for aquatic species. The direct loss would come from recruitment potential of large woody debris and temporary loss of organic input. Bridge and culvert inlets and outlets require protection from erosion potential according to the Washington State Hydraulic Code (Washington Administrative Code 220-110-070), so there would be no loss of bank stability.

Placement of Fill in Aquatic Habitat

Building new roadways would require filling some areas to maintain the appropriate highway grade. Some of these fill areas would be in the seasonally inundated portion of Keechelus Lake. Filled areas are unavailable as habitat. All of the areas proposed for fill are within portions of Keechelus Lake that are only seasonally inundated. Although these areas are of reduced quality due to the seasonal lake level fluctuations, they have the potential to be used by bull trout during the spring when the reservoir is filled.

Roadway Removal

Removal of existing roadway surfaces has the potential to affect water quality through the generation of fine concrete dust and slurry. Sediment control BMPs would prevent this dust and slurry from entering waters and causing increased turbidity that could be injurious to fish and amphibians.

Concrete Curing

Uncured concrete has the potential to cause elevated pH in water with which it comes in contact. The roadway and roadway supports would require casting concrete on site. To prevent alteration of pH or other water quality effects, coffer dams or other types of full containment structures and treatments would be used where necessary to prevent contact between curing concrete roadway supports and the water of Keechelus Lake or other bodies of water.

Cofferdams

Placement of coffer dams would result in temporary removal of aquatic habitat in the area occupied by each dam. The habitat would be expected to recover after dam removal and reestablishment of natural stream channel conditions. Placement and removal would cause disruption of the stream channel and embankments, resulting in temporary increases in suspended solids in the adjacent stream. BMPs would be implemented to minimize the duration of this effect. In-steam construction, including the use of cofferdams, would be subject to seasonal restrictions to avoid adverse impacts to fish spawning and larval development (Section 4.2.2).

Removal and Replacement of Existing Culverts

Culvert design defines the conditions for fish passage at each stream crossing, as well as influencing stream morphology, scour, sediment transport, and wood routing in the stream. Culvert removal, replacement, and installation would be completed according to the Washington State Hydraulic Code (Washington Administrative Code 220-110) and WDFW guidelines for stream crossing structures. Culverts and bridges over fish-bearing streams would be constructed

to allow fish passage and conveyance in excess of the 100-year storm event. Culverts installed for this project would be bottomless or three-sided.

Any in-water work has the potential to cause a temporary increase in turbidity and the suspension of fine sediment. Fish in the vicinity of the culvert can also be displaced during installation, and, if flow diversion is required, there is the potential for fish entrainment in the diverted flow. Prior to construction, aquatic species would be excluded from the culvert area, and culvert bypass structures would be installed for temporary use. During culvert projects, aquatic species may have to be captured and removed from the culvert vicinity.

EQUIPMENT MAINTENANCE AND FUELING

Heavy equipment and vehicles used during construction would require periodic fueling and maintenance. These activities have the potential to release deleterious substances such as diesel fuel, hydraulic fluids, coolant, and lubricants onto the ground where stormwater can transport them to surface waters. Spills are preventable with implementation of appropriate BMPs.

TIMING AND DURATION OF CONSTRUCTION

The potential for water quality effects from the project is weather dependent. In the project area, the majority of precipitation comes as snow during winter months. In general, construction would occur between May and October when precipitation is limited and runoff from the site is reduced. Tunnel building may go on all year; however, this activity would have relatively little effect since the earthmoving occurs under the cover of the tunnel itself.

OPERATIONAL WATER QUALITY EFFECTS

Traffic along the I-90 corridor is projected to increase by 3.5 percent annually. The additional traffic could add to the stormwater pollutant loading from the roadways. Pollutants include suspended solids (causing elevated turbidity), nutrients (nitrogen and phosphorus), and petroleum products. This increase would occur regardless of whether or not the project is constructed. Adding lanes would increase the impervious surface area where pollutants are collected and would require using additional deicer and traction sand during winter months. The measures discussed in Table 3.5-2 above would minimize such effects.

Traction sand is not expected to contain significant amounts of contaminants or to be toxic, but sand carried in runoff could adversely affect aquatic habitats through deposition that would change the physical nature of the substrate. This could make the substrate unsuitable for desirable plants, invertebrates, amphibians, and fish. It could also make stream substrate unsuitable for spawning by fish, notably salmonids such as steelhead, bull trout and other trout species.

Currently, WSDOT uses Cargill ClearLane deicers (a mixture of sodium chloride, magnesium chloride, and molasses). These substances are only detrimental in relatively high concentrations. Some of the trace substances in deicers may have biological effects. For example, ClearLane contains 0.5 percent to 0.7 percent orthophosphates. Orthophosphates can result in increased algal growth in the receiving waters since phosphorous is often the limiting nutrient in aquatic ecosystems. Given the present reduction in natural phosphorous input and the high flushing rate of Keechelus Lake, the phosphorous input from deicers would likely not be significant. The stormwater management measures discussed above under Construction of New Impervious Surfaces are expected to control water quality impacts to less than current levels.

3.5.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, none of the build alternatives for the Keechelus Lake area, nor any of the Improvement Packages for the other portions of the route, would be implemented. Therefore, none of the benefits of improved hydrological connections, and resulting restoration of habitat and passage for fish and other aquatic species, as described below for the four Keechelus Lake Alignment Alternatives and three Improvement Packages, would be achieved. However, long-term displacement of lakeshore and riparian vegetation and habitat resulting from highway realignment and/or construction of bridges within the route would also not occur. Short-term adverse impacts resulting from periodic maintenance of the route, as described in Section 3.5.2, would continue. The use of traction sand and deicers would be similar to Alternative 4, and, therefore, higher than Alternatives 1 through 3. The increased use of traction sand and deicers would be similar for all of the Improvement Packages. The potential water quality impacts of this, and measures to control these impacts, are discussed above under Construction of New Impervious Surfaces and Operational Water Quality Effects.

3.5.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

Construction for all of the build alternatives would be spread out over a period of several years. This would help to ameliorate the disturbance from earth-moving activities. Roadway construction would be limited to the snow-free period of the year, which would also help to minimize the potential for stormwater-related impacts. Additionally, storm drains would be outfitted with sediment filters during this procedure to capture wayward concrete dust, slurry, and asphalt grindings.

Rocky Run Creek, Wolfe Creek, and Resort Creek are CEAs that are addressed here because they are most closely associated with the Keechelus Lake Alignment Alternatives. Additionally, about 3 miles of Keechelus Lake shoreline would be impacted by the Keechelus Lake Alignment Alternatives and are addressed in this section. All of the build alternatives except Alternative 1 include a long bridge, approximately 1,500 feet in length, in the vicinity of the

existing snowshed. In addition to shoreline work, this bridge would require in-water work for the construction of bridge pier foundations. It is likely that the majority of this in-water work would be conducted from barges anchored in Keechelus Lake (some work may be done during low pool levels or using coffer dams). To minimize impacts to water quality, for in-water work, WSDOT would require utilization of BMPs such as silt curtains to contain turbidity, and measures to prevent discharges of petroleum products. Such measures are specified in the WSDOT/WDOE Implementing Agreement.

The Keechelus Lake Alignment Alternatives also include retaining walls along portions of the shoreline to minimize the amount of lake habitat lost to highway construction. These walls would likely be "geotextile walls", consisting of layers of geo-fabric folded into a structural embankment. Impacts from construction would be kept to a minimum using "construction limits" specified in the contract plans, and through the use of BMPs as discussed in the preceding paragraph. These walls are unlikely to replace the habitat functions and values for fish and other aquatic species of the habitat the walls displace. The area of such habitat that would be displaced under each alternative is discussed below.

Removal of the existing highway along the shoreline of Keechelus Lake may require blasting. Bull trout in Keechelus Lake are at potential risk for injury from acoustic shock associated with blasting near the lake edge. By restricting the size of the explosive charges used in proximity to the shoreline and the timing of their use, WSDOT would prevent acoustic shock that would be capable of injuring fish (i.e., 100 kilo Pascals or greater). Therefore, no injury to bull trout or other fish due to acoustic shock from blasting is expected.

Acoustic shock impacts to bull trout and other fish are also possible from pile driving. Impact hammer pile driving would get limited use to install temporary work platforms in shallow areas of Keechelus Lake; pile driving would not be used for construction of bridge foundations. Since bull trout occur in shallow parts of the lake, they could be affected by the pile driving, which produces sound/shock waves capable of causing injury or mortality of fish in close proximity. Measures would be used to exclude bull trout and other fish from the pile-driving site, and/or to minimize the strength of the sound/shock waves produced. Potential measures include steel sleeves or air bubble curtains around the piles being driven, or the use of vibratory or oscillatory methods that produce much lower sound levels than impact hammer pile driving.

Table 3.5-3 summarizes acres of shoreline habitat and riparian habitat that would be lost under each Keechelus Lake Alignment Alternative and Improvement Package.

Table 3.5-3. Shoreline and Riparian Impacts for the Keechelus Lake Alignment Alternatives and Improvement Packages

	Shoreline Impacts (acres)[1]	*Riparian Habitat Lost (acres)*
Keechelus Lake Alignment Alternatives		
Alternative 1	11.7	0.9
Alternative 2	16.2	1.0
Alternative 3	21.1	1.0
Alternative 4	17.5	0.6
Improvement Packages		
Improvement Package A	5.8	1.7
Improvement Package B	5.2	1.2
Improvement Package C	4.3	1.6

Note: 1. Primarily filling of aquatic and shoreline habitat in Keechelus Lake. Each Improvement Package also includes 0.6 acre of fill in Lake Easton.

Alternative 1: Long Tunnels

Installation of a 1.9-mile-long tunnel would have little impact on fish species, amphibians, and aquatic habitat at the three Connectivity Enhancement Areas (CEAs), and along the Keechelus Lake shoreline, assuming measures to minimize impacts to water quality are implemented as discussed in Sections 3.3.2 and 3.5.2. Construction of the long tunnel would occur away from the shoreline, further decreasing any construction-related impacts to Keechelus Lake.

Impacts may occur along 1.9 miles at the west end of Slide Curve, starting at MP 56.7, as a result of the removal of the existing highway (38 acres), and the east end of Slide Curve near MP 59.4. Impacts would be short-term in nature (during construction), and include general construction impacts, such as increased turbidity from ground disturbance and roadway removal, and temporary removal of riparian vegetation. Alteration of bull trout behavior may occur if the fish are using the shoreline in this area during construction. However, impacts of these types would be minimized by construction occurring in this area during low lake elevations when shoreline habitat would be dry. In the long-term, habitat would be restored though native plantings in the 38 acres where abandoned roadway would be removed.

The curved alignment near MP 57 would be realigned to straighten out the curves, and the new roadway would be placed further into the lakebed. Placement of fill would occur along approximately 0.7 mile of this shoreline prior to the tunnel, and fill would be placed 0.1 mile after the tunnel. A total of 12 acres of aquatic and shoreline habitat would be filled under this alternative. The following measures would be used to reduce the potential for impacts to lakebed and adjacent habitat:

- Structural foundations above 2,500 feet elevation would be constructed during low reservoir pool conditions if possible.

- Cofferdams or similar containment methods would be used to isolate lower elevation foundations and supports that could be constructed under the water surface.

- BMPs would be used to minimize impacts to water quality and aquatic habitat, as discussed in the original Discipline Report (WSDOT 2002c).

A small amount (0.9 acre) of riparian habitat would be lost under this alternative. Loss of riparian vegetation would be mitigated by replanting areas of disturbed vegetation as soon as possible, and by removing and replanting abandoned roadways (38 acres) after the new roadway is operational. Habitat restoration at the project area streams, lakes, and wetlands offer potential opportunities for mitigation. BMPs and regulatory required mitigation measures are discussed in Section 4.2.2.

A single span bridge would be constructed over Rocky Run Creek (vicinity of MP 56.8) in each direction to provide for fish and debris passage. These structures could improve fish passage as well as improve amphibian movement. However, FSR 4832 and an in-water piece of concrete slab just upstream would need improvements to realize actual benefits. Removal and replacement of stream crossing structures would require working in stream habitat.

Temporary sediment mobilization associated with in-water work has the potential to cause increased turbidity and deposition of fine sediment downstream. Use of the BMPs (WSDOT 2002c Appendix D) would reduce these impacts to a minimal risk. Due to the low density (or absence) of bull trout, fish removal efforts and any associated in-stream impacts are unlikely to have adverse impacts on bull trout.

In the long run, as the Rocky Run Creek watershed recovers from loss of habitat, conditions could become favorable for use by bull trout, and would immediately benefit passage for cutthroat and rainbow trout. The crossing structures would be the same under all of the build alternatives.

Opportunities for restoration at Wolfe Creek are restricted by the inherent limitations of such a high gradient stream. Natural barriers to passage prevent colonization by this aquatic species, and the small size of the stream limits habitat. However, large culverts would be constructed at Wolfe Creek in each direction to provide fish passage and increase amphibian movement across I-90.

Impacts from in-stream construction would be similar to Rocky Run Creek, and the lack of bull trout presence would result in no take of bull trout. Only cutthroat trout have been found upstream of I-90 and may realize the benefits of

improved hydrologic connectivity. The crossing structures would be the same under all of the build alternatives.

The existing culvert under I-90 at Resort Creek is a barrier to upstream fish passage except at high pool elevation, when the lake level backs up through the I-90 culvert. During periods of low lake level, the outlet drops about 20 feet to boulders below. Upstream of I-90, Resort Creek provides good habitat for trout. Under Alternative 1, single span bridges would be built to span the active channel migration zone. These structures could improve fish passage as well as improve amphibian movement. Installation, modification, removal, and replacement of stream crossing structures would require working in stream habitat. Short-term effects due to construction would be similar to Rocky Run Creek, and the lack of bull trout presence would result in no take of bull trout. In the long run, as the Resort Creek watershed recovers from loss of habitat, conditions could become favorable for use by bull trout and would immediately benefit passage for cutthroat trout.

Traction sand and deicers are routinely used along the project route, which may have detrimental effects to water quality and aquatic habitat. However, Alternative 1 would have the smallest release of traction sand and deicers, compared to Alternatives 2 through 4, since this alternative would feature the longest tunnel, decreasing the likelihood of these substances entering the aquatic environment.

Alternative 2: Short Tunnels

Similar to Alternative 1, installation of a shorter (0.6-mile-long) tunnel would have little impact on fish and aquatic species. Long-term improvement in lakeshore vegetation and habitat would be less than under Alternative 1 because less abandoned roadway would be removed (21 vs. 38 acres). Construction of new bridges over Keechelus Lake in the vicinity of the existing snowshed could result in disturbance or removal of existing lakeshore riparian habitat. Under Alternative 2, the encroachment into the Keechelus Lake shoreline would be slightly greater in the vicinity of Wolfe Creek than under Alternative 1, possibly reducing the recruitment of fine organic material from lakeshore vegetation, at least temporarily. Realignment of highway structures along the shoreline of Keechelus Lake may require blasting. Bull trout in Keechelus Lake are at potential risk for injury from acoustic shock associated with blasting near the lake edge. Under Alternative 2, the potential for acoustic shock to bull trout and other fish could increase compared to Alternative 1 because of increased road realignment and the development of a new bridge in the vicinity of the snowshed. However, no injury to bull trout or other fish from acoustic shock is expected because WSDOT would restrict the size of the explosive charges used in proximity to the shoreline.

There would be more placement of aquatic fill and construction of bridge footings under Alternative 2 than under Alternative 1 due to the construction of a

new bridge near the snowshed and roadway realignment west of Slide Curve. Placement of fill would occur between Rocky Run Creek and the west tunnel portal, and from the east tunnel portal to just east of Resort Creek. A total of 16 acres of aquatic and shoreline habitat would be filled under this alternative. Filled areas and bridge footings would no longer be natural habitat. A small amount (1 acre) of riparian habitat would be lost under this alternative. Short-term impacts to fish and aquatic species would be minimal assuming measures to minimize impacts to water quality are implemented as discussed in Section 4.2.2. The degree of long-term displacement of aquatic habitat is higher under Alternative 2 than under Alternative 1, and lower than Alternatives 3 and 4.

Under Alternative 2, the bridges constructed at Rocky Run Creek and Resort Creek would all be the same as in Alternative 1. In addition, culverts would be constructed at Wolfe Creek. Therefore, all short-term construction-related impacts and long-term fish passage improvements would be the same as Alternative 1.

Traction sand and deicers are routinely used along the project route, which may have detrimental effects to water quality and aquatic habitat. However, Alternative 2 would have a smaller release of traction sand and deicers in relation to Alternatives 3 and 4, since this alternative features a twin tunnel through Slide Curve and less open roadway.

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

Similar to Alternative 2, installation of a shorter (0.6-mile-long) westbound tunnel would have little impact on fish and aquatic species. Beneficial effects to fish and aquatic species would be less under this alternative than under Alternatives 1 and 2 because the eastbound lanes of I-90 would not be removed in the Slide Curve area (a total of 13 acres of abandoned roadway would be removed). Straightening of the highway alignment near MP 57 would result in filling of lakebed and shoreline. Construction of these bridges and realignment of the eastbound lanes could result in short-term construction-related disturbance, and/or long-term displacement of lakeshore vegetation and habitat. More placement of aquatic and shoreline fill and construction of bridge footings (total of 21 acres) would occur under Alternative 3 than under Alternative 1 (12 acres) and Alternative 2 (16 acres) due to the construction of new bridges near the snowshed and east of Slide Curve, and roadway realignment eastbound around Slide Curve. Therefore, Alternative 3 has more potential for long-term displacement of lakeshore aquatic habitat than Alternatives 1, 2, and 4. A small area (1 acre) of riparian habitat would be lost under this alternative. Short-term impacts to fish and aquatic species would be minimal assuming measures to minimize impacts to water quality are implemented as discussed in Section 4.2.2.

The release of traction sand and deicers would be greater under Alternative 3 than for Alternatives 1 and 2. This is because Alternative 3 features a westbound tunnel through Slide Curve and realignment of the eastbound lanes through this area, thus increasing the amount of open road that require these safety materials.

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

This alternative does not include the benefit of removing major sections of existing highway from the lakeshore, but realignment of the highway would result in the removal of 5 acres of abandoned roadway. Realignment of the highway in the Slide Curve area and construction of a new bridge at the west end of Slide Curve could result in short-term construction-related disturbance, and/or long-term displacement of lakeshore vegetation and habitat. Displacement of lakeshore vegetation and habitat could result in reducing the recruitment of fine organic material from lakeshore vegetation, which provides nutrients for the aquatic food web, at least temporarily.

Placement of fill would occur along approximately 0.7 mile of this shoreline near MP 56.7, and for approximately 0.1 mile after the tunnel at MP 59.4. There would be more placement of aquatic and shoreline fill under Alternative 4 (17.5 acres) than under Alternatives 1 and 2 because Alternative 4 does not feature a tunnel. Therefore, Alternative 4 has more potential for long-term displacement of lakeshore aquatic habitat than Alternatives 1 and 2. Alternative 4 would result in less fill than Alternative 3 (18.9 acres), which retains the eastbound highway around Slide Curve, and so would displace less lakeshore habitat than Alternative 3. A small area (0.6 acre) of riparian habitat would be lost under this alternative. Short-term impacts to fish and aquatic species would be minimal assuming measures to minimize impacts to water quality are implemented as discussed in Section 4.2.2.

The release of traction sand and deicers would be greater under Alternative 4 than for Alternatives 1, 2, and 3. This is because Alternative 4 features no tunnel through Slide Curve and realignment of the both lanes through this area, thus increasing the amount of open road that requires these safety materials.

3.5.2.3 IMPROVEMENT PACKAGES

The three Improvement Packages have been developed to provide three levels of improved (from existing conditions) hydrologic, habitat, and species movement connectivity along the I-90 corridor and to assess the effects of the roadway improvements. Overall, Improvement Package A would provide the greatest improvement in connectivity, while Improvement Package C would provide the least. All three Improvement Packages would improve hydrologic conditions in the vicinity of I-90, which would help restore fish passage, improve amphibian dispersal and overwintering habitat, reduce habitat disconnection, and help restore lakeshore vegetation and aquatic habitat. Impacts to fish and aquatic habitat are described for each Improvement Package corridor-wide outside the Keechelus Lake Alignment Alternatives. Table 3.5-4 summarizes these impacts and the Mitigation Development Team's (MDT's) recommendations for each CEA under the three Improvement Packages. The Improvement Packages would differ little in habitat lost due to construction and in operational impacts.

Table 3.5-4. Improvement Package Consequences for Fish/Aquatics (Page 1 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Gold Creek		
A	Provide substantially improved fish passage, hydrologic connectivity, and channel migration, which is expected to lead to improvement and expansion of aquatic habitat beneficial to fish (specifically bull trout) and other aquatic species.	Temporary disturbance of aquatic habitat and species due to construction. See text for a description of generic construction and operations impacts, and Package-wide habitat impacts. No loss of riparian habitat.
B	Impacts similar to Package A.	Temporary disturbance of aquatic habitat and species due to construction. See text for a description of generic construction and operations impacts, and Package-wide habitat impacts. No loss of riparian habitat.
C	Provide considerably less channel migration and restoration of aquatic habitat than the longer bridges, but conditions would still be improved over existing conditions.	Temporary disturbance of aquatic habitat and species due to construction. See text for a description of generic construction and operations impacts, and Package-wide habitat impacts. No loss of riparian habitat.
Townsend Creek		
A, B, and C	At I-90, the existing culvert at Townsend Creek is a barrier to upstream fish passage except at high pool elevation. The replacement of the existing culvert with a large culvert would improve hydrologic connection, and would restore partial and full barriers to fish passage, which improve fish access upstream of I-90. Habitat and movement connectivity for amphibians should also be improved.	Temporary disturbance of aquatic habitat and species due to construction.
Price/Noble Creeks		
A	Allows high restoration of complex channel habitat within the highway ROW. Restores natural fish passage and other aquatic organism passage.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.3 acre of riparian habitat.
B	Impacts similar to Package A except that the hydrologic connectivity zone east of Noble Creek would not provide the passage for amphibians that the bridges of Package A would provide. (The MDT [2004] defines a hydrologic connectivity zone as an area where special mitigation efforts are needed to provide for surface and subsurface hydrologic connectivity.)	Same as Package A.
C	The resulting benefit to surface and subsurface hydrologic connections, aquatic habitat, and fish/amphibian migration is somewhat less than under Packages A and B, but would still represent a substantial improvement over existing conditions.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.2 acre of riparian habitat.

Table 3.5-4. Improvement Package Consequences for Fish/Aquatics (Page 2 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Bonnie Creek		
A	This package would substantially improve the hydrologic connectivity in this area. Habitat and movement connectivity for amphibians should also be improved. Improving hydrologic connectivity should also alleviate the sediment retention problem at this site. There are isolated cutthroat trout populations upstream of I-90 due to sheet flow just upstream of I-90. Restoring hydrologic connectivity at the junction of Bonnie Creek and I-90 may help convert upstream sheet flow to channel flow and allow for fish migration.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.2 acre of riparian habitat.
B	The resulting benefit to surface and subsurface hydrologic connections, aquatic habitat, fish passage, and amphibian migration is likely to be somewhat less than under Package A, but would still represent a substantial improvement over existing conditions. Otherwise, impacts should be the same as described above for Package A.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.1 acre of riparian habitat.
C	This package would install large culverts at the two main branches of Bonnie Creek that would provide for fish passage only. These culverts would not provide significant hydrologic connections, however, and so would not benefit amphibian migration.	Same as Package B.
Swamp Creek		
A	This package would improve hydrologic connectivity, and improve surface and groundwater movement. Habitat and movement connectivity for amphibians should also be improved. Cutthroat and rainbow trout are likely to benefit from improved fish passage at Swamp Creek.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.3 acre of riparian habitat.
B	Improvements to hydrologic connectivity, fish passage, and amphibian migration would likely be slightly less than under Package A overall. However, Package B provides superior hydrologic connectivity at the west end of the CEA with the addition of twin single span bridges. Otherwise, impacts would be the same as described above for Package A.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.2 acre of riparian habitat.
C	This package would be less beneficial to fish species passage and amphibians, than under Packages A and B. However, conditions would still be improved over existing conditions.	Same as Package B.
Toll Creek		
A	This would improve hydrologic connectivity and accommodate aquatic components. It was determined that Toll Creek does not support fish, but hydrologic connectivity would likely benefit amphibian movement.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.2 acre of riparian habitat.
B	Similar impacts to Package A.	Same as Package A.
C	This package would provide minimal improvement in hydrologic connections.	Same as Package A.
Cedar Creek		
A, B, and C	Cedar Creek passes through a long culvert under I-90 and is a complete barrier to fish passage. Replacing the existing culvert with a larger culvert would improve hydraulic capacity and could contribute to minor improvements in hydrology. It was determined that Cedar Creek does not support fish, but hydrologic connectivity would likely benefit amphibian movement.	Temporary disturbance of aquatic habitat and species due to construction.

Table 3.5-4. Improvement Package Consequences for Fish/Aquatics (Page 3 of 3)

Improvement Package	*Beneficial Impacts*	*Adverse Impacts*
Telephone Creek		
A, B, and C	Telephone Creek passes through a long culvert under I-90 and is a complete barrier to fish passage. There are no fish passage issues since habitat upstream of I-90 is not conducive to fish utilization. Would improve hydraulic capacity, and could contribute to minor improvements in hydrology. Habitat and movement connectivity for amphibians would be improved.	Temporary disturbance of aquatic habitat and species due to construction.
Hudson Creek		
A	Hudson Creek passes through a long culvert under I-90 and is a complete barrier to fish passage. Would restore some of the surface and groundwater connections in this area, improving hydrological conditions downstream. Would generally benefit cutthroat and rainbow trout through improved hydrological connectivity that will likely benefit downstream habitat of Hudson Creek. Habitat and movement connectivity for amphibians should also be improved. Benefits to fish passage above I-90 will be limited by flows and steep terrain.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.7 acre of riparian habitat.
B	Fewer surface water and groundwater connections would be established compared to Package A, and benefits to fish and amphibians would be somewhat less. Conditions would still be improved over existing conditions.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.5 acre of riparian habitat.
C	This package would provide for fish passage only. These culverts would not provide significant hydrologic connections, however, and so would not benefit amphibian migration.	Temporary disturbance of aquatic habitat and species due to construction. Loss of 0.8 acre of riparian habitat.
Easton Hill		
A	No impact.	No impact.
B	No impact.	No impact.
C	No impact.	No impact.
Kachess River/Lake Easton		
A	No impact.	No impact.
B	No impact.	No impact.
C	No impact.	No impact.

Note: Information derived from the most current WSDOT design plans (4-16-04) and from the *Interstate 90 Snoqualmie Pass East MDT Draft Recommendation Package* (MDT 2004).

Improvement Package A

This Improvement Package would result in the greatest improvement in hydrologic and ecological connectivity in the project area, resulting in the greatest benefit to fish and amphibian habitat among the Improvement Packages. Under Improvement Package A, bridges of various lengths would be installed at all major and most minor stream crossings (culverts would be installed at the other sites), allowing for free water flow, channel migration, and movement of aquatic species under the highway.

Replacement of stream crossing structures at Gold Creek under this Improvement Package would directly benefit threatened bull trout populations above Keechelus Lake by greatly improving riparian habitat and hydrologic connections. For most creeks, salmonids benefiting from improvements in passage under this Improvement Package likely include rainbow trout, cutthroat trout, and possibly threatened bull trout and threatened steelhead (only downstream of Keechelus Dam).

Amphibians benefiting from improvements in passage for most creeks include Cascades frog, Columbia spotted frog, and the tailed frog. Replacement of stream crossing structures under this Improvement Package would benefit fish through major improvements in fish passage, and amphibian migration and overwintering.

Replacing stream crossing structures under this Improvement Package would have the beneficial impact of improved passage during all flows at the following streams: Rocky Run Creek, Price Creek, Noble Creek, Swamp Creek, Cedar Creek, Toll Creek, and Telephone Creek. These creeks have the most potential for benefit because the upstream habitats are conducive to fish utilization. Under existing conditions, this would have a relatively minor effect on bull trout because this species apparently does not inhabit these streams. However, as the watershed recovers from loss of riparian cover during timber harvest, conditions could become favorable for use of some of these streams by bull trout and amphibians (primarily Rocky Run, Price, and Noble creeks).

Under Improvement Package A, there would be slightly more construction than under the other Improvement Packages due to longer bridges and more culverts. Therefore, Improvement Package A would result in more of the temporary construction-related impacts described in Section 3.5.2 (temporary water quality effects and habitat disturbance). In addition, in this Improvement Package a total of 6 acres of aquatic and shoreline habitat would be filled and 1.7 acres of riparian habitat would be lost. These habitat losses would have an adverse impact on fish and other aquatic species; however, the three Improvement Packages are similar in acres of lake fill.

The beneficial effects of this Improvement Package, such as improved hydrologic connectivity and fish passage, and restoration of aquatic habitat,

outweigh the adverse impacts of the Improvement Package. Overall, under this Improvement Package, there would be a major improvement in fish passage and amphibian movement in the vicinity of I-90, and the effected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and hydrologic connectivity in the region. Table 3.5-4 summarizes fish and aquatic habitat impacts for each CEA for the three Improvement Packages.

Improvement Package B

The connectivity structures that would be installed under this Improvement Package are similar to those under Improvement Package A, except that shorter bridges or culverts would be installed at Price/Noble Creeks, Bonnie Creek, and Hudson Creek (all below Keechelus Dam). As a result, there would be slightly less benefit to channel migration, fish passage, and riparian habitat at these three CEAs. Therefore, benefits to cutthroat and rainbow trout, and possibly threatened steelhead would be slightly less due to less habitat being created for these creeks under this Improvement Package. Benefits to threatened bull trout above the dam would remain the same since the connectivity structures at the CEAs within Keechelus Lake would not change.

Under this Improvement Package, a total of 5 acres of aquatic and shoreline habitat would be filled, and 1.2 acres of riparian habitat would be lost. These habitat losses would have an adverse impact on fish and other aquatic species; however, the three Improvement Packages are similar in acres of lake fill. The beneficial effects of this Improvement Package, such as improved hydrologic connectivity and fish passage, and restoration of aquatic habitat, outweigh the adverse impacts of this Improvement Package, although to a lesser degree than under Improvement Package A.

Cutthroat trout isolated upstream of I-90 at Bonnie Creek would not benefit as much under this Improvement Package. Overall, under this Improvement Package there would be major improvement over existing conditions in hydrologic connectivity and fish passage in the vicinity of I-90, and the effected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and hydrologic connectivity in the region. Table 3.5-4 summarizes fish and aquatic habitat impacts for each CEA for the three Improvement Packages.

Improvement Package C

Under Improvement Package C, shorter bridges would be installed instead of longer bridges, or culverts would be installed instead of bridges, at six CEAs. The resulting benefits to hydrologic connectivity and riparian habitat conditions would be significantly less than under Improvement Packages A and B. Benefits to both threatened bull trout (above the dam) and threatened steelhead (below the dam) would therefore be significantly less than the other Improvement Packages.

Connectivity would not be improved for some low-mobility aquatic species such as amphibians.

Under this Improvement Package, a total of 4 acres of aquatic and shoreline habitat would be filled, and 1.6 acres of riparian habitat would be lost. These habitat losses would have an adverse impact on fish and other aquatic species; however, the three Improvement Packages are similar in acres of lake fill. The beneficial effects of this Improvement Package, such as improved hydrologic connectivity and fish passage, and restoration of aquatic habitat, outweigh the adverse impacts of the Improvement Package, although to a lesser degree than under Improvement Packages A and B.

This Improvement Package still represents significant improvement over existing conditions in terms of hydrologic connectivity. Bridges would be installed at three major CEAs containing fish: Gold Creek/Gold Creek West, Price/Noble creeks, and Swamp Creek. Although these bridges would be shorter than the other Improvement Packages, the benefit to fish passage, channel migration, and riparian habitat is a significant improvement from existing conditions. Therefore, bull trout and steelhead may realize considerable benefits relative to existing conditions. Large culverts would be installed at four additional CEAs: Townsend Creek, Bonnie Creek, Swamp Creek East, and Toll Creek West. These structures would allow for improved water flow conditions, and resulting fish and aquatic species passage.

Overall, under this Improvement Package, there would be considerable improvement in hydrologic connectivity and fish passage in the vicinity of I-90, and the effected tributaries to Keechelus Lake and the Yakima River. However, the highway would still represent an obstacle to water flow and hydrologic connectivity in the region. Table 3.5-4 summarizes fish and aquatic habitat impacts for each of the CEAs for the three Improvement Packages.

3.6 Terrestrial Species

Pacific silver fir

This section was prepared based on the *Interstate 90 – Snoqualmie Pass East Terrestrial Species Assessment Report* (Washington State Department of Transportation [WSDOT] 2003c, Garvey-Darda and Worthington 2003) and the *I-90 Snoqualmie Pass East Project, Terrestrial Species Analysis, Supplemental Report* (WSDOT 2004b) (Appendix T), which are incorporated into this document by reference, and the *Interstate 90 Snoqualmie Pass East Mitigation Development Team Draft Recommendation Package* (Appendix A). United States Forest Service (USFS) and WSDOT (2003 and 2004) crews completed project-specific investigations, which included plants, fungi, lichens, mollusks, and amphibian species. The Assessment Report also includes biologist surveys, and wildlife movement information provided by Singleton and Lehmkuhl (2000). For a complete list of species and their locations as identified in Interstate 90 (I-90) corridor surveys, please refer to Garvey-Darda and Worthington (2003).

Information on threatened and endangered species and priority habitats potentially occurring in the project area was obtained from the Washington Department of Natural Resources (WDNR) Natural Heritage Program, the Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species Program, and the United States Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration databases. This information was used in conjunction with the wildlife and habitat observations to generally assess the potential presence of protected species/habitats in the project area, and in areas that may be affected by the proposed action.

The study area for terrestrial species is the 15-mile I-90 corridor and areas on either side of that corridor providing habitat for animals potentially crossing the highway.

3.6.1 Affected Environment

The affected area spans 15 miles west to east, from Snoqualmie Pass to Easton along the Yakima River corridor. The western boundary rests on a 3,000-foot mountain pass in the central Cascades; to the east, it borders the Town of Easton. Vegetation is affected largely by precipitation, specifically the rain shadow effect, causing significantly decreased precipitation to the east.

The Yakima River Basin headwaters begin on mountain peaks that surround Snoqualmie Pass. Small tributaries flow into Keechelus Reservoir, which provides water retention capacity for the Yakima River and irrigation in the lower valley. There are at least 290 species of terrestrial vertebrates found in the Yakima River Watershed (Garvey-Darda et al. 2002). There are a variety of vegetation communities in the corridor, starting with sub-alpine meadows and forests at the west end of the project area (headwaters of the Yakima River), gradually changing to drier forests to the east. Wetland and riparian communities are interspersed throughout the project area.

There were 18 different plant associations comprising approximately 111 bryophyte species, 220 fungi species, and 260 vascular plant species found during surveys within the project area (Garvey-Darda and Worthington 2003). The plant associations changed from east to west, gradually shifting from grand fir and Douglas-fir associations, to western hemlock (*Tsuga heterophylla)* associations, to Pacific silver fir and mountain hemlock associations. Vegetation in the western-most portion of the project area is classified in Pacific silver fir and mountain hemlock series, and plant associations tend to be in the cool, moist shrub/herb plant association group. The Pacific silver fir series is found only in areas of strong maritime climatic influence, usually within a few miles of the Cascade Crest (Lillybridge et al. 1995). Plant associations include Pacific silver fir/white rhododendron/big huckleberry (*Abies amabilis/Rhododendron albiflorum/Vaccinium membranaceum*), and Pacific silver fir/Alaska huckleberry (*Abies amabilis/Vaccinium alaskaense*). The mountain hemlock series is widely distributed in the Pacific Northwest in cold, maritime climates. Its presence indicates cold, snowy habitats where snow accumulations of several feet or more

during winter are normal (Lillybridge et al. 1995). Associations found include mountain hemlock/false azalea/Alaska huckleberry (*Tsuga mertensiana/Menziesia ferruginea/Vaccinium alaskaense*) and mountain hemlock/big huckleberry.

To the east, vegetation is classified in warmer plant association groups in the grand fir and Douglas-fir series. The grand fir series is characterized by warm, moderately dry to moist forest habitats. On warmer and drier sites, grand fir grades into the Douglas-fir series. This series has habitats too dry for, or beyond the geographical range of, such tree species as western hemlock, western red cedar (*Thuja plicata*), and grand fir or sub-alpine fir (*Abies lasiocarpa*) (Lillybridge et al. 1995). Plant associations include grand fir/vine maple (*Abies grandis/Acer circinatum*) and Douglas-fir/Oregon boxwood (*Pseudotsuga menziesii/Pachistima myrsinites*).

The existing landscape is a mosaic of forest stands of different age classes. Past land uses and logging practices have left large tracts of clear-cut and single-aged stands throughout the I-90 corridor. There are some small patches of late-successional or old-growth forests within the corridor, much of it found in areas adjacent to or within the current WSDOT operating right-of-way (ROW). Other areas of late-successional patches include steep slopes and narrow, steep riparian corridors. Re-forestation of these areas has included a multi-species approach, and there appear to be no monoculture stands of Douglas fir in the I-90 corridor. In most of the surveys conducted throughout the I-90 corridor, closed canopy, mid-successional systems rarely provide the biological diversity within plant communities that is seen in undisturbed old-growth systems.

The project occurs in an area recognized as a critical connective link in the north-south movement of species in the Cascades Range (USFS and Bureau of Land Management [BLM] 1994, Singleton and Lehmkuhl 2000, Garvey-Darda and Worthington 2003). Demographic isolation of species and their habitats is a concern because it can reduce localized genetic variability and sustainability. The checkerboard pattern of lands along the I-90 project corridor presented a population risk for many species in the Washington Cascades (USFS 1997). Block ownership results in occasionally conflicting land management strategies, which can lead to habitat fragmentation, a threat to some species in the corridor. To date, approximately 72,000 acres of private land have been added to the National Forest System in the I-90 corridor as a result of the I-90 Land Exchange and other campaigns, donations, funds, and partnerships (Mitigation Development Team [MDT] 2004). Over time, these land acquisitions are expected to improve the habitat for species associated with old growth and/or are sensitive to roads (USFS 1999a).

The USFS recommends road densities of 2 miles/square miles or less for the Yakima watershed.

Surrounding land uses also pose a potential problem to species viability within the I-90 Snoqualmie Pass East corridor. Any road, including single lane, dirt roads, can cause a significant barrier to dispersal in some species. Throughout much of the I-90 corridor between Snoqualmie Pass and Easton, road densities

exceed 5 miles of roadway for every square mile of land. These are densities that exceed all species dispersal thresholds for large, highly mobile carnivore species (Theil 1985, Van Dyke et al. 1986, Mech et al. 1988, Lovallo and Anderson 1996, Mace et al. 1996). The area is a patchwork of regenerated forests, from relatively recent clear-cuts to single species, even-aged stands with a relatively small occurrence of old-growth forests. These elements, combined with the additional effects of I-90, and human development and presence within the corridor, have all contributed to the decline of species diversity and viability.

COAL CREEK TO WOLFE CREEK

Between Milepost (MP) 55.1 and MP 57.0, the I-90 corridor passes along the northern boundary of Keechelus Lake. A mature, privately-owned forest is located along the northwest edge of the Gold Creek Valley. The area was previously logged approximately 70 to 80 years ago. There is little herbaceous vegetation in the understory, and it is a closed canopy system. The slopes are relatively steep from the Gold Creek Valley floor. There is some structural diversity, with rocky outcrops and some large woody debris. The Gold Creek Valley provides some additional habitat, with thickets of willow and red osier dogwood. There are some mature forests upstream of the I-90 corridor, and the headwaters of Gold Creek begin in the Alpine Lakes Wilderness Area. The area is strategically located between several important wildlife refugia: the Alpine Lakes Wilderness Area, a late-successional reserve in the Teanaway River watershed, late-successional reserve areas in the Snoqualmie and Cedar river watersheds to the west, and the Norse Peak Wilderness area to the south (USFS 1999a).

The Connectivity Enhancement Area (CEA) in this section with the greatest potential for beneficial improvements to connectivity is Gold Creek. One of the three highest deer/elk (*Cervus elaphus*) roadkill areas in the corridor occurs at Gold Creek (Singleton and Lehmkuhl 2000). This area has been identified as the best linkage area for other wide-ranging species sensitive to high road densities, such as fisher, wolverine, gray wolf, and grizzly bear (refer to Table 3.6-1 for scientific names of threatened and endangered species and other species of concern) (Garvey-Darda and Worthington 2003). Additionally, American marten (*Martes americana*) have only been identified in this region of the Cascades Crest area (Singleton and Lehmkuhl 2000). This CEA has been identified as the only opportunity for linking habitat and species associated with mountain hemlock/sub-alpine fir associations (Garvey-Darda and Worthington 2003). Additionally, Gold Creek represents the best opportunity for linking habitat for a variety of small mammal, bryophyte, lichen, fungus, vascular plant, and mollusk species that only occur in the Snoqualmie Pass area. Constructing a terrestrial crossing in this area is expected to improve connectivity for 46 species of mammals, 12 amphibians, and 13 mollusks.

Humans heavily impact potential linkage areas. The Gold Creek Valley is a popular winter and summer recreational destination for residents of the Pacific

Northwest. It has numerous private land in-holdings with summer cabins. The area provides opportunities for cross-country skiing and snowmobiling in winter and hiking in the summer. Trailheads in the area provide access into the Alpine Lakes Wilderness Area.

The WSDOT Hyak maintenance facility is located along the lakeshore. A boat launch and trailhead are located along the southwest shore of Keechelus Lake. The area along the lakeshore to the south of I-90 is relatively steep, although vegetated with mature forest. Access is limited by fluctuations in water levels associated with Keechelus Dam operations. The area to the south of I-90 has been heavily logged and has a relatively high road density. Forests in this area are relatively young, and it will be many years before structural stages will support species associated with late-successional reserves.

Wolfe Creek to Keechelus Dam

Between MP 57.0 and MP 60.6, the I-90 corridor crosses three moderate to high gradient streams as it parallels the north side of Keechelus Lake: Wolfe Creek, Resort Creek, and Townsend Creek. The area east of I-90 along Keechelus Lake is relatively steep, with some near vertical rock outcrops. Keechelus Lake itself represents a barrier to many species of small mammals, amphibians, invertebrates, and plant species. Very few species will disperse over rugged terrain, with the exception of grizzly bear and wolverine, which readily travel through these areas. Large carnivores, such as wolf, lynx, wolverine, and grizzly bear are known to swim across relatively large bodies of water when dispersing from natal areas. The limiting factors in this location for wolverine and grizzly bear are high road densities, and lack of suitable habitat away from human disturbance (Garvey-Darda and Worthington 2003). Species dependent upon low road densities and late-successional forests may find dispersal across this area problematic. Forest and county road densities west of Keechelus Lake are high, and little late-successional habitat exists.

Keechelus Dam to Cedar Creek

From Keechelus Dam (MP 60.6) through Cedar Creek (MP 64.8), the I-90 corridor passes through a strip of older forest bisected by several stream and wetland complexes. Four CEAs occur in this section: Price/Noble Creeks, Bonnie Creek, Swamp Creek, and Toll Creek. The area to the south of Keechelus Lake provides good connectivity, with stands of late-successional forest found north and south of I-90. Townsend Creek is just northeast of Keechelus Dam with a very diverse wetland complex that extends southeast to Price/Noble Creeks. An unnamed drainage between Townsend and Price/Noble creeks still contains some late-successional forest that is over 100 years old, and does not have old stumps from past logging operations. It was also an area of high fungi diversity (Garvey-Darda and Worthington 2003).

The area around Swamp Lake contains a high level of plant species diversity (Garvey-Darda and Worthington 2003). There is some connectivity with areas to

the north, although past land use practices have eliminated much of the late-successional forests in the vicinity of Swamp Lake. A high density of roads and private in-holdings compromises connectivity to the south. However, purchases within the Yakima River corridor by conservation groups provide some additional refugia for wildlife migrating south.

South of I-90 and Swamp Lake is the Mosquito Creek Watershed that has an active road density of 5.8 miles/square miles. From Swamp Lake south, it is over 12 miles to the Norse Peak Wilderness area and over 6 miles to an area of lower road densities. Although it is recognized that the Swamp Lake area is important to maintaining biodiversity, the ecological connectivity for most species may be greatly compromised by past land use management in the general vicinity. A relatively intact corridor exists between Swamp Lake and the Alpine Lakes Wilderness area to the north. Swamp Lake is approximately 6 miles from the wilderness boundary. Human activities are on-going in this area and include the Rustic Inn, a towing business, a small dam on Swamp Creek, USFS roads, a large Sno-park to the southwest, and access roads for snowmobiles northeast of Swamp Lake. Summer recreational activities include camping at the Crystal Springs Campground and boating along the shoreline of Kachess Lake.

Although logging in the Price/Noble Creeks area has significantly impacted the vegetation upstream of I-90, the riparian conditions are still considered fair. On the downstream side, however, the riparian vegetation and canopy cover are considered excellent (Garvey-Darda and Worthington 2003). The Price/Noble Creeks area has been identified as a prime candidate for improved terrestrial connectivity as evidenced by its close proximity to one of the three highest deer/elk roadkill areas in the corridor (Garvey-Darda and Worthington 2003). The use of this area as a terrestrial species crossing is further evidenced by the location of five coyote (*Canis latrans*) crossings in the area and roadkilled mountain lions. The frequency of animal crossings here, combined with United States Bureau of Reclamation (USBR) dam operation, timber harvest, and high recreation use has created an opportunity to improve current terrestrial functioning in this area. Constructing an animal crossing in this area is expected to benefit up to 34 species of mammals, 8 species of amphibians and reptiles, and 19 species of mollusks (Garvey-Darda and Worthington 2003).

The terrestrial environment around Bonnie Creek includes high quality, late-successional habitat, which has helped characterize the terrestrial habitats as properly functioning. However, terrestrial connectivity has been rated as not properly functioning, again due to high roadkill occurrence in the area (Garvey-Darda and Worthington 2003). Improvements in terrestrial connectivity have been emphasized in this region due to the species diversity associated with the habitat at this CEA that is unique to the corridor. Constructing a terrestrial crossing at this CEA is expected to improve connectivity for 35 species of mammals, 8 amphibians, and 17 mollusks (Garvey-Darda and Worthington 2003).

The terrestrial habitat in the area of Swamp and Bonnie Creeks support the highest species diversity in the corridor, including the Kachess gravelly sandy loam soil type that supports low mobility species (LMS) (Garvey-Darda and Worthington 2003). Additionally, this area includes some high quality, late-successional habitat also known to support high terrestrial species diversity. Downstream of I-90, Swamp Creek riparian vegetation comprises a forested wetland complex. Habitat complexity above I-90 is considered low due to roads, development, and historical logging activities (Garvey-Darda and Worthington 2003). Constructing terrestrial crossings at each of these CEAs is expected to improve connectivity for 36 species of mammals, 10 amphibians, and 21 mollusks (Garvey-Darda and Worthington 2003).

CEDAR CREEK TO EASTON HILL

Between Cedar Creek (MP 64.8) and the top of Easton Hill near MP 67.0, the I-90 corridor passes through a forested landscape traversed by several small streams. The south slope of Amabilis Mountain adjacent to the roadway is mature forest. However, moving upslope, the area has been clear-cut within the last 20 years and is dominated by young conifers. The mature forest extends to both sides of the highway through most of the area. The steep slope and lack of mature forest limits the benefits at this location for connectivity.

Three CEAs occur in this section: Cedar Creek, Telephone Creek, and Hudson Creek. Terrestrial habitats upstream of I-90 along Cedar and Telephone creeks are strongly influenced by managed forests and clear-cuts. Terrestrial habitats have been rated as properly functioning; however, terrestrial connectivity has been rated as not properly functioning due to barriers to species movement and logging activities (Garvey-Darda and Worthington 2003). The 1998 discovery of wolverine tracks on nearby Amabilis Mountain may be an indication of the importance of this site for improvement in terrestrial species movement (Singleton and Lehmkuhl 2000). Constructing terrestrial crossings at each of these CEAs is expected to improve connectivity for 35 species of mammals, 8 amphibians and reptiles, and 14 mollusks (Garvey-Darda and Worthington 2003).

Hudson Creek includes the LMS-supporting Kachess gravelly sandy loam soil type habitats. Again, terrestrial habitats have been rated as properly functioning, while terrestrial connectivity has been rated as not properly functioning due to the power line corridor, barriers to species movement, and recreational activities (Garvey-Darda and Worthington 2003). Hudson Creek is the only location in the corridor that allows for connectivity with talus-associated habitats (Garvey-Darda and Worthington 2003). This is an important habitat type for species such as a recently discovered population of Larch Mountain salamanders, a rare mollusk (*Cryptomastix debia*), and small mammals such as pika (*Ochotona princes*). This area is also known for wide-ranging carnivores, such as relatively recent wolverine (*Gulo gulo*) sighting and known occurrences of mountain lion (*Puma concolor*). Constructing terrestrial crossings at this CEA is expected to improve

connectivity for 36 species of mammals, 9 amphibians and reptiles, and 19 mollusks (Garvey-Darda and Worthington 2003).

EASTON HILL TO EASTON INTERCHANGE

From the top of Easton Hill (MP 67.4) to the West Easton Interchange (MP 70.3), I-90 passes through an upland forested area with few streams or emergent wetlands. The area at Easton Hill between MP 67.0 and MP 69.0 has been identified as a highly permeable section for late-successional species (Singleton and Lehmkuhl 2000).

Roadkill data indicated that this area had the highest kill incidences in the corridor (Singleton and Lehmkuhl 2000). From September 1998 through October 1999, automatic cameras were used at Easton Hill. Black bears (*Ursus americanus*) were detected most frequently at the west, or top, of Easton Hill. Northern flying squirrels (*Glaucomys sabrinus*), bobcats (*Lynx rufus*), and deer (*Odocoileus* spp.) were detected at the west and east near Easton State Park. During snow tracking surveys, it was found that most animals crossed at the top of Easton Hill. The most common crossing of I-90 was by coyotes, with 20 crossings (Singleton and Lehmkuhl 2000).

At Easton Hill, terrestrial habitats have been rated as properly functioning, while terrestrial connectivity has been rated as not properly functioning due to high incidences of collisions between high mobility species (HMS) and vehicles, and public and private land uses. This area includes LMS-supporting Kachess gravelly sandy loam soil and high quality, late-successional habitat also known to support high terrestrial species diversity.

In the Kachess River/Lake Easton area, terrestrial habitats were classified as properly functioning, with not properly functioning linkages due to the fluctuating lake level, private land uses, and high recreational use (Garvey-Darda and Worthington 2003). Movement along the eastern slope of Amabilis Mountain may be motivated by human activities further to the east. North of I-90 at MP 69, a subdivision is being developed and another development short platted, with utility lines installed in the summer of 1999. Continuing development in the area may be detrimental to wildlife connectivity. Constructing terrestrial crossings at each of these CEAs is expected to improve connectivity for 46 species of mammals, 13 amphibians and reptiles, and 17 mollusks (Garvey-Darda and Worthington 2003).

3.6.1.1 THREATENED AND ENDANGERED SPECIES

Fish species are described in Section 3.5, *Fish, Aquatic Habitat, and Threatened and Endangered Fish Species.* Table 3.6-1 lists terrestrial Threatened, Endangered, and Species of Concern that have the potential to occur in the project area, their habitat associations, and potential corridor use. Included in the table are seven federally listed threatened species (Northern spotted owl, marbled murrelet, bald eagle, grizzly bear, gray wolf, Canada lynx, and Ute Ladies'-tresses) that have the potential to occur in the project area. In addition to being listed as a federally threatened species, the grizzly bear is listed as a Washington State endangered species. The table also identifies 15 USFWS Species of Concern occurring within the I-90 corridor; these species are of special concern but not yet listed under the Endangered Species Act (ESA). Threatened and endangered terrestrial species are addressed in greater detail in WSDOT reports on terrestrial species (WSDOT 2004a, 2004b).

3.6.1.2 USFS SPECIAL STATUS SPECIES, AND SENSITIVE PLANT SPECIES

The National Forest Management Act requires the USFS to prepare and adhere to plans for managing the National Forests, and to address USFS Special Status Species in National Environmental Policy Act (NEPA) documents. The *Forest Service Manual* (FSM 2672.4) requires that all projects on National Forest lands with the potential to affect federally listed or proposed species under Section 7(C) of the ESA conduct a biological evaluation. The purpose of the evaluation is to determine the effects of vegetation management on species listed as Proposed, Endangered, Threatened, or Sensitive, as well as Species of Concern, by the USFWS; Proposed, Endangered, Threatened, or Sensitive by the WDNR; or those listed by the USFS as special status (above) or by the Regional Forester as sensitive for Region 6 (USFS 1999b, USBR 2001a). In addition, USFS policy for sensitive species states that the agency must "develop and implement management practices to ensure that [sensitive] species do not become threatened or endangered because of Forest Service action" (Forest Service Manual 2670.22).

WSDOT surveys were conducted for wildlife, and both vascular and non-vascular plants (lichen, bryophytes, fungi) in the project corridor (Singleton and Lehmkuhl 2000, Garvey-Darda et al. 2002). A comprehensive list of these species, their distribution, and general soil type association in the project corridor is provided in Garvey-Darda and Worthington (2003).

Table 3.6-1. Threatened, Endangered, and Species of Concern
(Page 1 of 3)

Species	***Status[1]***	***Habitat Association***	***Potential for Using I-90 corridor***	***Comments***
Northern spotted owl (*Strix occidentalis caurina*)	FT SE	Requires mature and old growth forest, with multiple canopy layers, and large amounts of dead and down woody material; typically below 4,500 feet in Western Washington (Forest Ecosystem Management Assessment Team 1993).	Very little mature and old growth forest with multiple canopy layers within I-90 corridor. Within area designated as dispersal corridors.	Has been cited as an indicator species for important dispersal corridors.
Marbled murrelet *(Brachyramphus marmoratus marmoratus*)	FT ST	Requires mature and old growth forest with trees having large diameter branches for nesting (Hamer and Cummins 1991).	Limited habitat available at west end of project area within the Gold Creek Valley.	Only one sighting near the project area within the Gold Creek Valley.
Bald eagle (*Haliaeetus leucocephalus)*	FT ST	Almost always found near large bodies of water where primary prey items of fish and waterfowl can be found (USFWS 1986).	No recorded sightings along Keechelus Lake. However, bald eagles are known to occur throughout the winter months along the Yakima River.	One nest site reported at Lake Cle Elum.
Grizzly bear (*Ursus arctos horribilis*)	FT SE	Wilderness/Wide-ranging; isolation from human disturbance for denning (Paradiso and Nowak 1982).	Use of the area highly doubtful due to human activity in area. Limited security habitat available.	One Class 2 sighting five miles north of I-90 along Lake Cle Elum. Other sightings north of I-90 are in wilderness areas.
Gray wolf (*Canis lupus*)	FT ST	Wilderness/Wide-ranging; isolation from human disturbance for denning (Nowak and Paradiso 1983).	Habitat marginal due to human activities. Potential pass-through use as part of much larger territories.	No packs, den sites, or rendezvous areas known within area. One Class 2 sighting at Swamp Lake of one adult with two yearlings approximately 0.30 mile from I-90.
Canada lynx (*Lynx canadensis)*	FT ST	Requires early-successional forest for primary prey (snowshoe hare) and late-successional forest for breeding (Ruediger et al. 2000).	Habitat not expected to occur in western corridor. The Easton Hill area may be the most important corridor for this species. However, much of I-90 corridor area is potentially suitable foraging habitat but lacks the structural diversity for denning habitat.	The I-90 corridor provides ample early successional habitat for snowshoe hares. The drawback is that there is little potential denning habitat. One sighting southwest of I-90 corridor near Snoqualmie Pass.
Ute Ladies'-tresses (*Spiranthes diluvialis*)	FT	Endemic to mesic or wet meadows, and riparian/wetland habitats near springs, seeps, lakes, or perennial streams. Soils may be inundated early in the growing season, retaining subsurface moisture through the season. It occurs primarily in areas where the (over-story) vegetation is relatively open, and not dense or over-grown (USFWS 1995).	There are many wetland complexes throughout the I-90 corridor. However, most of them are forested systems with closed canopies and would not provide adequate habitat. Areas along the I-90 corridor do not dry out extensively during the summer. Current knowledge of this species would indicate that it is not found within the I-90 corridor.	Extensive surveys have been conducted throughout the corridor, and this species has not been found.

Table 3.6-1. Threatened, Endangered and Species of Concern
(Page 2 of 3)

Species	***Status[1]***	***Habitat Association***	***Potential for Using I-90 corridor***	***Comments***
Cascades frog (*Rana cascadae*)	SOC	Highly aquatic. Closely associated with edges of seeps and other wetlands (Leonard et al. 1993).	Present throughout the project area.	Surveys detected Cascades frogs in 8 CEAs.
Columbia spotted frog (*Rana luteiventris*)	SOC	Most aquatic native frog. Nearly always found in or near a perennial water body, such as a spring, pond, lake or sluggish stream. Associated with non-woody vegetation, such as sedges, rushes, and grasses (Leonard et al. 1993).	Has been found within the Yakima River Watershed downstream of the project area. It has not been found within the project limits.	Absence may be due to a lack of wetland habitats that are dominated by emergent vegetation.
Tailed frog (*Ascaphus truei*)	SOC	Turbulent mountain streams (Leonard et al. 1993). Has been found as high as 7,000 feet elevation.	Documented occurrences within the project area.	Improved culverts and bridges will enhance fragmented dispersal paths.
Larch Mountain Salamander (*Plethodon larselli*)	SOC	Steep, moist talus slopes, usually moss-covered and under a forest canopy (Leonard et al. 1993). Species has been found as far north as Cle Elum, Washington.	Potentially suitable habitat, and species may be present.	Improved culverts and bridges will improve genetic exchange between populations.
Clustered lady's slipper (*Cypripedium fasciculatum*)	SOC	Mid- to late seral Douglas-fir (*Pseudotsuga menziesii)* or ponderosa pine (*Pinus ponderosa*) over-stories with a closed herbaceous layer and variable shrub layer, mostly on northerly aspects.	This species has been documented north and south of the project area. Most likely to occur at the eastern end of the project area.	Unlikely to have survived past timber harvest and road building activities.
Little willow flycatcher (*Empidonax traillii*)	SOC	Found in the Cascades Range as a summer resident in wet meadow and montane riparian habitats with a dense growth of shrubby willows from 2,000-8,000 feet in elevation.	There are several areas within the project action area that provide suitable habitat for this species, including the Gold Creek Valley. Wetlands currently are found along the I-90 corridor in dense thickets.	No survey information in the general project area was found for this species.
Olive-sided flycatcher (*Contopus borealis*)	SOC	Found from sea level to timberline, but usually occur in higher elevation montane and boreal forests.	Most of the project action area could be considered suitable habitat for this species.	Probable breeding evidence is found throughout the corridor.
Harlequin duck (*Histrionicus histrionicus*)	SOC	Clear, clean, swiftly flowing second to fifth order streams (Leonard et al. 1993).	Most of the areas adjacent to the highway do not provide the necessary habitat elements essential for success of this species.	They are usually found at distances greater than 164 feet from trails or roads.

Table 3.6-1. Threatened, Endangered and Species of Concern
(Page 3 of 3)

Species	***Status[1]***	***Habitat Association***	***Potential for Using I-90 corridor***	***Comments***
Northern goshawk (*Accipiter gentilis*)	SOC	Described as a "habitat generalist" (Reynolds et al. 1992). Nests more frequently in late-successional forests with dense canopies.	Habitat suitability throughout the corridor has been significantly altered through past timber harvest. Although patches of mature and old-growth forests are still found in the corridor, most do not provide large enough areas to support home ranges of the northern goshawk.	Most forested habitat in the corridor does not provide large enough areas to support home ranges of the northern goshawk.
Yuma myotis (*Myotis yumanensis*)	SOC	Restricted to low elevation coastal forest, ponderosa pine/Douglas-fir forest, and arid grassland (Nagorsen and Brigham 1993).	The I-90 corridor provides suitable habitat for this species.	Their distribution is considered geomorphic because of their strong correlation with caves or cave-like structures for roosting habitat.
Long-eared myotis (*Myotis evotis*)	SOC	Commonly found in Ponderosa pine and mixed conifer habitat. Uses wetland complexes described as persistent emergent within the Palustrine system.	Although not a common species, they may be found sporadically throughout the project area.	It is believed that this species may forage in forest gaps and predominantly use old snags for day roosting.
Long-legged myotis (*Myotis volans*)	SOC	This species is dependent on wooded habitats such as pinion-juniper and coniferous forests at elevations from 4,000 to 9,000 feet.	Likely found within the project area.	One of the greatest threats is habitat fragmentation. In the project area, most old-growth and late-successional reserves have been reduced to remnant stands.
Pale Townsend's big-eared bat (*Corynorhinus townsendii*)	SOC	Found in a variety of habitats including desert scrub, sagebrush, and deciduous and coniferous forests.	Highly susceptible to human disturbance. Dependent on caves and old mines, which are not abundant in the project area. Foraging opportunities are probably abundant based on the availability of wetland systems within the corridor.	The lack of cave habitat in the I-90 corridor makes it unlikely that this species will be found within the project area.
Pacific fisher (*Martes pennanti*)	SOC	Extensive forest stands with contiguous canopy (Powell 1982).	Potential rare pass-through or foraging use.	Late-successional forests with significant riparian areas provide the best habitat.
Wolverine (*Gulo gulo*)	SOC	A true wilderness species requiring large areas of minimally disturbed habitats (Banci 1994).	Uncommon pass-through use as part of vast territory including adjacent wilderness areas north and south of the project area (Alpine Lakes and Norse Peak).	Wolverine habitat is best defined in terms of adequate year-round food supplies in large, sparsely inhabited areas.

Notes: 1. FT: Federally Threatened, ST: State Threatened, FE: Federally Endangered, SE: State Endangered, SOC: USFWS Species of Concern

3.6.1.3 LANDBIRD CONSERVATION STRATEGY SPECIES

The National Forest System has the responsibility to address landbird conservation in NEPA documents (*Forest Service Landbird Strategic Plan* and an Executive Order) and, where practicable, mitigate to reduce the potential for unintentional take (WSDOT 2003c). The species identified in the plan include primarily neotropical migratory birds, although many year-round residents are also included. One hundred eighteen species of neotropical migratory birds are known to breed in Washington (Andelman and Stock 1994 as cited in Garvey-Darda and Worthington 2003). The Terrestrial Species Discipline Report identifies a total of 32 species of concern for the two identified landbird habitat types in the project area, with 9 occurring in the Columbia Basin Plateau Area, and 23 from the Southern Pacific Rainforest Area (WSDOT 2003c).

3.6.2 Environmental Consequences

The following sections describe the general environmental consequences for terrestrial habitats and species due to construction procedures and project elements common to all of the alternatives. Most of these impacts result from construction activities. The impacts specific to each of the alternatives are discussed in Sections 3.6.2.1 through 3.6.2.3.

GROUND DISTURBANCE

Ground disturbance has the greatest impact based on the reduction in associated habitat for all species. Throughout the corridor, fragments of old growth and mature forest habitat are relatively uncommon. Although current forest management is geared toward increasing the amount of late-successional reserves in the I-90 corridor, the establishment of these forests is, at best, 50 to 100 years in the future. Old-growth forests within the corridor are important for re-colonization, and provide pockets of biological diversity that are essential if ecosystem health and long-term species viability are to be maintained. Many of the species within the I-90 corridor that are currently “at risk” or declining are species that depend on late-successional forest habitat for many stages of their life history.

Removal of vegetation can cause direct mortality to birds, small mammals, invertebrates, and plants. Although birds have the ability of flight, construction activities are likely to occur during the nesting season of many neotropical migratory birds that may abandon nest sites due to disturbance. Damage and/or mortality to eggs or young birds are very likely to occur.

Areas beyond the actual construction impact zone may also be affected by noise and increased activity, and may cause birds to abandon nest sites prematurely. Small mammals may also be unable to move young, or may desert den sites because of noise and human activity.

Noxious weeds are known to invade disturbed habitats alongside roads and highways. Thirteen Washington State noxious weed species are known to exist along the current I-90 corridor and roads in the vicinity of the project area (Garvey-Darda and Worthington 2003). State law requires the control of certain weed species within highway ROWs. Activities required for control have to be given priority over all other vegetation management activities except those that directly and immediately affect the safety of the public. However, the proposed action is not expected to increase the total roadside area where these species are known to initially establish themselves. Instead, the total roadside area would be relatively consistent with the current design. To be responsive to the problem of noxious weeds, WSDOT continues to develop roadside maintenance integrated vegetation management plans statewide. WSDOT continues to work closely with the county and state Noxious Weed Control Boards to keep noxious weeds from invading agricultural lands and native habitats.

EFFECTS OF HIGHWAYS ON WILDLIFE

Highways can affect wildlife in a number of ways, including habitat fragmentation, direct mortality, displacement and avoidance, and direct habitat loss. Highways have fragmented large, naturally connected landscapes into a mosaic of various-sized smaller land plots. Fragmentation begins with wildlife's behavioral avoidance of highways and progresses, as highways become sources of mortality (Forman et al. 2003). Large and mid-sized carnivores appear to be some of the most vulnerable wildlife species to habitat fragmentation resulting from highway construction. Carnivores have low population densities, low reproductive rates, and very large home range sizes. Species with large area home ranges are most likely to have these home ranges fragmented by highways. This has the potential to force some animals that are reluctant to cross highways to carry out life functions, such as feeding, courtship, and nesting, in small habitat patches. Gibeau and Heuer (1996) discovered that wolverine and other carnivores' home ranges tend to be along highways, rather than crossing them.

Direct mortality, or roadkill, resulting from failed attempts to cross highways reduces the viability of populations through reduced gene flow, and result in displacement and behavioral changes such as avoidance (Trombulak and Frissel 1999, Jackson 2000). Many wildlife species are reluctant to enter into or cross over highway, and display an avoidance behavior of highways (Lovallo and Anderson 1996, Jackson 2000). Highway construction also results in direct habitat loss through road construction. The habitat that is lost is not only the highway footprint itself, but the ROW and affected nearby habitats that no longer function properly.

Roadkill distributions appear to be driven largely by landforms that channel animal movement (e.g., lakes, rivers, and mountains), and by human development and disturbance (Singleton and Lehmkuhl 2000). Although permeability to wildlife is reduced along the entire I-90 corridor, areas of particularly high deer/elk roadkill have been determined as having low

permeability across I-90 and high wildlife use (Singleton and Lehmkuhl 2000). These areas have been identified as having some of the greatest potential for improvements to terrestrial species and habitat connectivity in the proposed action design. Singleton and Lehmkuhl (2000) collected deer/elk roadkill data from 1990 to 1998 to identify low permeability/high use portions of the corridor. The three locations with the greatest potential for decreasing roadkill are the portions of the highway at the north and south ends of Keechelus Lake, and at Easton Hill.

Within the project corridor, wildlife exclusion fencing is sporadic. This project represents an opportunity to collaboratively develop a fencing plan for the corridor. The plan will address important biological issues, as well as maintenance, motorist safety, and aesthetic issues. Refer to Section 4.2.3 for a discussion of fencing as a mitigation measure.

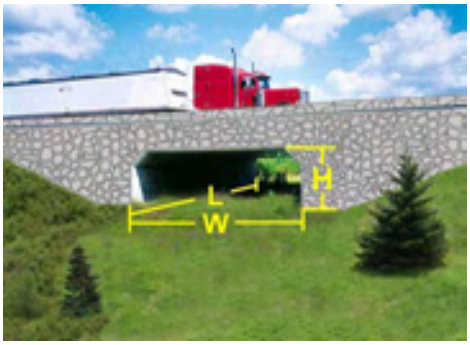
The net effect of the proposed project would be to reduce roadkill compared to the No-Build Alternative.

The proposed widening of the highway and potentially higher traffic speeds would tend to increase roadkill. However, one purpose of the proposed action is to reduce roadkill by increasing permeability of the highway to wildlife through the installation of permeability structures at key locations. Improved fencing would also reduce roadkill, while projected increases in traffic volume would tend to increase roadkill. However, increased traffic volume would occur regardless of whether the proposed project is built. The net effect of the proposed project would be to reduce roadkill compared to the No-Build Alternative. Project design efforts to improve terrestrial connectivity in these low permeability portions of the corridor are addressed in the proposed Improvement Packages (Section 3.6.2.3).

Use of Crossing Structures by Wildlife

Clevenger and Waltho (2000) found that the single dominant factor affecting large carnivores was human activity near crossing structures. This would greatly reduce the suitability of the Gold Creek Valley, Swamp Lake, and Lake Easton for habitat connectivity for these species based on avoidance of areas with high levels of human activity. However, it was also found that elk and deer are less likely to be affected by human activity, and will use crossing structures near towns and recreational areas. Elk and deer are also more likely to use areas that are not associated with a drainage area. Prey species may avoid crossing structures that are used by predators.

The “Openness Ratio” is defined as the characteristics of a structure that represent what an animal’s “perception” of the crossing passage under the roadway might be. The goal is to provide crossing passages that will encourage wildlife species to use them and that will actually develop into established wildlife paths. As the passage length (roadway width) of a structure increases, the opening at the far end appears smaller. This effect is likely to decrease the opportunity for passage for most species. An increase in length should be accompanied by a proportionate increase in the height and width of the structure



Typical Openness Ratio Dimensions

passage. Most wildlife species need an openness ratio that makes the opening appear safe to enter. Based on available research, the minimum crossing structure for deer appears to be an opening of 8 feet x 24 feet and approximately 210 feet in length, resulting in an openness ratio of 0.90 (Knapp et al. 2004).

The openness ratio is calculated as follows: width of opening x height/length (Reed and Ward 1985, Clevenger and Waltho 2000, Singleton 2000). Openness ratios calculated for structures on this project are calculated in this manner, using the area of the opening divided by the length, which takes irregular or trapezoidal-shaped openings into account.

Blasting and Other Noise Impacts

Noise associated with blasting can have adverse impacts on nesting birds. Although temporary in nature, blasting within 500 feet of nests can cause sensitive bird species to abandon nest sites. All mammal and bird species may be temporarily startled, and experience stress from blasting activities. Other new sources of noise from the project would be general construction noise during construction and noise from increased traffic volume and speed over the longer term. Tunnel ventilation structures for some of the Keechelus Lake Alignment Alternatives would also generate considerable noise. This noise would disturb sensitive organisms in the vicinity of the highway and may impair or preclude certain activities such as nesting or feeding in these areas (such effects would be incremental to existing noise effects in the highway corridor). Wildlife movement may also be affected by this noise, but this effect is expected to be relative minor compared to the improvement in movement across the highway resulting from the various connectivity structures included in the project alternatives.

Removal of Riparian Vegetation

Removal of riparian vegetation would decrease the amount of available habitat for species of birds, small mammals, amphibians, and invertebrates. Direct loss of habitat would be long-term based on the expansion of I-90 from four to six lanes. Indirect impacts would be a change in climate within the microhabitat of the riparian corridor.

Placement of Fill In Aquatic Habitat

Placement of fill in aquatic habitats would reduce available habitat and may cause mortality for amphibian and invertebrate species. It would also affect terrestrial species that use aquatic habitats for food sources and as travel corridors.

ROADWAY REMOVAL

Roadway removal within the existing roadway prism would not adversely affect the terrestrial environment. Most noise associated with this procedure does not exceed ambient levels. Proper disposal ensures that any deleterious material would not enter the natural environment.

LAKEBED DISTURBANCE

Lakebed disturbance is likely to cause some reduction in prey species for bald eagle and osprey (*Pandion haliaetus*) that may be found near large bodies of water. It may also reduce food availability and habitat for some species of waterfowl.

REMOVAL AND REPLACEMENT OF EXISTING CULVERTS

The removal and replacement of existing culverts could cause mortality to amphibians and invertebrates. However, once the new structures are in place, no negative impacts are expected. This may also temporarily impact small mammal species that use culverts as travel corridors.

EQUIPMENT MAINTENANCE AND FUELING

Heavy equipment and vehicles used during construction would require periodic fueling and maintenance. These activities have the potential to release deleterious substances such as diesel fuel, hydraulic fluids, coolant, and lubricants onto the ground where stormwater can transport them to surface waters. Spills are preventable with implementation of appropriate Best Management Practices (BMPs).

TIMING AND DURATION OF CONSTRUCTION

Based on weather conditions and other environmental factors, timing and duration of construction may be long-term, and extend over multiple years. This may have adverse impacts to wildlife based on continual disruption of life history events. However, the majority of construction activity may be limited to summer months when human activity within the corridor is relatively high. Phased construction in the 15-mile corridor would provide opportunities for large carnivores to move through areas not currently under construction at any given time.

3.6.2.1 NO-BUILD ALTERNATIVE

Under the No-Build Alternative, none of the Keechelus Lake Alignment Alternatives, nor any of the Improvement Package for the other portions of the route, would be implemented. Therefore, none of the benefits of improved terrestrial species movement and habitat connections described below for those alternatives and Improvement Packages would be achieved. In addition, due to increased traffic volume, roadkill would be expected to increase under this alternative. Short-term adverse impacts resulting from construction, as described

in Section 3.6.2, would also not occur. The habitat losses that would occur under the various alternatives and Improvement Packages, described in the following sections, would not occur. Overall, the short-term impacts and habitat losses that would be avoided under the No-Build Alternative are considered less biologically important than the beneficial effects of implementing the Keechelus Lake Alignment Alternatives and the Improvement Packages.

3.6.2.2 KEECHELUS LAKE ALIGNMENT ALTERNATIVES

Alternative 1: Long Tunnels

Construction of the 1.9-mile-long tunnel would remove the barrier to species movement and the source of human disturbance on wildlife represented by existing I-90 along Keechelus Lake. However, improvements to north-south terrestrial habitat connectivity are limited due to the steep terrain and the presence of Keechelus Lake that provide a significant natural barrier to wildlife movement and connectivity in the Slide Curve area.

Highway realignment and other construction would result in the loss of approximately 35 acres of terrestrial habitat but recovery of 38 acres of existing roadway.

Connectivity improvements for terrestrial mammals would probably be improved most for grizzly bear and wolverine, which prefer steep terrain and are good swimmers. However, these species are uncommon in the area. Terrestrial wildlife would benefit from improved access to Keechelus Lake, and improved or restored lakeshore habitats. Benefits of the long tunnel to terrestrial species include removal of 38 acres of existing roadway along the shoreline of Keechelus Lake in this area. This would result in improvement or recovery of terrestrial and lakeshore vegetation and habitat in that area. Highway realignment and other construction would result in the loss of approximately 35 acres of terrestrial habitat, including one acre of old-growth forest, 7 acres of other forested areas, and 26 acres of other types of vegetation such as grass or clear-cut areas. Table 3.6-2 summarizes terrestrial habitat impacts (losses) for the Keechelus Lake Alignment Alternatives and Improvement Packages.

Table 3.6-2. Terrestrial Habitat Impacts for the Keechelus Lake Alignment Alternatives and Improvement Packages (acres lost)

	Mature Forest (>80 years)	*Younger Forest (<80 years)*	*Riparian*	*Other Vegetated*[1]	*Total Lost*
Keechelus Lake Alignment Alternatives					
Alternative 1	1	7	1	26	35
Alternative 2	3	10	1	39	53
Alternative 3	3	8	1	49	61
Alternative 4	2	4	1	47	54
Improvement Packages					
Improvement Package A	24	85	2	103	214
Improvement Package B	22	82	1	105	210
Improvement Package C	24	84	2	102	212

Note: 1. Primarily grassland and clearcut areas.

As a measure of the permeability of the highway to wildlife, WSDOT has calculated the "Openness Ratio" for each of the over-creek structures proposed under each of the Keechelus Lake Alignment Alternatives (Table 3.6-3).

As shown in Table 3.6-3, all of the Keechelus Lake Alignment Alternatives would improve the Openness Ratio at each creek, and the total Openness Ratio, substantially over existing conditions (No-Build Alternative). Only at Resort Creek would there be a difference among the alternatives, with Alternatives 1 and 2 having the same Openness Ratio, a slightly lower ratio for Alternative 3, and a considerably lower ratio for Alternative 4. By this measure, Alternatives 1 and 2 would provide the best highway permeability for wildlife, but all of the alternatives would improve permeability substantially over existing conditions.

Although tunnel construction and highway realignment along the shoreline of Keechelus Lake may require blasting, and would likely result in avoidance behavior for terrestrial species during the construction period, connectivity improvements under this alternative would be greater than for the other Keechelus Lake alternatives. Additionally, operation of the tunnel would have little impact on terrestrial species.

Alternative 2: Short Tunnels

Highway realignment and other construction would result in the loss of approximately 53 acres of terrestrial habitat but recovery of 21 acres of existing roadway.

Similar to Alternative 1, impacts on terrestrial species would be minor. Improvement to terrestrial habitat would be less than under Alternative 1 because less abandoned roadway would be removed (21 vs. 38 acres). Cutting the road into the hillside to straighten out the "S" curve between Rocky Run Creek and the snowshed could result in disturbance of terrestrial habitats. Highway realignment and other construction would result in the loss of approximately 53 acres of terrestrial habitat, including 3 acres of old-growth forest, 10 acres of other forested areas, and 39 acres of other types of vegetation (Table 3.6-2).

Under Alternative 2, the encroachment into the shoreline habitat would be slightly greater in the vicinity of Wolfe Creek than under Alternative 1. Further, tunnel construction and highway realignment along the shoreline of Keechelus Lake may require blasting, and would likely result in avoidance behavior for terrestrial species during construction, although, due to the shorter tunnel, this may be lower for Alternative 2 than the long tunnel option of Alternative 1. The steep terrain on the north side and the presence of the lake on the south side of the existing I-90 footprint in the Slide Curve area do not support productive terrestrial habitats. Again, operation of the tunnel would have little impact on terrestrial species. As a result, the existing on-site potential for noticeable improvements in terrestrial connectivity under Alternative 2 is limited.

Table 3.6-3. Openness Ratio Calculations for the Keechelus Lake Alignment Alternatives

LOCATION	MILE POST		EXISTING STRUCTURE		TUNNEL ALIGNMENT ALTERNATIVE 1		TUNNEL ALIGNMENT ALTERNATIVE 2		TUNNEL ALIGNMENT ALTERNATIVE 3		TUNNEL ALIGNMENT ALTERNATIVE 4
Rocky Run Creek	55.3	Structure Type	Single Span Bridge Eastbound	Double 6 foot Corrugated Metal Culvert Westbound	Single Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)
		Opening Area	398 sq. feet	57 sq. feet	832 sq. feet		832 sq. feet		832 sq. feet		832 sq. feet
		Passage Length	40 feet	75 feet	70 feet		70 feet		70 feet		70 feet
		Openness Ratio	0.75		11.89		11.89		11.89		11.89
Wolfe Creek	55.5	Structure Type	6 foot Corrugated Metal Culvert		Large Span Bottomless Culvert (Both Aligns)		Large Span Bottomless Culvert (Both Aligns)		Large Span Bottomless Culvert (Both Aligns)		Large Span Bottomless Culvert (Both Aligns)
		Opening Area	28 sq. feet		200 sq. feet		200 sq. feet		200 sq. feet		200 sq. feet
		Passage Length	150 feet		75 feet		75 feet		75 feet		75 feet
		Openness Ratio	0.19		2.67		2.67		2.67		2.67
Resort Creek	60.6	Structure Type	6 foot Corrugated Metal Culvert		Single Span Bridge Eastbound	Single Span Bridge Westbound	Single Span Bridge Eastbound	Single Span Bridge Westbound	4 Large Span Bottomless Culverts Eastbound	Single Span Bridge Westbound	4 Large Span Bottomless Culvert (Both Aligns)
		Opening Area	28 sq. feet		1,000 sq. feet	1,000 sq. feet	1,000 sq. feet	1,000 sq. feet	1,000 sq. feet	1,000 sq. feet	1000 sq. feet
		Passage Length	150 feet		62 feet	62 feet	62 feet	62 feet	75 feet	62 feet	150 feet
		Openness Ratio	0.19		16.13		16.13		13.33		6.67
Total Openness Ratio			1.13		30.68		30.68		27.89		21.22

The dimensions shown are approximate, and were developed for preliminary evaluation and assessment of impacts. Actual bridge and culvert sizes will vary, depending on the topography and intended purpose of the structure.
If additional clearance is needed on single span bridges, thin slab spans may be used to obtain clearance for bridge lengths of up to 80 feet.
Bottomless culverts will be included at locations where fish passage is required, and will be designed using standards required by WDF&W and WSDOT.
For adjacent structures, only the smaller openness ratio is displayed.

Alternative 3: Short Tunnel Westbound, No Tunnel Eastbound

Highway realignment and other construction would result in the loss of approximately 61 acres of terrestrial habitat but recovery of 13 acres of existing roadway.

This alternative would have minimal beneficial impacts on terrestrial species and habitats because the eastbound lanes of I-90 would not be removed in the Slide Curve area. Removal of 13 acres of abandoned roadway (westbound lanes) would make area available for habitat restoration. New bridges would be built at the site of the existing snowshed and at the west end of Slide Curve. Construction of these bridges and realignment of the eastbound lanes could result in short-term construction-related disturbance of terrestrial species and habitats. Highway realignment and other construction would result in the loss of approximately 61 acres of terrestrial habitat, including 3 acres of old-growth forest, 8 acres of other forested areas, and 49 acres of other types of vegetation (Table 3.6-2).

As with Alternative 2, the shorter tunnel may result in reduced blasting from Alternative 1, potentially reducing the avoidance behavior for terrestrial species during the construction period. But again, the steep terrain on the north side and the presence of the lake on the south side of I-90 in the Slide Curve area do not support productive terrestrial habitats, so disturbances would be minimal. As a result of the steep terrain, the potential for improvements in terrestrial connectivity under Alternative 3 is limited.

Alternative 4: Both Directions of Traffic Along Keechelus Lake Around Slide Curve

Highway realignment and other construction would result in the loss of approximately 54 acres of terrestrial habitat but recovery of 5 acres of existing roadway.

This alternative does not include the potential benefit of removing the highway from the lakeshore. However, removal of 5 acres of abandoned roadway would make area available for habitat restoration. Realignment of the highway in the Slide Curve area and construction of a new bridge at the west end of Slide Curve could result in disturbances or displacement of terrestrial species and habitats. Highway realignment and other construction would result in the loss of a total of approximately 54 acres of terrestrial habitat, including 2 acres of old-growth forest, 4 acres of other forested areas, and 47 acres of other types of vegetation (Table 3.6-2).

Highway realignment along the shoreline of Keechelus Lake would require blasting, likely resulting in avoidance behavior for terrestrial species during construction. As with Alternative 3, Alternative 4 would result in lakeshore displacement, with the roadway being built out across lakeshore habitat into the lake. Construction of an 800-foot-long bridge at the west end of Slide Curve and the realignment of the eastbound lanes could result in short-term construction-related disturbance, and/or long-term displacement of lakeshore vegetation and habitat. As mentioned previously, the steep terrain on the north side and the presence of the lake on the south side of the existing I-90 footprint in the Slide Curve area do not support productive terrestrial habitats. As a result, the potential for improvements in terrestrial connectivity under Alternative 4 is limited.

3.6.2.3 IMPROVEMENT PACKAGES

The three Improvement Packages have been developed to provide three different approaches to enhance hydrologic, habitat, and species movement connectivity along the I-90 corridor from the existing conditions. Overall, Improvement Package A provides the greatest improvement in connectivity, while Improvement Package C provides the least. All three packages would improve hydrologic conditions in the vicinity of I-90, which would help to restore wetlands, aquatic, and riparian habitat; reduce habitat disconnection; and facilitate movement of wildlife across the highway (beneficial effects). Improvement Package A attempts to make passage under the highway an easy and common occurrence, and provides a high confidence that connectivity would be successful for all species. Improvement Package A focuses on long bridges with enough space and sunlight underneath the bridges that plants can grow under the highway. The passage of animals and natural processes under the highway is relatively unimpeded. Some animals may have home ranges that include lands on both sides of the highway. Because the plant communities extend under the bridges, even low mobility species such as snails and salamanders can readily pass under the highway, crawling from plant to plant.

In contrast, Improvement Package C attempts to provide connectivity at reduced costs and accepts a lower probability of success. Improvement Package C focuses on smaller bridges and large culverts strategically placed in the CEAs. Many animal and plant species may not readily find and/or voluntarily pass through these smaller structures, which may or may not permit growth of plant cover within the structures. Individuals of each species might not find their way across the highway every year through these structures. Low mobility species in particular may not move across the highway with any regularity. However, it is likely that enough individuals of each species would get across the highway (intentionally or accidentally) to maintain minimal genetic connections of the species across the highway. Improvement Package B provides connectivity with greater certainty than Improvement Package C but with less certainty than Improvement Package A.

This section describes corridor-wide (outside the Keechelus Lake Alignment Alternatives) impacts for each of the Improvement Packages. Table 3.6-4 discusses the specific effects of each Improvement Package on terrestrial habitats and functions at each of the stream crossings, or CEAs, in the corridor.

Table 3.6-4. Improvement Package Consequences for Terrestrial Species (Page 1 of 4)

Connectivity Enhancement	*Beneficial Impacts*	*Adverse Impacts*
Gold Creek		
A	High probability of connecting wide-ranging HMS populations contingent on restoration of Forest Service Road (FSR) 4832 and recreation access management. Lower probability of connecting LMS populations. Crossing structures are expected to benefit up to 46 mammal, 12 amphibian, and 13 mollusk species. Changes to adjacent habitats from removal of existing road embankment allow for minor restoration, and improvement of riparian and terrestrial habitat conditions.	Disturbance of habitat and species during construction, and loss of habitat through widening of the existing approach embankments. However, restoring aquatic, riparian, and terrestrial habitats where the existing road embankment is located would compensate for the approach widening. See text for description of generic construction and operations impacts, and Package-wide habitat loss impacts.
B	Impacts similar to Package A.	Impacts similar to Package A.
C	Moderate potential for in-structure habitat development. The proposed bridges are adequate for ungulate passage, although passage for some other species is less certain. Changes to adjacent habitats from removal of existing road embankment allow for minor restoration and improvement of riparian and terrestrial habitat conditions.	Impacts similar to Package A.
Townsend Creek		
A, B, and C	Minor improvement in hydrologic connectivity may slightly improve both terrestrial and riparian habitats. However, the steep terrain in the area and the presence of Keechelus Lake provide limited potential for terrestrial species movement.	Construction would not result in any loss of terrestrial habitat.
Price/Noble Creeks		
A	The structure at the western draw has a high probability of connecting HMS and LMS populations to diverse adjacent habitats. The structure over the creeks has a high probability of connecting HMS and LMS populations to diverse adjacent habitats, would improve hydrologic connectivity and function, riparian habitats, and riparian function. The structure east of Noble Creek has a high probability of connecting HMS and LMS to adjacent habitats. The two hydrologic connectivity structures have a high probability of improving hydrologic connectivity and function, riparian habitats, and riparian function. Additionally, the removal and restoration of the Sno-park pavement structure, and the expected natural habitat recovery would also improve surface hydrologic and terrestrial habitat connectivity.	Disturbance of species and habitat during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW. However, restoring habitat where the existing Sno-park is located would compensate for the approach widening.
B	The structure at the western draw has a moderate to high probability of connecting both HMS and LMS populations to diverse adjacent habitats. The structure over the creeks has a reduced vertical clearance from Package A and may only allow for improved terrestrial species movement during periods of low or no snow. The two hydrologic connectivity structures have a high probability of improving hydrologic connectivity and function, riparian habitats, and riparian function. Additionally, the removal and restoration of the Sno-park pavement structure, and the expected natural habitat recovery would also improve surface hydrologic and terrestrial habitat connectivity.	Disturbance of species and habitats during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW. However, restoring habitat where the existing Sno-park is located would compensate for the approach widening.
C	The smaller single span bridges and potential year-round use of the Sno-park results in a lower probability of improving connectivity for LMS and HMS than Packages A and B. Moderate probability of LMS movement if crossing structures incorporate appropriate physical habitat features in the design. Terrestrial habitat improvement is rated as low. The two hydrologic connectivity structures have a high probability of improving hydrologic connectivity and function, riparian habitats, and riparian function.	Disturbance of species and habitat during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.

Table 3.6-4. Improvement Package Consequences for Terrestrial Species (Page 2 of 4)

Connectivity Enhancement	*Beneficial Impacts*	*Adverse Impacts*
Bonnie Creek		
A	High probability of connecting both HMS and LMS populations associated with old growth, wetland, and riparian habitats. Good habitat condition and diverse habitats provide for high species permeability. Structures should decrease the high number of roadkill incidents. High probability of improving LMS movement if crossing structures incorporate appropriate physical habitat features in the design. Habitat conditions are expected to improve on the south side due to more natural connection of wetland and terrestrial habitats present, and the high and wide crossing structures. The high bridge structures should allow for plant growth to occur under the bridges.	Disturbance of species and habitat during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
B	High probability of connecting both HMS and LMS populations associated with wetland habitats. Low probability of connecting both HMS and LMS populations associated with old growth. Reduced vertical clearance from Package A may only allow for improved permeability of some species during periods of low or no snow. High probability of improving LMS movement if crossing structures incorporate appropriate physical habitat features in the design. Habitat conditions are expected to improve on the south side due to more natural connection of wetland habitat.	Disturbance of species and habitat during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
C	No improvement to baseline terrestrial connectivity or adjacent habitat conditions.	Disturbance of species and habitat during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
Swamp Creek		
A	Bridge to the west has a low probability of connecting HMS and a moderate probability of connecting LMS to habitats on opposite sides of I-90. Bridge to the east has a high probability of connecting species associated with rare soil types. Landscape connectivity is high in the region of Swamp Lake, where associated wetlands have high biodiversity and contain rare plant and fungi species, although topographic fit for connectivity is low.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
B	Together, bridges have a moderate probability of connecting HMS and LMS to habitats on either side of I-90. Bridge to the east has a high probability of connecting species associated with rare soil types, although reduced vertical clearance from Package A may only allow for improved permeability for other species during periods of low or no snow. Landscape connectivity is high in the region of Swamp Lake, where associated wetlands have high biodiversity and contain rare plant and fungi species, although topographic fit for connectivity is low. Hydrologic connectivity is expected to improve associated habitats.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
C	Proposed bridges are adequate for ungulate passage. Hydrologic connectivity is expected to improve associated habitats.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.

Table 3.6-4. Improvement Package Consequences for Terrestrial Species (Page 3 of 4)

Connectivity Enhancement	*Beneficial Impacts*	*Adverse Impacts*
Toll Creek		
A	High potential for improving HMS and LMS connectivity. Riparian and terrestrial habitat will improve due to fill removal with the potential of improving wetland, riparian, and terrestrial habitats and connectivity.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
B	Impacts similar to Package A.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
C	Low to moderate potential for improving HMS and LMS connectivity. Riparian and terrestrial habitat would marginally improve due to increased wetland function.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
Cedar Creek		
A, B, and C	Replacement of the existing culvert with a larger structure is expected to improve stream functioning and riparian habitats downstream of I-90. There may be some benefit to LMS permeability.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
Telephone Creek		
A, B, and C	Replacement of the existing culvert with a larger structure is expected to improve stream functioning and riparian habitats downstream of I-90. There may be some benefit to LMS permeability.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
Hudson Creek		
A	Moderate to high improvement over baseline for HMS connectivity. Marginal topographical HMS fit. High potential for improvement of LMS and talus-associated species, although low vertical clearance may limit habitat connectivity/permeability during periods of low or no snow. This is the only place in the corridor to connect talus-associated species. Improvement in hydrologic connectivity is expected to improve riparian conditions downstream of the bridges.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
B	Impacts similar to Package A.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
C	No improvements to existing terrestrial connectivity or habitat conditions are expected to occur under this design.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.

Table 3.6-4. Improvement Package Consequences for Terrestrial Species (Page 4 of 4)

Connectivity Enhancement	*Beneficial Impacts*	*Adverse Impacts*
Easton Hill		
A	Topographic fit for landscape is high. Moderate potential for HMS connectivity and LMS species. Relatively low vertical clearance may limit improved permeability during periods of low or no snow, and limit potential under-structure habitat improvements. Design change should reduce the prevalence of high roadkill densities in this area. Should also reduce this threat to other late-successional species in the area. Removal and restoration of old roadbed to terrestrial and wetland habitat would also occur.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
B	Topographic fit for local features is high but not for wildlife movement patterns at the landscape scale. High probability of upland HMS and LMS connectivity. Design change should reduce the prevalence of high roadkill densities in this area. Should also reduce this threat to other late-successional species in the area. Removal and restoration of old roadbed to terrestrial and wetland habitat would also occur.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
C	Topographic fit is high for landscape connectivity. This design package appears to be best suited for terrestrial species movement. Low to moderate improvement for LMS species. Design change should reduce the prevalence of high roadkill densities in this area. Should also reduce this threat to other late-successional species in the area. Removal and restoration of old roadbed to terrestrial and wetland habitat would also occur.	Disturbance of habitat and species during construction, and loss of habitat through ground disturbance, vegetation removal, and placement of fill from widening of the existing ROW.
Kachess River/Lake Easton		
A	Minimal potential to improve HMS and LMS habitat connectivity. Low to moderate potential of improving HMS and LMS species connectivity through increased permeability.	Minimal disturbance of habitat and species from bridge widening.
B, C	Minimal potential to improve HMS and LMS habitat connectivity, or HMS and LMS species connectivity through increased permeability.	Minimal disturbance of habitat and species from bridge widening.

Notes: 1. Meets with some design revision (see Appendix A details)
Information derived from the most current WSDOT design plans (4-16-04) and from the *Interstate 90 Snoqualmie Pass East MDT Draft Recommendation Package* (MDT 2004).

Road density in the project area may affect the permeability benefits of the proposed improvements. Road density in the Upper Yakima sub-watershed is 3.8 miles/square miles (Theil 1985, Van Dyke et al. 1986, Mech et al. 1988, Lovallo and Anderson 1996, Mace et al. 1996). Recommendations based on the best available science indicate that road density (including major highways and primary, secondary, and tertiary roads within public lands) above 2.0 miles/square miles are detrimental to movement of large carnivore species (Theil 1985, Van Dyke et al. 1986, Mech et al. 1988, Lovallo and Anderson 1996, Mace et al. 1996). Since large carnivores are wide-ranging species, it is reasonable to assume that less mobile species (small mammals, amphibians, reptiles, invertebrates, and plants) are also affected adversely by these road densities. The USFS is in the process of reducing road density on USFS land in the project corridor; this is expected to help realize the potential permeability benefits of the proposed project.

Table 3.6-5 shows Openness Ratios for each option at each of the CEAs, as well as the total Openness Ratio for each Improvement Package. These values support the idea that Improvement Package A provides the best overall permeability for terrestrial species, and that Improvement Packages A and B provide substantially better permeability than Improvement Package C. Improvement Package C has a total Openness Ratio approximately twice that of existing structures, supporting the idea that even Improvement Package C improves permeability considerably. The CEAs with the greatest differences among the Improvement Packages in Openness Ratio are Gold Creek, Price/Noble Creek, Bonnie Creek, and Easton Hill. Improvement Package C fares the worst in comparison to the other Improvement Packages at these CEAs (C is worse than B but better than A at Easton Hill). Of these CEAs, Improvement Package B has a greater Openness Ratio than Improvement Package A at Gold Creek and Easton Hill. Openness Ratios are low at CEAs for which passage of large wildlife is a low priority and culverts are proposed under all three Improvement Packages (Townsend Creek, Toll Creek, Cedar Creek, and Telephone Creek). Hydrologic Connectivity Zones obviously have low Openness Ratios.

Several additional limitations to the success of all of the Improvement Packages include Keechelus Lake water elevations that may prevent year round movement of species. Lake elevations may be high enough in spring and summer to flood terrestrial connections under the bridge at Gold Creek, for example. At Price/Noble Creek, closure of the Sno-park would be essential in providing connectivity. At the Bonnie Creek site, the Crystal Springs Campground may elicit avoidance during summer months; however, during most of the week, the campground is relatively empty. In addition, the Swamp Lake area is heavily impacted by recreational activities and private landholdings, and development is occurring at Hyak and Easton.

Table 3.6-5. Openness Ratio Calculations for the Improvement Packages
(Page 1 of 4)

LOCATION	MILE POST		EXISTING STRUCTURE		Improvement Package A		Improvement Package B		Improvement Package C	
Gold Creek West	55.3	Structure Type	No Structure		Single Span Bridge (Both Aligns)		No Structure		Single Span Bridge (Both Aligns)	
		Opening Area			1,512 sq. feet				1,152 sq. feet	
		Passage Length			62 feet				62 feet	
		Openness Ratio			24.39				18.58	
Gold Creek	55.5	Structure Type	Multi-Span Bridge Eastbound	Multi-Span Bridge Westbound	Multi-Span Bridge Eastbound	Multi-Span Bridge Westbound	Multi-Span Bridge Eastbound	Multi-Span Bridge Westbound	Multi-Span Bridge Eastbound	Multi-Span Bridge Westbound
		Opening Area	1,713 sq. feet	1,849 sq. feet	31,200 sq. feet	25,200 sq. feet	32,700 sq. feet	26,700 sq. feet	7,200 sq. feet	7,200 sq. feet
		Passage Length	40 feet	40 feet	62 feet	62 feet	62 feet	62 feet	62 feet	62 feet
		Openness Ratio	42.82		406.45		430.65		116.13	
Townsend Creek	60.6	Structure Type	6 foot diam. Corrugated Metal (CM) Culvert		Large Span Bottomless Culvert		Large Span Bottomless Culvert		Large Span Bottomless Culvert	
		Opening Area	28 sq. feet		160 sq. feet		160 sq. feet		160 sq. feet	
		Passage Length	150 feet		75 feet		75 feet		75 feet	
		Openness Ratio	0.19		2.13		2.13		2.13	
Price/Noble Vicinity West	60.9	Structure Type	2 foot Culvert		Single Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)	
		Opening Area	3 sq. feet		1,512 sq. feet		1,512 sq. feet		1,512 sq. feet	
		Passage Length	150 feet		60 feet		60 feet		60 feet	
		Openness Ratio	0.02		25.20		25.20		25.20	
Price Creek	61.3	Structure Type	10 foot Box Culvert		Multi-Span Bridge (Both Aligns)		Multi-Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)	
		Opening Area	100 sq. feet		13,752 sq. feet		6,966 sq. feet		1,092 sq. feet	
		Passage Length	200 feet		60 feet		60 feet		60 feet	
		Openness Ratio	0.50		229.20		116.10		18.20	

Table 3.6-5. Openness Ratio Calculations for the Improvement Packages
(Page 2 of 4)

LOCATION	MILE POST		EXISTING STRUCTURE		Improvement Package A	Improvement Package B	Improvement Package C
Noble Creek	61.4	Structure Type	4 foot diam. CM Culvert		Multi Span Bridge for Price Creek Spans Noble Creek Also	Multi Span Bridge for Price Creek Spans Noble Creek Also	Single Span Bridge (Both Aligns)
		Opening Area	13 sq. feet				1,092 sq. feet
		Passage Length	250 feet				60 feet
		Openness Ratio	0.05				18.20
Price/Noble Vicinity East[1]	61.8	Structure Type	2 foot diam. Culverts		Multi-Span Bridge (Both Aligns)	Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.	Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.
		Opening Area	3 sq. feet		798 sq. feet		
		Passage Length	250 feet		60 feet		
		Openness Ratio	0.01		13.30		
Bonnie Creek West Fork	62.2	Structure Type	2 foot diam. CM culvert		Multi-Span Bridge (Both Aligns)	Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.	Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.
		Opening Area	3 sq. feet		11,200 sq. feet		
		Passage Length	150 feet		60 feet		
		Openness Ratio	0.02		186.67		
Bonnie Creek East Fork[1]	62.3	Structure Type	6 foot x 6 foot Box Culvert	6 foot diam. CM Culvert	Multi Span Bridge Spans Both West and East Forks	Multi-Span Bridge (Both Aligns)	Large Span Bottomless Culvert
		Opening Area	36 sq. feet	28 sq. feet		2,712 sq. feet	150 sq. feet
		Passage Length	150 feet	150 feet		60 feet	75 feet
		Openness Ratio	0.19			45.20	2.00
Swamp Creek Vicinity West	62.5	Structure Type	No Structure		Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.	Single Span Bridge (Both Aligns)	Hydrologic Connectivity Zone – Conveyance methods and limits to be determined through further study.
		Opening Area				1,152 sq. feet	
		Passage Length				60 feet	
		Openness Ratio				19.20	

Table 3.6-5. Openness Ratio Calculations for the Improvement Packages
(Page 3 of 4)

LOCATION	MILE POST		EXISTING STRUCTURE	Improvement Package		
				A	B	C
Swamp Creek[1]	62.8	Structure Type	8 foot double box	Multi-Span Bridge (Both Aligns)	Single Span Bridge (Both Aligns)	Single Span Bridge (Both Aligns)
		Opening Area	128 sq. feet	3,300 sq. feet	1,152 sq. feet	1,152 sq. feet
		Passage Length	200 feet	84 feet	60 feet	60 feet
		Openness Ratio	0.64	39.29	19.20	19.20
Swamp Creek Vicinity East	63.3	Structure Type	18 inch diam. culvert	Single Span Bridge (Both Aligns)	Single Span Bridge (Both Aligns)	Large Span Bottomless Culvert
		Opening Area	2 sq. feet	1,000 sq. feet	1,000 sq. feet	150 sq. feet
		Passage Length	150 feet	84 feet	84 feet	75 feet
		Openness Ratio	0.01	11.90	11.90	2.00
Toll Creek Vicinity West	63.6	Structure Type	8 foot X 8 foot box culvert	Single Span Bridge (Both Aligns)	Single Span Bridge (Both Aligns)	Large Span Bottomless Culvert
		Opening Area	64 sq. feet	1,388 sq. feet	1,388 sq. feet	180 sq. feet
		Passage Length	150 feet	60 feet	60 feet	75 feet
		Openness Ratio	0.43	23.13	23.13	2.40
Toll Creek	64.2	Structure Type	4 foot diam. conc. culvert	Culvert	Culvert	Culvert
		Opening Area	13 sq. feet	30 sq. feet	30 sq. feet	30 feet
		Passage Length	200 feet	225 feet	225 feet	225 feet
		Openness Ratio	0.06	0.13	0.13	0.13
Cedar Creek	64.6	Structure Type	4 foot box culvert	Culvert	Culvert	Culvert
		Opening Area	16 sq. feet	16 sq. feet	16 sq. feet	16 feet
		Passage Length	150 feet	80 feet	80 feet	80 feet
		Openness Ratio	0.11	0.20	0.20	0.20
Telephone Creek	65.6	Structure Type	5 foot X 4 foot box culvert	Culvert	Culvert	Culvert
		Opening Area	20 sq. feet	16 sq. feet	16 sq. feet	16 feet
		Passage Length	150 feet	150 feet	150 feet	150 feet
		Openness Ratio	0.13	0.11	0.11	0.11

Table 3.6-5. Openness Ratio Calculations for the Improvement Packages
(Page 4 of 4)

LOCATION	MILE POST		EXISTING STRUCTURE		Improvement Package A		Improvement Package B		Improvement Package C	
"Hudson Creek Vicinity East"	67.2	Structure Type	2 foot diam. conc. culvert		Multi-Span Bridge (Both Aligns)		Single Span Bridge (Both Aligns)		Culvert	
		Opening Area	3 sq. feet		2,100 sq. feet		1,000 sq. feet		16 sq. feet	
		Passage Length	150 feet		72 feet		72 feet		180 feet	
		Openness Ratio	0.02		29.17		13.89		0.09	
Easton Hill	67.5	Structure Type	No Structure		Single Span Bridge (Both Aligns)		Animal Overcrossing Structure (Both Aligns)		Single Span Bridge Eastbound	Animal Overcrossing Structure Westbound
		Opening Area			1,000 sq. feet		N/A		1,350 sq. feet	N/A
		Passage Length			72 feet		250 feet		72 feet	150 feet
		Openness Ratio			13.89		N/A		18.75	N/A
Lake Kachess Vicinity (County Road)	69.5	Structure Type	Single Span Bridge Eastbound	Single Span Bridge Westbound	Single Span Bridge (Both Aligns)		Single Span Bridge Eastbound	Single Span Bridge Westbound	Single Span Bridge Eastbound	Single Span Bridge Westbound
		Opening Area	406 sq. feet	440 sq. feet	2,040 sq. feet		406 sq. feet	440 sq. feet	406 sq. feet	440 sq. feet
		Passage Length	38 feet	50 feet	72 feet		60 feet	72 feet	60 feet	72 feet
		Openness Ratio	8.79		28.33		6.11		6.11	
Kachess River	69.8	Structure Type	Multi-Span Bridge Eastbound	Multi-Span Bridge Westbound	Widen Existing Bridge (Both Aligns)		Widen Existing Bridge (Both Aligns)		Widen Existing Bridge (Both Aligns)	
		Opening Area	806 sq. feet	1,497 sq. feet	819 sq. feet	1,495 sq. feet	819 sq. feet	1,495 sq. feet	819 sq. feet	1,495 sq. feet
		Passage Length	38 feet	32 feet	60 feet	60 feet	60 feet	60 feet	60 feet	60 feet
		Openness Ratio	21.22		13.65		13.65		13.65	
Total Openess Ratio			75.08		1047.13		767.59		263.08	

Notes: 1. At Price/Noble, Bonnie, and Swamp Creek CEAs, as well as other areas, minor culverts will be installed in all packages as needed to provide added hydrologic connectivity.
The dimensions shown are approximate, and were developed for preliminary evaluation and assessment of impacts. Actual bridge and culvert sizes will vary, depending on the topography and intended purpose of the structure.
If additional clearance is needed on single span bridges, thin slab spans may be used to obtain clearance for bridge lengths of up to 80 feet.
Bottomless culverts will be included at locations where fish passage is required, and will be designed using standards required by WDFW and WSDOT.
Culverts will be used in non-fish bearing streams and will be designed to the appropriate hydraulic standards.
For adjacent structures only the smaller openness ratio is displayed.
Additional hydrologic connectivity zones have been identified throughout the corridor. Specific attributes of hydrologic connectivity zones will be determined through field study and detailed design.

The three Improvement Packages differ little in the terrestrial habitat that would be lost due to construction, but there are moderate differences among the Improvement Packages in the size of roadway reclamation areas where natural habitat could potentially be restored (see following sections). Table 3.6-2 summarizes habitat loss and habitat restoration areas for the Improvement Packages.

Improvement Package A

The options provided under Improvement Package A represent a high level of permeability within the I-90 corridor. Improvement Package A provides longer bridges, in most cases, than Improvement Package B. Improvement Package A provides connectivity of the greatest range of habitat types, including the best opportunity to connect talus-associated species in the Hudson Creek area.

Under Improvement Package A, multiple bridges of various lengths would be installed at all major and most minor stream crossings (culverts would be installed at the other sites), allowing for more natural stream channel migration, improvement of riparian habitat function, and facilitation of terrestrial species movement across the highway. These changes would improve the viability of, and interaction between, wildlife in the North Cascades with those from the South Cascades through increased permeability, and habitat connectivity and function. Improvement Package A would significantly improve terrestrial habitats and terrestrial linkages for both LMS and HMS in the project area (Appendix A).

The removal of highway fill at the bridge sites would allow terrestrial communities to re-establish themselves in the ROW at many of these sites and would promote connectivity between terrestrial systems on opposite sides of the highway. Terrestrial benefits expected from this Improvement Package include improved species movement across a more permeable highway, improved terrestrial habitat linkages and function, reduced genetic isolation of populations, and improved community and species viability. This Improvement Package would result in the greatest improvement of hydrologic and ecological connectivity in the project area, resulting in the greatest benefit to terrestrial habitats and species among the Improvement Packages.

Overall, under this Improvement Package, there would be a major improvement in terrestrial habitat connectivity, function, and permeability for species movement in the vicinity of the I-90 corridor. However, the highway would still represent an obstacle to north-south terrestrial connectivity and species movement in the region, and this Improvement Package is not expected to result in the complete restoration of ecological connectivity in the region to pre-I-90 conditions.

Although Improvement Package A greatly increases the permeability within the corridor, limiting issues discussed in Section 3.6.2.3 would apply. Human access

to connectivity structures should be limited, if possible, to improve the likelihood of successful crossings by sensitive wildlife. Improvement Package A removes the existing Sno-park at Price/Noble Creek, which would decrease the amount of human activity at this location.

Under this Improvement Package, a total of 214 acres of terrestrial habitat would be lost due to highway construction, of which 24 acres are old-growth (late-successional) forest, 85 acres are other forested areas, and 103 acres are other vegetated areas (Table 3.6-2). Roadway reclamation areas, where natural habitat could potentially be restored, would total approximately 29 acres.

Improvement Package B

The options with Improvement Package B represent a high level of connectivity that is economically constrained. This Improvement Package represents a strong commitment to enhance ecological connectivity but focuses on using higher-cost structures (i.e., multi-span bridges) at CEAs where multiple ecological needs overlap. Although this Improvement Package does not make the interstate as permeable as Improvement Package A, Improvement Package B allows for much greater permeability than Improvement Package C or the current baseline conditions.

Multi-span bridges allow for greater connectivity between different habitat types, such as streams, riparian, and upland areas, which does not occur with culverts or small bridges. Higher clearance provides not only a greater openness ratio, but also the ability to establish vegetation and large woody debris that would provide a more hospitable environment for dispersing small mammals, amphibians, and invertebrates.

The connectivity structures that would be installed under Improvement Package B are similar to those under Improvement Package A, except that shorter bridges or culverts would be installed at Price/Noble East, Bonnie Creek, and Hudson Creek, and an animal overcrossing would be installed at Easton Hill instead of a short bridge. As a result, there would be slightly less benefit to terrestrial species, habitat linkages, and functions than under Improvement Package A. The installation of crossing structures is expected to facilitate movement of terrestrial species across the highway. Where fill would be removed for bridge installation, terrestrial habitats and wetlands could develop in the ROW, with improved connectivity between habitats on opposite sides of the highway.

Improvement Package B provides improved passage at Gold Creek but does not address the issues of human activity within the watershed. The WSDOT Maintenance Facility, Hyak Lodge, Hyak Water Treatment Facility, and the Snoqualmie Ski area all contribute to human disturbance within the Gold Creek Valley. In addition, the Gold Creek Valley contains private landholdings and year-round recreational activities.

Improvement Package B removes the existing Sno-park at Price/Noble Creek, which would decrease the amount of human activity at this location. However, road densities remain the same and may not be conducive to movement of large carnivore species that are sensitive to human presence. The additional limiting factors discussed in Section 3.6.2.3 would also apply.

There would be a significant improvement in terrestrial linkages in the vicinity of I-90 over current conditions under this Improvement Package. However, the highway would still represent an obstacle to north-south terrestrial connectivity and species movement in the region.

Under this Improvement Package, a total of 210 acres of terrestrial habitat would be lost due to highway construction, of which 22 acres are old-growth (late-successional) forest, 82 acres are other forested areas, and 105 acres are other vegetated areas (Table 3.6-2). Roadway reclamation areas, where natural habitat could potentially be restored, would total 16 acres.

Improvement Package C

Compared to Improvement Package B, under Improvement Package C, shorter bridges would be installed and culverts would be installed instead of bridges at seven CEAs. The resulting benefits to terrestrial connectivity and terrestrial habitat conditions would be significantly less than under Improvement Packages A and B. It represents a substantial improvement over existing conditions in terms of terrestrial connectivity and benefits to terrestrial habitat.

Those areas indicated by Singleton and Lehmkuhl (2000) as high roadkill areas contain structures large enough under this Improvement Package to adequately allow for the passage of large ungulates. They include Gold Creek, Price/Noble Creek, Swamp Creek, and Easton Hill. Large culverts would be installed at four additional CEAs: Townsend Creek, Bonnie Creek, Swamp Creek East, and Toll Creek West. In addition, hydrologic connectivity zones at Price/Noble Creek and Bonnie Creek would provide passage for smaller organisms. These structures are intended to improve terrestrial habitat connectivity and function, and allow for improved terrestrial species movement across the highway. Overall, under this Improvement Package, there would be a substantial improvement in terrestrial connectivity and conditions for terrestrial habitat in the vicinity of I-90. However, the highway would still represent an obstacle to terrestrial species movement and terrestrial habitat connectivity in the region.

Improvement Package C, will improve terrestrial connectivity over the existing baseline conditions, but will provide minimal exchange among populations within the corridor. The options within Improvement Package C may limit the dispersal ability of small organisms based on distance between connectivity elements. The factors limiting the ecological benefits of all the Improvement Packages (Section 3.6.2.3) would apply. The Price Creek Sno-park would remain; however, human use of the westbound Sno-park and year-round activity

at the eastbound toilet facilities may cause animals to avoid this area and discourage use of crossing structures.

Under this Improvement Package, a total of 212 acres of terrestrial habitat would be lost due to highway construction, of which 24 acres are old growth (late-successional) forest, 84 acres are other forested areas, and 102 acres are other vegetated areas (Table 3.6-2). Roadway reclamation areas, where natural habitat could potentially be restored, would total approximately 7 acres.

3.7 Transportation

This portion of I-90 transitions from the mountainous terrain of the Cascades to the more level plateaus of eastern Washington.

This part of the Environmental Impact Statement (EIS) was prepared based on the *Transportation Discipline Reports* (Washington State Department of Transportation [WSDOT] 2002f and 2004g) (Appendix U). The purpose of the discipline report was to analyze how the existing transportation system functions, and predict how the facility would function in the future (design year 2028). It also evaluated existing conditions for the roadway, roadside hazards, crash rates, traffic volumes, operations, bicycles and pedestrians, and construction impacts.

A Level of Service (LOS) analysis was used to determine how the facility functions. This included traffic counts to develop a trend line for future traffic volumes. For a list of LOS categories, refer to Table 3.7-1.

The primary area of influence for transportation is a 15-mile portion of Interstate 90 (I-90) from Hyak interchange at Milepost (MP) 55.1 to the West Easton Interchange at MP 70.3 in Kittitas County.

3.7.1 Affected Environment

3.7.1.1 Transportation System and Network

Roadway Facilities

Nationally, I-90 extends from the Port of Seattle east to Boston, Massachusetts. This 3,111-mile corridor is the longest limited access highway in the world, and links the Seattle/Puget Sound area with Eastern Washington and the rest of the country.

The project area, from the Hyak vicinity at MP 55.1 to the West Easton Interchange at MP 70.3, is on the eastern side of Snoqualmie Pass. This portion of I-90 transitions from the mountainous terrain of the Cascades to the more level plateaus found in eastern Washington. There are four interchanges in this 15-mile portion of I-90: the Hyak Interchange, Stampede Pass Interchange, Cabin Creek Interchange, and West Easton Interchange.

Table 3.7-1. Level of Service Categories

LOS A	Free-flow speed prevails. Vehicles can maneuver easily; incidents such as accidents, vehicles on road shoulders, etc., or point breakdowns (land reduction, merging, or weaving segments, etc.) do not affect traffic flow.
LOS B	Free-flow speeds are maintained. Vehicles can maneuver easily with only slight restriction; minor incidents and point breakdowns are still easily absorbed.
LOS C	Speed remains near free-flow, but freedom to maneuver is noticeably restricted. Minor incidents may still be absorbed, but the local deterioration in service will be substantial.
LOS D	Speed begins to decline slightly with increasing flows, and density increases more quickly. Freedom to maneuver is noticeably limited, and driver comfort level is significantly reduced; even minor incidents can be expected to create queuing since the traffic stream has little space to absorb disruptions.
LOS E	Unstable flow, with volume at capacity. Maneuverability within the traffic stream is extremely limited, and driver comfort level is poor; the traffic stream has no ability to dissipate even the most minor disruption, and any incident can be expected to produce a serious breakdown with extensive queuing.
LOS F	Breakdown in traffic flow. Queuing generally forms behind breakdowns.

I-90 is a four-lane facility in the project area. In areas where an unpaved median is present, each direction of traffic has two 12-foot lanes, a 4-foot inside shoulder, and an 8 to 10-foot outside shoulder. In areas where the alignments come together and have a common paved median, the paved median is 15 feet wide, and the directions of travel are separated by concrete barrier. The posted speed varies depending on the weather conditions, with a maximum speed of 65 miles per hour (mph). I-90 design deficiencies are described in detail in Chapter 1 *Purpose and Need*.

There are two primary existing transportation plans guiding future improvements to I-90, and other transportation facilities and systems in Washington. These plans are:

- *Washington Transportation Plan*, adopted by the Washington State Transportation Commission on February 20, 2002.
- *Mountains-to-Sound Greenway Implementation Plan, Vol. 4* created by WSDOT.

Bicycle and Pedestrian Facilities

There are numerous trail systems that serve pedestrians near the project area. These trail systems vary from strenuous backcountry hiking trails to paved flat walking trails, and are heavily used for recreational purposes. I-90 serves as their access point.

The project corridor is located within the 100-mile long Mountains-to-Sound Greenway path, which serves pedestrians, bicycles, equestrian travel, and disabled persons through a network of trails found near the I-90 corridor. Once these trails are linked according to the *Mountains-to-Sound Greenway Implementation Plan, Vol. 4*, they will provide a continuous trail system through the Mountains-to-Sound Greenway (WSDOT 1998). Selected trails to be linked by the Mountains-to-Sound Greenway include:

- High Point/Preston link: 3 miles.
- Snoqualmie Centennial Trail: 2 miles, paved.
- Cross-state John Wayne Pioneer Trail: 60 miles east from the Cedar Falls trail and accessible at seven points along I-90. This trail is

handicapped-accessible at one point. With repairs now underway, this rail bed trail will provide a continuous, easy grade, handicapped-accessible, unpaved trail to the Mountains-to-Sound Greenway terminus at Thorp.

Other trails accessed within the project corridor:

- Pacific Crest Trail: a 2,600-mile backcountry National Scenic Trail that crosses I-90 at Snoqualmie Pass.
- Alpine Lakes Wilderness trail system: a large network of scenic backcountry trails north of the project.

Currently, cyclists use the 10-foot outside shoulders along I-90. Pedestrian access is prohibited. Large numbers of cyclists use the I-90 shoulders during two bike rallies that occur during the summer. Use by cyclists during the remainder of the year is minimal.

The Washington State Legislature passed the Growth Management Act in 1990 to encourage wise land use and planning. Transportation planning is recognized as a vital element of growth management, and the Growth Management Act calls on local communities to rethink the traditional approach to transportation planning. Under the Growth Management Act, transportation plans need to be consistent with the community's comprehensive plan. In addition, regions are to agree on a framework for transportation facilities and strategies. The project corridor is located within Kittitas County, which has adopted a comprehensive plan under the Growth Management Act.

3.7.1.2 System Demand, Capacity, and Levels of Service

Traffic Growth Rate and Volumes

Data from four automatic traffic counters were used to establish the traffic growth rate used for the project. The base project growth rate was determined to be 3.5 percent using the data from the counter near the Cabin Creek Interchange. Because the Cabin Creek Interchange counter was installed in 1998 and there were only four years worth of data, one counter west of the project in North Bend and two counters east of the project in Cle Elum were used to provide historical trends. Data used to determine the growth rate on the project is presented in the *Transportation Discipline Report* (WSDOT 2004g). The historical trends from the other counters verified that the 3.5 percent growth rate selected for the project was reasonable. This growth rate is assumed to include the effects of induced growth resulting from improved travel conditions.

Table 3.7-2. Predicted AADT for I-90

Year	*AADT*
2002	26,968
2003	27,912
2004	28,856
2005	29,800
2008	32,631
2013	37,351
2018	42,070
2023	46,789
2028	51,509

Using the growth rate determined for the project and the existing traffic data at the Cabin Creek Interchange counter, Average Annual Daily Traffic (AADT) was determined for the project design period. AADT is defined as the total number of vehicles passing a point on the highway in both directions in a year divided by the number of days in that year (WSDOT 2004g). The AADT is used to determine the number of lanes needed, and the need for safety devices such as barriers and lighting. The design period for traffic analysis is defined from the year 2008 to 2028. Table 3.7-2 gives the Predicted AADT used in the project traffic analysis.

Forecast Methodology and Level of Service

To maintain facility performance at an acceptable service level, a "design hour" must be selected to reflect the traffic conditions on the project. The design hour refers to the highest hourly volume of traffic that would be accommodated with acceptable traffic flow conditions. The design hour is then translated into corresponding facility engineering requirements. Typically, the design hour ranges from the 30th to the 100th highest peak hour volume. The highest peak hour is not used because designing the facility at that level would be excessive and expensive.

To select the design hour, a graph of the data is created. The design hour is typically selected at the point along the curve of the graphed data where an upward bend in the curve is visible. The location of the bend reflects the point where a compromise between LOS and economic efficiency is clear. For this portion of I-90, the 100th peak hour volume was selected because the traffic data showed a relatively level trend from the 10th hour to the 200th hour (Figure 3.7-1). The 100th highest hour is justified because 90 percent of the highest hour volumes occurred on a weekend, which means the 100th hour level will accommodate the typical weekend traffic volumes. Additional descriptions and details in relation to the selection of the design hour are presented in the *Transportation Discipline Report* (WSDOT 2004g).

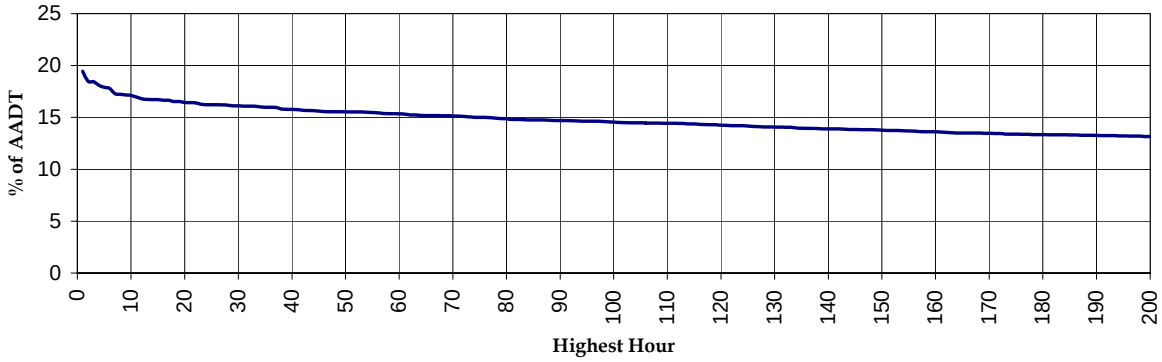


Table 3.7-3. LOS Thresholds

LOS	*Density Range (pc/mi/ln)*
A	0-11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	>45

pc/mi/ln = passenger cars per mile per lane

Figure 3.7-1. Highest 200 Hours for I-90 in 2002

A basic highway segment can be characterized by three performance measures: 1) density in terms of passenger cars per mile per lane (pc/mi/ln); 2) speed in terms of mean passenger-car speed; and 3) volume-to-capacity ratio. Each of these measures indicates how well traffic flow functions on the highway. The measure used to provide an estimated LOS is density. For a basic highway segment, the LOS thresholds are summarized in Table 3.7-3. In simple terms, LOS A reflects good driving conditions with few cars on the road; LOS B reflects good driving conditions with cars on the road, but no related driving limitations; LOS C reflects increasing numbers of cars on the road and driving conditions with some limitations; LOS D reflects driving conditions where vehicle speeds drop and driving conditions are limited; LOS E reflects that the system is near capacity with no gaps between vehicles, and the traffic stream has slowed considerably and is volatile; and LOS F reflects driving conditions where vehicle speeds have dropped substantially, and stop-and-go conditions may exist. Current traffic volumes exceed the highway design capacity during peak travel periods. In the future, anticipated traffic volumes will result in conditions that will exceed design capacity on a far more frequent basis. The anticipated lack of capacity is expected to lead to higher crash rates, adverse economic impacts, and increased travel times, which will greatly reduce the ability of the interstate to function as a safe and efficient roadway (see Section 3.7.2.1, *No-Build Alternative*).

3.7.1.3 WSDOT Operations and Maintenance

I-90 operations and maintenance includes activities typical of aging Interstate highways such as minor and major pavement repairs and lane striping, and additional activities typical of roads through steep terrain at relatively high elevations such as snow removal, avalanche control and slope stabilization. With respect to transportation conditions, snowy conditions, landslides, avalanches, and various operations and maintenance activities frequently cause travel delays.

For example, from 1991 to 2004, I-90 had, on average, 120 hours of annual closures on the pass with 65 hours related to avalanche control/risk within the project limits. The remaining 55 hours were due to accidents and weather conditions that caused closure of the pass for reasons other than avalanche control, such as cleanup of rock falls and routing oversized loads.

3.7.1.4 Safety and Crash Information

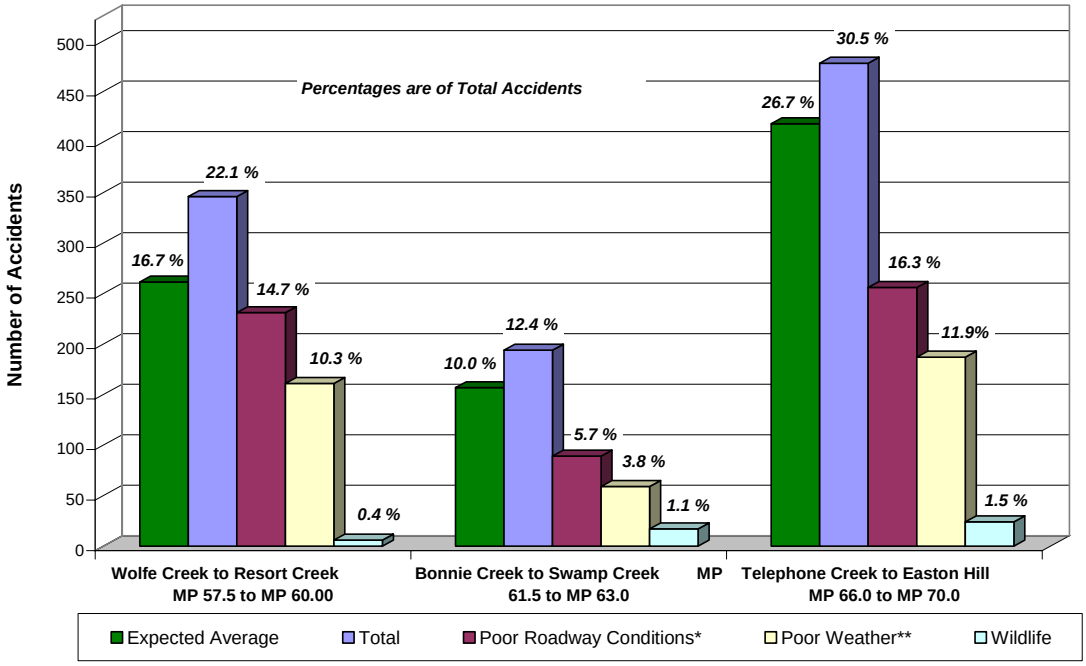
Road conditions along I-90 as it crosses the Cascade Mountains via Snoqualmie Pass are extremely variable. Snoqualmie Pass is the lowest and most heavily traveled pass in the Cascades. Even at this low elevation, the pass averages nearly 450 inches (37.5 feet) of snowfall each winter and over 100 inches of rainfall per year. Rainfall, by way of wet pavement and decreased visibility, significantly contributes to the occurrence of crashes along I-90. Other hazards created by the heavy precipitation include ice, flooding, avalanches, and rock slides.

In addition to adverse weather conditions, this portion of I-90 has significant horizontal and vertical alignment variations. From MP 55.10 to MP 66.20, the terrain is basically level; however, the existing horizontal alignment has sharp curves that are posted at a reduced speed (advisory). From MP 66.20, free flow speed in this section was assumed to be 60 mph. From MP 66.20 to MP 70.30, the terrain is mountainous with grades nearing 5 percent.

WSDOT developed the following information through analysis of accidents reported through the State Patrol within the project limits from January 1, 1991, to December 31, 2001. The data were used to develop accident trends and to find existing flaws in the highway that may contribute to higher accident rates. On a corridor level during the analysis period, there were 1,568 reported accidents. Of these accidents

- 72 (4.6 percent) involved wildlife;
- 626 (40 percent) occurred in inclement weather such as ice, fog, or snow; and
- 863 (55 percent) occurred with poor roadway conditions such as wet pavement, snow, ice, or slush.

An evaluation of the accident locations indicated that three segments exhibited substantially higher-than-average accident rates. The first segment runs from MP 57.5 to MP 60.0 between Wolfe Creek and Resort Creek. The existing roadway is highly curved and constricted with Jersey barrier on both sides. The second segment runs from MP 61.5 to MP 63.0 between Bonnie Creek and Swamp Creek. The existing roadway is curved with an open median. The Stampede Pass Interchange is immediately east of this segment. The third segment runs from MP 66.0 to MP 70.0 east of Telephone Creek to the top of Easton Hill. The existing roadway is highly curved and constricted with Jersey barrier on both sides. As shown in Figure 3.7-2, poor pavement conditions and inclement weather contribute to the majority of the accidents in these locations. These factors often occur together (e.g., one accident occurs due to poor conditions and poor weather).



* Poor Roadway Conditions include snow, ice, slush, and extremely wet roadway surfaces.
** Poor Weather conditions include snow, freezing rain, fog, or hail

Figure 3.7-2. High Accident Segments Within the Project Corridor

3.7.2 Environmental Consequences

3.7.2.1 NO-BUILD ALTERNATIVE

Construction Impacts

The No-Build Alternative would avoid the construction impacts of the build alternatives (see Section 3.7.2.2.). No detours, lane closures, or related impacts on travel time and congestion levels would occur.

Operation and Maintenance Impacts

The No-Build Alternative would perpetuate the frequent congestion associated with routine weekday lane closures associated with roadway rehabilitation and other maintenance activities. With the increased traffic in the future and further long-term degradation of the roadway over time, delays associated with the No-Build Alternative would become more frequent and substantial.

In order to keep the pavement in a drivable condition, the following maintenance activities have been projected as necessary under the No-Build Alternative. These activities are the roadway rehabilitations that would be required through design life of the proposed pavement in the other alternatives.

- In 2005 and 2009, projects would be required to rotomill (remove by grinding) and replace the existing Asphalt Concrete Pavement (ACP) in areas that are currently overlaid with ACP.
- In 2014, the entire length of the project would be overlaid with 0.6 foot of ACP.
- In 2021, the lanes would be rotomilled to a depth of 0.5 foot and repaved with 0.5 foot of ACP.
- In 2027, the lanes would be rotomilled to a depth of 0.5 foot and repaved with 0.6 foot of ACP.
- In 2032, 2036 and 2041, the lanes would be rotomilled to a depth of 0.6 foot and repaved with 0.6 foot of ACP.

The cost to maintain the roadway in a drivable condition throughout these rehabilitation years is estimated to be $123 million. These improvements would result in substantial traffic congestion and delay.

Changes to the Transportation System And Network

The No-Build Alternative would not change the existing transportation system, network, or capacity in any way.

Changes to Levels of Service

The lack of improvements under the No-Build Alternative would result in substantial increases in the frequency, duration, and intensity of congestion over time. In 2028, the No-Build Alternative would be operating at LOS E (free flow speed of 65 miles per hour, four lanes in each direction, and density of 38.3 pc/mi/ln) during the design hour. At LOS E, vehicles would be closely spaced, leaving little room to maneuver within the traffic stream. The traffic stream would have no ability to dissipate minor disruptions, so any incident could produce a breakdown resulting in extensive queuing.

Table 3.7-4 shows the predicted LOS degradation under the No-Build Alternative over time through breakdown (LOS F) in 2032. A LOS F represents a facility breakdown; there is not enough capacity to handle the demand. At LOS F, I-90 would operate as stop-and-go traffic with long queues.

Table 3.7-4. Existing Highway LOS Degradation

Year	*AADT*	*LOS*
2011	35,611	D
2024	47,913	E
2039	61,534	F

Source: WSDOT 2004g

Impact to Traffic Safety and Crash Rates

Under the No-Build Alternative, the number of crashes, the severity of crashes, and the delay associated with crashes would substantially increase as traffic volumes increase in the future. The No-Build Alternative would have the most road curvature relative to the build alternatives. Existing curvature is related to safety and crash rates, so the No-Build Alternative would present increased accident risk relative to the build alternatives.

The No-Build Alternative would mitigate two of the more hazardous rock slopes, by slope scaling, rock bolting, and installing wire mesh. One of the slopes is located between MP 58.19 and MP 58.35, and the other slope is located between MP 66.06 and MP 66.14. No other actions are planned to improve avalanche problems. Consequently, avalanches or rockslides that reach the roadway would have a greater hazard potential due to the increased traffic over time. Low vertical clearance structures would remain and thus require the removal of the existing Portland Cement Concrete Pavement (PCCP) prior to overlaying with ACP.

3.7.2.2 BUILD ALTERNATIVES

Overall Construction Period Impacts of the Build Alternatives

The build alternatives would be constructed over a period of time ranging from 5 to 15 years. The timing and potential staging of the construction effort would depend on how funding for the project is allocated. Construction could begin soon after funding becomes available. For analysis purposes, it has been assumed construction could begin as early as 2008 and as late as 2023, with project completion occurring as early as 2013 or as late as 2028.

Each construction segment of the build alternatives would most likely be built in four phases (See Figure 3.7-3). For the portion of the corridor from MP 55.1 to MP 67, the construction phasing would be as follows:

- Phase 1: Site preparation, widening of the existing westbound lanes, and bridge construction.

- Phase 2: Excavation, embankment, and temporary paving of the proposed alignment, and bridge construction, while traffic is detoured onto the widened westbound alignment.

- Phase 3: Excavation, embankment, and paving of the proposed westbound alignment, and bridge construction, while traffic is detoured onto the eastbound alignment.

- Phase 4: Involves finish work throughout the project and final paving of the eastbound with traffic being detoured onto the westbound alignment.

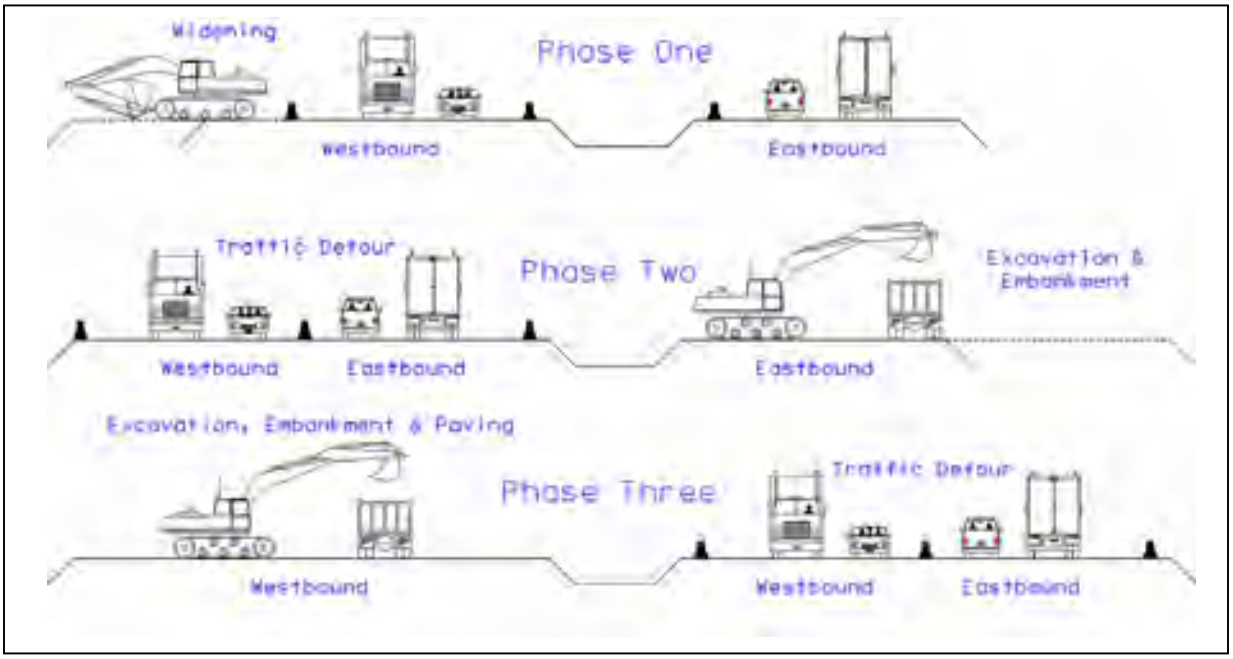


Figure 3.7-3. Construction Staging From MP 55.1 to MP 67.0

If a tunnel alternative is selected (Keechelus Lake Alignment Alternatives 1, 2, or 3), tunnel work would proceed through all four phases of construction.

The construction sequence of the highway from MP 67 to the end of the project differs from the staging above because of the split alignment of the roadway. The eastbound or westbound alignments can be built independent of each other so they could be constructed in different phases. For this portion of the corridor beyond MP 67, the staging would be altered as follows:

- Phase 1: Shoulder widening on the north half of the roadway in preparation for the detour in Phase 2.

- Phase 2: Detour traffic on north half of the roadway and grading/paving of the south half.

- Phase 3: Detour traffic on the newly constructed south half of the eastbound and grading/paving of the north half.

- Phase 4: Final paving, and roadside cleanup and restoration.

Detours would be configured as shown in Figure 3.7-4. Two exceptions to this configuration would occur at new bridges and the westbound climb up Easton Hill (MP 67.30 to MP 69.20). Over new bridges, during construction phases, the outside shoulders would have a width of 2 feet. By the year 2010, the westbound climb up Easton Hill would require three lanes; right shoulder widths would be reduced to 2 feet and emergency turnouts would be provided every half-mile, during construction phases.

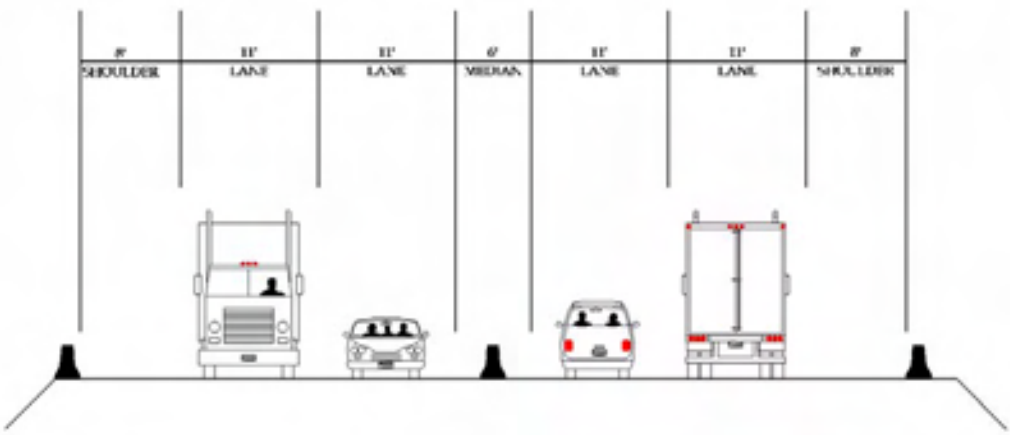


Figure 3.7-4. General Detour Configuration

Project construction would require detours between April and October. During the winter months, traffic would be separated from construction zones using a four-lane configuration similar to existing conditions (four 12-foot lanes, a 10-foot outside shoulder, and a 4-foot minimum inside shoulder).

Reducing traffic to a single lane would be required to perform some of the work. These lane closures will be relatively short in nature and would only occur from Monday through Thursday. During blasting operations, traffic traveling both ways would need to be stopped as a precautionary measure.

In general, the construction period configuration is similar to the existing configuration of I-90, so LOS impacts during construction would be minimized. Table 3.7-5 presents construction period LOS impacts by construction year and subcorridor. In summary, congestion and delay caused by construction that begins on 2008 would be less severe than if construction occurs later. This difference is primarily due to the anticipated increase in traffic volumes over time in the project area. In other words, in the future there would be more traffic to

disrupt. Table 3.7-4 also indicates that construction disruption involving activity that creates three lanes rather than two lanes would be less disruptive than construction that only creates two lanes. This difference results from the amount of in-lane disruption that can be avoided with a widening effort that allows for three lanes and keeps more lanes open, more often. In other words, construction of two lanes where two lanes already exist is more disruptive than widening into a new area where no traffic lanes currently exist.

Table 3.7-5. LOS During Construction, 2008 to 2028

Construction Year	*Location*	*Free Flow Speed*	*Total Number of Lanes*	*Density pc/mi/ln*	*LOS*	*Volume to Capacity Ratio*
2008	MP 55.6 to MP 66.0	60	4	28.5	D	1.32
	MP 66.0 to MP 70.3	60	5	21.7	C	1.00
2013	MP 55.6 to MP 66.0	60	4	32.6	D	1.50
	MP 66.0 to MP 70.3	60	5	24.8	C	1.14
2018	MP 55.6 to MP 66.0	60	4	36.7	E	1.69
	MP 66.0 to MP 70.3	60	5	28.0	D	1.29
2023	MP 55.6 to MP 66.0	60	4	40.9	E	1.89
	MP 66.0 to MP 70.3	60	5	31.1	D	1.44
2028	MP 55.6 to MP 66.0	60	4	44.9	E	2.07
	MP 66.0 to MP 70.3	60	5	34.2	D	1.58

Construction Period Impacts Associated with the Keechelus Lake Alignment Alternatives

The primary impact to traffic during construction of the Keechelus Lake Alignment Alternatives is the tunnel construction that will occur in Alternatives 1, 2, and 3. According to the Conceptual Tunnel Study (WSDOT 2004g), tunnel construction could take as long as seven years for Alternative 1, and four years for Alternatives 2 and 3, with year-round construction. This could mean that detours would remain in place through the winter. Although construction period LOS does not vary by alignment alternative, LOS is expected to worsen because speeds are generally reduced in winter weather. Since longer construction periods are required for alignment alternatives that include tunnels, LOS impacts would increase if the start of construction is delayed. Short-term lane closures would be needed for blasting operations for all Keechelus Lake Alignment Alternatives.

Construction Period Level of Service Conditions Associated with the Improvement Packages

There are no differences in construction period LOS for the Improvement Packages. The construction impacts that differ between the Improvement Packages are the amount of excavation and embankment areas, bridge lengths, and interchange reconfigurations. These components would affect the duration of construction and may limit access to the highway for brief periods.

Longer bridges and the larger excavations and embankments for Improvement Package A would extend the time needed to complete constructions segments for this Improvement Package. Typical bridges in this Improvement Package could take as long as 300 working days to complete, but durations could be reduced by using schedule acceleration (with increased cost). Improvement Package B has large bridges, but less excavation and embankment than Improvement Package A so impacts are expected to be less. Bridge construction durations in Improvement Package B would range from 150 working days for the single span bridges to 300 working days for the larger multi-span bridges. Improvement Package C has similar levels of excavation and embankment as Improvement Package B, but has shorter bridges so impacts are expected to be the least. Typical durations for bridge construction in Improvement Package C would be at 150 working days.

Overcrossing

Undercrossing

Figure 3.7-5. Interchange Configuration Examples at the Stampede Pass Interchange

Under Improvement Package A, the Stampede Pass Interchange would be reconfigured from an undercrossing to an overcrossing (Figure 3.7-5). This reconfiguration, which would route the highway over the county road, may require a closure of Stampede Pass Road for traffic crossing I-90 between Phase 2 and Phase 3. This closure, which could range from several weeks to a few months depending on construction sequencing, would cause traffic to detour 18 miles for southbound traffic and 2 miles for northbound traffic crossing I-90. Because the configuration of Improvement Packages B and C remain the same as the existing undercrossing, they should not require any long-term closure of the county road crossing I-90.

Impacts on WSDOT Operation and Maintenance

Overall Operation and Maintenance Conditions for the Build Alternatives

Operation and maintenance activities such as plowing snow and repairing pavement would change with the build alternatives relative to existing conditions. This change would be most noticeable after the new construction associated with the build alternatives is completed. For example, routine maintenance that is common now and anticipated to become more frequent in the future under No-Build conditions, such as pavement repair, would not be needed

for many years. The anticipated reduction in activities of this type would prevent associated travel time delays for many years. However, in the future, if a build alternative is chosen, new and increased operations and maintenance activities would be necessary for the additional lanes, possible tunnels, and bridges. Rebuilding the pavement structure with a high design life pavement, bridge improvements offering more clearance for trucks, and other improvements to the transportation system and network would help reduce long-term maintenance and operation requirements for WSDOT.

After construction, the snow plowing operation would increase with the build alternatives due to the additional lanes in each direction and additional bridges. Many of the long bridges will have curves with super elevated slopes. These are the first areas to ice over, so measures to automatically deice these surfaces may be considered.

WSDOT Operation and Maintenance Differences Associated with the Keechelus Lake Alignment Alternatives

The main operation and maintenance difference between the Keechelus Lake Alignment Alternatives is the use of tunnels or bridges. Tunnels would eliminate the need for avalanche control in the tunnel zone, but would require additional maintenance personnel to maintain tunnel operations. Bridges require additional maintenance such as inspections and repairs, but overall maintenance (labor and cost) is at a much lower level. Alternative 1, which has tunnels that would require ventilation systems and a tunnel maintenance facility, would need to employ between 30 and 50 full time maintenance personnel, based on staffing requirements for tunnels of similar length in other states. Maintenance activities include cleaning, monitoring, fire suppression, and ventilation system maintenance and repair. Alternatives 2 and 3 would not need a mechanical ventilation system, so the number of required maintenance personnel would be reduced. Alternative 4, which has more bridges and no tunnels, would require a slight increase in traditional maintenance forces to maintain the new facility due to the additional roadway and a greater number of bridges.

The level and type of avalanche control is the other key difference in the Keechelus Lake Alignment Alternatives. Alternative 1 would bypass all the active avalanche zones, eliminating the need for avalanche control within the limits of the alternative. Alternatives 2, 3, and 4 would protect the roadway from a 30-year avalanche but would still need active avalanche control for events beyond the 30-year avalanche. Avalanche control staff would still be needed to service minor avalanche areas for all alignment alternatives within the project limits, but at a much lower priority than the existing control program. Alternatives 3 and 4 would use avalanche fencing to protect the avalanche areas at Slide Curve, which would require additional maintenance and repair costs compared to traditional slope treatments.

WSDOT Operation and Maintenance Differences Associated with the Improvement Packages

Operation and maintenance differences between the Improvement Packages are related to the length of bridges and the amount of barrier used. Additional information on closures and heavy weather conditions is found 3.13.1.2. Improvement Package A, which has longer bridges, uses the most traffic barriers of the three Improvement Packages. The extra barriers increase the work required in maintaining storm drain systems, cleaning litter, and cleaning plow debris. Improvement Package B, which has shorter bridges and fewer barriers, would need a smaller storm drain system and would result in less work to maintain the facility. Improvement Package C uses approximately the same amount of barrier as Improvement Package B but has much shorter bridges, resulting in the least amount of maintenance effort for the roadway. All Improvement Packages would require additional maintenance efforts due to increased roadway areas and longer bridges.

Changes to the Transportation System and Network

The build alternatives would improve I-90 from the vicinity of Hyak (MP 55.10) to the West Easton Interchange (MP 70.30) by widening this four-lane highway to six lanes. The additional lanes would accommodate increased traffic, reduce congestion during peak periods, substantially reduce lane and road closures due to avalanche control and unstable slopes, eliminate structure deficiencies, and improve ecological connectivity. Overall, the system and network improvements would meet interstate standards, be consistent with local plans, and facilitate economic development and growth by reducing I-90 transportation constraints within the corridor.

Rebuilding the pavement structure with a high design life pavement would result in an improved ride, and reduce the wear and tear on vehicles using the system. Replacing low-clearance bridges and constructing new interchange structures that would be raised to meet or exceed the minimum 16-foot 6-inch clearance to accommodate oversized vehicles will require fewer oversized trucks to detour around them. Routing around the snowshed (by a tunnel in Alternative 1 and bridge in Alternatives 2, 3, and 4), would eliminate the need to close I-90 in order to move oversized loads around it.

There are no substantial differences between the build alternatives regarding the transportation system and network.

Long-Term Changes to Levels of Service on I-90

In 2028, LOS under the build alternatives would be virtually identical because each alternative generally provides the same level of capacity to accommodate anticipated traffic volumes. Slight LOS differences would occur eastbound from MP 66.0 and 67.5 (LOS C rather than LOS D) and westbound between 67.5 and

69.3 (LOS C rather than LOS D). These differences would be inconsequential in relation to alternative selection.

From a traffic volume standpoint, there is little difference between the various build alternatives. Given that the grades, lane and shoulder width, and posted speed limit, are the same, the LOS for all alternatives would be identical. The LOS in 2008 drops from a C in the existing condition to a B under the build alternatives. In 2028, the LOS will degrade to a LOS C as compared to a LOS of E in the existing project area. Under these alternatives, the LOS D will be attained 18 years later than existing and reach capacity (LOS E) 24 years later.

After 2028, LOS would be expected to degrade as shown in Table 3.7-6.

Table 3.7-6. Proposed Level of Service Degradation

Year	*AADT*	*LOS*
2029	52,314	D
2048	70,354	E
2069	90,398	F

Impact to Traffic Safety and Crash Rates Near Unstable Slopes

Despite higher volumes and increased average speeds on I-90, the reduced congestion, straighter curves, and increased sight distances associated with the build alternatives would eliminate many potential hazards, and improve overall safety. More specifically, new or longer bridges at critical animal crossing locations may further reduce the number of animal/vehicle collisions and corresponding costs associated with vehicle damage. Overall, the “risk” locations within the corridor would be eliminated or reduced.

The build alternatives would realign the road in the vicinity of the unstable slopes located from MP 64.5 to MP 66.3. These areas would also be rock-bolted, and wire mesh would be installed. The other unstable slope along Easton Hill would be cut to a stable slope of 1:1. This slope, however, does create potential avalanche areas. These slopes would be benched, and snow retention nets would be installed to prevent avalanches from occurring.

The Keechelus Lake Alignment Alternatives would incrementally reduce motorist exposure to winter driving conditions that contribute to crash rates, and would reduce or eliminate safety issues associated with avalanches and unstable slopes.

Alternative 1 would construct a tunnel behind all of the unstable slope and avalanche areas along Keechelus Lake.

Alternative 2 would stabilize the unstable slopes along Keechelus Lake, be aligned onto a bridge in front of the existing snowshed, and include a tunnel through Slide Curve. Alternative 2 would stabilize the slopes by using slope

scaling (forcing the looser rocks to fall in a controlled setting), rock bolting, and installing wire mesh.

Alternative 3 would stabilize all of the unstable slopes along Keechelus Lake, be aligned onto a bridge in front of the existing snowshed, and include a tunnel through Slide Curve for westbound traffic. Alternative 3 would use the same slope scaling approach described for Alternative 2.

Alternative 4 would stabilize all of the unstable slopes along Keechelus Lake and be aligned onto a bridge in front of the existing snowshed. Alternative 4 would use the same slope scaling approach described for Alternative 2.

All of these improvements would be expected to improve traffic safety and reduce crash rates.

The sharpness of the road curvature and the placement of barriers directly affect the accident risk of the roadway. The four Keechelus Lake Alignment Alternatives have similar amounts of barriers. Alternative 1 is the straightest and has the least amount of accident risk. Alternatives 2, 3, and 4 have progressively sharper curves, increasing the accident risk from Alternative 2 to Alternative 4, respectively.

The Improvement Packages essentially follow the same route, so their accident risks do not differ substantially. The three Improvement Packages, considered as a whole, would not present substantial differences relative to existing traffic safety or crash rates. All of the new features would comply with applicable safety standards.

3.8 Noise

Housing areas may be considered noise-sensitive receptors.

This section was prepared based on the *Noise Discipline Report* (Washington State Department of Transportation [WSDOT] 2003e) (Appendix P). The study area for noise includes the residential dwellings and campgrounds within the 15-mile project corridor that are classified as sensitive land uses or sensitive receptors. Calculated peak-hour noise levels were modeled for receptors north of westbound lanes and receptors south of eastbound lanes. The distances range from 50 feet from the edge of the highway to over 1,200 feet. These distances make up the study area for noise.

This analysis was prepared in accordance with Federal Highway Administration (FHWA) National Environmental Policy Act (NEPA) regulations, with additional guidance as provided in the WSDOT document entitled *Traffic Noise Analysis and Abatement Policy and Procedures*. The following methods were used to evaluate potential noise impacts associated with the project: