Appendix A Final Fisheries Technical Report

Final Fisheries Technical Report

Bonneville Power Administration Kangley-Echo Lake Transmission Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97208-3621

Prepared by:

Jones & Stokes
11820 Northup Way, Suite E300
Bellevue, Washington 98005-1946

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The analysis in this technical report is generally based on typical construction activities and impacts for transmission lines. Detailed information for this project has been updated as much as possible. However, the most current information about this project is in the Final Environmental Impact Statement.

This document should be cited as:

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1.0 Executive Summary

This report describes the existing conditions and potential impacts on fisheries from the proposed Bonneville Power Administration (BPA) Kangley-Echo Lake Transmission Line Project. This report serves as the primary basis for the fisheries discussion in the National Environmental Policy Act (NEPA) environmental impact statement (EIS) prepared for the project.

1.1 Alternatives

This EIS evaluates five alternative routes for constructing a new 500-kilovolt (kV) electrical transmission line intended to increase the reliability of the Seattle metropolitan area's transmission system. This increased reliability would reduce the potential for rolling brownouts or blackouts that could transpire by the winter of 2002-2003 if the current rate of development continues and if severe winter weather were to cause inordinate power demand.

The transmission line would start at the Schultz-Raver No. 2 500-kV transmission line near the unincorporated community of Kangley in central King County, Washington and travel approximately 9 miles (mi.) to the Echo Lake Substation, located north of the Kangley area and southwest of North Bend (Figure 1).

1.1.1 Construction Methods

BPA would construct all of the action alternatives using the existing practices described below for building transmission lines and substations. BPA would build or improve access roads as necessary. If additional easements for right-of-way (ROW) or access roads were needed, additional rights would be obtained from landowners. BPA typically uses existing, cleared staging areas in which to store and assemble materials or structures.

After the structures are in place and conductors are strung between the structures, BPA would restore disturbed areas.

The following sections describe in greater detail the sequential steps that BPA typically takes to construct a transmission line.

1.1.1.1 Right-of-Way Requirements

BPA would obtain easements from landowners for the new transmission line ROW, and easements for the access roads outside of the transmission line ROW easements. The easements give BPA the right to construct, operate, and maintain the line and access roads. A 150-foot (ft.) ROW width is assumed for the 500-kV line.

Fee title to the land comprising the easement generally remains with the owner, subject to the provisions of the easement. The easement prohibits large structures, tall trees, storing of flammable materials, and other activities that could be hazardous to people or could endanger the transmission line. Activities that do not interfere with the transmission line or endanger people are usually not restricted.

Rights (usually easements) for new access roads would be acquired from property owners, as necessary. A 50-ft. ROW easement generally would be acquired for new access roads measuring about 16 ft. wide, and 20 ft. of ROW would be required for any existing access roads.

1.1.1.2 Clearing

The height of vegetation within the ROW would be restricted to provide safe and reliable operation of the line. Trees would be cleared within the ROW as well as outside of the ROW to prevent trees from falling onto the lines. A clearing advisory would be generated using ground information from cross section data. This clearing advisory would specify a safe vegetation height along and at varying distances from the line. The amount of vegetation removed would be based on this clearing advisory and local knowledge of regional conditions such as weather patterns, storm frequency and severity, general tree health, and soils. Other factors that influence the amount of clearing along the line are the line voltage; vegetation species, height, and growth rates; ground slope; conductor elevation above the ground; and clearance distance required between the conductors and other objects.

Merchantable timber purchased from private owners would be marketed and non-merchantable timber would be left lopped and scattered, piled, chipped, or would be taken off-site. Contractors would be required to use equipment that leaves low-growing vegetation in place instead of dirt blades on bulldozers for clearing. Other specialized brushing/mulching equipment may also be required. Additional best management practices (BMPs) for timberland would also be used.

At the tower sites, all trees, brush, and snags would be felled. Stumps would be removed at these sites only if they interfere with tower and guy installation. The site would be graded to provide a relatively level work surface. The total amount of clearing required for this project is unknown at this time.

An additional amount of land would be cleared for roads that are needed off the ROW and for roads determined to be in poor condition and requiring upgrading by BPA.

1.1.1.3 Access Road Construction and Improvement

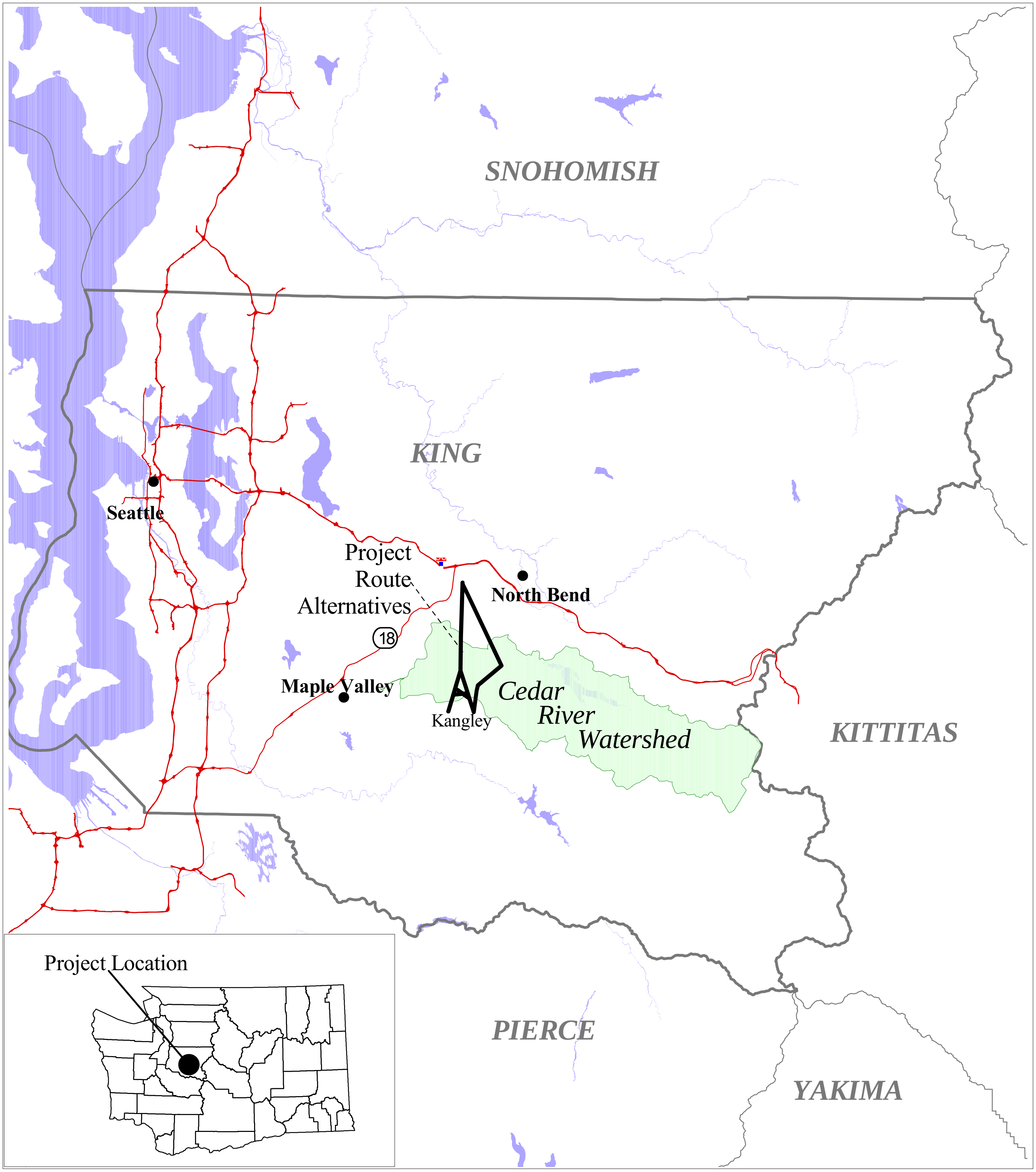
An access road system within and outside of the ROW would be used to construct and maintain a new line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. Roads generally would be surfaced with gravel, and appropriately designed for drainage and erosion control. The access roads would generally have grades of 6% or less for erodible soils and 10% or less for resistant soils. The maximum grades would be 15% for trunk roads and 18% for spur roads. No permanent access road construction would be allowed in cultivated or fallow fields.

Clearing and construction activities for new access roads would disturb an area about 20 ft. wide, depending on terrain. New roads would be constructed within the ROW wherever possible, but where conditions dictate otherwise, roads would be constructed and used outside of the ROW.

Dips, culverts, and waterbars would be installed within the roadbed to provide drainage. Fences, gates, cattle guards, and additional rock would be added to access roads as necessary.

Where temporary roads are used, any disturbed ground would be repaired and, where land use permits, the road would be reseeded with grass or other appropriate seed mixtures. After construction, access roads would be used for line maintenance. Where ground must be disturbed for maintenance activities, the roadbed would be repaired and reseeded as necessary.

The amount of new roads required for this project would vary depending on the alternative chosen and the feasibility of using existing roads along the line.



County, contour data, King County, 2000.

LOCATION MAP

Transmission line alternatives

Counties
Highway

Cedar River Watershed
Waterbodies

BONNEVILLE POWER ADMINISTRATION
GIS
GEOGRAPHIC INFORMATION SYSTEM

N

0ft 50000ft 100000ft
0mi 5mi 10mi 15mi 20mi

Figure 1.
Location Map

Figure 1

Path/apr: S:\Temp\BPA_Kangley_0P005\GIS\Projects\intro1.apr (Date:2001-10-25) rpe

1.1.1.4 Storage, Assembly, and Refueling Areas

Construction contractors usually establish storage areas near the transmission line where they can stockpile materials for structures, spools of conductor, and other construction materials. These areas would be accessible from major highways. Structural steel would be delivered in pieces on flatbed trucks and would be assembled on-site. A mobile crane may be needed to handle the bundles. If the terrain were too steep at the actual tower site, general assembly yards would be used to erect the tower in pieces. The structure would then be transported to the tower site by truck or helicopter. Because trucks and helicopters need to refuel often, these construction areas could also be used for refueling.

1.1.1.5 Tower Site Preparation

Site preparation begins with removing all vegetation from a tower site. In areas of uneven topography, the site would be graded to provide a level work area. An average area of 30,000 square feet (150 by 200 ft.) would be disturbed at each tower site. Additional areas that could be disturbed include the site where the conductor is strung and pulled. These disturbances could be as large as a 370-ft. radius from the tower center.

Bulldozers would be used to clear and construct any new access roads to the transmission line towers and any new tower site landings. Manual methods, including chainsaws and brush hogs, would be used to clear the new ROW. BMPs would be used during clearing and construction to reduce impacts.

In addition to clearing the ROW for the transmission line towers, construction crews would remove selected trees outside of the ROW. This additional clearing would be done to reduce the possibility of blowdown. Blowdown occurs when newly exposed trees fall after the initial clearing process because they have not developed the root structure to remain standing once they become more fully exposed to strong winds.

1.1.1.6 Towers and Tower Construction

Steel lattice towers would be erected to support the transmission line conductors. The new towers would be similar in design to those used in the existing Schultz-Raver No. 2 500-kV transmission line. The height of each tower would vary by location and surrounding land forms. Towers would average 135 ft. high and would be spaced about 1,100 to 1,200 ft. apart. Under Alternatives 1 and 2 (described in the next section), where the new line would parallel a portion of the existing Raver-Echo Lake transmission line, towers would be staggered so that a tower from one line would not contact a tower from the other line in the unlikely event that a tower falls.

Most towers used on the proposed line would be “tangent” or “suspension” towers. This type of tower is designed to support conductors strung along a virtually straight line with only small turns or angles. “Deadend” towers would also be used on a limited basis where stresses on the transmission line conductors would have to be equalized because of changes in direction, because of the need to support an excessively long span, or where a span crossing is needed for extremely steep or rugged terrain or a river. Deadend towers use more insulators and heavier steel than tangent or suspension towers, thus making them more visible. Deadend towers also are more costly to build than suspension towers.

The towers would usually be constructed from the ground, rather than using helicopters. The equipment used depends on the weight and size of the towers and such site conditions as weather and soil characteristics. Most 500-kV lines would be built using mobile cranes; helicopter tower erection could be used if access was not available or if sensitive resources would be encountered.

Steel towers would be assembled in sections near the tower site. Each tower contains three components: the legs, body, and bridge. The bridge is the uppermost portion of the tower and serves as the attachment point for the insulators that support the conductors.

Steel towers are anchored to the ground by footings. Each tower requires four footings placed in holes that have been excavated, augered, or blasted. Large machinery, such as backhoes or truck-mounted augers, would be used to excavate the footings. Topsoil would be stockpiled during excavation. The design of the footings would vary based upon soil properties, bedrock depth, and the soundness of the bedrock at each site. Typically, towers would be attached to steel plates or grillages placed within the excavated area. The areas would then be backfilled with excavated material or concrete. Topsoil would then be replaced to restore the original ground surface.

Typical footings for single-circuit towers include 4- by 4-ft. plates placed 10 to 12 ft. deep for suspension towers and 12.5- by 12.5-ft. grillage placed 14 to 16 ft. deep for heavy dead-end towers. On average, for an entire transmission line project, each footing would occupy an area about 10 by 10 ft. to a depth of 15 ft. if bedrock was not encountered. The holes in which the plates and grillage would be installed must be large enough to provide about 1 ft. of clearance on each side of the plate or grillage. If bedrock were encountered and had properties that allowed anchor borings, holes would be drilled and steel rods grouted into the rock. These rods would either be attached to a concrete footing or welded directly to a tower member and embedded in compacted backfill. If rock properties were not suitable for anchor rods, the rock may be blasted to obtain adequate footing depth.

As the towers were built, heavy machinery would disturb the ground surface and/or compact soils at the tower site and along access roads. Noise and dust also would be generated by the machinery.

1.1.1.7 Conductors, Overhead Ground Wires, and Insulators

The wires or lines that carry the electrical current in a transmission line are called conductors. Alternating-current transmission lines such as the proposed line require three wires or sets of wires, each of which is referred to as a “phase.” Three 1.3-in. Bunting conductors would be included for each phase. Each bundle is 16 by 20 in.

Conductors are not covered with insulating material. Instead, air is used for insulation. Conductors are physically separated by insulators on transmission towers.

After the transmission towers are in place, workers would attach a smaller steel cable to the towers and then pull the conductor under tension through the towers. Conductors would be attached to the structure using glass, porcelain, or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors on the tower, the tower itself, and the ground. As the conductors are strung, the ground surface would be disturbed at the tensioning sites, and noise and dust would be generated by the machinery.

Transmission towers elevate conductors to provide safe clearance for people and structures within the ROW. The National Electrical Safety Code (NESC) establishes minimum conductor heights.

The minimum conductor-to-ground clearance for a 500-kV line is a little more than 29 ft. Greater clearances would be provided by BPA over county roads and highways, railroads, and river crossings.

One or two smaller wires, called overhead ground wires, would also be attached to the top of the transmission towers. Overhead ground wires would protect the transmission line against lightning damage. The diameter of the wire would vary from 0.375 to 0.625 in.

1.1.1.8 Substation Additions

Under the current proposal, the Echo Lake Substation would be expanded to the east on land owned in fee title by BPA. The size of the expansion would be 300 by 750 ft. The site would be cleared in the same manner as the ROW for the transmission line. The site would include a fenced yard and a graded and graveled parking lot. The existing road around the substation would be realigned to the east to accommodate this expansion. New transformers, switches, and other equipment would be installed in the expanded area. A continuous ground wire would also be installed.

1.1.1.9 Site Restoration and Clean-up

Disturbed areas around the towers, conductor reels, and pull site locations would be reshaped and contoured to be consistent with their original condition. Access roads would be repaired.

Disturbed areas would be reseeded with grass or an appropriate seed mixture to prevent erosion. The seed mixture would include native plant species and would be free of noxious weeds. All solid waste from construction would be removed and properly disposed offsite, and equipment would be removed from the ROW.

1.1.2 Alternative Rights-of-Way

A portion of the action alternatives would be located within the Cedar River Municipal Watershed. The alternatives would begin at the Schultz-Raver No. 2 500-kV transmission line and generally travel northward to the Echo Lake Substation. (See Figure 2.) Under all alternatives, the transmission line ROW would be 150 ft. wide. Miles of new access roads were calculated for a 20-ft. ROW within a 0.25-mile buffer on each transmission line alternative.

1.1.2.1 Alternative 1: Preferred Alternative

The alignment for Alternative 1 would be immediately adjacent and parallel to a portion of the existing 12-mi. Raver-Echo Lake transmission line from a point approximately 3 mi. north of Raver (S26, T22N, R7E) to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 0.8 mi. of new access roads. The existing 150-ft. ROW would be widened to 300 ft., with the widening and new line located east of the existing corridor.

1.1.2.2 Alternative 2

Alternative 2 would originate from tap point #2 (Figure 2) located approximately 2 mi. east of the tap point #1 for Alternative 1 (S25, T22N, R7E). The line would traverse approximately 3 mi. to S11, T22N, R7E before continuing north along the same alignment as Alternative 1, paralleling the existing Raver-Echo Lake transmission line, and terminating at the Echo Lake Substation

(S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 2.8 mi. of new access roads.

1.1.2.3 Alternative 3

Alternative 3 would begin at the tap point #2 (S25, T22N, R7E); traverse northeast to S8, T22N, R8E; and then turn north-northwesterly to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 10.2 mi. long and would require about 6.4 mi. of new access roads.

1.1.2.4 Alternative 4a

Alternative 4a would begin about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverse northwest to connect with Alternative 1 over 1 mi. (S23, T22N, R7E) further south from where Alternative 2 reconnects (S11, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.5 Alternative 4b

Alternative 4b would begin slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverse west to connect with Alternative 1 further south from where Alternative 4a reconnects (S23, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.6 No Action Alternative

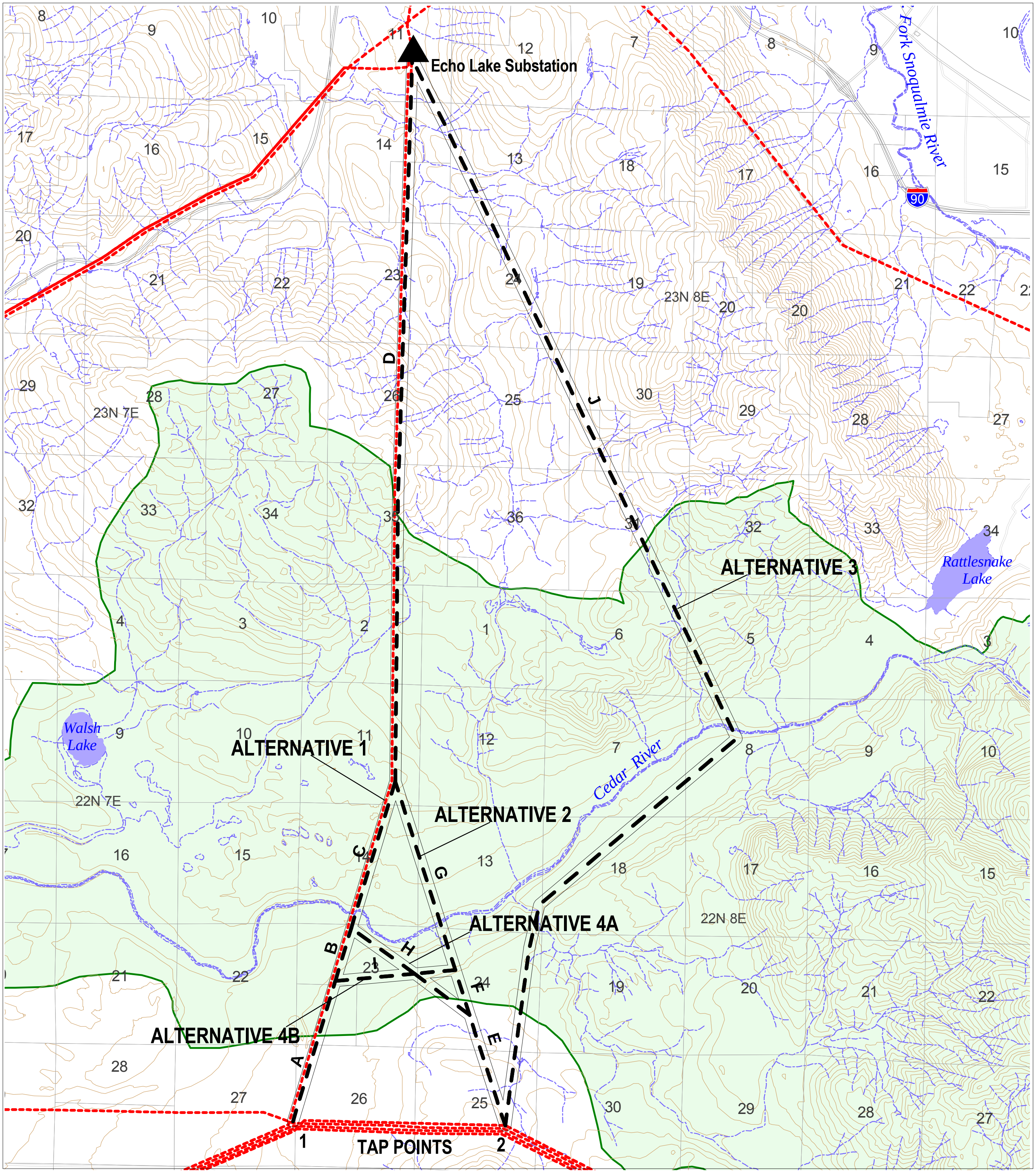
Under the No Action Alternative, a new 500-kV electrical transmission line would not be built. As a result, transmission line capacity could be reached or exceeded as early as 2002-2003 if a cold winter were to occur in the Seattle metropolitan area and the existing Raver-Echo Lake transmission line were to go out of service. Relying upon the existing transmission system during periods of increased demand and compromised reliability could result in brownouts or rolling blackouts in the area. Thus, residents, businesses, and government agencies could experience as much as several days without electricity. Loss of electricity for lights and heating could halt business and government activities. Residents would have to rely upon other energy sources for heating, cooking, and lighting, such as wood and gas fireplaces, stoves and barbecues, oil lamps and candles, etc.

1.2 Key Issues for Fisheries

Two key issues have been identified during the scoping process:

- The proposed project could adversely affect habitat for two fish species listed as threatened under the Endangered Species Act (ESA), Puget Sound chinook salmon and Puget Sound bull trout.

- The proposed project could impact riparian areas and streams in lands currently administered by the Seattle Public Utilities (SPU) under provisions of the Cedar River Watershed (CRW) Habitat Conservation Plan (HCP) (City of Seattle 2000). Under the HCP, all forest clearing is prohibited except for purposes of habitat restoration.



ROUTE ALTERNATIVES

- Transmission line alternatives
- E Segment of alternative
- 150ft Clearing area
- Existing transmission lines
- Highway
- Primary roads
- Public land survey sections
- Cedar River Watershed
- Fish-bearing streams
- 100 Ft contours

0ft 6000ft 12000ft
0mi 1mi 2mi 3mi

N

Figure 2.
Existing Transmission Lines and Proposed ROW Alternatives

Figure 2

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1.3 Major Conclusions

All action alternatives would have similar impacts to fish and their habitat. All action alternatives would require removal of riparian forest vegetation in an area where such activity has previously been determined to cause adverse effects to fish species listed as threatened under the ESA. Although some measures could be taken to minimize vegetation clearing in riparian areas, the residual impacts would persist throughout the life of the project. All action alternatives would also require the construction and maintenance of roads. Mitigation methods are available that would reduce road-related impacts to a negligible level.

2.0 Study Scope and Methodology

2.1 Data Sources and Study Methods

Because of the recent listings of several fish species as threatened under the ESA, the recent preparation of the CRW HCP, and the general concerns regarding fish populations, fish and fish habitat in the Cedar River and adjacent watersheds have been extensively studied. Unless otherwise stated, this fisheries analysis is based on the following sources:

- The StreamNet Database (www.streamnet.org).
- National Marine Fisheries Service (NMFS) formal status reviews of fish populations within the project area (Busby et al. 1996, Gustafson et al. 1997, Johnson et al. 1999, Myers et al. 1998, Weitkamp et al. 1995).
- The CRW HCP (City of Seattle 2000).
- Geographic Information System (GIS) data provided by BPA and the U.S. Geological Survey (USGS).
- Interviews with agency personnel (see Section 6).
- Examination and interpretation of 1:24,000-scale USGS topographic maps and 1:24,000-scale color aerial photographs flown on July 20,1999.
- Field studies conducted in late October 2000.
- Scientific and agency publications and studies, as cited below.

The impact assessment for this analysis relied upon remote methods to identify potential fish-bearing streams. GIS data provided by BPA were used to identify potential fish-bearing streams. Potential fish-bearing streams were identified as all streams in the GIS database having a gradient of less than 20% and a headwater catchment of more than 50 acres (ac.) as measured from USGS topographic maps. The GIS database was not found to include any non-fish-bearing streams, so these streams were not inventoried. It is assumed that the project area contains at least twice as many non-fish-bearing streams as fish-bearing streams. For reasons described below, all stream reaches located within 300 ft. of an area proposed for vegetation clearing under any of the action alternatives were considered to be potentially affected streams.

Color aerial photographs were reviewed to collect information about the size and species composition of riparian vegetation, and the existing riparian shade, along all potentially affected streams. This review used methods established for watershed analysis in Washington (WFPB 1998). Field studies were undertaken to visit representative examples of fish-bearing streams, observe channel geomorphology and fish habitat, and ground-truth the aerial photograph assessment.

For the impact assessment, it was assumed that the action alternatives would require clearing vegetation over a 150-ft. wide corridor along the entire project area. This assumption is conservative because BPA would seek to minimize vegetation clearing in riparian areas by not placing towers in riparian areas. However, it is not yet known to what degree such mitigation would be possible. It was also assumed that vegetation clearing within 300 ft. of any stream would have potential adverse effects on stream microclimate and large woody debris (LWD) recruitment potential, and that vegetation clearing within 100 ft. of any stream would additionally have potential adverse effects on bank reinforcement by roots, fine litter inputs to the stream, and riparian shade. These 100 and 300-ft. widths, supported by locally applicable analyses such as FEMAT (1993) and City of Seattle (1998), nonetheless represent simplifications because the structural and functional importance of the riparian ecosystem varies continuously as a function of distance from the stream.

2.2 Agencies Contacted

During the course of preparing this report, the following agencies were contacted and consulted:

- Washington Department of Fish and Wildlife (WDFW)
- U.S. Fish and Wildlife Service (USFWS)
- Tulalip Indian Tribe
- SPU
- King County Department of Natural Resources

3.0 Affected Environment

3.1 Regional Overview

The fish resources in the study area include resident and anadromous species. Resident species live their life cycles within the watershed. Anadromous species are hatched in fresh water, then spend part of their life at sea before returning to their home waters to spawn.

3.2 Regulations, Standards, and Guidelines

3.2.1 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by SPU to establish a comprehensive plan for long-term management of the CRW, which is the principal water supply for the City of Seattle and 27 other purveyors and communities, serving a population of 1.3 million people. The HCP includes numerous provisions intended to maintain the quality of fish habitat and the health of fish populations in the watershed. Many of these provisions apply to management procedures such as fish hatchery operation or manipulation of instream flows and thus are not directly relevant to this analysis. Other provisions, specifically those contained in the Aquatic and Riparian Ecosystem component of the " Watershed Management Mitigation and Conservation Strategies," address the effects of forest removal, road construction, and road maintenance on fish and their habitat. These strategies are every detailed; the interested reader is referred to the CRW HCP, Section 4.2, pages 13 to 117 (City of Seattle, 2000) for their exposition.

3.2.2 Washington Department of Natural Resources

Each of the proposed action alternatives crosses one parcel of Washington Department of Natural Resources (WDNR)-managed land. The WDNR HCP was prepared by that agency to establish a comprehensive long-term management plan for all WDNR-managed timberlands within the range of the northern spotted owl in Washington. The WDNR HCP includes numerous provisions intended to maintain the quality of fish habitat and the health of fish populations in the watershed. These provisions are summarized in the Riparian Conservation Strategy Objectives:

1. To maintain or restore salmonid freshwater habitat on WDNR managed lands, and

2. To contribute to the conservation of other aquatic and riparian obligate species.

The purpose of these objectives is to maintain or restore the functions of riparian and upland areas that directly affect the quality of salmonid freshwater habitat.

3.2.3 Designated Critical Habitat for Listed Species

The ESA requires that, to the maximum extent prudent and determinable, NMFS and USFWS must designate critical habitat for federally listed species at the time of their listing. Critical habitat designation establishes areas that are to be given special consideration in Section 7 consultations. Of the listed species occurring in the project area (described later in this section), critical habitat has only been designated for the chinook salmon Puget Sound evolutionarily significant unit (ESU).

Critical habitat for the chinook salmon includes all river reaches accessible to chinook salmon within the range of the Puget Sound ESU. It specifically excludes waters upstream of the Landsburg Diversion Dam (65 FR 7777), and therefore excludes streams in the CRW within the project area. However, it does include portions of the Raging River Watershed situated downstream of the known anadromous fish passage barriers shown in Figure 3.

3.2.4 Special-Status Fish Species

Special-status fish species include those that are listed, proposed, or candidates for listing as threatened or endangered under the federal ESA, or that are regarded as species of concern by the USFWS, or that are listed as species of concern (including endangered, threatened, sensitive and candidate categories) according to the WDFW. Table 1 summarizes special-status fish potentially present in streams crossed by the alternative ROWs.

Table 1. Special-Status Fish in Streams Crossed by the Alternative Routes

Fish	Scientific name	Federal status	State Status
Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	Candidate
Coho salmon	*Oncorhynchus kisutch*	Candidate	None
Bull trout	*Salvelinus confluentus*	Threatened	Candidate
Pacific lamprey	*Entosphenus tridentatus*	Species of Concern	None
River lamprey	*Lampetra ayresi*	Species of Concern	Candidate

3.2.4.1 Federally Listed Species

All action alternatives could affect two species of fish recently listed as either threatened or endangered under the ESA, referred to as listed species. The following paragraphs provide additional information about listed species and habitats that could be affected by the project.

The Puget Sound ESU **chinook salmon** was listed by NMFS as threatened under the ESA on March 24, 1999 (64 FR 14308). This ESU includes all naturally spawned chinook populations residing below impassable natural barriers in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. Chinook salmon are potentially present in one or more streams crossed by each of the action alternatives (Table 1).

In a separate rule, NMFS also designated critical habitat for the chinook salmon on February 16, 2000 (65 FR 7764). All surface waters accessible to chinook salmon in the Puget Sound basin are included in the listing, as are riparian habitats necessary to support those surface waters. As noted above, portions of the CRW upstream of the Landsburg Diversion Dam are specifically excluded from the listing.

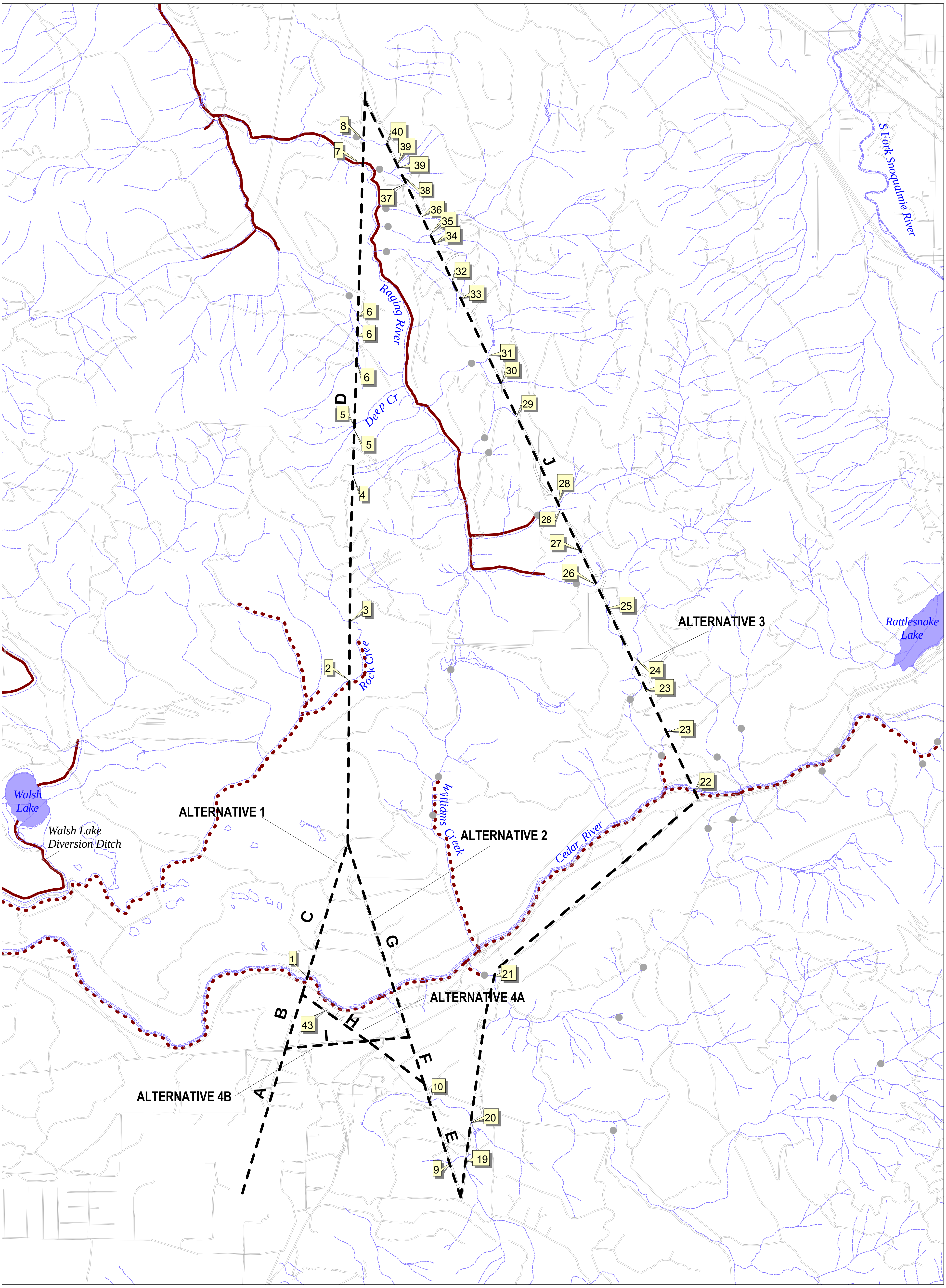
The Puget Sound distinct population segment (DPS) **bull trout** was listed by the USFWS as threatened under the ESA on November 1, 1999 (64 FR 58910). All naturally spawning populations of bull trout in the continental United States are included in the listing. Critical habitat for this species has not yet been proposed or designated. Bull trout are potentially present in one or more streams crossed by each of the action alternatives (Table 1).

3.2.4.2 Federal Candidate Species

All action alternatives could affect one species of fish that is a candidate for listing under the ESA, referred to as a candidate species. The Puget Sound/Strait of Georgia ESU **coho salmon** was proposed for listing by NMFS as threatened under the ESA on July 25, 1995 (60 FR 38011). This ESU includes coho salmon from drainages of Puget Sound and Hood Canal, the eastern Olympic Peninsula (east of Salt Creek), and the Strait of Georgia from the eastern side of Vancouver Island and the British Columbia mainland (excluding the upper Fraser River). Although NMFS, in its proposal, found listing to be "not warranted," the species has not been withdrawn from candidate status and may be listed in the future. Coho salmon are potentially present in one or more streams crossed by each of the action alternatives (Table 1).

3.2.4.3 Federal Species of Concern

The USFWS has identified the Pacific lamprey and river lamprey as species of concern potentially occurring in the project area (USFWS 2000).



Stream data from Seattle Public Utilities, based on WA DNR, 1997.

FISH

Transmission line alternatives
E Segment of alternative
Proposed access roads
Roads

Fish-bearing streams
Known anadromous fish distribution.
Post-dam removal anadromous streams

Lakes
Barriers to fish passage
12 Transmission line / stream crossing

0ft 4000ft 8000ft
0mi 1mi 2mi

N

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fish3

Figure 3.
Current Fish Distribution and Riparian Impact Areas under the Action Alternatives

The **Pacific lamprey** is widely distributed in coastal and Columbia River drainages, but the extent of its distribution and population trends are poorly understood. It is thought that destruction of spawning and rearing habitat as well as reduced numbers of prey (salmonids) have contributed to a reduction in the population of Pacific lamprey. Spawning habitat is similar to salmonids including cool, flowing water and clean gravel. Rearing areas are slow-moving backwaters with fine sediment (ODFW 1995). Pacific lamprey are potentially present in one or more streams crossed by each of the action alternatives (Table 1).

The habitat, distribution, and status of the **river lamprey** are essentially the same as Pacific lamprey. The two species differ primarily in size; Pacific lampreys may grow considerably larger (to 30 in.) than river lampreys (to 12 in.) (Wydoski and Whitney 1979). River lamprey are potentially present in one or more streams crossed by each of the action alternatives (Table 1).

3.2.4.4 Washington State Special-Status Species

Chinook salmon, bull trout, and river lamprey, all described above, are state candidates for listing by the WDFW (2000).

3.2.5 Essential Fish Habitat

All actions could affect two fisheries protected by the Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Act (16 U.S.C. 1855(b)): the chinook salmon and coho salmon fisheries. All streams in the project area are included in designated EFH for these two fisheries. Some streams are included because they may support spawning, rearing and migratory use by chinook and coho salmon. Other streams are included because they are situated upstream of areas used by salmon, and the salmon are sensitive to water quality in these streams. Since chinook salmon is a federally listed species (Section 3.2.4.1) and coho salmon is a federal candidate species (Section 3.2.4.2), the analyses of current conditions and potential impacts (Section 4) to these species also serve to describe all potential impacts to EFH.

3.3 Study Area and Approach

The study area examined includes all mapped streams (USGS 7.5-minute topography coverage) that are within 300 ft. of the centerline of the proposed ROW. These streams occur within three watersheds, those of the Raging River, the Cedar River, and the Green River, located within Water Resource Inventory Areas (WRIA) 7, 8, and 9 (Ecology 2000).

3.4 Transmission Line Alternatives

The following sections discuss existing fisheries resources in drainages crossed by the five action alternatives. The streams within the study area (i.e., within 300 ft. of either side of alternative ROWs) are listed in detail with documented fish presence data in Appendix A.

3.4.1 Alternative 1: Preferred Alternative

From south to north, the Alternative 1 ROW begins within the Green River Watershed, crosses the CRW, and ends in the watershed of the Raging River (a tributary to the Snoqualmie River). The route parallels an existing 500-kV BPA transmission line. The following sections summarize fisheries in the various segments that comprise the Alternative 1 ROW. See Appendix A for details of streams along this alternative.

Segment A—Segment A lies within the Green River and Cedar River watersheds. No streams have been identified within the 750-ft. corridor in this short (1.2 mi.) segment. It is possible that non-fish-bearing seasonal streams occur within the project area. Such streams would likely drain to the Cedar River or its floodplain.

The topography of Segment A is mostly flat, and most of the land has been developed for agricultural or rural residential purposes. Any surface waters in this segment have little shading by vegetation. Runoff draining this area could adversely impact fish habitat by conveying warm water and fine sediment to fish-bearing streams.

Segment B—Segment B is part of the Alternative 1 and 4a ROWs. This short (0.5 mi.) segment also lies within the CRW. No streams have been identified within the 750-ft. corridor in this segment. It is possible that non-fish-bearing seasonal streams occur within the 750-ft. corridor. Such streams would likely drain to the Cedar River or its floodplain.

The topography of Segment B is mostly flat. Most of the land is conifer forest within the CRW. Any surface waters in this segment are likely well shaded by vegetation, and runoff from them would have a beneficial impact on downstream fish habitat.

Segment C—Segment C is part of the Alternative 1, 4a, and 4b ROWs. This segment crosses the Cedar River and its floodplain. No other fish-bearing streams have been identified within the 750-ft. corridor in this short (1.3 mi.) segment. It is possible that non-fish-bearing seasonal streams occur within the 750-ft. corridor. Such streams would likely drain to the Cedar River or its floodplain.

The topography of Segment C includes a steep, north-facing slope above the south side of the Cedar River floodplain, the relatively flat floodplain, and a dissected area of former gravel mines near the north side of the floodplain. The entire area is largely forested by mixed hardwood and conifer stands. Trees are large enough to provide recruitment of functional LWD to the river, with many trees larger than 20 in. diameter breast height (dbh). However, the river and its floodplain are wide enough that the existing forest can provide only about 10% riparian shade, so that riparian shade likely is not a primary control on stream temperature in this reach. The river in this area has deep pools and a gravel bed very well suited for salmon spawning, and the floodplain is not confined, contains a complex of gravel bars and back channels, and is well suited as anadromous fish rearing habitat. Currently, this reach of the Cedar River supports rainbow trout and a small population of cutthroat trout. Once passage around the Landsburg Diversion Dam has been established (in September 2002), it is likely that this reach would support all anadromous species now prevented from upstream migration by the Landsburg Diversion Dam except sockeye salmon, including chinook and coho salmon, and steelhead. Under the terms of the CRW HCP, sockeye salmon would continue to be prevented from migrating upstream past Landsburg Diversion Dam.

Segment D—Segment D is part of the Alternatives 1, 2, 4a, and 4b. From south to north, this segment crosses Rock Creek in the Walsh Lake subbasin of the CRW, and the Raging River and several of its tributaries in the Raging River Watershed. This segment is 6.0 mi. long. An undetermined number of non-fish-bearing streams occur within the 750-ft. corridor, including tributaries to Rock Creek and Williams Creek in the CRW, and Deep Creek and Raging River in the Raging River Watershed.

The topography of Segment D consists primarily of a long rise on a slope of approximately 20 to 40% to the Cedar-Raging watershed divide, and a long descent of comparable gradient to the

Raging River. The Raging River runs in a canyon approximately 250 ft. deep with slopes of 60 to 70%. North of the Raging River, the ROW climbs over uneven moderate slopes to a terminus at the Echo Lake Substation. Most of the segment is largely forested by mixed hardwood and conifer stands with closed canopies but varying ages ranging from very young (approximately 10 years) to old growth (approximately 200 years), although submature stands predominate. Trees adjoining fish-bearing streams are large enough to provide recruitment of functional LWD to the stream, with most stands dominated by trees larger than 12 in. dbh. Forest stands adjoining fish-bearing streams are capable of providing more than 80% shade to the stream, and in such settings, shade is likely a primary control on water temperature both directly, by preventing solar radiation from striking the stream, and indirectly, by providing relatively low air temperatures in the riparian area.

The affected streams have a pool-riffle morphology with bed materials varying from gravel to small boulders; the Raging River additionally has a gravel floodplain approximately 165 ft. wide. Thus, these streams likely provide suitable spawning and rearing habitat for anadromous and resident fish. Rock Creek, in this segment, is known to be a fish-bearing stream; once fish passage is established at the Landsburg Diversion Dam in September 2002, the creek is expected to be accessible to anadromous fish (City of Seattle 2000). Rock Creek, downstream of this segment, is known to be used by cutthroat trout. The Raging River and its tributaries in this segment are known to be used by rainbow trout, cutthroat trout and their hybrids (“cutbows”), as well as by coho salmon and steelhead (McHenry pers. comm.).

3.4.2 Alternative 2

From south to north, the Alternative 2 ROW begins within the Green River Watershed, crosses the CRW, and ends in the Raging River Watershed. The following sections summarize fisheries in the various segments that comprise the Alternative 2 ROW. See Appendix A for details of streams along this alternative.

Segments E and F—Segment E is part of the Alternative 2, 4a, and 4b ROWs. Segment F is part of the Alternative 2 and 4b ROWs. These short (1.0 and 0.4 mi.) segments lie within the Green River and Cedar River watersheds. No streams have been identified within the 750-ft. corridor in these segments. It is possible that non-fish-bearing seasonal streams occur within the 750-ft. corridor. Such streams would likely drain to the Cedar River or its floodplain.

The topography of Segments E and F is mostly flat. Most of the land is conifer forest within the CRW. Any surface waters in this segment are likely well shaded by vegetation, and runoff from them would have a beneficial impact on downstream fish habitat.

Segment G—Segment G is part of the Alternative 2 ROW. This segment crosses the Cedar River and its floodplain. No other fish-bearing streams have been identified within the 750-ft. corridor in this short (1.6 mi.) segment. It is possible that non-fish-bearing seasonal streams occur within the 750-ft. corridor. Such streams would likely drain to the Cedar River or its floodplain.

The topography of Segment G is generally flat, except for relatively steep slopes at the north and south margins of the Cedar River floodplain, which is approximately 400 ft. wide. The entire area is largely forested by mixed hardwood and conifer stands. Trees are large enough to provide recruitment of functional LWD to the river, with many trees being 16 to 24 in. dbh. However, the river and its floodplain are wide enough that the existing forest can provide only about 20% riparian shade, so that riparian shade likely is not a primary control on stream temperature in this reach. The river in this area has scattered pools associated with boulders and a gravel bed very well suited for salmon spawning. The floodplain is not confined, contains a complex of gravel bars and back channels, and is well suited as anadromous fish rearing habitat. Currently, this reach of the Cedar River supports rainbow and cutthroat trout. Once passage around the Landsburg Diversion Dam has been established in September 2002, it is likely that this reach would support all anadromous species now prevented from upstream migration by the dam except sockeye salmon, including chinook and coho salmon, and steelhead. Under the terms of the CRW HCP, sockeye salmon would continue to be prevented from migrating upstream past Landsburg Diversion Dam.

Segment D—See the Alternative 1 description.

3.4.3 Alternative 3

From south to north, the Alternative 3 ROW begins within the Green River Watershed, crosses the CRW, and ends in the Raging River Watershed. The Alternative 3 ROW includes a single segment, Segment J, which is 10.2 mi. long. See Appendix A for details of streams along this alternative.

Segment J—The route first travels nearly due north from its southern terminus, crossing Taylor Creek in approximately 1.6 mi. and then turning northeast to parallel the Cedar River for about 2.2 mi. The ROW then turns north-northwest to cross the Cedar River and its floodplain, as well as a major tributary, Steele Creek (crossed twice), before crossing into the Raging River Watershed. In that watershed, the ROW crosses the Raging River, Canyon Creek, and several unnamed creeks that are potentially fish-bearing. In addition, it is likely that non-fish-bearing seasonal streams occur within the 750-ft. corridor. Such streams would drain to the Cedar or Raging Rivers or their floodplains.

Within the project area, Taylor Creek is known to contain resident cutthroat and rainbow trout, but a natural falls near its mouth renders the stream inaccessible to anadromous fish. Within the project area, the stream has a steep gradient and a highly confined channel, and thus provides poor fish habitat despite high riparian shade and abundant in-stream LWD.

The Cedar River, in the project area, has a riffle-glide morphology with few pools. The bed is predominantly gravel and large cobble, and the stream may provide good anadromous spawning once passage is established at the Landsburg Diversion Dam in September 2002. The river in this area has about 35% shade and thus water temperature is not likely to be affected very much by changes in riparian shading. The riparian forest has many large conifers, mostly more than 20 in. dbh, which are capable of providing functional LWD to the river. Currently, this reach of the Cedar River supports rainbow and cutthroat trout.

3.4.4 Alternative 4a

From south to north, the Alternative 4a ROW begins within the Green River Watershed, traverses the CRW, where it joins with the Alternative 1 ROW, and ends in the Raging River Watershed. The following sections summarize fisheries in the various segments that comprise the Alternative 4a ROW. See Appendix A for details of streams along this alternative.

Segment E—See the Alternative 2 description.

Segment H—Segment H lies within the CRW. No streams have been identified within the 750-ft. corridor in this short (1.2 mi.) segment. It is possible that non-fish-bearing seasonal streams occur within the project area. Such streams would likely drain to the Cedar River or its floodplain.

Segments C and D—See the Alternative 1 description.

3.4.5 Alternative 4b

From south to north, the Alternative 4b ROW begins within the Green River Watershed, traverses the CRW, where it joins with the Alternative 1 ROW, and ends in the watershed of the Raging River (a tributary to the Snoqualmie River). It differs from the Alternative 4a ROW by joining the Alternative 1 route before crossing the Cedar River, following the route of an existing Seattle City Light 115-kV transmission line between the Alternative 1 and 2 ROWs. The following sections summarize fisheries in the various segments that comprise the Alternative 4b ROW. See Appendix A for details of streams along this alternative.

Segments E and F—See the Alternative 2 description.

Segment I—Segment I lies within the CRW. No streams have been identified within the 750-ft. corridor in this short (1.0 mi.) segment. It is possible that non-fish-bearing seasonal streams occur within the project area. Such streams would likely drain to the Cedar River or its floodplain.

Segments B, C and D—See the Alternative 1 description.

3.5 Access Roads

All new access roads that have the potential to affect fish-bearing streams would be situated within the alternative ROWs discussed in Section 3.4.

3.6 Substation

The proposed substation expansion does not have the potential to affect fish-bearing streams.

4.0 Environmental Consequences

This section describes the potential environmental consequences that could occur from each alternative, the project facilities, and the potential mitigation that could be implemented to minimize those impacts. Impacts have been categorized as high, moderate, and low, as described below.

An impact would be **high** if an action causes:

- an adverse effect on a federally listed threatened fish species, as determined through interagency consultation with the USFWS and NMFS under Section 7 of the Endangered Species Act; or

- substantial adverse effects to essential fish habitat; or

- a regional adverse effect on the populations, habitat, or viability of fish species of concern, which would tend toward endangerment and the need for federal listing of the species.

An impact would be **moderate** if an action causes:

- an effect on threatened or endangered species that could be mitigated through interagency consultation with the USFWS and NMFS under Section 7 of the ESA; or

- minimal adverse effect or less than substantial adverse effect to essential fish habitat; or

- a localized and/or short-term (up to three years) reduction in the quality or quantity of aquatic resources or habitats that does not result in the take of a federally listed species, or have a major effect on a fish species of concern.

An impact would be **low** if an action causes:

- an effect on fish species not listed under the ESA, that would be largely mitigated; or

- no adverse effect to essential fish habitat; or

- a temporary (less than three years) reduction in the quantity or quality of aquatic resources or habitats confined to the site of the action.

No impacts would occur if the action would result in no loss of quantity or quality of aquatic resources, temporary or otherwise.

Construction, operation, and maintenance of transmission facilities could impact fish and their habitat as a result of:

- reduced in-stream LWD, reduced LWD recruitment potential, and changes in stream thermal regime associated with vegetation and tree clearing within designated riparian buffers for the transmission line ROW and access roads;

- disturbance of fish habitat or passage from placement of culverts, fords, or other crossing structures in streams;

- degradation of water or spawning gravel quality from ground surface disturbance associated with ROW clearing or road construction that contributes sediment to streams;

- catastrophic loss of habitat and fish populations if a debris torrent affects a stream channel as a result of ROW clearing, road construction, or road maintenance;

- acoustic shock from the use of explosives in or close to fish-bearing streams; or

- toxicity or deterioration of water quality from accidental spills of hazardous materials.

All of these are recognized as common impacts to fish populations and habitat as a result of timber harvest and associated activities in mountainous terrain in the Pacific Northwest (WFPB 1998, City of Seattle 2000). It is largely incidental that timber harvest would be followed by installation of a transmission line for the proposed project. The physical transmission line structure would not be expected to impact fish or their habitat. All impacts would be associated with ROW clearing for construction and maintenance of the transmission facilities and access roads.

The sensitivity of fish and fish habitat in individual streams to potential impacts from the proposed project would depend on a number of factors. In regard to existing conditions, impacts would be greater in streams occupied by threatened, endangered, or sensitive species than if the streams were not occupied by such species. Actions within riparian zones of perennial streams would have a greater potential impact to fish and their habitat than actions within riparian zones of intermittent streams or wetlands. The removal of mature or older timber, particularly conifers, from riparian zones would have a greater potential effect on fish habitat than removal of small, young trees, hardwood trees, or shrub vegetation, or spanning conductors over riparian vegetation. The number, location, design, and maintenance of stream crossings; the amount of disturbed area (tower sites, access roads, etc); the erodibility of soils in different areas; and the stability of slopes potentially delivering landslides or debris torrents to streams could also affect the severity of potential impacts.

The following section discusses potential impact mechanisms common to all action alternatives. Potential impacts resulting from each action alternative are discussed later in this section.

4.1 Construction Impacts

4.1.1 Impacts Common to All Action Alternatives

4.1.1.1 Impacts

Disturbance to Fish Habitat from Removal of Riparian Vegetation—Removal of riparian trees during construction could affect fish habitat. Such effects would be permanent because the ROW would be kept clear during operation and maintenance. Riparian trees protect fish habitat by filtering runoff before it reaches the stream, shading the stream and reducing mid-summer temperatures, providing LWD to streams which increases habitat complexity, stabilizing streambanks, and providing organic matter to the stream which increases productivity in the aquatic food chain. Removal of riparian trees and disturbance of the streambank could result in increased erosion, sediment loading, and turbidity; increased temperature; changes in habitat complexity; and lower productivity.

There has been a great deal of debate about how the ecological role of riparian vegetation varies with distance from the stream. The principal ecological variables of concern include LWD delivery to streams, root reinforcement of streambanks, litterfall, and shading (FEMAT 1993). All of these variables are generally agreed to vary approximately in proportion to the distance from the channel, relative to site potential tree height (SPTH). The SPTH is the height that trees in the riparian forest may reasonably be expected to achieve within an appropriate time period, often established as 50 or 100 years. Most analysts also agree that the size of the affected stream should be considered in assessing riparian zone effects on the stream. In Washington, streams are commonly classified from Type 1 to 5, according to a system established by the WDNR and summarized in Table 2.

Table 2. WDNR Stream Classification System (WAC 22-16-030)

Stream Type	Definition
Type 1	Major streams: waters inventoried as "shorelines of the state" under RCW 90.58.
Type 2	Waters that are not Type 1 and are used for domestic water supplies, or that are used by fish hatcheries, or that have a bankfull width of more than 20 ft. and a gradient of less than 4%, or are lakes larger than 1 ac., or are used by salmonids for off-channel habitat.
Type 3	Waters that are not Type 1 or 2 and have major fish use. Streams with a bankfull width of 2 ft. or more and a gradient of less than 16% are assumed to have major fish use. If the basin is larger than 50 ac., major fish use is assumed for streams with a gradient less than 20%. Ponds smaller than 1 ac. are also Type 3 waters.
Type 4	Waters that are not Type 1, 2, or 3 and have perennial flow.
Type 5	Waters that are not Type 1, 2, 3, or 4 and have a defined channel.

Land management agencies in the Pacific Northwest have had to manage for riparian ecological functions in response to development pressures that generally entail removal of forest cover. The most widespread removal activity is logging, but loss of riparian vegetation is also a major concern in areas subject to agricultural, residential, industrial, and other land uses. The usual response by management agencies has been to require preservation of a "riparian buffer" or "riparian management zone" (RMZ), within which tree removal is restricted or prohibited and impacts to riparian vegetation must be minimized. Within the project area, three regulatory standards have been approved by the USFWS and NMFS as being sufficiently protective of riparian and fisheries resources to ensure compliance with the ESA. These regulatory standards are the CRW HCP (City of Seattle 2000), WDNR HCP (WDNR 1997), and Washington Forest Practices Rules, as amended in March 2000 (WAC 222). These regulatory standards are summarized in Table 3.

Each of these three regulatory standards has received concurrence from the USFWS and NMFS as having low potential to adversely affect listed salmonid species. Therefore, vegetation clearing under each of the action alternatives, if performed under the applicable regulatory standard, is assumed to have no (or low) impact to fish and their habitat. Conversely, vegetation clearing that exceeds the criteria specified in Table 3 is assumed to have a moderate or high impact to fish resources. Moderate and high impacts are further distinguished by the criteria described earlier in this section.

Clearing of the transmission line ROW would involve removal of trees and other tall vegetation for construction. Trees adjoining the ROW that could fall on the line (danger trees) would also be removed. Not all trees in the ROW would be removed. Transmission towers are typically sited on higher ground, and they generally span drainages and associated riparian areas. This siting requirement would minimize potential impacts from riparian clearing because topography facilitates placement of structures that span drainages and increases the likelihood that conductors would be above many riparian areas and require only limited removal of danger trees.

Table 3. Regulatory Standards for RMZs on Lands in the Project Area

Standard	Jurisdiction	Stream Type	Provisions
Cedar River Watershed Habitat Conservation Plan (City of Seattle 2000)	Cedar River Municipal Watershed	not applicable	No commercial forest harvest within the Cedar River Watershed. Manage all forests to provide certain enumerated ecological functions.
Department of Natural Resources Habitat Conservation Plan (WDNR 1997)	State-owned timberlands	Type 1, 2, or 3	No trees to be cut in a buffer width corresponding to the 100-year SPTH, with a minimum 100-ft. width.
		Type 4	No trees to be cut in a 100-ft. wide buffer.
		Type 5	Buffer width to be determined on a case-by-case basis pending further studies.
Washington Forest Practices Rules (WAC 222)	Privately owned commercial timberlands	Type 1, 2, or 3	For Site Class 2 lands (50-year SPTH, 119 to 136 ft.): No trees to be cut in a 50-ft. wide core buffer; very limited tree removal in an additional buffer 63-ft. wide on streams with a bankfull width of less than 10 ft., or 78 ft. wide on streams with a bankfull width of more than 10 ft.; leave 20 trees per acre larger than 12 in. dbh in an additional buffer 57 ft. wide on streams with a bankfull width of less than 10 ft., or 78 ft. wide on streams with a bankfull width of more than 10 ft.
		Type 4	No trees to be cut in a 50-ft. wide buffer within 300 ft. of a junction with a WDNR Type 1, 2 or 3 stream. On longer streams, buffer at least 50% of stream length with a 50-ft. wide buffer. No trees to be cut near certain sensitive sites. Numerous additional restrictions.

Construction of the transmission line would result in high impacts to fish from clearing of riparian vegetation. BPA would prepare a clearing advisory as part of the design of the project. This plan would evaluate areas to be cleared and the permissible height of existing vegetation that could remain. As noted in the mitigation section, facilities would be sited to minimize clearing of riparian forests along each of the action alternatives.

BPA would also minimize potential effects to fish habitat from vegetation clearing during road construction. As noted in the mitigation section, roads would be constructed outside of riparian zones except at stream crossings, steep and erodible areas would be avoided, and water bars and drainage features would be installed where needed in accordance with the Washington Forest Practices Rules.

Culvert or Bridge Installation—During the construction of the transmission line, BPA may need to install some culverts or bridges to provide or upgrade stream crossings for access roads. Improper stream crossing installation may cause drainage network extension, increasing peak flows in affected streams. It may also result in increased delivery of fine sediment to affected streams, either by exposing erodible surfaces during stream crossing placement, by channeling ditch runoff to the streams, or by increasing stream power due to the above-mentioned changes in peak flows. Peak flow increases may cause stream channel instability, altering fish habitat and increasing scour in spawning gravels. Fine sediment effects are detailed below.

Improperly installed stream crossings may block or impede fish passage by increasing the velocity or decreasing the depth of water flowing through the structure, or because the culvert poses a physical barrier (as with a hung culvert). Blocking a stream to fish passage could result in a loss of access to spawning and rearing habitat. Some fish in the streams along the proposed transmission line ROW, including sensitive species such as bull trout, steelhead, and salmon, migrate upstream to spawn. Although spawning fish could tolerate short delays in migration, blocking or prolonged delays in migration to spawning grounds could locally reduce the productivity of these species.

BPA would comply with guidelines for fish passage in the design of all culverts as specified in the WDFW guidelines and criteria for stream crossings (WDFW 1999) and would comply with WDFW guidelines for in-water work, as specified in the Hydraulic Project Approval (HPA) for each stream-crossing structure. In addition, as specified in the mitigation measures, BPA would design roads to minimize the number of stream crossings. Because of these measures, culvert and bridge installations would result in low impacts to fish and their habitat. Because of the methods used to design and site culverts, construction of the transmission line would not affect fish passage.

Fine Sediment Delivery to Streams—Clearing of the transmission line ROW, grading and placement of tower footings, and construction of new access roads and their associated stream crossing structures would expose soil to the erosive forces of wind, rain, and surface runoff during construction and until sites were revegetated. Such erosion would deliver fine sediment into streams.

Excessive delivery of fine sediment to streams would degrade water quality and fish habitat. Increased turbidity, the fine suspended sediment load carried by a stream, could affect fish and other aquatic organisms directly by abrasion, clogging of gills, decreasing feeding success due to reduced visibility, and by affecting other organisms that fish eat. As sediment settled, it could enter spawning gravels, reducing spawning gravel permeability and causing increased egg and fry mortality and reduced fry growth rates. Fine sediment could also reduce plant or phytoplankton productivity, reduce flows within gravels that are important to maintaining low stream temperatures, and smother or displace aquatic invertebrates. In very large quantities, fine sediment could fill pools (which are important habitat for fish).

Construction of the transmission line would cause low impacts to fish and their habitat as a result of erosion and sedimentation. BPA has constructed transmission lines using a number of standard construction practices and BMPs that would minimize potential impacts to fish from turbidity and sedimentation (see Section 4.1.1.2 for discussion of mitigation common to all action alternatives). Briefly, these measures include minimizing removal of riparian vegetation, siting towers and roads in stable areas where possible, minimizing the number of stream crossings, using appropriate sizing and culvert installation techniques, timing culvert installation to avoid sensitive periods for fish, and using effective sediment and erosion control methods.

Catastrophic Channel Disturbance—Clearing of the transmission line ROW and for new access road construction would entail removal of forest vegetation. On steep slopes (generally slopes steeper than 70%), such clearing may reduce soil strength as tree roots decay that formerly stabilized the soil. This mechanism has been shown to be a principal cause of landsliding in logged areas (WFPB 1998). Such landslides typically occur during exceptional winter storms, which occur about once every 10 years in the mountains of western Washington. If such a landslide enters a stream, it becomes a debris torrent or debris flow, which is a water-rich landslide that descends a stream channel. A debris torrent may cause greatly increased erosion rates, effectively multiplying the destructive power of the landslide and allowing it to descend the stream channel to the point where the stream gradient drops below 16%. At that point, most streams in the project area are thought to support populations of fish.

The effect of debris torrents on fish habitat is commonly described as "catastrophic" because they cause loss of most in-stream LWD, remove much riparian vegetation, provide a large source of fine sediment that is redistributed downstream, and kill all fish in the directly affected channel (WFPB 1998, Coho and Burges 1994). Improper construction or maintenance of stream crossing structures commonly exacerbates the effects of debris torrents. If a debris torrent should clog a culvert or bridge situated on a steep stream channel (gradient typically greater than 20%), the stream crossing may act as a dam. The debris torrent pools behind the dam and overtops it. The resulting event is called a dam-break flood and may be much more destructive than a normal debris torrent, scouring all sediment and LWD from the steep stream channel and delivering it to lower gradient channel reaches occupied by fish (Coho and Burges 1994).

The proposed project is expected to cause low impacts to fish and their habitat as a result of catastrophic events. Very few portions of the proposed ROWs are on slopes steeper than 70%, so the likelihood of landsliding due to timber harvest is very low. No stream crossing structures are expected to be installed on stream channels with a gradient of more than 20%, so the likelihood of causing a dam-break flood is also very low.

Adverse Effects to Fish from Acoustic Shock Associated with Blasting Tower Footings— Although specific sites have not yet been identified, it is likely that BPA would need to blast bedrock to install some tower footings. Detonating explosives in or adjacent to fish habitat could cause disturbance, injury, or death to fish and destruction or alteration of their habitat.

Blasting could affect fish through two different mechanisms, depending on where charges were placed (Wright 1982). First, if the charge was detonated in water, it would produce a post-detonation compressive shockwave that could rupture the swim bladder (a gas-filled organ that allows fish to maintain buoyancy) or affect other organs. Fish eggs and larvae could also be affected by this pressure wave. Second, when a charge is detonated next to fish-bearing waters, the charge sets up a vibration, which may damage incubating eggs.

BPA does not expect that any in-water blasting would be necessary. However, some towers would be located within 400 ft. of streams. If blasting was required for those footings, and streams near the blast site were fish-bearing, BPA would blast footings during periods when eggs or alevins were not present in gravels. If blasting was required in or adjacent to streams supporting federally listed or proposed species, BPA would also be required to contact the USFWS and/or NMFS. Construction, including blasting near streams, would only be performed during authorized in-water work windows based on WDFW procedures for protection of salmon and their eggs. (See Section 4.1.1.2 for mitigation common to all action alternatives.)

Certain other construction activities, such as operation of heavy machinery, would also generate noise. Noise from such relatively low-intensity sources, when not generated by in-water equipment, has not been shown to have any impact on salmonid fishes.

Adverse Effects to Fish from Accidental Spills of Hazardous Materials—Construction of the proposed transmission line and access roads would require several fairly common construction materials (e.g., concrete, paint, and wood preservatives) and petroleum products (e.g., fuels, lubricants, and hydraulic fluids) that could be toxic to fish and other aquatic organisms. BPA might store small quantities of these materials either along the ROWs or in staging areas. An accidental spill of these materials that reached streams, lakes, ponds, or wetlands could impact fish.

The potential for impacts to fish from accidental spills of these materials would be low. BPA would prepare a Spill Prevention and Contingency Plan to minimize the potential for spills of hazardous materials to streams and other water bodies (see Section 4.1.1.2 for discussion of mitigation common to all action alternatives). The plan would include restrictions on storage or transfer of fuels or other hazardous materials within riparian areas, and plans for clean-up in the unlikely event of a spill.

Impacts to Species Listed and Proposed for Listing under the Endangered Species Act— Any of the action alternatives could potentially impact chinook salmon, bull trout, and coho salmon. These species would be susceptible to the impact mechanisms discussed above. Reduced LWD recruitment potential and impacts to stream thermal regime are the two primary issues of concern. The level of these impacts would be high for the following reasons. First, the loss of LWD recruitment would be permanent and would affect streams that, by and large, already contain insufficient LWD. Second, in view of the low project area elevation, potential thermal effects could harm fish by causing thermal stress during low flows. Third, there would be little opportunity to mitigate these impacts, although impacts would be less for some streams than for others because in some settings relatively little vegetation clearing would be required.

Bull trout and chinook salmon have not been recorded to use streams in the project area of any of the five action alternatives. However, all streams accessible to anadromous fish in the project area are regarded by the USFWS and NMFS as having the potential to support chinook salmon and bull trout (listed federally as threatened) and coho salmon (a candidate for federal listing). Chinook salmon have been recorded in the Raging River less than 1 mi. downstream of the Segment D crossing, and their apparent absence in the project area may only be due to inadequate surveying. The Cedar River contains suitable chinook salmon spawning habitat, and such use is expected to occur after the Landsburg Diversion Dam fish ladder is completed in September 2002, prior to project construction. Other streams in the project area are too narrow and steep to support chinook salmon spawning habitat, and all streams in the project area are too warm to support bull trout spawning habitat (KCDNR 2000). All streams accessible to anadromous fish in the project area are assumed to have the potential to provide coho salmon spawning habitat, although many of these streams are locally too steep to support such use.

4.1.1.2 Mitigation

To minimize potential impacts to fisheries habitat from clearing of vegetation:

- BPA would site the transmission line to minimize clearing of riparian vegetation. In some cases, the topography would allow BPA to site towers so that the conductor would span drainages and associated riparian areas. Hazardous trees within the riparian zone would be removed with a minimum of disturbance to ground cover.

- BPA would maximize the use of existing roads during construction, and would site all new stream crossings within cleared ROWs. Thus, no additional clearing in riparian areas would be required for road construction.

To ensure adequate fish passage at stream crossings:

- BPA would design stream crossings following WDFW guidelines. Factors that could affect fish passage through culverts include the type, length, size, and gradient of the culvert; the number of culverts that need to be passed; and the condition of the culverts. BPA would design and install culverts, when necessary, with consideration for fish passage. Culverted crossings in areas where fish are present would be designed to achieve appropriate flow and depth for fish passage and would be large enough to prevent clogging with debris. Where practical, the culvert would be set to grade and provide direct entrance and exit for water flow. Where necessary, BPA would armor the culvert entrance and exit to prevent erosion and development of physical barriers.

To minimize the potential for increases in fine sediment delivery to streams:

- BPA would site towers and roads appropriately, use sediment and erosion control methods during construction, and minimize clearing of riparian vegetation.

- BPA uses several standard methods to minimize erosion and sedimentation associated with transmission line construction. BPA would maximize the use of existing roads, minimizing the need for new road construction. BPA would, where feasible, avoid tower construction on potentially unstable slopes.

- BPA would prepare an Erosion Control Plan as part of their stormwater National Pollutant Discharge Elimination System (NPDES) permit. BPA would incorporate appropriate erosion protection techniques during site clearing, tower assembly and erection, line stringing, and counterpoise installation. These techniques typically include installation of erosion control devices such as weed-free hay bales or sediment fencing where appropriate, to minimize transport of sediments to streams via runoff. In areas that could be susceptible to erosion, BPA would stabilize the site or road using a variety of methods, which may include riprapping or mulching. All disturbed areas would be reseeded following construction.

- ROW clearing would use methods that minimize erosion. BPA would prepare a clearing plan that allows as much vegetation to remain on the ROW as possible, yet assures that the reliability of service is not jeopardized. The clearing plan would include a clearing back-line, which would be marked in the field to delineate areas for contractors where vegetation would be retained. The plan would also identify the permissible height of remaining vegetation for each area. During the clearing of the ROW, contractors would be required to use a brush hog to minimize damage to root systems of low-growing vegetation, thus providing more rapid recovery of this vegetation and greater protection against runoff in the ROW.

- Access roads would be designed to minimize the potential for erosion. Construction of steep, straight road sections, which could result in channelization and concentration of runoff, would be avoided. Waterbars and drainage would be installed where appropriate.

- Except at stream crossings, roads would be constructed outside of the riparian corridors of streams, so that vegetation provides a protective buffer between streams and construction areas. Stream crossings would be designed to minimize impacts to the bed and banks by orienting crossings perpendicular to streams, minimizing the removal of riparian vegetation, preventing the disruption of normal flow patterns, and choosing the appropriate crossing structure (i.e., bridges, culverts, or fords). Stream crossings would be sited to minimize the potential for erosion and avoid sensitive fisheries habitat.

- Construction activities near streams would be scheduled to avoid sensitive fish spawning, incubation, and migration periods (following WDFW in-water work timing guidelines).

- Culverts would be sized to convey 100-year flows. Culverts would be installed using standard construction techniques that minimize the potential for erosion during or after installation. Methods may include (where appropriate) isolating the working area from the streamflow (using temporary diversions or dams), providing sediment containment devices during construction, armoring streambanks near the culvert entrance and exit, installing culverts on straight sections of stream to ensure unimpeded flow, and following the contour of the stream channel. In areas that provide fish habitat or migration corridors, culverts would be sized and sloped to allow appropriate depth and flow velocities for fish passage, and culvert design would follow WDFW fish passage guidelines.

To minimize the potential for impacts from accidental spills:

- BPA would develop and implement a Spill Prevention and Contingency Plan to minimize the potential for spills of hazardous materials and its transport to streams and other water bodies. The plan would include provisions for storage of hazardous materials and refueling of construction equipment outside of riparian zones, a spill containment and recovery plan, and notification and activation protocols.

To avoid potential impacts to fish from acoustic shock:

- Blasting for tower footings near fish-bearing streams containing spawning habitat would occur only during periods when no spawning fish were in the area and when fish eggs and alevins were not present in gravels.

To avoid impacts to fish from vegetation management:

- BPA would comply with the standards and guidelines established in the Record of Decision (ROD) for vegetation management (BPA 2000).

4.1.1.3 Cumulative Impacts

Cumulative impacts on fish and other aquatic resources are those impacts that act not only on the local area where the impact occurs, but at every point downstream that is influenced by the impact. Fine sediment load, stream temperature, LWD recruitment, and toxic pollutant load could be impacted by vegetation removal and road building. These impacts could be additive throughout a watershed, and they could produce a moderate or high impact in the lower reaches, even if the upper reaches appear to have adequate conditions. In the case of the proposed transmission line, cumulative impacts include impacts associated with the existing transmission line, and impacts associated with other human uses of the affected watersheds, such as forest practices (in the Raging River watershed) and watershed restoration activities (in the Cedar River Watershed).

Many possible cumulative impacts could be minimized by applying appropriate construction methods (including BMPs) and rapidly correcting erosion problems associated with routine maintenance of the transmission line ROW or roads. To minimize cumulative impacts, BPA should seek to perform construction and maintenance activities consistent with the highly conservative guidelines established in the CRW HCP, and the somewhat less conservative regulation contained in the Washington Forest Practices Rules. Operations performed under these guidelines have been evaluated by the USFWS and NMFS as having a low potential to adversely affect threatened and endangered fish species.

Fine Sediment Load—Fine sediment that could harm fish and degrade fish habitat is transported downstream through a river system. Downstream habitat is, therefore, dependent on the conditions in all headwater streams. The effect of an increase in sediment load is not just a local concern, but becomes additive with sediment increases throughout the watershed. Timber harvesting, agriculture, road building, and other development resulting in clearing of vegetation and construction of impervious surfaces such as parking lots and roof tops could all contribute to increased sediment load in a watershed. The sensitivity of a watershed to the cumulative effects of additional sediment load depends on the distribution of resources sensitive to fine sediment inputs, such as spawning beds, as well as the quantity and location of fine sediment sources, soils, slopes, vegetation cover, and flow regime.

LWD Recruitment—Large woody debris or LWD is critical to maintaining structure and stability of streams in the western Cascade Mountains. LWD forms pools, traps sediment, provides cover for fish, creates "steps" that can facilitate stream passage, and provides a substrate and food source for aquatic invertebrates. Most streams in parts of the Northwest that have experienced timber harvest are currently depleted in LWD relative to historic conditions, and recovery of in-stream LWD concentrations is a principal goal of land management agencies in the region. The Washington Forest Practices Rules, and the Cedar River and WDNR HCPs, seek to restore LWD levels by maintaining a riparian forest of large conifers that would occasionally fall into the stream, thereby maintaining stable in-stream LWD structure. Thus, the entire project area is currently managed to recover and sustain LWD recruitment. Any activity that removes large trees from the riparian forest would tend to decrease the loading of in-stream LWD with resulting adverse impacts to fish habitat. If the affected fish were not special-status species, the impact would be moderate. If affected fish were protected under the ESA, the impact would be high.

Stream Temperature—Although reduction of shading along a small length of stream may have a small influence on stream temperature, this effect could produce a moderate or high impact if there were many such reductions in shading throughout the watershed. In Washington state, research has determined that riparian shade and elevation are the two principal determinants of peak annual stream temperatures (Sullivan et al. 1990). At the elevations found in the project area, 700 to 2,000 ft., riparian shade levels of 50 to 85% are necessary to prevent stream temperatures from exceeding state water quality standards (WAC 173-202, WFPB 2000). Vegetation clearing could reduce riparian shade enough to cause impairment of water quality standards, with concomitant adverse impacts to designated beneficial uses of the water body, such as fish habitat.

Toxic Pollutant Loading—Toxic substances could enter the stream system of a watershed from a number of sources. No herbicides would be used for vegetation control within 400 ft. of streams and none would be used in the CRW. In addition, assuming that BMPs were used to prevent fuel spills on or near construction sites, petroleum products used in vehicles and other machinery during transmission line installation would probably be diluted in the watershed to the point where there would be no cumulative effect. Therefore, cumulative effects of toxic substances from the power line would be unlikely even when combined with other sources in the watersheds.

In the future, the transmission line ROW could be a logical choice for construction of other linear projects, such as additional transmission lines or fiber optic cables. The decision to create new ROW in this area could increase the likelihood of such proposals.

4.1.1.4 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

Even with BMPs to control erosion, road construction would likely cause some fine sediment to enter nearby streams. This effect could be minimized by consistent monitoring, especially during storm events, and by proper maintenance of road and stream crossings.

Because native vegetation in the project area consists of dense conifer forests, maintaining a ROW free of tall trees would increase moderate solar radiation and convective heating in all streams by allowing more sunlight to reach these streams (Adams and Sullivan 1989, Sullivan et al. 1990). This effect would be greatest on streams more than about 20 ft. wide, where low-growing vegetation could not shade the entire stream. Stream temperature impacts are very site specific and dependent on elevation, local topography, existing vegetation, stream gradient, the presence of groundwater, drainage from riparian wetlands, channel morphology, and microclimatic effects (Beschta et al. 1987, Sullivan et al. 1990). Existing standards for water protection in the Washington Forest Practices Act (WAC 222) do not acknowledge the importance of factors other than shade and elevation as determinants of stream temperature and are generally inadequate to ensure that stream temperatures do not exceed the state water quality criterion (Earle 1998).

Studies on timberlands in the western foothills of the Washington Cascade Range have found that in the absence of adequate riparian shade, fish-bearing streams commonly achieve peak annual temperatures of 18 to 21^{o} Celsius (Earle 1998; see also data cited in Ecology 2000). Such temperatures may cause stress in most salmonid fishes but would not be lethal (Bell 1991). Moreover, most streams contain thermal refugia in the form of deep pools, tributary junctions, or areas of groundwater influx, where more equable temperatures persist and fish could hold during peak water temperature periods (Beschta et al. 1987, Keller and Hofstra 1982, Nielsen et al. 1994). Bull trout, if present in the area, may be severely stressed and may suffer some mortality if subjected to temperatures as high as 18 to 21^{o} Celsius (McCullough 1999). However, it would be very unlikely that bull trout occur in the project area because water temperatures are generally too high to support bull trout spawning even in relatively undisturbed portions of the Cedar River and Raging River watersheds at the moderate elevations found in the project area.

4.1.2 Substation Impacts

4.1.2.1 Impacts

No fish-bearing streams are known to occur near the proposed substation expansion. However, the potential exists for undocumented non-fish-bearing streams to occur within the area. It is possible, but unlikely, that fine sediment could be eroded from exposed ground surfaces during construction and then be conveyed by surface flow to fish-bearing streams during storms.

4.1.2.2 Mitigation

Erosion control BMPs described in Section 4.1.1.2 would be implemented to avoid impacts to fish or their habitat.

4.1.2.3 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

No unavoidable, irreversible, or irretrievable impacts would occur.

4.1.3 Alternative Transmission Line Impacts

4.1.3.1 Alternative 1: Preferred Alternative

Impacts—Because Alternative 1 is the preferred alternative, potential impacts were evaluated in greater detail for this alternative. Figure 4 shows new and existing road and tower locations, along with fish use of streams, along the Alternative 1 ROW.

The types of potential impacts to fish under Alternative 1 would be the same as those discussed earlier for all the alternatives. In order to compare ROW alternatives, a number of factors that could affect fish were evaluated (Table 4), including the extent of clearing required (assuming that the full width of the ROW were cleared), number and location of potential fish-bearing streams crossed by the ROW, the number and location of stream-crossing structures (culverts or bridges) associated with new roads, and the sensitivity of fish resources (whether accessible to anadromous fish). Note that the estimates of clearing in Table 4 reflect the assumption that all trees in the ROW would be cleared. In practice, clearing requirements would be reduced in some areas due to local topography. Conversely, clearing requirements may be greater in other areas to accommodate hazards such as very tall trees or unfavorable topography. Thus, the cleared areas shown in Table 4 could vary from final actual clearing by as much as +/- 20 percent.

Table 4. Riparian Buffer Areas to be Cleared under Each Action Alternative

Affected Area	Alternative				
	1	2	3	4a	4b
No. Fish-Bearing Streams Crossed by Conductors or Roads	9	11	25	11	11
No. Fish-Bearing Streams within 100 ft. of Clearing	11	14	28	13	13
Area Cleared within 100 ft. of Fish-Bearing Stream (ac.)	12	14	34	14	14
No. Fish-Bearing Streams within 300 ft. of Clearing	15	16	28	15	15
Area Cleared within 300 ft. of Fish-Bearing Stream (ac.)	33	40	77	37	37
New Fish-Bearing Stream Crossing Structures Required	0	2	7	2	2
Length of Fish-Bearing Stream within Cleared Area (ft.)	2,869	3,058	6,196	3,177	3,177

The Alternative 1 ROW would be 9 mi. long and cross nine fish-bearing (Type 1, 2, or 3) streams and an unknown number of non-fish-bearing (Type 4 or 5) streams. The ROW would cross three watersheds: Green River, Cedar River, and Raging River. No fish-bearing streams would be crossed in the Green River Watershed.

Construction of Alternative 1 would result in the clearing of 33 ac. within 300 ft. of potentially fish-bearing streams, and 12 ac. within 100 ft. of potentially fish-bearing streams. About 2,900 ft. of stream would be within the cleared ROW. Impacts from clearing of vegetation would be as described in Section 4.1.1.1. Clearing within 300 ft. of the stream could affect LWD recruitment to the stream and stream microclimate. Clearing within 100 ft. of the stream could reduce riparian shading, bank reinforcement by roots, and fine litter contributions to the stream. New roads would not cross any fish-bearing streams, so no culverts or bridges would be built.

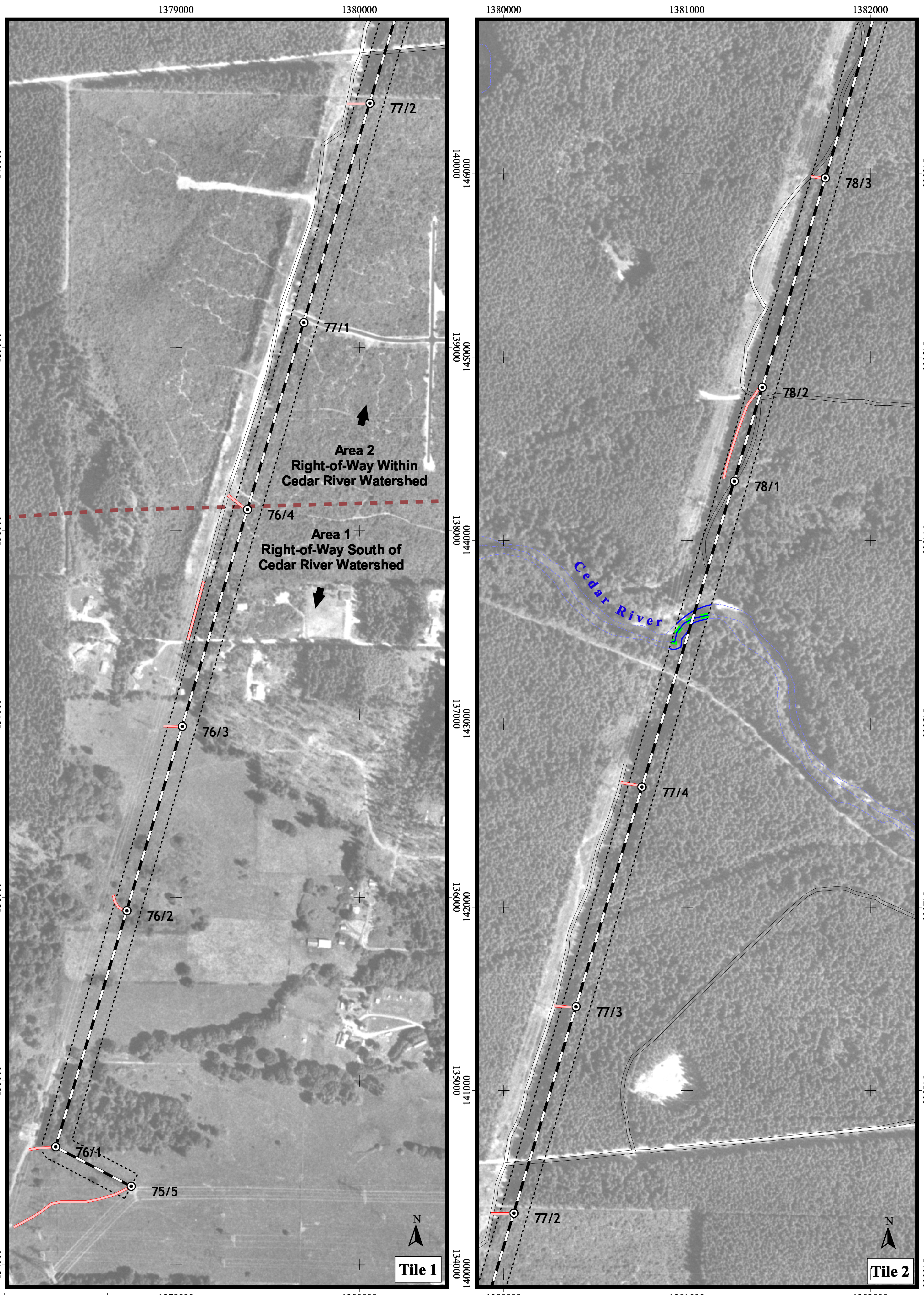
Mitigation—All of the mitigation measures cited in Section 4.1.1.2 would apply to Alternative 1.

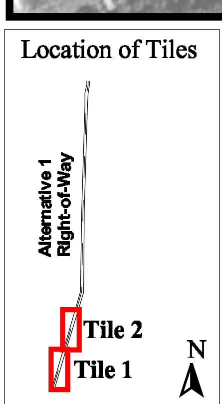
Cumulative Impacts—*Fine Sediment Load*: Fine sediment could be produced during vegetation clearing, maintenance of the existing road system, and tower construction. Currently, the only other anthropogenic source of fine sediment is forest road maintenance. Under applicable regulations, current fine sediment production is low. If Alternative 1 were implemented, fine sediment production would continue to be low.

Stream Temperature: Currently, stream temperature is protected by provisions of the Washington Forest Practices Rules and the Cedar River and WDNR HCPs that ensure retention of adequate riparian shade. Of these three regulatory standards, the Washington Forest Practices Rules are the least restrictive. The Rules require maintaining a certain amount of riparian shade in order to avoid exceeding the state water quality standards for temperature. The standard calls for less shade with increasing elevation because ambient air temperatures tend to be lower at high elevations. At the elevation of most streams in the project area, 600 to 1,800 ft., between 50% and 86% riparian shade is needed to avoid exceeding the Class AA water quality criterion of 61ºF. The Cedar River HCP applies a much more restrictive standard, which recognizes the antidegradation provisions of Washington's water quality standards (WAC 173-201(a)). Under this standard, any reduction in riparian shade would be expected to cause increased stream temperatures, degrading the stream's capacity to provide optimal fish habitat.

Proposed vegetation clearing would not comply with riparian shade protections called for by either the Washington Forest Practices Rules or the CRW HCP, and may result in local peak stream temperatures exceeding metabolic optima for salmonids. In streams only utilized by resident salmonids, this would constitute a moderate impact. In the three streams potentially utilized by threatened salmonid species (Cedar River, Raging River, and Rock Creek), this could constitute a high impact. However, two of those streams, the Cedar River and the Raging River, run in relatively deep canyons where little vegetation clearing may be required. The third stream, Rock Creek, would be crossed in a headwaters area and would be very unlikely to be utilized by chinook salmon (which avoid such narrow, high-gradient streams) or bull trout (which do not spawn in such warm streams; see KCDNR (2000)). These considerations may result in a moderate or low impact to threatened species, but this conclusion cannot be confirmed until the extent of clearing needed in the affected areas is known.

LWD Recruitment: Currently, LWD recruitment is protected by provisions of the Washington Forest Practices Act and the Cedar River and WDNR HCPs that ensure retention of riparian forest buffers at least 100 ft. wide. Proposed vegetation clearing would not comply with those protections and may result in reduced LWD recruitment and resulting adverse impacts to in-stream fish habitat. In streams only utilized by resident salmonids, this would constitute a moderate impact. In the three streams potentially utilized by threatened salmonid species (Cedar River, Raging River, and Rock Creek), this could constitute a high impact. However, one of those streams, the Raging River, runs in a relatively deep canyon where little vegetation clearing may be required. A second stream, Rock Creek, would be crossed in a headwaters area that





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Non-Fish Bearing Stream
- Fish Bearing Stream
- Known Anadromous Fish Bearing Stream
- Post-Dam Removal Anadromous Fish Bearing Stream

500 0 500 Feet
Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4a.
Photomap of Fish Resources and Proposed New Facilities
Tiles 1 & 2

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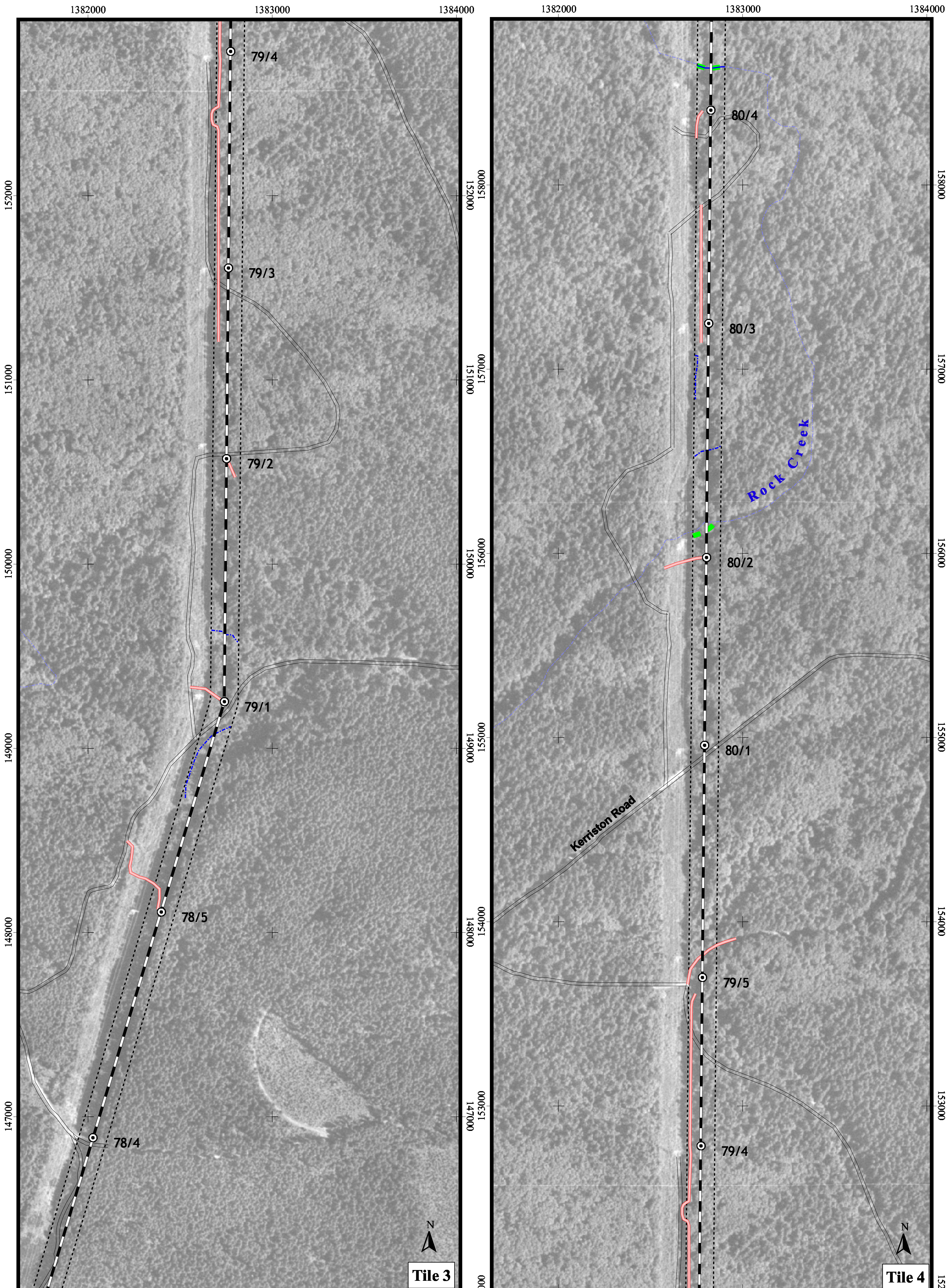
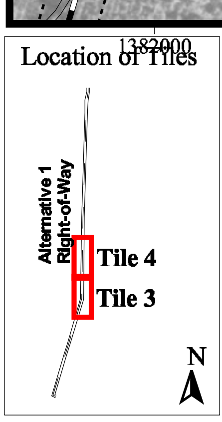
Wet5





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Non-Fish Bearing Stream
- Fish Bearing Stream
- Known Anadromous Fish Bearing Stream
- Post-Dam Removal Anadromous Fish Bearing Stream

500 0 500 Feet

Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4b.
Photomap of Fish Resources and Proposed New Facilities
Tiles 3 & 4

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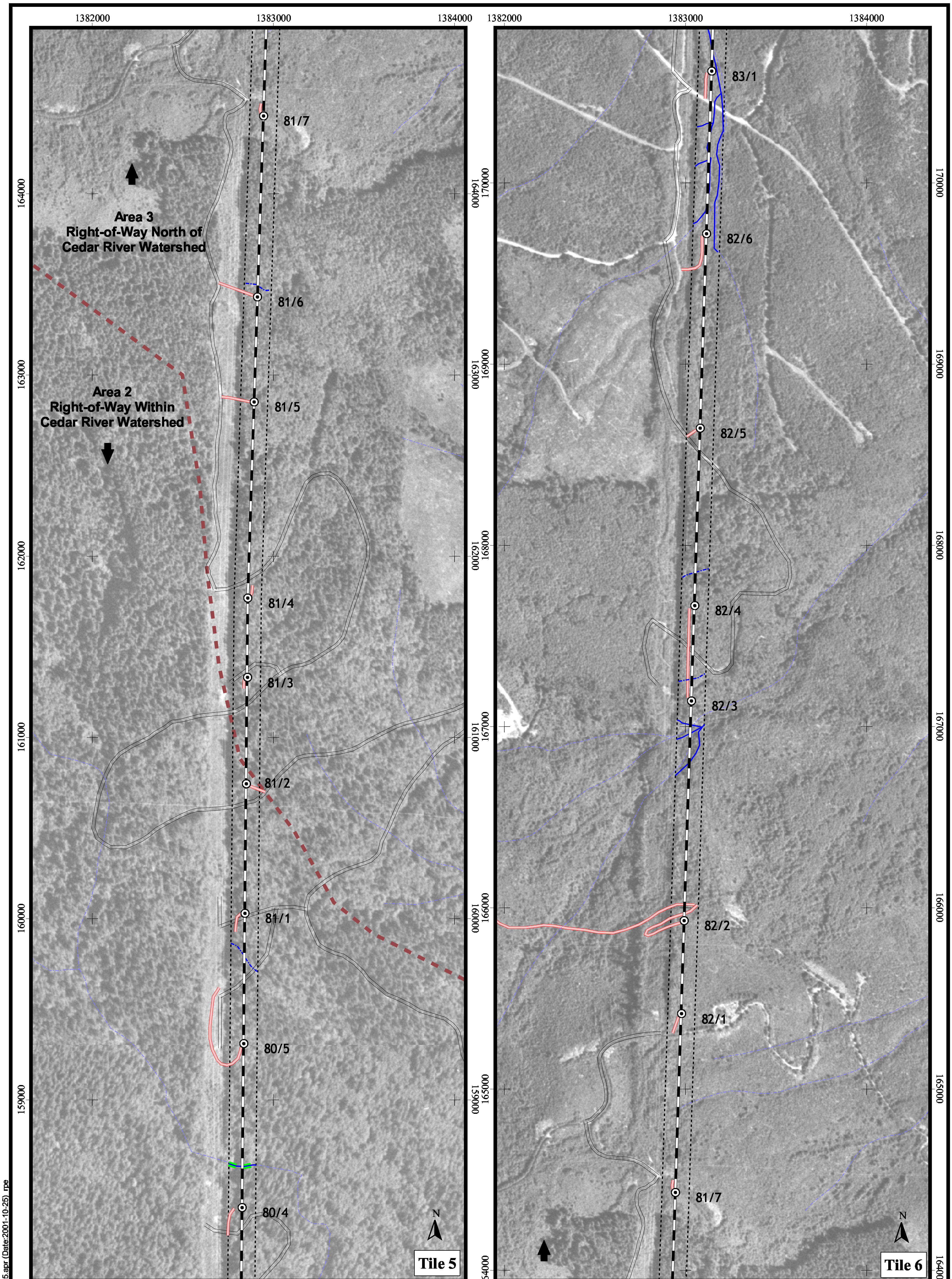
Wet5



Location of Tiles

Alternative 1 Right-of-Way

Tile 6

Tile 5

LEGEND

New Tower Locations

New Transmission Line

Transmission Line Right-of-Way

New Access Roads

Existing Roads

Non-Fish Bearing Stream

Fish Bearing Stream

Known Anadromous Fish Bearing Stream

Post-Dam Removal Anadromous Fish Bearing Stream

500 0 500 Feet

Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4c.
Photomap of Fish Resources and Proposed New Facilities
Tiles 5 & 6

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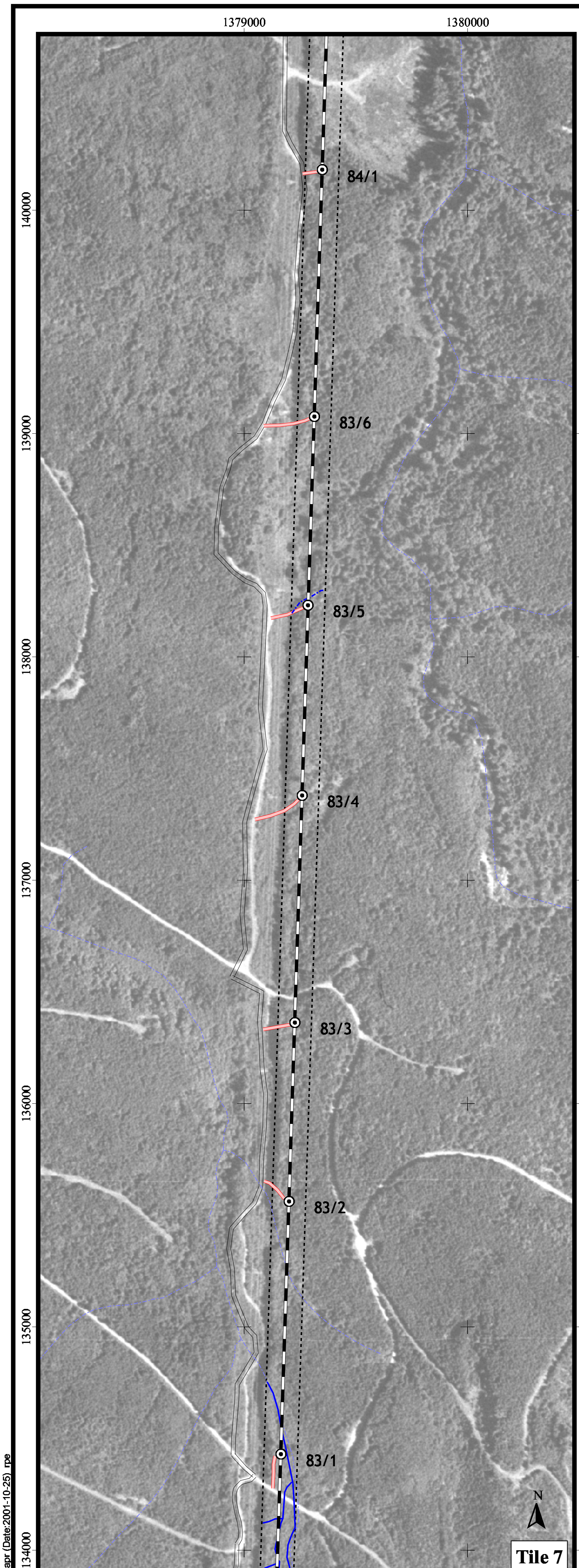

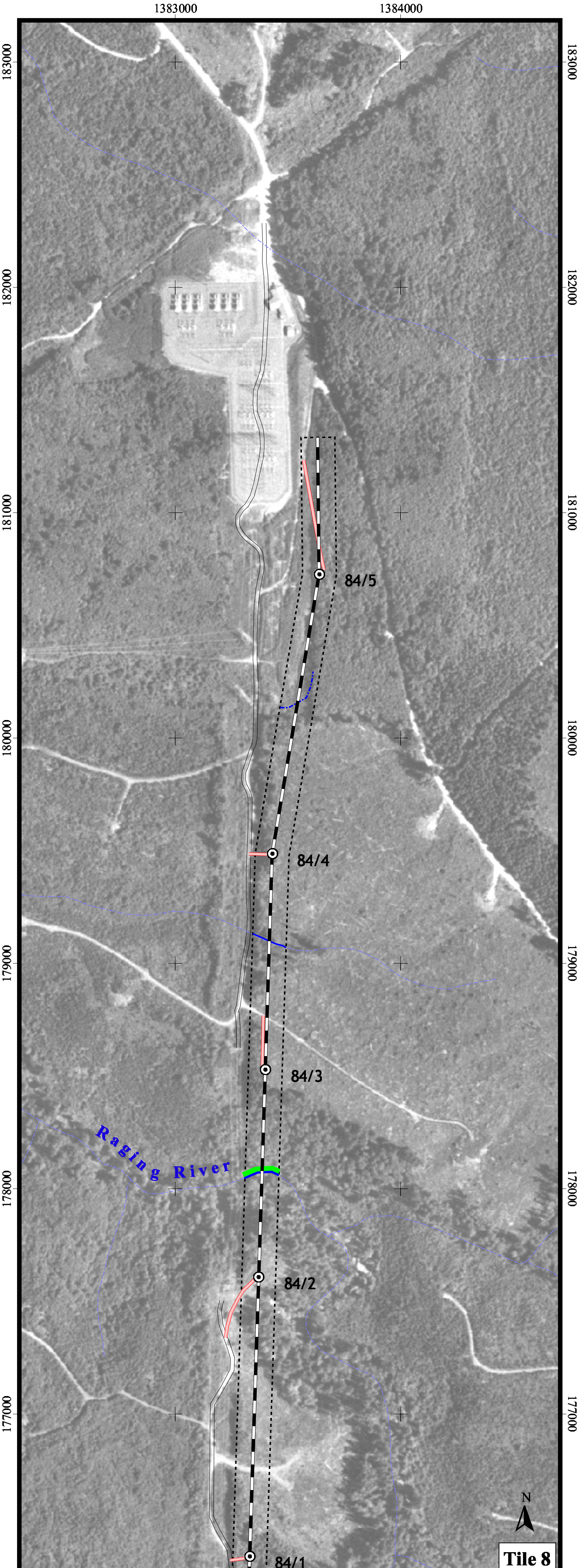

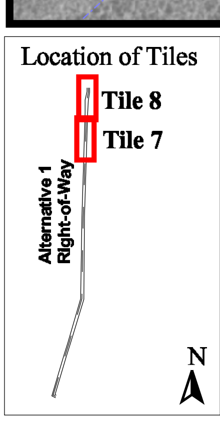

LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Non-Fish Bearing Stream
- Fish Bearing Stream
- Known Anadromous Fish Bearing Stream
- Post-Dam Removal Anadromous Fish Bearing Stream

500 0 500 Feet

Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4d.
Photomap of Fish Resources and Proposed New Facilities
Tiles 7 & 8

Path/apr: S:\Temp\BPA_Kangley_0P005\GIS\Projects\wet5.apr (Date:2001-10-25) rpe would be very unlikely to be utilized by chinook salmon (which avoid such narrow, high-gradient streams) or bull trout (which do not spawn in such warm streams; see KCDNR (2000)). In these streams, a low impact would be expected for threatened species. However, the Cedar River is a large stream where very large conifers are required to provide recruitment of functional LWD. Trees removed along this stream would not be available to provide LWD, resulting in a high impact.

Toxic Pollutant Loading: Some toxic pollutant loading could occur as a result of road maintenance and tower construction. In view of the mitigation measures described earlier, the likely impact would be low. Because no herbicides would be used in vegetation control within 400 ft. of streams and none would be used in the CRW, cumulative effects of toxic substances from the power line would be unlikely even when combined with other sources in the watersheds.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Alternative 1 would require vegetation clearing in riparian areas. This unavoidable impact would result in increased fine sediment delivery to streams in association with project construction, as well as permanent reductions in LWD recruitment to streams, stream shading, bank reinforcement by tree roots, and fine litter inputs. None of these impacts would be irreversible or irretrievable. If all maintenance of the proposed project were to stop, and stream crossing structures were to be removed, project impacts would become negligible or undetectable within approximately 150 years.

4.1.3.2 Alternative 2

Impacts—The types of potential impacts to fish under Alternative 2 would be the same as those described earlier for all the action alternatives. Table 4 shows the various factors evaluated in comparing Alternative 2 with the other action alternatives.

The Alternative 2 ROW would be 9 mi. long and cross 11 fish-bearing (Type 1, 2, or 3) streams and an unknown number of non-fish-bearing (Type 4 or 5) streams. The ROW would cross three watersheds: Green River, Cedar River, and Raging River.

Construction of Alternative 2 would result in the clearing of 40 ac. within 300 ft. of potentially fish-bearing streams, and 14 ac. within 100 ft. of potentially fish-bearing streams. About 3,100 ft. of stream would be within the cleared ROW. Impacts from clearing of vegetation would be as described in Section 4.1.1.1. Clearing within 300 ft. of the stream would potentially affect LWD recruitment to the stream and stream microclimate. Clearing within 100 ft. of the stream would potentially reduce riparian shading, bank reinforcement by roots, and fine litter contributions to the stream. New roads would cross two fish-bearing streams, requiring that culverts or bridges be built.

Alternative 2 would cross 11 fish-bearing streams. All of these streams potentially support resident salmonids, including cutthroat and rainbow trout. One of these streams, the Raging River, is currently accessible to anadromous fish. Two of these streams, Rock Creek and the Cedar River, are expected to be accessible to anadromous fish by the time the project would be constructed, due to completion of the fish ladder at Landsburg Diversion Dam. These three streams could all be utilized by chinook salmon and bull trout by the time the project would be constructed.

Mitigation—All of the mitigation measures cited in Section 4.1.1.2 would apply to Alternative 2.

Cumulative Impacts—Cumulative impacts resulting from fine sediment loading, stream temperature, LWD recruitment, and toxic pollutant loading under Alternative 2 would be the same as for Alternative 1 because Alternative 2 would involve the same types of construction activities within the same general area.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Alternative 2 would require vegetation clearing in riparian areas, construction of new roads, and installation of two new stream crossing structures. These impacts would be unavoidable and would result in increased fine sediment delivery to streams in association with project construction, as well as permanent reductions in LWD recruitment to streams, stream shading, bank reinforcement by tree roots, and fine litter inputs. None of these impacts would be irreversible or irretrievable. If all maintenance of the constructed project were to stop, and stream crossing structures were to be removed, project impacts would become negligible or undetectable within approximately 150 years.

4.1.3.3 Alternative 3

Impacts—The types of potential impacts to fish under Alternative 3 would be the same as those described earlier for all the action alternatives. Table 4 shows the various factors evaluated in comparing Alternative 3 with the other action alternatives.

The Alternative 3 ROW would be 10.2 mi. long and cross 25 fish-bearing (Type 1, 2, or 3) streams and an unknown number of non-fish-bearing (Type 4 or 5) streams. The ROW would cross three watersheds: Green River, Cedar River, and Raging River.

Construction of Alternative 3 would result in the clearing of 77 ac. within 300 ft. of potentially fish-bearing streams, and 34 ac. within 100 ft. of potentially fish-bearing streams. About 6,200 ft. of stream would be within the cleared ROW. Impacts from clearing of vegetation would be as described in Section 4.1.1.1. Clearing within 300 ft. of the stream would potentially affect LWD recruitment to the stream and stream microclimate. Clearing within 100 ft. of the stream would potentially reduce riparian shading, bank reinforcement by roots, and fine litter contributions to the stream. New roads would not cross any fish-bearing streams, so no culverts or bridges would be built.

Alternative 3 would cross 25 fish-bearing streams. All of these streams potentially support resident salmonids including cutthroat and rainbow trout. None of these streams are currently known to support anadromous fish, due to the presence of natural passage barriers on most streams, as well as the artificial barrier of the Landsburg Diversion Dam on the Cedar River.

The Landsburg Diversion Dam is scheduled for construction of a fish ladder between mid-July and mid-September 2002. The ladder is expected to be operational in time for the fall salmon run (Bachen pers. comm.). Beginning in mid-September 2002, adult and juvenile anadromous salmonids may be present in the project area as shown in Table 5. Bull trout are not expected to occur in the project area.

Table 5. Potential Anadromous Salmonid Presence in Project Area within the Cedar River Watershed following Completion of Landsburg Dam Fish Ladder

Species	Utilization	Months											
		1	2	3	4	5	6	7	8	9	10	11	12
Chinook salmon	Upstream migration												
	Spawning												
	Intragravel development												
	Rearing												
	Outmigration												
Coho salmon	Upstream migration												
	Spawning												
	Intragravel development												
	Rearing												
	Outmigration												
Steelhead	Upstream migration												
	Spawning												
	Intragravel development												
	Rearing												
	Outmigration												

Because there is some uncertainty regarding the precise location of Alternative 3, its potential impacts were reviewed under two alternative scenarios. In one scenario, the ROW would be located in a 175-ft. wide area west of the centerline. In this scenario, 84 ac. would be cleared within 300 ft. of streams, and 38 ac. would be cleared within 100 ft. of streams. This would result in approximately 125% greater impact than the centerline ROW. In a second scenario, the ROW would be sited in a 175-ft. wide area east of the centerline. In this scenario, 87 ac. would be cleared within 300 ft. of streams, and 36 ac. would be cleared within 100 ft. of streams. This would result in approximately 10% greater impact than for the centerline ROW. Thus, both of the alternative scenarios would produce a greater impact to riparian habitat compared with the Alternative 3 centerline ROW.

Mitigation—All of the mitigation measures cited in Section 4.1.1.2 would apply to Alternative 3.

Cumulative Impacts—*Fine Sediment Load*: Impacts would be the same as for Alternative 1 because the same types of construction techniques would be employed.

Stream Temperature: Proposed vegetation clearing would not comply with provisions of the Washington Forest Practices Act and the Cedar River and WDNR HCPs that ensure retention of adequate riparian shade. Vegetation clearing may result in local peak stream temperatures exceeding metabolic optima for salmonids. In streams only utilized by resident salmonids, this would constitute a moderate impact. The one stream potentially utilized by threatened salmonid species, the Cedar River, runs in a relatively deep canyon where little vegetation clearing may be required—in this case, a low impact would be expected for threatened species. If extensive clearing were required, however, this would result in a high impact.

LWD Recruitment: Proposed vegetation clearing would not comply with provisions of the Washington Forest Practices Act and the Cedar River and WDNR HCPs that ensure retention of riparian forest buffers at least 100 ft. wide. Vegetation clearing may result in reduced LWD recruitment and adverse impacts to in-stream fish habitat. In streams only utilized by resident salmonids, this would constitute a moderate impact. However, the Cedar River is a large stream where very large conifers are required to provide recruitment of functional LWD. Any removal of trees along this stream would substantially reduce their likelihood of recruitment or their functional value as LWD, resulting in a high impact.

Toxic Pollutant Loading: Impacts would be the same as for Alternative 1 because the same types of construction techniques, construction equipment, and potentially hazardous substances would be employed.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Alternative 3 would require vegetation clearing in riparian areas, construction of new roads, and installation of seven new stream crossing structures. These unavoidable impacts would result in increased fine sediment delivery to streams in association with project construction, as well as permanent reductions in LWD recruitment to streams, stream shading, bank reinforcement by tree roots, and fine litter inputs. None of these impacts would be irreversible or irretrievable. If all maintenance of the proposed project were to stop, and stream crossing structures were to be removed, project impacts would become negligible or undetectable within approximately 150 years.

4.1.3.4 Alternative 4a

Impacts—The types of potential impacts to fish under Alternative 4a would be the same as those described earlier for all the action alternatives. Table 4 shows the various factors evaluated in comparing Alternative 4a with the other action alternatives.

The Alternative 4a ROW would cross three watersheds: Green River, Cedar River, and Raging River. Construction of Alternative 4a would result in the clearing of 37 ac. within 300 ft. of potentially fish-bearing streams, and 14 ac. within 100 ft. of potentially fish-bearing streams. About 3,200 ft. of stream would be within the cleared ROW. Impacts from clearing vegetation would be as described in Section 4.1.1.1. Clearing within 300 ft. of the stream would potentially affect LWD recruitment to the stream and stream microclimate. Clearing within 100 ft. of the stream would potentially reduce riparian shading, bank reinforcement by roots, and fine litter contributions to the stream. New roads would cross seven fish-bearing streams, requiring that culverts or bridges be built.

The Alternative 4a ROW would be 9.5 mi. long and cross 11 fish-bearing (Type 1, 2, or 3) streams and an unknown number of non-fish-bearing (Type 4 or 5) streams. All of these streams potentially support resident salmonids including cutthroat and rainbow trout. One of these streams, the Raging River, is currently accessible to anadromous fish. Two of these streams, Rock Creek and the Cedar River, are expected to be accessible to anadromous fish by the time the proposed project would be constructed, due to completion of the fish ladder at Landsburg Diversion Dam. These three streams could be utilized by chinook salmon and bull trout by the time the proposed project would be constructed.

Mitigation—All of the mitigation measures cited in Section 4.1.1.2 would apply to Alternative 4a.

Cumulative Impacts—Impacts related to fine sediment and toxic pollutant loading would be the same as for Alternative 1 because the same construction techniques, equipment, and potentially hazardous substances would be used.

Impacts related to stream temperature and LWD recruitment would be the same as for Alternative 2 because Alternative 4a shares some of the same ROW and stream crossings as Alternative 2.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—These impacts would be the same as for Alternative 2 because Alternative 4a shares some of the same ROW and stream crossings as Alternative 2.

4.1.3.5 Alternative 4b

Impacts would be the same as Alternative 4a.

4.1.3.6 Access Roads

All access roads within 300 ft. of fish-bearing streams would be located within the cleared ROW. Thus, vegetation clearing impacts due to access roads are incorporated within the assessments given above for each of the action alternatives. Additionally, access roads could affect fish and fish habitat because construction of stream-crossing structures (bridges and culverts) could create a fish passage barrier or cause direct physical harm to fish, while delivery of fine sediment to streams may be caused by road construction or road surface erosion. Table 4 shows that Alternative 1 would require no new stream crossing structures, Alternative 3 would require seven such structures, and each of the other alternatives would require two such structures.

Mitigation—The mitigation measures cited in Section 4.1.1.2 would result in a low impact due to roads and stream crossing structures under each of the action alternatives.

Cumulative Impacts—Because all roads in the project area are currently managed to avoid delivery of fine sediment to fish-bearing streams, cumulative impacts due to roads would be low under each of the action alternatives.

Unavoidable, Irreversible or Irretrievable Impacts—Alternative 1 would not require new road construction. Some road wear and erosion could occur in association with increased vehicle usage during project construction, and some of those vehicles might leak or spill petrochemicals. These impacts, although minimized by mitigation measures (Section 4.1.1.2), would be unavoidable, irreversible, and irremediable.

Each of the other action alternatives would require new road construction. Land contours would be altered, flow paths would be disrupted, road wear and erosion could occur in association with increased vehicle usage during project construction, and some of those vehicles might leak or spill petrochemicals. These impacts, although minimized by mitigation measures (Section 4.1.1.2), would be unavoidable. The roads could be decommissioned at some future date, with this process potentially including regrading of land surfaces. In that event, no irreversible or irremediable impacts would occur.

4.1.3.7 Cumulative Impacts

Current and anticipated land uses in the project area include management to preserve and restore a wide range of ecological functions (in the Cedar River Watershed) and management for commercial timber production (in the Raging River Watershed). Both management regimes call for full protection of fish habitat. Thus, no impacts would occur in the project area, apart from those impacts associated with the proposed project.

4.1.3.8 No Action Alternative

Impacts—No project-related impacts to fish or their habitat would occur under the No Action Alternative because no vegetation clearing or new access road construction would occur.

Mitigation—Because no impacts would occur, no mitigation would be required.

Cumulative Impacts—Because the proposed project is the only anticipated impact to fish or their habitat in the project area (as discussed in Section 4.1.3.7), no cumulative impacts are expected.

Unavoidable, Irreversible, or Irretrievable Impacts—Because no impacts are expected under the No Action Alternative, no unavoidable, irreversible, or irretrievable impacts are expected.

4.2 Operation and Maintenance Impacts

4.2.1 Impacts Common to All Action Alternatives

4.2.1.1 Impacts

Once the project is constructed, BPA would conduct routine monitoring of the transmission line. BPA generally inspects transmission lines and access roads every three to four months by air or by using light ground vehicles. Routine inspection activities would not affect fish.

Management of vegetation within the ROW is necessary to control tall vegetation that may fall onto conductors or provide a flashover point, which could jeopardize reliable continued service of the transmission line. BPA has prepared a programmatic NEPA EIS for its vegetation management program associated with transmission lines, roads, and related facilities. The EIS identifies appropriate measures to protect the environment while minimizing hazard tree risks and maintaining the ROW within safe, reliable conditions. The program seeks to manage vegetation in ROWs by:

- promoting the establishment of low-growing plant communities on the ROWs to "out compete" trees and tall-growing brush; and

- having all possible vegetation control methods available for use to maintain ROWs (manual, mechanical, and biological) (BPA 2000).

These guidelines additionally provide for protecting water resources by using herbicide buffer zones. As requested by SPU, BPA would use no herbicides anywhere within the CRW. These standards and guidelines provide sufficient mitigation to avoid disturbance of listed, sensitive, or other fish species.

During routine maintenance, BPA would also inspect roads, identify potential erosion problems, and correct any erosion problems identified.

4.2.1.2 Mitigation

The mitigation measures cited in Section 4.1.1.2 would be implemented.

4.2.1.3 Cumulative Impacts

Current and anticipated land uses in the project area include management to preserve and restore a wide range of ecological functions (in the Cedar River Watershed) and management for commercial timber production (in the Raging River Watershed). Both management regimes call for full protection of fish habitat. Thus, no impacts in the project area are expected, apart from those impacts associated with the proposed project.

4.2.1.4 Unavoidable, Irreversible, or Irretrievable Impacts

During the project lifetime, maintenance of the road system and continued absence of forest in the cleared ROW would perpetuate the impacts identified in Section 4.1. None of these impacts would be irreversible or irretrievable. If all maintenance of the constructed project were to stop, and stream crossing structures were to be removed, project impacts would become negligible or undetectable within approximately 150 years.

4.2.2 Access Roads

4.2.2.1 Impacts

Some road wear and erosion could occur in association with increased vehicle usage during project maintenance, and some of those vehicles might leak or spill petrochemicals. These impacts would be low.

4.2.2.2 Mitigation

Mitigation measures identified in Section 4.1.1.2 would be implemented.

4.2.2.3 Cumulative Impacts

Current and anticipated land uses in the project area include management to preserve and restore a wide range of ecological functions (in the Cedar River Watershed) and management for commercial timber production (in the Raging River Watershed). Both management regimes call for full protection of fish habitat. Thus, no impacts in the project area are expected, apart from those impacts associated with the proposed project.

4.2.2.4 Unavoidable, Irreversible, or Irretrievable Impacts

Some road wear and erosion could occur in association with increased vehicle usage during project construction, and some of those vehicles might leak or spill petrochemicals. These impacts, although minimized by mitigation measures (Section 4.1.1.2), would be unavoidable, irreversible, and irretrievable.

4.2.3 Substation

4.2.3.1 Impacts

No streams are known to be located near the proposed substation expansion. It is possible, but unlikely, that fine sediment could be eroded from exposed ground surfaces during operations and then be conveyed by surface flow to fish-bearing streams during storms.

4.2.3.2 Mitigation

Erosion control BMPs described in Section 4.1.1.2 would be implemented to avoid impacts to fish or their habitat.

4.2.3.3 Cumulative Impacts

Current and anticipated land uses in the project area include management to preserve and restore a wide range of ecological functions (in the Cedar River Watershed) and management for commercial timber production (in the Raging River Watershed). Both management regimes call for full protection of fish habitat. Thus, no impacts in the project area are expected, apart from those impacts associated with the proposed project.

4.2.3.4 Unavoidable, Irreversible or Irretrievable Impacts

No unavoidable, irreversible or irretrievable impacts would occur.

4.2.4 Cumulative Impacts

Current and anticipated land uses in the project area include management to preserve and restore a wide range of ecological functions (in the Cedar River Watershed) and management for commercial timber production (in the Raging River Watershed). Both management regimes call for full protection of fish habitat. Thus, no impacts in the project area are expected, apart from those impacts associated with the proposed project.

4.2.5 No Action Alternative

4.2.5.1 Impacts

No impacts to fish or their habitat are expected because vegetation clearing and access road construction would not occur.

4.2.5.2 Mitigation

Because no impacts are expected, no mitigation is required.

4.2.5.3 Cumulative Impacts

Because the proposed project is the only anticipated impact to fish or their habitat in the project area (as discussed in Section 4.1.3.7), no cumulative impacts are expected.

4.2.5.4 Unavoidable, Irreversible, or Irretrievable Impacts

Because no impacts are expected under the No Action Alternative, no unavoidable, irreversible, or irretrievable impacts are expected.

5.0 Environmental Consultation, Review and Permit Requirements

Activities that involve modifying the vegetation, hydrology, or soils within the project area may require local, state, and federal review. Permits and agency review that may be required based on the proposed action and construction methods are as follows.

5.1 Federal

Public Law 104-297, the Sustainable Fisheries Act of 1996, amended the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) to establish new requirements for "Essential Fish Habitat" (EFH) descriptions in federal fishery management plans and to require federal agencies to consult with National Marine Fisheries Service (NMFS) on activities that may adversely affect EFH. The Magnuson-Stevens Act requires all fishery management councils to amend their fishery management plans to describe and identify EFH for each managed fishery. The Pacific Fishery Management Council (1999) has issued such an amendment in the form of Amendment 14 to the Pacific Coast Salmon Plan, and this amendment covers EFH for all fisheries under NMFS jurisdiction that would potentially be affected by the proposed action. Specifically, these are the chinook and coho salmon fisheries. EFH includes all streams, lakes, ponds, wetlands, and other currently viable water bodies and most of the habitat historically accessible to salmon. Activities occurring above impassable barriers that are likely to adversely affect EFH below impassable barriers are subject to the consultation provisions of the Magnuson-Stevens Act.

The Magnuson-Stevens Act requires consultation for all federal agency actions that may adversely affect EFH. EFH consultation with NMFS is required by federal agencies undertaking, permitting, or funding activities that may adversely affect EFH, regardless of its location. Under section 305(b)(4) of the Magnuson-Stevens Act, NMFS is required to provide EFH conservation and enhancement recommendations to federal and state agencies for actions that adversely affect EFH. Wherever possible, NMFS utilizes existing interagency coordination processes to fulfill EFH consultations with federal agencies. For the proposed action, this goal would be met by incorporating EFH consultation to the Endangered Species Act Section 7 consultation, described below.

The Endangered Species Act of 1973 (16 USC 1536) provides for conserving endangered and threatened species of fish, wildlife, and plants. Federal agencies must determine whether proposed actions would adversely affect any endangered or threatened species. When conducting an environmental impact analysis for specific projects, agencies must identify practicable alternatives to conserve or enhance such species.

The ESA protects species whose populations are declining to the point where they are now at risk of extinction, or are likely to be in the future. The ESA prohibits "taking" any species listed as endangered. The prohibition against taking can be extended to threatened species under regulations promulgated by the USFWS and NMFS. Under the Act, "to take" is defined as "to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 USC 1532(18)). "Harming" includes any action that reduces an individual species' ability to feed, breed, or seek shelter and can include major habitat modifications that result in killing or injuring wildlife by materially impairing behavioral patterns.

Section 7 of the ESA requires federal agencies to consult with the USFWS and/or the NMFS on actions leading to activities that might affect listed species. Consultation typically involves preparing a Biological Assessment that describes the expected effects of a proposed action on a listed species. If the Biological Assessment indicates that the action is likely to adversely affect a listed species, then formal consultation with the USFWS or NMFS is required. Formal consultation results in the issuance of a Biological Opinion – a formal determination on whether or not an action will jeopardize the continued existence of the species or destroy or adversely modify a species' critical habitat, and if so whether there are reasonable and prudent alternatives that avoid such a result (50 CFR 17.3).

Under Section 10 of the ESA, as amended in 1982, incidental takes (those that are incidental to otherwise lawful activity) of listed species may be authorized through voluntary agreements including HCPs. HCPs must be approved by the Secretary of the listing department. When approving a plan, the Secretary must find that:

1. the plan will minimize and mitigate the impacts of the incidental take to the maximum extent possible;

2. the incidental take will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

3. adequate funding for the plan is provided.

HCP agreements must also satisfy consultation requirements specified in Section 7 of the ESA.

5.1.1 Designated Critical Habitat for Listed Species

The ESA requires that, to the maximum extant determinable, NMFS and USFWS must designate critical habitat for federally listed species at the time of their listing. Critical habitat designation establishes areas that are to be given special consideration in Section 7 consultations. Of the listed fish species potentially present in the project area (Table 1), critical habitat has been defined only for chinook salmon.

5.2 State

Washington State-listed threatened and endangered species are not protected in the same way as federally listed species, where a "taking" is generally prohibited unless authorized by an Incidental Take Permit or an Incidental Take Statement. Instead, the State uses these classifications to assist with agency management programs and decision making. The State also defines Priority Habitats as those habitats having unique or significant value to species because they contain a unique vegetation type or a specific habitat element that is key to fish and wildlife.

5.3 Other Standards and Guidelines

5.3.1 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by SPU to establish a comprehensive plan for long-term management of the CRW. The HCP includes numerous provisions intended to maintain the quality of fish habitat and the health of fish populations in the watershed. The proposed project would not comply with forest protection measures specified in this HCP.

5.3.2 Washington Department of Natural Resources Habitat Conservation Plan

WDNR prepared an HCP to establish a comprehensive long-term management plan for all WDNR-managed timberlands within the range of the northern spotted owl in Washington. The HCP also includes numerous provisions intended to maintain the quality of fish habitat and the health of fish populations. The proposed project would not comply with riparian protection measures specified in this HCP.

5.3.3 Washington Department of Natural Resources Forest Practices Rules

The WDNR Forest Practices Rules (WAC 222) describe the types of forest practices allowed under the State of Washington Forest Practices Act (RCW 76.09). They divide forest practices into four classes, based on potential impact to public resources, and outline the processes for permitting of each class. The proposed project would not comply with riparian protection measures specified in the Forest Practices Rules.

6.0 Individuals and Agencies Contacted

Sylvia Cavazos
Communications Specialist
Seattle Public Utilities - Habitat Conservation Office
Contacted by telephone October 25, 2000

Jamie Glasgow
Fisheries Biologist
Washington Trout
Contacted by telephone November 6, 2000

Cindy Holtz
Assistant HCP Program Manager
Seattle Public Utilities - Habitat Conservation Office
Contacted by telephone October 25, 2000

Curt Kraemer
Fish Biologist
WDFW
Contacted by telephone November 9, 2000

Michael McHenry
Tribal Biologist
Tulalip Tribes
Contacted by telephone November 6, 2000

Lisa Rennie
Biologist
King County Department of Natural Resources
Contacted by e-mail October 26, 2000

Fran Solomon
Senior Ecologist
King County Department of Natural Resources
Contacted by telephone November 6, 2000

7.0 List of Preparers

Bonnie Blessing, Aquatic and Wildlife Biologist
Six years of experience in wetland and stream surveys, habitat assessment, field surveys for fish and wildlife, and watershed and wetland rehabilitation.
B.S., Microbiology and Immunology, University of Washington, 1993.

Christopher Earle, Fisheries and Aquatic Biologist
Over 14 years of experience in watershed analysis and terrestrial/aquatic ecosystem interactions.
Ph.D., Forest Ecology, University of Washington, 1993.

Leigh Kienker, CAD/GIS Specialist
Thirteen years of experience in the CAD/GIS and photogrammetry industries.
M.U.P., Urban Planning, University of Washington, expected 2001.

Gregory Poremba, Project Manager
Twenty years of experience managing and preparing EISs.
Ph.D., Sociology, Washington State University, 1990.

Sean Robertson, CAD/GIS Specialist
Two years of experience in GIS mapping and evaluations.
B.S., Environmental and Resource Sciences, University of California – Davis, 1999.

Chris Soncarty, Fisheries Biologist
Four years of experience in habitat assessment.
B.S., Environmental Science, The Evergreen State College, 1994.

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9.0 Glossary and Acronyms

This chapter contains a list of acronyms, abbreviations, and technical terms used in this report. Words that would be defined in a desk-size dictionary (for example, the College Edition of the American Heritage Dictionary) are not included.

Glossary

Access roads are constructed to each structure site first to build the tower and line and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, short spurs are built to the structure sites. Access roads are maintained after construction, except where they pass through cultivated land where the roads would be removed and crop production would be restored after construction is completed.

Alternatives refer to different choices or means to meet the need for action.

Anthropogenic is of, relating to, or resulting from the influence of human beings on nature.

Aquifers are water-bearing rock or sediments below the surface of the earth.

Best Management Practices are a practices or a combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Biological Evaluations are the means by which the U.S. Forest Service conducts a review and documents the findings of the effects of an action or proposed action on any sensitive species.

Culverts are corrugated metal or concrete pipes used to carry or divert runoff water from a discharge. Culverts are usually installed under roads to prevent washouts and erosion.

Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Cut and fill is the process by which a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (filled).

CWA signifies the Clean Water Act, a federal law intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters and secure water quality.

Danger trees or high-growing brush occur in or alongside the project right-of-way and are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the right-of-way is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A contains any tree that in 15 years will grow within about 5 m (18 ft.) of conductors when the conductor is at maximum sag (100^o C or 212^o F) and is swung by 30 kg per sq/m (6 lb per sq/ft.) of wind (93 kph or 58 mph); Category B represents any tree or high-growing bush that after 8 years of growth will fall within about 2 m (8 ft.) of the conductor when it reaches maximum sag (80^o C or 176^o F) in a static position.

Dead ends are heavy towers designed for use where the transmission line loads the tower primarily in tension rather than compression. Dead ends are used in turning large angles along a line or in bringing a line into a substation.

Easement is a grant of certain rights to use a piece of land, which then becomes a "right-of-way." BPA normally acquires easements for its transmission lines. Easement includes the right to enter the ROW to build, maintain, and repair facilities.

Emergent plants have their bases submerged in water.

Endangered species are those officially designated by the USFWS as being in danger of extinction throughout all or a significant portion of their range.

Floodplain refers to a portion of a river valley adjacent to the stream channel that is covered with water when the stream overflows its banks during flood stage.

Footings are the supporting base for the transmission towers. They are usually steel assemblies buried in the ground for lattice-steel towers.

Forb is any herbaceous plant that is not a grass or grasslike.

Ford is a travelway across a stream where water depth does not prevent vehicle movement. Ford construction can include grading and stabilizing streambanks at the approaches and adding coarse fill material within the channel to stabilize the roadbed.

GIS signifies Geographic Information System, a computer system that analyzes graphical map data.

Ground wire (overhead) is wire strung from the top of one tower to the next; it shields the line against lightning strikes.

HCP is Habitat Conservation Plan.

Hydrology addresses properties, distribution, and circulation of water.

Insulators are ceramic or other nonconducting materials used to keep electrical circuits from jumping to ground.

Intermittent refers to periodic water flow in creeks or streams.

Internal drainage refers to streams that are not connected to the ocean by surface waters.

Jurisdictional wetlands are areas that are consistently inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Kilovolt is one thousand volts.

Lattice steel refers to a transmission tower constructed of multiple steel members that are connected together to make up the tower's frame.

Low-gradient refers to gentle slopes.

LWD is large woody debris, defined as any piece of downed wood larger than 4 in. diameter and 6 ft. long.

Mitigation is the step(s) taken to lessen the potential environmental effects predicted for each resource impacted by the transmission project. Mitigation may reduce the impact, avoid it completely, or compensate for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is enacted during the design and location process. Other mitigation, such as reseeding access roads with desirable grasses and avoiding weed proliferation, is taken after construction.

National Environmental Policy Act (NEPA) requires an environmental impact statement on all major Federal actions significantly affecting the quality of the human environment. (42 U.S.C. 4332 2(2)(C))

Noxious weeds are plants that are injurious to public health, crops, livestock, land, or other property.

100-year floodplains are areas that have a 1% chance of being flooded in a given year.

Perennial streams and creeks have year-round water flows.

Permeability refers to the capability of various materials to transport liquids.

Pulling site is a staging area for machinery used to string conductors.

Revegetation is reestablishment of vegetation on a disturbed site.

Right-of-way (ROW) is an easement for a certain purpose over the land of another owner, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Riparian habitat is a zone of vegetation that extends from the water's edge landward to the edge of the vegetative canopy. The term is associated with watercourses such as streams, rivers, springs, ponds, lakes, or tidewater.

Sensitive species are those plants and animals identified by the USFWS and/or NMFS for which population viability is a concern. This classification is evidenced by significant current or predicted downward trends in populations or density and significant or predicted downward trends in habitat capability.

Silt is a designation referring to individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05 mm).

Sole source aquifer is designated by the U.S. Environmental Protection Agency as an aquifer providing at least half of an area's drinking water.

Substation is the fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Substation dead ends are towers within the confines of the substation where incoming and outgoing transmission lines end. Dead ends are typically the tallest structures in a substation.

Threatened species are those officially designated by the USFWS as likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Transmission dead end towers are the last transmission line towers on both the incoming and outgoing sides of the substation. These towers are structurally reinforced to reduce conductor tension on substation dead ends and provide added reliability to the substation.

Transmission line includes the structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Water bars are smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

Wetlands are areas where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Acronyms and Abbreviations

ac.	acre or acres
BMPs	best management practices
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
CRW	Cedar River Watershed
dbh	diameter at breast height
DPS	distinct population segment
EIS	environmental impact statement
ESA	Endangered Species Act
ESU	Evolutionarily Significant Unit
FR	Federal Register
ft.	foot or feet
GIS	Geographic Information System
HCP	Habitat Conservation Plan
HPA	Hydraulic Project Approval
in.	inch or inches
KCDNR	King County Department of Natural Resources
kV	kilovolt
LWD	large woody debris
mi.	mile or miles
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
RMZ	Riparian Management Zone
ROD	Record of Decision
ROW	right-of-way
SPTH	site potential tree height
SPU	Seattle Public Utilities
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources
WRIA	Water Resource Inventory Area

Appendix A.

Data and Comments for Streams, Map and Aerial Photo-Based Surveys

Appendix A.

Table A-1. Data and comments for streams, map and airphoto-based survey.

Stream name	Number	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Cedar River	1	Conifers	C	Rainbow, Cutthroat	None	Kokanee, Steelhead, Chinook, Coho, Sockeye, Bull trout		WDF 1975, CRW, SN2000	Above Landsburg Dam	20	300	140' tall PSME, THPL >14" dbh border stream	Clearing may be avoidable given that trees exist within RMZ of existing transmission line. Proposed alignment will intersect.
Trib to Rock Creek	2	Conifers w/ a thin line of hardwoods adjacent to creek & existing transmission line.	D	Rainbow, Cutthroat	None	Steelhead, Coho		WDF 1975	Above Landsburg Dam, Falls Downstream (WDF 1975). Potential anadromous habitat (CRW)	82	300	PSME, THPL, TSHE and 70-90' tall ALRU	Proposed alignment will intersect. Clearing appears to be necessary.
Rock Creek	3	Conifers w/ some hardwoods.	D	Rainbow, Cutthroat	None	Steelhead, Coho		SN2000, WDF 1975	Above Landsburg Dam, falls downstream (WDF 1975), Potential anadromous habitat (CRW). Gradient ~20%.	80	300	PSME,THPL< TSHE, ALRU 70-90' tall	Tall conifers present under existing transmission line. Tributary and existing veg. Located w/n canyon.
Trib to Raging River	4	Conifers	D	Rainbow, Cutthroat	None	None		WDF 1975	Cascades block passage (WDF 1975). Raging river 3000 feet downstream.	85	300	Conifers.	Tall conifers present under existing transmission line. Tributary and existing veg. Located w/n canyon. Proposed alignment will intersect.
Trib to Deep Creek	5	Primarily hardwoods w/ some conifers	D	Rainbow, Cutthroat	None	None		WDF 1975	Cascades block passage (WDF 1975). Steelhead 5000 feet downstream.	95	200	Mixed forest.	Hardwood (ALRU) dominated RMZ.
Trib to Raging River	6		D	Rainbow, Cutthroat	None	Coho, Steelhead		WDF 1975, SN 2000	Steelhead and Coho 1000' downstream in Raging River.	70	300	Mixed forest	

Stream name	Number	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Raging River	7	Conifers w/ occasional hardwoods (most likely alder).	D	Rainbow, Cutthroat	Rainbow, Cutthroat	Coho, Steelhead	Coho, Steelhead, Chinook	SN2000, WDF 1975	ROW crosses Raging River 5000' upstream of Chinook Spawning area.	75	150	PSME, THPL, PICI 14-35" dbh. Heights variable 80-120'	To the east of ROW: South of Raging River is clearcut for 800'. 35-40' tall PSME borders ROW for the next 3500' south. 14-35" DBH trees border the Raging River in a 150' swath along the River; due to deep canyon, clearing may be avoidable.
Trib to Raging River	8	No buffer of large trees.	D	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	>20% gradient to Raging River 2500 feet downstream.	30	50	Young ALRU. PSME	Clearcut with 10 year old PSME bordering stream. 15' tall ALRU within the RMZ provide shade.
Unnamed channel	9		E	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	No connection to anadromous streams	0	0	Shrub/herbaceous	New road crossing location
Unnamed channel	10	Deciduous shrubs/herbaceous spp., w/ few conifers (less than 20)	E	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	No connection to anadromous streams. Appears to be non-fish bearing.	50	25	PSME and ALRU	Young deciduous shrubs and PSME regen. New road crossing location.
Cedar River	11	Conifers w/ hardwoods adj. to river bed	G	Rainbow, Cutthroat	None	Coho, Steelhead, Chinook, Bull trout, Kokanee		SN2000, WDF 1975	Above Landsburg Dam.	20	300	70 year old PSME, TSHE, PTHP 16-28" tall	Road corridors on north and south side of river. Proposed Option 2 would intersect river. Clearing necessary.
Unnamed channel	19		J	Rainbow, Cutthroat	None	None		WDF 1975	No connection to anadromous	20	0	Young deciduous, shrub and PSME regen.	NEW ROAD CROSSING LOCATION.
Unnamed channel	20	Conifers w/ some hardwoods.	J	Rainbow, Cutthroat	None	None		WDF 1975	No connection to anadromous. Associated with wetland complex within Green River Watershed.	60	125	20" dbh THPL, TSHE	NEW ROAD CROSSING LOCATION.

Stream name	Number	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Taylor Creek	21	Conifers on NW & S side of Pole Line Rd. Hardwoods on SW side.	J	Rainbow, Cutthroat	None	None		WDF 1975	Cascades barrier to anadromous (WDF 1975).	40	300	Mixed forest	Coniferous spp. on NW side of Pole Line Rd. Deciduous spp. On SW side. Conifers on south side of road. Proposed ROW intersects; clearing appears necessary.
Cedar River	22	Conifers	J	Rainbow,. Cutthroat	None	Chinook, Coho, Steelhead, Bull trout, Sockeye		WDF 1975	Above Landsburg Dam.	35	300	Mixed forest	Cutting required due to floodplain topography; proposed ROW would intersect.
Steele Creek	23		J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975)	75	300	Mixed forest and road	NEW ROAD CROSSING LOCATION.
Trib to Steele Creek	23.1			Rainbow, Cutthroat	None	None			Barrier at Holamar Road downstream (WDF 1975)	60	30	Mixed young forest.	NEW ROAD CROSSING LOCATION.
Steele Creek	24	Interspersed hardwoods & conifers.	J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975)	40	30	Mixed young forest. Existing road compromises shade.	
Trib to Steele Creek	25	Conifers	J	Rainbow, Cutthroat	None	None		WDF 1975	Barrier at Holamar Road (WDF 1975).	30	30	Mixed young conifer forest. Wetland	Clearing most likely avoidable; intersects proposed ROW.
Trib to Raging River	26		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Raging River 4000' downstream. Steelhead documented 1000' downstream.	60	60	Mixed 60' tall PSME and ALRU	NEW ROAD CROSSING LOCATION.
Trib to Raging River	27		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Raging River 4000' downstream. Steelhead documented 1000' downstream.	65	50	Mixed 60' tall PSME and ALRU	NEW ROAD CROSSING LOCATION.
Upper Raging River	28		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	Chinook spawn more than 3.5 miles downstream. (In Raging River upper watershed). Steelhead barrier about 1000' downstream.	90	75	Mixed forest. 10-20" dbh TSHE, PSME, ALRU, POBA	

Stream name	Number	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Trib to Raging River	29		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Raging River 2500' downstream. Cascades barrier and >20% downstream.	95	300	47' tall PSME and ALRU (8" dbh) border stream	
Trib to Raging River	30		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Steelhead 300+' downstream. Cascades barrier (WDF 1975)	95	300+	56' tall PSME 11" dbh	High density PSME borders stream. NEW ROAD CROSSING LOCATION.
Trib to Raging River	31		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Steelhead 500' downstream. Cascades barrier (WDF 1975)	95	300+	56' tall PSME 11" dbh	High density PSME borders stream.
Trib to Raging River	32		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Cascade barrier downstream, watershed < 50 acres	0	NA	Shrub/herbs	
Trib to Raging River	33		J	Rainbow, Cutthroat	None	None		SN2000, WDF 1975	Cascade barrier downstream, watershed < 50 acres	0	NA	Shrub/herbs	
Trib to Raging River	34		J	Rainbow, Cutthroat	None	None		WDF, 1975	Raging River 1500' downstream. Cascades barrier (WDF 1975)	50	70'	35-40' tall PSME, ALRU 6" dbh	
Trib to Raging River	35		J	Rainbow, Cutthroat	None	None		WDF 1975	Cascade barrier downstream	50	90	50 year old TSHE/THPL and 35-40' tall ALRU/PSME border stream	
Canyon Creek (Trib to Raging River)	36		J	Rainbow, Cutthroat	None	Coho, Steelhead		SN2000, WDF 1975	12% grade to Raging River ~2000' downstream.	75	100	15-20" dbh TSHE, THPL border stream.	
Trib to Raging River	37		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River ~2000' downstream. Coho and Steelhead 2000' downstream. Cascade Barrier	0	NA	Shrub/herbs	
Trib to Raging River	38		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River and associated Coho and Steelhead 2000' downstream. Cascade barrier.	0	NA	Shrub/herbs	

Stream name	Number	Description of RMZ	Segment	Potential Resident	Documented Resident	Potential Anadromous	Documented Anadromous	References	Fish Comments	Shade	Buffer	Vegetation	Vegetation Comments
Trib to Raging River	39		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River 2000' downstream. Cascade barrier.	60	50	12-14" dbh conifers border stream in narrow swath	ALRU and shrubs also provide shade to stream.
Trib to Raging River	40		J	Rainbow, Cutthroat	None	None		WDF 1975	Raging River 2000' downstream. Cascade barrier.	0	NA	Shrub/herbs	Clearcut. (shrubs and herbs may provide shade).
Cedar River Riparian Area	43	Conifers	H	Rainbow, Cutthroat	None	Chinook, Coho, Kokanee, Bull trout, Steelhead		WDF 1975, Seattle 1998, SN2000		65	300+	140' tall PSME >14" dbh border stream	Conifers border river on both sides. Riparian zone encroachment on south side of Cedar River. Proposed 4A parallels Cedar River for ~1000'. Clearing nec because of flat terrain.

References:

WDF 1975 = Washington Department of Fisheries. 1975. A catalog of Washington streams and salmon utilization. Volume 1, Puget Sound.
Seattle 1998 = City of Seattle, Cedar River Watershed Habitat Conservation Plan.
SN2000 = www.Streamnet.org, data accessed November, 2000.

BPA Kangley Field Notes, 27 & 31 October 2000.
CJ Earle and C Walcker, Cedar River Watershed.

Stop	1	10:15. Culvert 20/4, lowermost line crossing on Steele Creek.					
Photo(s)	001027_02, 3, 4	**GPS**	10T 0588689 5251960				
Forest	PSME, secondary ACMA and ALRU and TSHE. Hardwoods 12-18" dbh, conifers 12-36", hillslopes 30-40%.						
Understory	Riparian understory RUSP						
Stream:		**Shade**	80%				
Bankfull width	6m	**Bankfull depth**	0.6m	**Wetted width**	2.5m	**Wetted depth**	0.2m
Bed material	cobble/sm boulder	**Embedding**	no	**Gradient**	12%	**LWD**	within target
Comments	Stream has been torrented, perhaps as recently as 1995/6, 60" CMP is a passage barrier with a drop at lower end onto riprap						

Stop	2	Upper Steele Ck crossing, where line and road both cross the creek - see map.					
Photo(s)	001027_05	**GPS**	No data, heavy forest cover.				
Forest	PSME 20-40" DBH, riparian ALRU & ACMA within 20' of creek, 40-60% hillslope gradient.						
Understory	POMU, riparian RUSP.						
Stream:		**Shade**	80%, much due to shrubs				
Bankfull width	5m	**Bankfull depth**	0.5 m	**Wetted width**	2.75m	**Wetted depth**	0.15m
Bed material	gravel/sm cobble	**Embedding**	no	**Gradient**	2-4%	**LWD**	within target
Comments	Deep, numerous pools. Suitable resident spawning gravels. No evidence of torrents. Prelogging stand big THPL. Culvert, 36" boiler, is at grade & passable.						

Stop	3	Dense forest with small (4/5) stream.					
Photo(s)	001027_07	**GPS**	No data, heavy forest cover.				
Forest	Dense TSHE/PSME 6-18" DBH						
Understory	Depauperate. LYAM.						
Stream:		**Shade**					
Bankfull width		**Bankfull depth**		**Wetted width**		**Wetted depth**	
Bed material		**Embedding**		**Gradient**		**LWD**	
Comments	Prelogging (ca. 1940), a very fine THPL OG. A big PSME here, 110 cm DBH, photo of CW with it, 42 rings on a 36 cm core, est. 65-70 years old.						

Stop	4	At a bend in the watershed boundary, with a stream just beyond.					
Photo(s)	001027_08	**GPS**	10T 0587821 5254914 at edge of young PSME stand.				
Forest	ABAM/TSHE/PSME 12-20" DBH, with a 3" DBH (20-30 ft tall) PSME stand across the creek just beyond an intact 30' buffer.						
Understory	Depauperate, TSHE regen, Depauperate across the creek. Riparian RUSP, POMU, BLSP.						
Stream:		**Shade**	75%				
Bankfull width	5 m	**Bankfull depth**	0.6 m	**Wetted width**	2.5 m	**Wetted depth**	0.3 m
Bed material	cobble/sm boulder	**Embedding**	mod	**Gradient**	4-8%	**LWD**	below target
Comments	No pools. No torrenting.						

Stop	5	Along Cedar River on No. 10 Road.					
Photo(s)	001027_09	**GPS**	10T 0589222 5241925				
Forest	70% slope has a stand of 12-20" DBH PSME. Riparian forest is mostly PSME, >20" DBH, also PISI and THPL 16-24" DBH.						
Understory	POMU, riparian POMU/GASH.						
Stream:		**Shade**	35%. Trees 30m tall, 95% opaque				
Bankfull width	50 m	**Bankfull depth**	1.5 m	**Wetted width**	15 m	**Wetted depth**	0.5 m
Bed material	cobble/ lg gravel	**Embedding**	unkn	**Gradient**	1%	**LWD**	below target
Comments	River is riffle/glide. A road on this slope would likely be unstable.						

Stop	6	Mouth of Steele Creek at Road 10.					
Photo(s)	001027_10	**GPS**	No data, heavy cover.				
Forest	Upland forest PISI/PSME/TSHE 12-24" DBH on 40% slope. Riparian zone about 32 feet wide has ALRU and ACMA						
Understory	Riparian RUSP, minor RUPA.						
Stream:		**Shade**	90%				
Bankfull width	27 ft	**Bankfull depth**	3 ft	**Wetted width**	6 ft	**Wetted depth**	
Bed material	sm bld/cobb	**Embedding**	mod	**Gradient**	8%	**LWD**	
Comments	Pool-riffle stream. Crossing beneath a bridge, 60 ft upstream of river.						

Stop	7	On a Cedar R. terrace, near reputed small stream.					
Photo(s)	none	**GPS**	No data, heavy cover.				
Forest	45-50 c m DBH PSME						
Understory	Moss, POMU, RUSP, RUUR, VAPA, TSGE regen.						
Stream:		**Shade**					
Bankfull width		**Bankfull depth**		**Wetted width**		**Wetted depth**	
Bed material		**Embedding**		**Gradient**		**LWD**	
Comments							

Stop	8	Taylor Creek crossing (Option 3)					
Photo(s)	none	**GPS**	10T 0586961 5248885 is on road due E of stream data point.				
Forest	16-24" DBH PSME, secondary TSHE/THPL, a few ACMA/ALRU on stream banks. Steep (75%) slopes and no real riparian zone.						
Understory	POMU, minor OPHO, RUSP, VAPA, BENE.						
Stream:		**Shade**	90%				
Bankfull width	10 m	**Bankfull depth**	unkn	**Wetted width**	5-6 m	**Wetted depth**	unkn
Bed material	cob/gravel	**Embedding**	unkn	**Gradient**	4-8%	**LWD**	within target
Comments	Pool-riffle creek runs in a deep gorge, about 150 ft below road level, so riparian area will likely not need to be cut.						

Photos 14, 15 look downstream on Taylor Creek from the bridge crossing about 1/4 mile south of Stop 8.

Stop	9	On Cedar River at Option 2 crossing					
Photo(s)	001027_16	**GPS**	No data, heavy cover.				
Forest	16-24" PSME and smaller hardwoods on S side on a low flat terrace. Across river on N side a 25% slope has a forest of 16-24" DBH PSME and THPL.						
Understory	RUSP/POMU on S side						
Stream:		**Shade**	20%				
Bankfull width	30 m	**Bankfull depth**	1.5 m	**Wetted width**	20 m	**Wetted depth**	0.5 m
Bed material	grav/cob	**Embedding**		**Gradient**	1%	**LWD**	some,
Comments	Full clearing may be needed due to gentle topography. River is forced pool-riffle, but river is too large to retain much LWD except on bars. Most pools associated with scattered large boulders, up to 5 m diameter.						

Stop	10	On **Cedar River** at Option 1 crossing					
Photo(s)	001027_19, 20	**GPS**					
Forest	20" DBH TSHE, minor ACMA. Point bar on the N side is willows, small ALRU, a PISI sapling. Far bank, on a 40% slope, has 16-24" DBH PSME with ABGR and TSHE.						
Understory	POMU.						
Stream:		**Shade**	10%				
Bankfull width	50 m	**Bankfull depth**	4 m	**Wetted width**	15 m	**Wetted depth**	2 m
Bed material	Gravel	**Embedding**		**Gradient**		**LWD**	within target
Comments	Crossing is at a very deep pool, with a point bar across the river. Abundant gravels ideal for salmon spawning. Where existing line crosses, mature trees have been topped to avoid interfering with conductors (photo 19). Saw a mature redtail about 0.7 miles W of here.						

Stop	11	**Culvert 33/1 and 33/2**					
Photo(s)	none	**GPS**	Near 10T 0584941 5251974				
Forest	16-24" DBH TSHE/THPL/PSME						
Understory	RUSP, POMU						
Stream:		**Shade**	100%				
Bankfull width		**Bankfull depth**		**Wetted width**		**Wetted depth**	
Bed material		**Embedding**		**Gradient**		**LWD**	
Comments	18" CMP's on Type 5 streams in Option 1 ROW						

Stop	12	**Rock Creek or tributary**					
Photo(s)	001027_25, 26	**GPS**	10T 0584860 5252808				
Forest	16-24" DBH PISI-PSME-TSHE, riparian ALRU being shaded out from a 20 ft wide riparian vegetation area.						
Understory							
Stream:		**Shade**					
Bankfull width		**Bankfull depth**		**Wetted width**	1.7 m	**Wetted depth**	0.05 m
Bed material	grav/sand	**Embedding**		**Gradient**		**LWD**	none
Comments	48" CMP, a bit of a downstream drop but may be passable to resident cutthroat at some flows. The stream on the existing ROW provides evidence of the nature of likely project impacts on streams. It is bordered by ACCI, SARA, RUSP and shrubs to produce high shade but air temperatures are also likely high at times. Stream has relatively fine bed, no LWD. We walk up the alignment for about 1500 feet, to Waypoint 48 (10T 0584873 5253203). Much of the ROW is effectively wetland. There is widespread PHAR and numerous seeps. The implication is that opening up large areas of forest will produce opportunities for direct solar heating and convective heating of surface waters that can then flow off into fish-bearing streams.						

Stop	13	**Upper Rock Creek on Option 1.**					
Photo(s)	001027_29	**GPS**	10T 0584854 5253532				
Forest	16-24" DBH PSME, PISI, THPL, ABPR and 8-16" DBH ALRU.						
Understory	ACCI, RUSP and POMU.						
Stream:		**Shade**	100%				
Bankfull width	12 m	**Bankfull depth**	0.5 m	**Wetted width**	1.5 m	**Wetted depth**	0.1 m
Bed material	gravel/cobble	**Embedding**	no	**Gradient**	4-8%	**LWD**	within target
Comments	Photo shows how about a year ago BPA came through and cut down the entire riparian forest on this stream. The forest consisted of 30-40 ft tall ALRU. Because the stream runs at the base of a steep N-facing embankment, the trees had ample clearance below the lines. This is an example of likely management of streams in the proposed alignments. Hillslopes hereabouts are mostly upland but still have spots of PHAR.						

Stop	1A	**Canyon Creek**					
Photo(s)	upstream, downstream	**GPS**					
Forest	Forest w/n flood plain is primarily ALRU (12"-20" dbh) mixed w/ smaller TSHE. Adjoining stand on N. side is TSHE/PSME (12"-24" dbh). Stand is adjoined by clear-cut on S. side w/ buffer extending to bottom of inner gorge. Veg. on S. side consists of POMU, secondary RUSP and OPHO, ACCI, GASH, TOME, BLSP, RIBR, ATFI. 60-80% hillslope gradient.						
Understory	Primarily RUSP w/ some POMU, OPHO						
Stream:		**Shade**	riparian ~90%				
Bankfull width	30m (including back channel areas)	**Bankfull depth**	1.5m	**Wetted width**	3.0m	**Wetted depth**	0.2m
Bed material	grav, lrg cobb	**Embedding**	lightly embedded	**Gradient**	4-8%	**LWD**	Above target, good sized conifers (12"-24" dbh)
Comments	Good spawning habitat. Creek associated w/ floodplain ~30m wide w/ two back channels, both dry w/ OHWM of 1.0-2.0m. Most of instream LWD recruited by windfall. Stream is pool/riffle; pools formed by LWD.						

Stop	2A	**Raging River Tributary**					
Photo(s)	upstream	**GPS**	10T 0584851 5253530				
Forest	Surrounding forest consists only of an inner gorge buffer ~50' on both sides and includes TSHE/PSME (6-24" dbh). Forest logged in ~1995. 30' wide riparian corridor includes ALRU (3-8" dbh) along w/ TSHE regen., riparian corridor includes a floodplain (20m).						
Understory	Primarily old growth RUSP (2-3m), with some POMU/ACCI						
Stream:		**Shade**	90-95%				
Bankfull width	20m	**Bankfull depth**	.08m	**Wetted width**	1.5m	**Wetted depth**	10cm
Bed material	Grav	**Embedding**	moderate	**Gradient**	4-8%	**LWD**	Above target
Comments							

Stop	3A	Raging River tributary					
Photo(s)	(1)Upstream, (2)culvert	**GPS**	10T 0586795 5256711				
Forest	Young PSME plantation (5-8" dbh) on hillslopes. 10-20' wide riparian corridor contains ALRU (2-5" dbh).						
Understory	Riparian corridor consists primarily of RUSP with some SARA and Salix spp. Absence of understory veg. in PSME stand.						
Stream:		**Shade**					
Bankfull width	15.0'	**Bankfull depth**	0.4m	**Wetted width**	5.0'	**Wetted depth**	10cm
Bed material	Cobb	**Embedding**	Heavy	**Gradient**	2-4%	**LWD**	Below target
Comments	Trib. is crossed by a logging road. Alignment will cross this data point a short distance downstream. Associated with passable metal culvert (8.0' in dia.). Step/pool morphology upstream, continuous riffle downstream, residual pool depth <2dm.						

Stop	4A	**Upper Raging River (or tributary to it – REFER TO GPS to confirm)?**					
Photo(s)	(1) looking upstream	**GPS**	10T 0587302 5255050				
Forest	Logged recently. Remaining riparian buffer strip is ~100-130' wide, contains PSME, ABAM, TSHE (16-30" dbh). Inner section of buffer contains hardwoods including ALRU (12" dbh).						
Understory	RUSP (3-4m tall) w/ some RIBR. Adjacent forest understory contains young ALRU, ACCI, POMU						
Stream:		**Shade**					
Bankfull width	15.0m	**Bankfull depth**	1.2m	**Wetted width**	20.0'	**Wetted depth**	20.0cm
Bed material	Lrg. cobb/sm bouldr	**Embedding**	mod	**Gradient**	8-16%	**LWD**	Under target
Comments	Wetted width includes two 7-8' channels. Most pools formed around larger boulders, no LWD in this reach. Torrented since orig. logging. Old RR grade runs along this stream.						

Stop	5A	**Raging River (**100m above where Option 1 is proposed to cross).					
Photo(s)	(1) upstream (2) downstream	**GPS**	10T 0585030 5259463				
Forest	Floodplain consists of RUSP, TSHE regen., ALRU (10-12" dbh). Bank on far aside appears to be a mature forest. Bank on this side contains old growth (PISI, TSHE, THPL w/ dbh's of 24->40"); slope ranges from 60-70%.						
Understory	TSHE regen., moss, mixed herbs, POMU, OPHO						
Stream:		**Shade**	60-70% due to low veg. on floodplain width				
Bankfull width	~30.0m **(double check w/ aerial)**	**Bankfull depth**		**Wetted width**	8.0m	**Wetted depth**	0.4m
Bed material	Cobb, sm. boulder	**Embedding**	Low	**Gradient**	8.0%	**LWD**	W/n target
Comments	Floodplain has an additional channel (possibly more than one). River is somewhere btwn. pool/riffle & step/pool. Upstream is step/pool. Lrg. boulders aid in pool forming. LWD exists mostly in side channel jams. Excellent anadromous habitat due to pool dist., size and gravels.						

Stop	6A	**238cm dbh PISI (200 yds. up from Hwy. 18**

Other Photos:

001027_01	CW & vehicle
001027_06	THPL snag
001027_11	Moss
001027_13	CW in field vest
001027_18	CW in car
001027_21, 22, 23	Melissa Chaun & David Jones in field.
001027_24	Looking up the existing alignment.
001027_27	CW in field
001027_28	Looking down the existing alignment

Clearing assessment

Field Names:

ID = Stream number as shown on GIS map.
Name = Stream name, if named.
RMZ = Description of RMZ within 100 ft. on either side of the stream.
Shade = Percent shade cover
I/P = Whether proposed alignment Intersects or Parallels the stream.
Clearing = Amount of clearing likely to be required.

ID	Name	RMZ	Shade	I/P	Clearing	Comment
1	Raging River	Conifer w/ some hardwood	75	I	Unnecessary because stream is in deep canyon.	
2		Hardwood/mixed	95	P		W of extant ROW.
3		Conifer	85	I	Tall conifers present under existing transmission line.	
4	Rock Creek	Conifer/mixed	80	I	Tree removal possibly avoidable due to canyon/depression.	
5	Cedar River	Conifer	35	I	Cutting required due to floodplain topography.	
6	Rock Creek	Conifer w/ alder adjacent to creek.	95	I	Necessary	
8	Cedar River	Conifer	20	I	Trees exist within RMZ of existing transmission line.	
18	Taylor Creek	Conifer on NW side of Pole Line Rd., hardwoods on SW side.	40	I	Necessary	
19	Cedar River	Conifer	10	P	Necessary	
20	Cedar River	Conifer w/ riparian hardwoods	0	I	Necessary	
21		Hardwoods	100	I	Uncertain.	Non-fish bearing.
22		Conifer/mixed	85	I	Necessary	Drainage is associated with a wetland complex.

Appendix B Final Wildlife Technical Report

Final Wildlife Technical Report

Bonneville Power Administration Kangley-Echo Lake Transmission Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97208-3621

Prepared by:

Jones & Stokes
11820 Northup Way, Suite E300
Bellevue, Washington 98005

April 2002

The analysis in this technical report is generally based on typical construction activities and impacts for transmission lines. Detailed information for this project has been updated as much as possible. However, the most current information about this project is in the Final Environmental Impact Statement.

This document should be cited as:

Jones & Stokes. 2002. Bonneville Power Administration Kangley-Echo Lake Transmission Project. Final wildlife technical report. April 2. (JSA 0P005.00.) Bellevue, WA. Prepared for Bonneville Power Administration, Portland, OR.

Table of Contents

List of Tables and Figures

1.0 Executive Summary

This report describes the existing conditions and potential impacts on wildlife from the proposed Bonneville Power Administration (BPA) Kangley-Echo Lake Transmission Line Project. This report serves as the primary basis for the wildlife discussion in the National Environmental Policy Act (NEPA) environmental impact statement (EIS) prepared for the project.

1.1 Alternatives

This EIS evaluates five alternative routes for constructing a new 500-kilovolt (kV) electrical transmission line intended to increase the reliability of the Seattle metropolitan area's transmission system. This increased reliability would reduce the potential for rolling brownouts or blackouts that could transpire by the winter of 2002-2003 if the current rate of development continues and if severe winter weather were to cause inordinate power demand.

The transmission line would start at the Schultz-Raver No. 2 500-kV transmission line near the unincorporated community of Kangley in central King County, Washington and travel approximately 9 miles (mi.) to the Echo Lake Substation, located north of the Kangley area and southwest of North Bend (Figure 1).

1.1.1 Construction Methods

BPA would construct all of the action alternatives using the existing practices described below for building transmission lines and substations. BPA would build or improve access roads as necessary. If additional easements for right-of-way (ROW) or access roads were needed, additional rights would be obtained from landowners. BPA typically uses existing, cleared staging areas in which to store and assemble materials or structures.

After the structures are in place and conductors are strung between the structures, BPA would restore disturbed areas.

The following sections describe in greater detail the sequential steps that BPA typically takes to construct a transmission line.

1.1.1.1 Right-of-Way Requirements

BPA would obtain easements from landowners for the new transmission line ROW, and easements for the access roads outside of the transmission line ROW easements. The easements give BPA the right to construct, operate, and maintain the line and access roads. A 150-foot (ft.) ROW width is assumed for the 500-kV line.

Fee title to the land comprising the easement generally remains with the owner, subject to the provisions of the easement. The easement prohibits large structures, tall trees, storing of flammable materials, and other activities that could be hazardous to people or could endanger the transmission line. Activities that do not interfere with the transmission line or endanger people are usually not restricted.

Rights (usually easements) for new access roads would be acquired from property owners, as necessary. A 50-ft. ROW easement generally would be acquired for new access roads measuring about 16 ft. wide, and 20 ft. of ROW would be required for any existing access roads.

1.1.1.2 Clearing

The height of vegetation within the ROW would be restricted to provide safe and reliable operation of the line. Trees would be cleared within the ROW as well as outside of the ROW to prevent trees from falling onto the lines. A clearing advisory would be generated using ground information from cross section data. This clearing advisory would specify a safe vegetation height along and at varying distances from the line. The amount of vegetation removed would be based on this clearing advisory and local knowledge of regional conditions such as weather patterns, storm frequency and severity, general tree health, and soils. Other factors that influence the amount of clearing along the line are the line voltage; vegetation species, height, and growth rates; ground slope; conductor elevation above the ground; and clearance distance required between the conductors and other objects.

Merchantable timber purchased from private owners would be marketed and non-merchantable timber would be left lopped and scattered, piled, chipped, or would be taken off-site. Contractors would be required to use equipment that leaves low-growing vegetation in place instead of dirt blades on bulldozers for clearing. Other specialized brushing/mulching equipment may also be required. Additional best management practices (BMPs) for timberland would also be used.

At the tower sites, all trees, brush, and snags would be felled. Stumps would be removed at these sites only if they interfered with tower or guy installation. The site would be graded to provide a relatively level work surface. The total amount of clearing required for this project is unknown at this time.

An additional amount of land would be cleared for roads that are needed off the ROW and for roads determined to be in poor condition and requiring upgrading by BPA.

1.1.1.3 Access Road Construction and Improvement

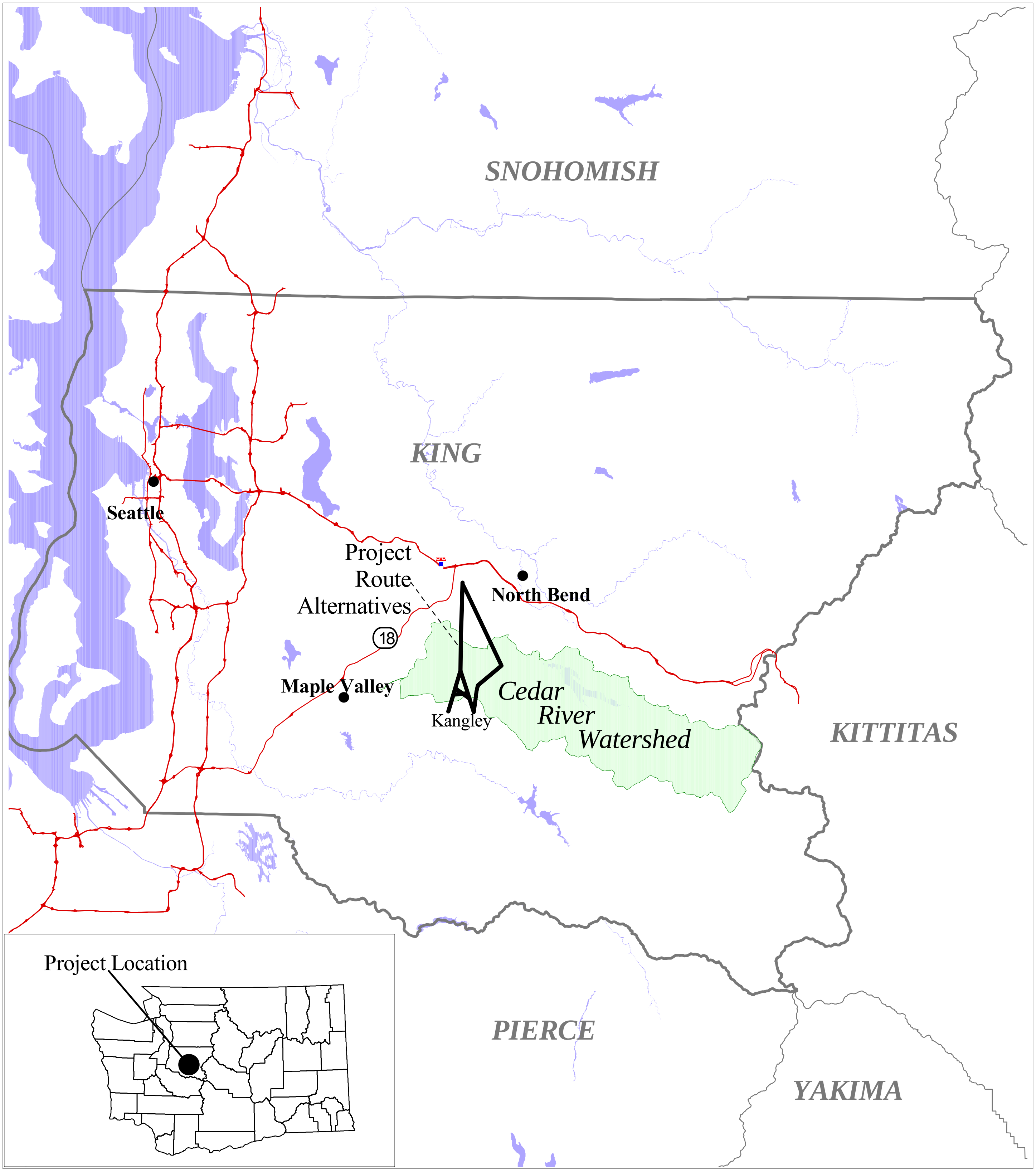
An access road system within and outside of the ROW would be used to construct and maintain a new line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. Roads generally would be surfaced with gravel, and appropriately designed for drainage and erosion control. The access roads would generally have grades of 6% or less for erodible soils and 10% or less for resistant soils. The maximum grades would be 15% for trunk roads and 18% for spur roads. No permanent access road construction would be allowed in cultivated or fallow fields.

Clearing and construction activities for new access roads would disturb an area about 20 ft. wide, depending on terrain. New roads would be constructed within the ROW wherever possible, but where conditions dictate otherwise, roads would be constructed and used outside of the ROW.

Dips, culverts, and waterbars would be installed within the roadbed to provide drainage. Fences, gates, cattle guards, and additional rock would be added to access roads as necessary.

Where temporary roads are used, any disturbed ground would be repaired and, where land use permits, the road would be reseeded with grass or other appropriate seed mixtures. After construction, access roads would be used for line maintenance. Where ground must be disturbed for maintenance activities, the roadbed would be repaired and reseeded as necessary.

The amount of new roads required for this project would vary depending on the alternative chosen and the feasibility of using existing roads along the line.



County, contour data, King County, 2000.

LOCATION MAP

Transmission line alternatives

Counties
Highway

Cedar River Watershed
Waterbodies

BONNEVILLE POWER ADMINISTRATION
GIS GEOGRAPHIC INFORMATION SYSTEM

N

0ft 50000ft 100000ft
0mi 5mi 10mi 15mi 20mi

Figure 1

Figure 1.
Location Map

Path/apr: S:\Temp\BPA_Kangley_0P005\GIS\Projects\intro1.apr (Date:2001-10-25) rpe

1.1.1.4 Storage, Assembly, and Refueling Areas

Construction contractors usually establish storage areas near the transmission line where they can stockpile materials for structures, spools of conductor, and other construction materials. These areas would be accessible from major highways. Structural steel would be delivered in pieces on flatbed trucks and would be assembled on-site. A mobile crane may be needed to handle the bundles. If the terrain were too steep at the actual tower site, general assembly yards would be used to erect the tower in pieces. The structure would then be transported to the tower site by truck or helicopter. Because trucks and helicopters need to refuel often, these construction areas could also be used for refueling.

1.1.1.5 Tower Site Preparation

Site preparation begins with removing all vegetation from a tower site. In areas of uneven topography, the site would be graded to provide a level work area. An average area of 30,000 square feet (150 by 200 ft.) would be disturbed at each tower site. Additional areas that could be disturbed include the site where the conductor is strung and pulled. These disturbances could be as large as a 370-ft. radius from the tower center.

Bulldozers would be used to clear and construct any new access roads to the transmission line towers and any new tower site landings. Manual methods, including chainsaws and brush hogs, would be used to clear the new ROW. BMPs would be used during clearing and construction to reduce impacts.

In addition to clearing the ROW for the transmission line towers, construction crews would remove selected trees outside of the ROW. This additional clearing would be done to reduce the possibility of blowdown. Blowdown occurs when newly exposed trees fall after the initial clearing process because they have not developed the root structure to remain standing once they become more fully exposed to strong winds.

1.1.1.6 Towers and Tower Construction

Steel lattice towers would be erected to support the transmission line conductors. The new towers would be similar in design to those used in the existing Schultz-Raver No. 2 500-kV transmission line. The height of each tower would vary by location and surrounding land forms. Towers would average 135 ft. high and would be spaced about 1,100 to 1,200 ft. apart. Under Alternatives 1 and 2 (described in the next section), where the new line would parallel a portion of the existing Raver-Echo Lake transmission line, towers would be staggered so that a tower from one line would not contact a tower from the other line in the unlikely event that a tower falls.

Most towers used on the proposed line would be “tangent” or “suspension” towers. This type of tower is designed to support conductors strung along a virtually straight line with only small turns or angles. “Deadend” towers would also be used on a limited basis where stresses on the transmission line conductors would have to be equalized because of changes in direction, because of the need to support an excessively long span, or where a span crossing is needed for extremely steep or rugged terrain or a river. Deadend towers use more insulators and heavier steel than tangent or suspension towers, thus making them more visible. Deadend towers also are more costly to build than suspension towers.

The towers would usually be constructed from the ground, rather than using helicopters. The equipment used depends on the weight and size of the towers and such site conditions as weather and soil characteristics. Most 500-kV lines would be built using mobile cranes; helicopter tower erection could be used if access was not available or if sensitive resources, such as wetlands or other unique habitat types or known locations of special status species, would be encountered.

Steel towers would be assembled in sections near the tower site. Each tower contains three components: the legs, body, and bridge. The bridge is the uppermost portion of the tower and serves as the attachment point for the insulators that support the conductors.

Steel towers are anchored to the ground by footings. Each tower requires four footings placed in holes that have been excavated, augered, or blasted. Large machinery, such as backhoes or truck-mounted augers, would be used to excavate the footings. Topsoil would be stockpiled during excavation. The design of the footings would vary based upon soil properties, bedrock depth, and the soundness of the bedrock at each site. Typically, towers would be attached to steel plates or grillages placed within the excavated area. The areas would then be backfilled with excavated material or concrete. Topsoil would then be replaced to restore the original ground surface.

Typical footings for single-circuit towers include 4- by 4-ft. plates placed 10 to 12 ft. deep for suspension towers and 12.5- by 12.5-ft. grillage placed 14 to 16 ft. deep for heavy dead-end towers. On average, for an entire transmission line project, each footing would occupy an area about 10 by 10 ft. to a depth of 15 ft. if bedrock was not encountered. The holes in which the plates and grillage would be installed must be large enough to provide about 1 ft. of clearance on each side of the plate or grillage. If bedrock were encountered and had properties that allowed anchor borings, holes would be drilled and steel rods grouted into the rock. These rods would either be attached to a concrete footing or welded directly to a tower member and embedded in compacted backfill. If rock properties were not suitable for anchor rods, the rock may be blasted to obtain adequate footing depth.

As the towers were built, heavy machinery would disturb the ground surface and/or compact soils at the tower site and along access roads. Noise and dust also would be generated by the machinery.

1.1.1.7 Conductors, Overhead Ground Wires, and Insulators

The wires or lines that carry the electrical current in a transmission line are called conductors. Alternating-current transmission lines such as the proposed line require three wires or sets of wires, each of which is referred to as a "phase." Three 1.3-in. Bunting conductors would be included for each phase. Each bundle is 16 by 20 in.

Conductors are not covered with insulating material. Instead, air is used for insulation. Conductors are physically separated by insulators on transmission towers.

After the transmission towers are in place, workers would attach a smaller steel cable to the towers and then pull the conductor under tension through the towers. Conductors would be attached to the structure using glass, porcelain, or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors on the tower, the tower itself, and the ground. As the conductors are strung, the ground surface would be disturbed at the tensioning sites, and noise and dust would be generated by the machinery.

Transmission towers elevate conductors to provide safe clearance for people and structures within the ROW. The National Electrical Safety Code (NESC) establishes minimum conductor heights. The minimum conductor-to-ground clearance for a 500-kV line is a little more than 29 ft. Greater clearances would be provided by BPA over county roads and highways, railroads, and river crossings.

One or two smaller wires, called overhead ground wires, would also be attached to the top of the transmission towers. Overhead ground wires would protect the transmission line against lightning damage. The diameter of the wire would vary from 0.375 to 0.625 in.

1.1.1.8 Substation Additions

Under the current proposal, the Echo Lake Substation would be expanded to the east on land owned in fee title by BPA. The size of the expansion would be 300 by 750 ft. The site would be cleared in the same manner as the ROW for the transmission line. The site would include a fenced yard and a graded and graveled parking lot. The existing road around the substation would be realigned to the east to accommodate this expansion. New transformers, switches, and other equipment would be installed in the expanded area. A continuous ground wire would also be installed.

1.1.1.9 Site Restoration and Clean-up

Disturbed areas around the towers, conductor reels, and pull site locations would be reshaped and contoured to be consistent with their original condition. Access roads would be repaired.

Disturbed areas would be reseeded with grass or an appropriate seed mixture to prevent erosion. The seed mixture would include native plant species and would be free of noxious weeds. All solid waste from construction would be removed and properly disposed offsite, and equipment would be removed from the ROW.

1.1.2 Alternative Rights-of-Way

A portion of the action alternatives would be located within the Cedar River Municipal Watershed. The alternatives would begin at the Schultz-Raver No. 2 500-kV transmission line and generally travel northward to the Echo Lake Substation. (See Figure 2.) Under all alternatives, the transmission line ROW would be 150 ft. wide. Miles of new access roads were calculated for a 20-ft. ROW within a 0.25-mile buffer on each transmission line alternative.

1.1.2.1 Alternative 1: Preferred Alternative

The alignment for Alternative 1 would be immediately adjacent and parallel to a portion of the existing 12-mi. Raver-Echo Lake transmission line from a point approximately 3 mi. north of Raver (S26, T22N, R7E) to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 0.8 mi. of new access roads. The existing 150-ft. ROW would be widened to 300 ft., with the widening and new line located east of the existing corridor.

1.1.2.2 Alternative 2

Alternative 2 would originate from tap point #2 (Figure 2) located approximately 2 mi. east of the tap point #1 for Alternative 1 (S25, T22N, R7E). The line would traverse approximately 3 mi. to

S11, T22N, R7E before continuing north along the same alignment as Alternative 1, paralleling the existing Raver-Echo Lake transmission line, and terminating at the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 2.8 mi. of new access roads.

1.1.2.3 Alternative 3

Alternative 3 would begin at the tap point #2 (S25, T22N, R7E); traverse northeast to S8, T22N, R8E; and then turn north-northwesterly to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 10.2 mi. long and would require about 6.4 mi. of new access roads.

1.1.2.4 Alternative 4a

Alternative 4a would begin about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverse northwest to connect with Alternative 1 over 1 mi. (S23, T22N, R7E) further south from where Alternative 2 reconnects (S11, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.5 Alternative 4b

Alternative 4b would begin slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverse west to connect with Alternative 1 further south from where Alternative 4a reconnects (S23, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.6 No Action Alternative

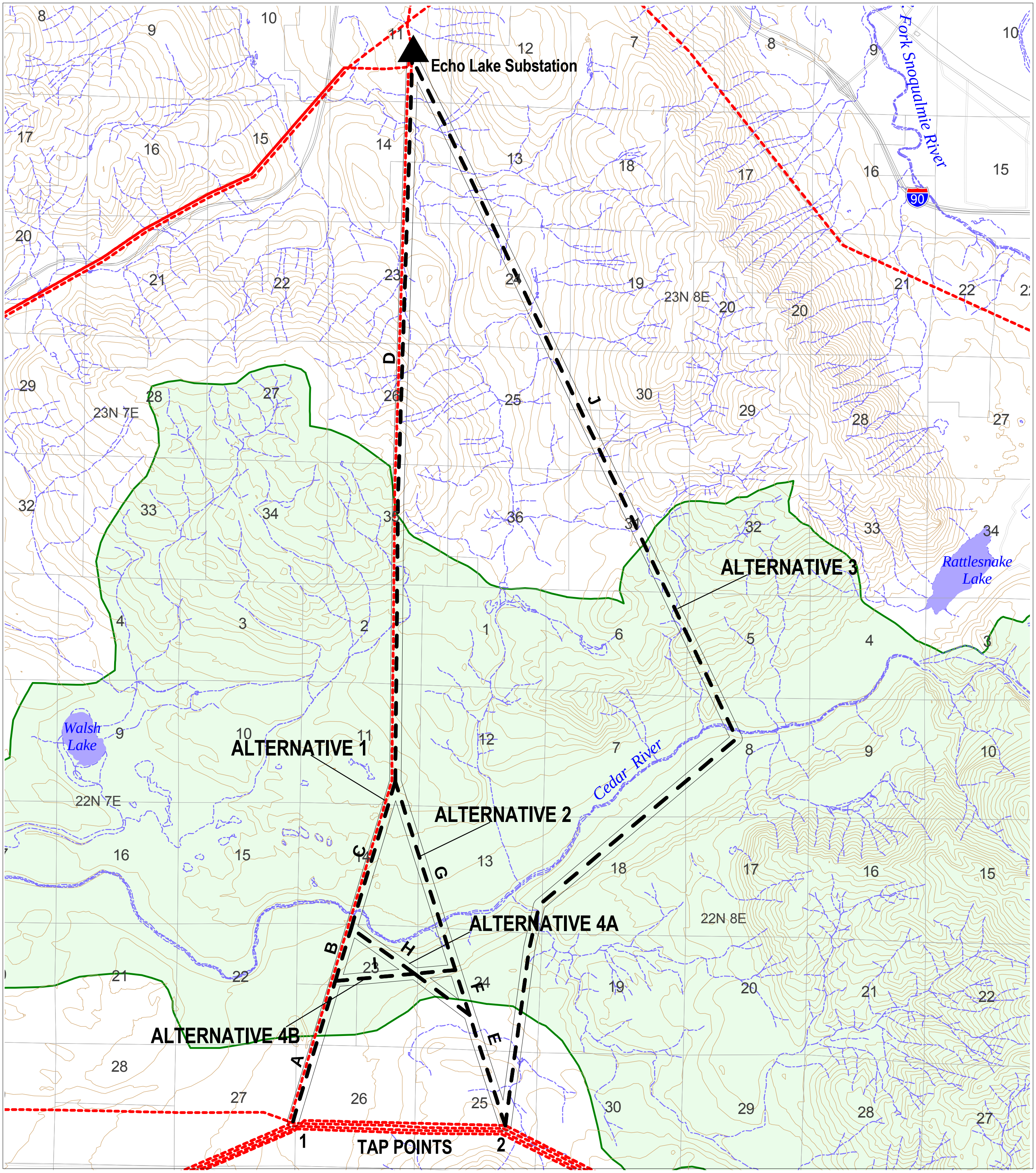
Under the No Action Alternative, a new 500-kV electrical transmission line would not be built. As a result, transmission line capacity could be reached or exceeded as early as 2002-2003 if a cold winter were to occur in the Seattle metropolitan area and the existing Raver-Echo Lake transmission line were to go out of service. Relying upon the existing transmission system during periods of increased demand and compromised reliability could result in brownouts or rolling blackouts in the area. Thus, residents, businesses, and government agencies could experience as much as several days without electricity. Loss of electricity for lights and heating could halt business and government activities. Residents would have to rely upon other energy sources for heating, cooking, and lighting, such as wood and gas fireplaces, stoves and barbecues, oil lamps and candles, etc.

1.2 Key Issues for Wildlife

Key wildlife issues were developed from public comments made during the scoping period for this project; from issues developed in the Cedar River Watershed (CRW) Habitat Conservation Plan (HCP); and from consultation with federal and state agencies.

1.2.1 Impacts on Threatened, Endangered, and other Sensitive Species

The project area provides habitat or potential habitat for several species of wildlife that are listed either federally under the Endangered Species Act (ESA) or by the State of Washington. Habitat conditions and availability within the project area and potential impacts from the proposed project to these species and their habitats have been identified as potential issues of concern.



Watershed data from City of Seattle.
Road data from King County GIS, 1999.

ROUTE ALTERNATIVES

- Transmission line alternatives
- E Segment of alternative
- 150ft Clearing area
- Existing transmission lines
- Highway
- Primary roads
- Public land survey sections
- Cedar River Watershed
- Fish-bearing streams
- 100 Ft contours

N

0ft 6000ft 12000ft
0mi 1mi 2mi 3mi

BONNEVILLE POWER ADMINISTRATION
GIS
GEOGRAPHIC INFORMATION SYSTEM

Figure 2.
Existing Transmission Lines and Proposed ROW Alternatives

Figure 2

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1.2.2 Habitat Loss

Construction of the proposed project would require varying amounts of vegetation clearing, depending upon the alternative selected. This would result in the removal of habitat or potential habitat for many species, potential alteration of habitat conditions for wildlife species, and loss of recruitment habitat for late successional forest dependent species within the CRW.

1.2.3 Habitat Fragmentation

Construction of the proposed project, including associated access road construction, would involve vegetation clearing possibly increasing the amount of habitat fragmentation and the amount of edge habitat within the project area.

1.2.4 Bird Collision or Electrocution

Birds may be injured either through collisions with power lines or overhead ground wires, or through electrocution caused by perching on conductors or towers.

1.2.5 Disturbance of Wildlife

Many species of wildlife are sensitive to noise and human presence, particularly during the breeding season. The U.S. Fish and Wildlife Service (USFWS) identified this as an issue of concern for spotted owls and marbled murrelets potentially occurring in the project area. Disturbance may occur during project construction or as a result of operation and maintenance activities, including maintenance of the transmission line and the use and maintenance of access roads.

1.3 Major Conclusions

Construction impacts would occur under all action alternatives. Potential habitat for threatened, endangered, and other sensitive species, which is present along the ROW for all alternatives, would experience a moderate-level impact overall. Impacts to different species groups would vary, with construction impacts to forested community species expected to be low level; impacts to riparian and aquatic community species expected to be moderate level; and impacts to early seral communities expected to be either beneficial, minimal, or non-existent.

Habitat fragmentation is also expected to occur under all action alternatives, with the least amount occurring under Alternative 1 and the greatest amount under Alternative 3. This is expected to be a moderate-level impact.

Mortality of listed bird species is possible under all alternatives, resulting from either collisions with the transmission line or overhead ground wires, or electrocution. If this were to occur it would be a high-level impact. Because the project area is not known to be a high use area for listed species, the probability of mortality of listed species from collision or electrocution should be low. Listed species are those listed as either threatened or endangered under the Endangered Species Act, and listed bird species potentially occurring in the area include bald eagle, northern spotted owl, and marbled murrelet.

Under all action alternatives there is the potential for wildlife disturbance as a result of construction activities. With proper planning, this is expected to be a low-level impact.

Impacts would also occur as a result of maintenance and operation of the proposed project. Impacts resulting from the maintenance of the ROW in an early seral condition would include both potential noise from maintenance activities and long-term impacts to wildlife habitat caused by maintaining both edge habitat and the ROW opening.

Impacts from noise disturbance could be minimized through planning. Maintenance of the ROW as edge habitat and a potential barrier to species that avoid openings would reduce the value of habitat in the area of the ROW and be considered a moderate-level impact.

2.0 Study Scope and Methodology

2.1 Data Sources and Study Methods

Data sources for this project include discussions with Seattle Public Utilities (SPU); review of the HCP developed for the CRW; analysis of aerial photographs; review of pertinent literature; and field reconnaissance surveys of the project area. Field reconnaissance surveys were conducted by a wildlife biologist and consisted of an aerial survey of the proposed alignments, walking the sections of the proposed alignments that are forested, and compiling field notes on the habitats encountered and any signs of wildlife use observed.

Species potentially present and habitat associations for these species were determined by review of:

- The HCP for the CRW.
- A data search of the Washington Priority Habitats and Species database.
- A list of threatened species and species of concern provided by the USFWS.
- Local field guides for birds and amphibians.
- Scientific literature regarding the natural history and habitat associations of wildlife species potentially present in the project area, as listed in the references (Section 8.0) of this document.

Aerial photograph analysis was conducted to identify general habitat types and to facilitate field review of the proposed ROWs. Field visits occurred on October 25, 26, and 27, 2000.

2.2 Agencies Contacted

- USFWS, species request letter.
- City of Seattle, CRW.

3.0 Affected Environment

3.1 Regulations, Standards, and Guidelines

The ESA requires federal agencies to assess potential impacts to species listed under the ESA resulting from implementation of federal projects. If impacts to species are expected, then consultation with the USFWS is required to determine whether "take" would occur. Take is defined as killing or causing direct harm to a listed species as well as any form of harassment that potentially affects a species' ability to breed, feed, or seek shelter.

The Migratory Bird Treaty Act protects birds defined as migratory, which includes many songbirds, waterfowl, and raptors. This Act prohibits the killing, harming, or capture of migratory birds, bird parts, nests, and eggs, unless permitted by regulation.

The Bald Eagle Protection Act prohibits the taking of both bald and golden eagles or any parts, nests, or eggs. This Act prohibits killing, collection, and disturbance of these species.

The Washington Forest Practices Act has provisions for managing riparian and wetland vegetation and wildlife habitats in areas where timber harvest is planned. It requires landowners to consult with the Washington Department of Fish and Wildlife (WDFW) to protect critical habitats; to preserve wildlife reserve trees; and to avoid disturbance to both spotted owls and marbled murrelets during their nesting seasons.

3.2 Regional Context

The proposed project is located within the foothills of the western Cascades of Washington. This is a region with a long history of resource extraction, particularly timber harvest. This region is also known for its ancient forests and associated species. Since the 1980s, a major shift in land management has occurred, largely in response to the listing of species under the ESA, toward protection of forested habitats, streams and rivers, and the species dependent upon them. This has resulted in a reduction of timber harvest on public lands and changes in the way timber is harvested on both public and private lands.

Due to the listing of the northern spotted owl and marbled murrelet under the ESA, protection of late-successional forest habitats has become a major issue in the Cascade Mountains. The listing and potential future listing of several fish species has led to an increased concern for protecting water quality and riparian habitats.

This region has also experienced a large influx of people in the last two decades, resulting in increased urbanization from the Cascade foothills to Puget Sound. This has reduced habitat available for species living at lower elevations, as areas historically managed for timber production are converted to residential development.

The proposed transmission line ROWs pass through three distinct land management areas: rural residential, municipal watershed, and industrial forest lands. Rural residential areas occur along the southern portion of the proposed ROWs and along the northern boundary of the municipal watershed along the proposed route of Alternative 3. Land use in these areas is largely governed by the Washington State Growth Management Act and by local regulations. The CRW is owned by the City of Seattle and is subject to Washington State law and the policies of the Seattle City Council, as well as provisions for managing lands in the watershed acquired from the federal government. An HCP has recently been signed that governs the management of the watershed for the next 50 years. The northern portion of the ROW crosses privately owned industrial forest lands, and a section of land owned by the Washington Department of Natural Resources (WDNR) and managed for timber production. These forest lands are managed under the Washington State Forest Practices Act.

3.3 Study Area and Approach

Wildlife species and their habitats occurring or potentially occurring within the affected environment are discussed at two levels. The first is the broad project vicinity, encompassed by Kent-Kangley Road to the south, the lower CRW, and Highway 18, Interstate 90, and Rattlesnake Ridge to the north. Discussion of this area is general and is intended to address issues related to wide-ranging species, migratory species, and species with large home ranges. The project area addressed in a more focused manner includes only the area within 0.25 mi. of the proposed transmission line ROWs. This distance was chosen because data were readily available, and the majority of direct and indirect impacts from the proposed project would occur within this area. Where impacts are expected outside of this focused project area, they are discussed at the project vicinity level.

As mentioned previously, the proposed ROWs pass through three distinct land management areas. Along the southern portion of the proposed ROWs, as well as in the area where Alternative 3 exits the CRW, the ROWs pass through rural residential areas. These areas are characterized by low-density housing, with agricultural/pasture land interspersed with second-growth forest. This area provides potential habitat for species adapted to human activity and disturbed sites including some songbirds and raptors, rodents and small mammals, some amphibian species, elk, deer, bear, and cougar.

The proposed ROWs then pass through the lower portion of the CRW, which is owned and managed by the City of Seattle. This area has an extensive history of timber management, and it is dominated by second-growth coniferous forest interspersed with hardwood stands, early seral vegetation, wetlands, and non-forested areas. The lower CRW is dominated by stands that are between 70 and 119 years old, and favorable growing conditions within the watershed have resulted in second-growth stands producing large trees and, therefore, some characteristics of mature forest. Forest stands meeting the definitions of old-growth occur within the lower CRW, though none occur within the project area. The closest patch of this forest type to the project area is approximately 1.5 mi. west of Alternative 1 (City of Seattle 2000).

To the north of the CRW, the proposed ROWs cross lands managed primarily as industrial forest land, after passing through an area of rural residential land along the northern boundary of the CRW where Alternative 3 leaves the CRW. Alternatives 1, 2, 4a, and 4b are all within the same ROW in this area and cross lands owned by Trillium, the Weyerhaeuser Company, and WDNR. Alternative 3 also crosses lands owned by the Weyerhaeuser Company and the WDNR. Lands in this portion of the project area have been intensively managed for timber production, and they are predominantly second and third growth. Within the ROWs, the predominant vegetation type is early and mid- regeneration mixed and coniferous forest, as described in Table 1. The exception to this is where the ROWs cross buffers left in riparian areas, where older regeneration stands predominate.

Table 1. Wildlife Habitat Types within the Project Area

Habitat Type	Code	Description
Managed grass/forb/shrub	GFS	Habitat types that are maintained in an early seral condition; primarily occurs under the existing transmission line.
Natural non-forest	NNF	Naturally nonforested habitats such as meadows and natural shrub communities.
Cliff/talus	C/T	Either cliff habitat or talus.

Habitat Type	Code	Description
Natural non-vegetated	NNV	Naturally non-vegetated areas such as rock outcrops or natural slides.
Developed	DEV	Developed areas such as roads, residential areas, building sites, and quarries.
Early regeneration closed deciduous forest	DFE	Early regeneration second- or third-growth deciduous forest.
Mid-regeneration, closed deciduous forest	DFM	Mid-regeneration second- or third-growth deciduous forest.
Mature deciduous regeneration	DFL	Mature regeneration second- or third-growth deciduous forest. Reaching a mature stage but not considered late-successional habitat.
Early regeneration, open coniferous canopy	CFE	Early regeneration second- or third-growth coniferous forest.
Mid-regeneration, closed coniferous canopy	CFM	Mid-regeneration second- or third-growth coniferous forest.
Mature coniferous regeneration	CFL	Mature regeneration second- or third-growth coniferous forest. Reaching a mature stage but not considered late-successional habitat.
Early regeneration, mixed canopy	CFE	Early regeneration second- or third-growth mixed deciduous and coniferous forest.
Mid-regeneration, mixed canopy	MFM	Mid-regeneration second- or third-growth mixed deciduous and coniferous forest.
Mature regeneration, mixed canopy	MFL	Mature regeneration second- or third-growth mixed deciduous and coniferous forest. Reaching a mature stage but not considered late-successional habitat.
Lakes/ponds	L/P	Lakes and ponds.
Wetlands	WET	Wetlands.
Streams	STR	Rivers and streams.

3.3.1 Wildlife Habitats Within the Project Area

A vegetation type cover map was developed for the project area (Figure 3) based on Geographic Information System (GIS) data from the CRW HCP, satellite imagery data for the area north of the watershed, and aerial photograph interpretation for the areas north and south of the CRW.

Field reconnaissance visits were also conducted to verify data. Habitat types within the proposed ROWs are presented in Table 1. For a more complete description of these vegetation types, refer to the Vegetation Technical Report prepared for this project.

In addition to the above habitat types, the King County Comprehensive Plan (King County 2000) identifies wildlife network corridors as important habitat components to be protected within the comprehensive planning area. These corridors have been mapped within King County, and two occur within the proposed project area. One corridor follows the Cedar River and would be crossed by all action alternatives. The second corridor in the area splits from the corridor along the Cedar River downstream of the point where Alternative 3 crosses the river, and runs west and north. This corridor would be crossed by the segment of the proposed new alignment that is common to Alternatives 1, 2, 4a, and 4b.

3.3.2 Species to be Analyzed

For the purpose of this document, species that are federally-listed as threatened or endangered; federal species of concern; and Washington State listed threatened, endangered, sensitive or monitor species with the potential to occur on the west side of the Cascade Mountains were selected for analysis. This resulted in a list of 45 species. Based on the habitat requirements of these species and the availability of habitat within the project area, 14 of these species are not expected to occur within the project area, reducing the list to 31 species. In addition, five species identified in the King County Comprehensive Plan (King County 2000) as being of local concern, and which may occur in the project vicinity, were included. One species, the black-tailed deer, was also included as being of local concern in response to comments received during public scoping for the proposed project.

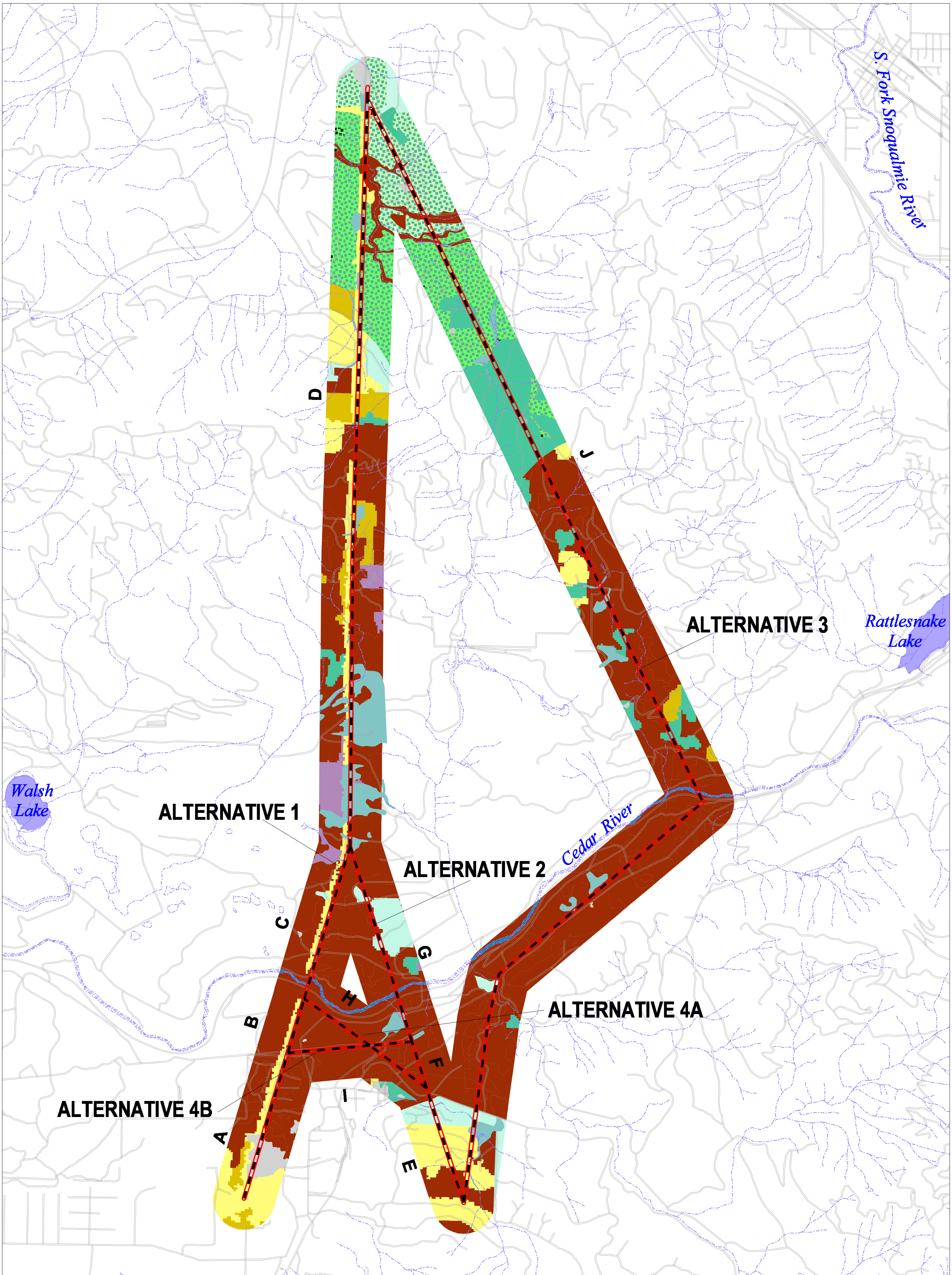
These species have been sorted by their primary habitat associations, defined as forest communities, aquatic communities, riparian communities, early seral communities, and special or unique habitats. Species are addressed in these groups throughout the remainder of this document. A complete list of species, their primary habitat associations, and the probability of the species occurring in the proposed project area are described in Table 2. Table 3 describes the species excluded from analysis, their primary habitat associations, and the rationale for not including them.

3.3.2.1 Forest Community Dependent Species

A number of wildlife species, including invertebrates, were identified as potentially occurring within the project area and as having a primary association with forested community habitat, as discussed below. For definitions of the wildlife habitat type codes used in the text, see Table 1.

Northern spotted owls may occur within the project area; although given the lack of old-growth forest, no nesting habitat occurs in the project area. Potential dispersal habitat for spotted owls occurs in areas of mid and mature coniferous regeneration forest (CFM, CFL). In addition, mature coniferous regeneration forest (CFL) may provide foraging habitat for spotted owls.

No spotted owls are known to occur within the lower CRW, although surveys have not been conducted (Paige pers. comm.). However, forested habitat in this area could be important for dispersal between suitable nesting habitat in the upper CRW, areas of current or future potential nesting habitat in the lower CRW, and areas outside the CRW.



Cover data from Seattle Public Utilities, 1998;
Wetlands modified Jones & Stokes, 2000.

VEGETATION COVER TYPES

Transmission line alternatives
E Segment of alternative
150ft Clearing area
Roads
Streams

Vegetation cover types
- Early regeneration, open coniferous canopy
- Mid-regeneration, closed coniferous canopy
- Mature coniferous regeneration
- Early regeneration, open deciduous canopy
- Mid-regeneration, closed deciduous canopy
- Mature deciduous regeneration
- Early regeneration, open mixed canopy
- Mid-regeneration, closed mixed canopy
- Managed grass / forb / shrub
- Naturally non-forested
- Wetlands
- Lakes / ponds / rivers
- Developed

N

0ft 4000ft 8000ft
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veg3.apr

Path/apr: S:\Temp\BPA Kangley 0P005\GIS\Projects\veg3.apr (Date:2001-10-25) rpe

Figure 3.
Vegetation Cover Types, Potential Clearing, and Affected Habitat within 0.25-mi. of the Action Alternatives

Table 2. Wildlife Species with Federal or State Listing Status Potentially Present in Proposed Project Area

Species Name	Status*	Habitat Association	Probability of Occurrence
Primary Association with Forested Communities			
Northern spotted owl (*Strix occidentalis caurina*)	FT, SE	Mature and old-growth forest with multiple canopy layers and large amounts of dead and down woody material (FEMAT 1993).	Known to occur within the CRW; no suitable nesting habitat within 1.5 mi. of the proposed ROWs, however potential dispersal habitat does occur (City of Seattle 2000). Potential dispersal habitat also occurs in riparian buffers on industrial forest lands. May occur in the project area.
Marbled murrelet (*Brachyramphus marmoratus*)	FT, ST	Mature and old-growth forest with trees having large-diameter branches for nesting (Hamer and Cummins 1991).	Known to occur within the CRW; no suitable nesting habitat within 0.25 mi. of the proposed ROWs however (City of Seattle 2000). Habitat lacking in project area outside of CRW. May occur in project vicinity; may pass through project area, particularly in Cedar River corridor, while traveling to suitable habitat in the upper CRW.
Northern goshawk (*Accipiter gentilis*)	FC, SC	Generally found in large stands of multi-layered, old-growth forest containing small openings. May forage in younger stands. (Reynolds et al. 1992).	Known to occur within the CRW; no suitable nesting habitat within 0.25 mi. of the proposed ROWs, however potentially suitable foraging habitat does occur (City of Seattle 2000). Nesting habitat may occur within 1.0 mile of the ROW, May occur in the project area.
Black swift (*Cypseloides niger*)	SM	Forested habitats at moderate elevations in the Washington Cascades; mid- to late seral conifer and mixed forests and forested riparian areas above the Puget Sound Douglas fir zone. May nest in cliffs (Smith et al. 1997).	Known to occur within the CRW (City of Seattle 2000); potentially suitable habitat occurs within the CRW, within riparian buffers on industrial forest lands on the northern portion of the proposed ROWs, and within the low-density developed portions of the proposed ROWs south of the CRW. May occur in the project area.
Merlin (*Falco columbarius*)	SC	A migratory bird with potential nesting habitat in high-elevation forests along the Cascade crest; coniferous forest in the Pacific silver fir zone and above (Smith et al. 1997).	Known to occur within the CRW; nesting most likely to occur at higher elevations. May utilize lower elevation areas in the CRW and in the project area outside the CRW as a migrant. May occur in the project area.
Olive-sided flycatcher (*Contopus borealis*)	FC	Forested areas where large patches of trees are adjacent to openings caused by factors such as fire, timber cutting, and water bodies; at all elevations (Smith et al. 1997).	Known to occur within the CRW; potential nesting habitat occurs within the project area in forested stands in the CRW; in the rural residential area south of the CRW where large trees remain; and in riparian buffers on industrial forest lands north of the CRW. May occur in the project area.
Pileated woodpecker (*Dryocopus pileatus*)	SC	Mature and old-growth forest; second growth with abundant snag and down wood component (Rodrick and Milner 1991).	Known to occur within the CRW; potential habitat occurs within the proposed ROWs, although snags are not abundant. Potential habitat also occurs within riparian buffers on industrial forest lands and within the rural residential area where large trees remain. May occur in the project area.

Species Name	Status*	Habitat Association	Probability of Occurrence
Vaux's swift (*Chaetura vauxi*)	SC	Mature and old-growth coniferous forest; large hollow trees needed for roosting and nesting; occasionally utilize chimneys and cliffs (Rodrick and Milner 1991).	Known to nest within the CRW; although large snags are generally lacking within the proposed ROWs, potential habitat occurs within the CRW, within riparian buffers on industrial forest lands, and within the rural residential area where swifts may also utilize chimneys. May occur in project area.
Band-tailed pigeon (*Columba fasciata)*	LC	Migratory birds that breed in western Washington, primarily below 1,000 ft. in elevation in early to late seral coniferous or deciduous forests. Move to higher elevations in late summer (Rodrick and Milner 1991).	Known to occur within the CRW (City of Seattle 2000); suitable habitat within the proposed alignments both within the CRW and to the north and south. May occur within the project area.
Red-tailed hawk (*Buteo jamaicensis*)	LC	Require trees for nesting and open habitats for foraging (Udvardy 1977). In western Washington, nest in hardwoods, preferring black cottonwood and red alder. Occur in all forested areas except dense mature or old-growth forest and alpine/parkland areas. Common around human developments and roads (Smith et al. 1997).	Potentially suitable habitat throughout the forested portions of the project area; may occur in project area.
Blue grouse (*Dendragapus obscurus*)	LC	Mixed and coniferous forests at all elevations (Smith et al. 1997).	Potentially suitable habitat throughout the forested portions of the project area; may occur in project area.
Fisher (*Martes pennanti*)	FC, SC	Dense mature forest; second growth with adequate cover; require snags and down logs; low to mid elevational forest (Johnson and Cassidy 1997).	May occur within forested areas of the proposed alignments within the CRW, within riparian buffers on industrial forest lands, and within the rural residential area where large trees remain. Snags and large hollow logs likely limit breeding within the project area. May occur in the project area.
Fringed myotis (*Myotis thysanoides*)	FC, SM	Primarily an eastside species that utilizes dry woodlands, desert, and grassland. Not strongly associated with human structures (Johnson and Cassidy 1997). Also found in immature coniferous forest west of the Cascade crest (City of Seattle 2000).	May occur within forested areas in the CRW, within riparian buffers on industrial forest land, and within the rural residential area. May occur in the project area.
Keen's myotis (*Myotis keenii*)	SM	Low-elevation forests in the Puget Sound Douglas fir and western hemlock zones; coastal forests (Johnson and Cassidy 1997).	May occur within forested areas in the CRW, within riparian buffers on industrial forest land, and within the rural residential area. May occur in the project area.
Long-eared myotis (*Myotis evotis*)	FC, SM	Forested habitat below the subalpine/parkland zone; roosts in trees, buildings, and caves and occurs in areas of low-density development (Johnson and Cassidy 1997).	May occur within forested areas in the CRW; within riparian buffers on industrial forest land; and within the rural residential area. May occur within project area.
Long-legged myotis (*Myotis volans*)	FC, SM	Widespread within a wide range of habitats. Breeds in caves, abandoned mine tunnels, and attics (Barbour and Davis 1969).	May occur within forested areas in the CRW, within riparian buffers on industrial forest land, and within the rural residential area. May occur in the project area.

Species Name	Status*	Habitat Association	Probability of Occurrence
Townsend's western big-eared bat (*Plecotus townsendii*)	FC, SC	Caves, lava tubes, abandoned buildings, away from human disturbance (Rodrick and Milner 1991). Any forest type containing suitable roost, nursery, or hibernation sites such as caves, mines, buildings, and bridges; forage along forest edges (Christy and West 1993).	May occur within forested areas in the CRW, within riparian buffers on industrial forest land, and within the rural residential area. May occur in the project area.
Blue-gray tail-dropper (*Prophysaon coeruleum*)	SM	Puget Trough and western Cascade Range and possibly on eastern slope of the Cascade Range to 3,000 ft. elevation. Found in open to moist conifer and mixed conifer forests within areas of high shade and moisture levels; associated with partially decayed logs, leaf litter. (Furnish et al. 1997; Frest and Johannes 1993).	Potential habitat occurs within the project area in forested areas with a large down wood component. May occur in the project area.
Oregon megomphix (*Megomphix hemphilli*)	SM	Moist low- to mid-elevation forests, preferably undisturbed; late-successional forest in riparian areas (Frest and Johannes 1993).	Potential habitat occurs within the project area in forested areas with a large down wood component. May occur in the project area.
Papillose tail-dropper (*Prophysaon dubium*)	SM	Widespread from the east slopes of Washington Cascades to Olympic Mountains south to northern California. Strongly associated with hardwood logs and leaf litter, similar to but somewhat more exposed than sites for *P. coeruleum*. (Furnish et al. 1997, Tables 1 and 2; Frest and Johannes 1993).	Potential habitat occurs within the project area in forested areas with a large down wood component; hardwood component also preferable. May occur in the project area.
Puget Oregonian (*Cryptomastix devia*)	SM	Western Cascade Range and Puget Trough at low to moderate elevations. On or under hardwood logs and litter and cool, moist talus and rocks; under sword ferns, bigleaf maples; western hemlock zone. (Furnish et al. 1997, Tables 1 and 2; Frest and Johannes1993).	Potential habitat occurs within the project area in forested areas with a large down wood component. May occur in the project area.
Johnson's (mistletoe) hairstreak (butterfly) (*Mitoura johnsoni*)	SC	Lowland old-growth coniferous forest containing mistletoe in the genus Arceuthobium, which is usually associated with western hemlock but may occur in true firs (Larsen et al. 1995).	No old growth forest habitat within 0.25 mi. of the proposed ROWs. Mistletoe may occur in mature coniferous regeneration stands containing western hemlock; may occur in project area.
Primary Association with Riparian Communities			
Bald eagle (*Haliaeetus leucocephalus*)	FT (PD), ST	Usually found near large bodies of water where primary prey items of fish and waterfowl can be found (USFWS 1986).	No known nests within the project area (City of Seattle 2000, WDFW 2000); known to occur as transients in the CRW; may forage along the Cedar and Raging Rivers. May occur in the project area.

Species Name	Status*	Habitat Association	Probability of Occurrence
Great blue heron (*Ardea herodias*)	SM	Breed in colonies located in deciduous or evergreen trees; feed on aquatic and marine animals in shallow water; small mammals also utilized (Quinn and Milner in press).	No known nesting colonies within the project area; potential foraging habitat occurs in wetlands and along streams within the project area. May occur in the project area.
Osprey (*Pandion haliaetus*)	SM	Nests constructed in large snags or live trees with flat tops; prey on fish captured near water surface (Rodrick and Milner 1991).	Known to nest within the CRW**.** Potential habitat exists within riparian areas in the CRW; in the rural residential area south of the CRW where large trees remain; and in riparian buffers on industrial forest lands north of the CRW. May occur in the project area.
Willow flycatcher (*Empidonax traillii*)	FC	Low-elevation wetlands, clearcuts, and shrub habitats. Forested areas below the pacific silver fir zone in western Washington containing suitable microhabitats (Smith et al. 1997).	Known to nest within the CRW; potential habitat occurs throughout the project area. May occur in the project area.
Harlequin duck (*Histrionicus histrionicus*)	LC	Nests in riparian areas of clear, clean, swiftly flowing second- to fifth-order streams; winters in coastal waters (Rodrick and Milner 1991).	Known to occur within the CRW; potential nesting habitat occurs within the proposed alignments where it crosses forested riparian areas, including riparian buffers. May occur in project area.
Mink (*Mustela vison*)	LC	Found along the banks of streams, rivers, lakes, ditches, and wetlands and in surrounding forests and meadows at all elevations (Johnson and Cassidy 1997).	Potential habitat occurs within the project area in riparian areas. May occur in the project area.
Van Dyke's salamander (*Plethodon vandykei*)	SC	Usually among large, woody debris within the wetted edge of streams and seeps. Near the northernmost edge of known range. (Leonard et al. 1993).	Potential habitat occurs within the project area in forested riparian areas. May occur in the project area.
Primary Association with Aquatic Communities			
Cascades frog (*Rana cascadae*)	FC, SM	Highly aquatic. Closely associated with edges of seeps and other wetlands (Leonard et al. 1993).	Known to occur within the CRW; potential habitat occurs in project area in ponds, wetlands, slow-moving streams, and riparian areas. May occur in the project area.
Red-legged frog (*Rana aurora*)	FC, SM	Breeds in ponds or slow-moving water containing aquatic vegetation; adults highly terrestrial, occurring in forested areas or disturbed sites with a residual down wood component (Dvornich et al. 1997).	Known to occur within the CRW; potential habitat occurs within the project area in riparian forest, wetlands, seeps, and slow-moving streams. May occur in the project area.
Cascade torrent salamander (*Rhyacotriton cascadae*)	SC	Associated with splash zones of cold-water seeps, streams, and waterfalls in the southern Cascades, primarily within the western hemlock zone; known to occur from Mount Rainier south in the Cascades (Dvornich et al. 1997).	May occur where seeps and small cold streams occur within the project area. May occur in the project area.

Species Name	Status*	Habitat Association	Probability of Occurrence
Oregon spotted frog (*Rana pretiosa*)	FC, SC	Marshes, ponds, streams and lakes; shallow, slow-moving water with abundant emergent vegetation (Nordstrom and Milner 1997).	Potential habitat occurs within the project area in wetlands and ponds. May occur in the project area.
Tailed frog (*Ascaphus truei*)	FC, SM	Turbulent mountain streams (Leonard et al. 1993). Has been found as high as 7,000 ft. elevation.	Known to occur in the CRW; potential habitat occurs within the project area in cold, fast-flowing streams. May occur in the project area.
Western toad (*Bufo boreas*)	FC	Ponds and shallow lakes, with forest, brush, and meadow associated; adults terrestrial, large down wood an important habitat component (Corkran and Thoms 1996).	Known to occur within the CRW; potential habitat exists within project area in wetlands and forested riparian habitats. May occur in the project area.
Fender's Soliperlan stonefly (*Solipera fenderi*)	FC	Cold fast-flowing streams and springs; seeps and headwaters of small streams (Pacific Biodiversity Institute 2000).	Potential habitat exists in project area in streams. May occur in the project area.
Primary Association with Unique Habitats			
Peregrine falcon (*Falco peregrinus*)	SE	Cliffs, areas with large concentrations of waterfowl or flocking birds (Johnsgard 1990).	Potentially suitable nesting habitat located on Rattlesnake Ridge in the lower CRW; may occur in project vicinity and in project area.
Larch Mountain salamander (*Plethodon larselli)*	FC, SS	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, WA.	May occur within forested habitats within the project area where either talus or woody debris occur. May occur in the project area.
Primary Association with Early Seral Communities			
Elk (*Cervus elaphus*)	LC	Combination of forest and open habitats; edge habitats; seclusion from human disturbance important for calving (Thomas and Toweill 1982).	Known to occur in the project area year-round.
Black-tailed deer (*Odocoileus hemionus*)	LC	Hardwood and coniferous forest; dense shrubs or other early successional stages containing trees or shrubs. Also meadows and grasslands (Johnson and Cassidy 1997).	Known to occur in the project area year-round.
Western bluebird (*Sialia mexicana*)	SM	Insectivorous cavity-nesting bird; lowlands and foothills of Washington (Rodrick and Milner 1991).	Limited nesting habitat present within the CRW, riparian buffers on industrial forest lands, and within the rural residential areas within the proposed ROWs. May occur in the project area.
FT = federal threatened, FE = federal endangered, FT(PD) = federal threatened, proposed for delisting, FC = federal (USFWS) species of concern, SE = state endangered, SS = state sensitive, ST = state threatened, SC = state candidate, SM = state monitor, and LC = local concern.			

Table 3. Species with Federal or State Listing Status Not Expected to Occur within the Proposed Project Area

Species	Status	Habitat Association	Probability of Occurrence
Three-toed woodpecker (*Picoides tridactylus*)	SM	Conifer forests at high elevation; may occur in the Pacific silver zone but more likely in higher zones. Closed-canopy forests preferred; also known to use open habitats including burns (Smith et al. 1997).	May occur within the CRW at higher elevations. Habitat lacking within the lower elevation forests of the project area, within riparian buffers on industrial forest lands, and within the rural residential area. Not expected to occur in the project area.
Canada lynx (*Lynx canadensis*)	FT, ST	Requires early successional habitat for primary prey (snowshoe hare) and late successional subalpine fir/spruce forest for breeding. (Ruediger et al. 2000).	Project area is not within the expected range of Canada lynx in the western Cascades; may occur in the upper elevations of the CRW. Not expected to occur in the project area.
Common loon (*Gavia immer*)	SC	Large lakes with minimal human disturbance (Rodrick and Milner 1991).	Known to occur within the CRW; however no suitable nesting habitat occurs within or adjacent to the proposed ROWs either within the CRW or areas outside the boundary. Not expected to occur in the project area.
Western pond turtle (*Clemmys marmorata*)	FC, SE	Marshes, sloughs, and slow-moving streams; soils that drain quickly are preferred for nesting (Dvornach et al. 1997).	Habitat for this species lacking within the proposed ROWs. Not expected to occur in the project area.
Beller's ground beetle (*Agonum belleri*)	FC, SC	Sphagnum bogs from sea level to 3,300 ft. elevation (Rodrick and Milner 1991).	Not expected to occur in the project area due to a lack of sphagnum bogs.
Hatch's click beetle (*Eanus hatchi*)	FC, SC	Eutrophic sphagnum bogs from sea level to the 3,300 ft. elevation (Rodrick and Milner 1991).	Not expected to occur in the project area due to a lack of sphagnum bogs.
Long-horned leaf beetle (*Donacia idola*)	SC	Eutrophic sphagnum bogs from sea level to 3,300 ft. elevation (Rodrick and Milner 1991).	Not expected to occur in the project area due to a lack of sphagnum bogs.
Golden eagle (*Aquila chrysaetos*)	SC	Nests primarily in high rocky cliffs in areas with a suitable prey base, primarily rabbits and marmots. West of the Cascades is known to utilize the high-elevation subalpine/parkland zones and has been observed foraging in clearcuts at moderate elevation (Smith et al. 1997).	No known occurrence in the project area; may occur in the upper portion of the CRW, at mid to high elevation, but not expected to occur in the project vicinity.
Grizzly bear (*Ursus arctos*)	FT, SE	Large tracts of wilderness; meadows, wet areas, open slopes with huckleberries for foraging (USFWS 1993).	Not known to occur in the CRW; may occur in more remote locations. Not expected in the lower CRW due to high road density; not expected to occur on industrial forest lands or in the rural residential area due to high levels of human activity. Not expected to occur in the project vicinity.

Species	Status	Habitat Association	Probability of Occurrence
Gray wolf (*Canis lupus*)	FE, SE	Wilderness; isolation from human disturbance for denning (Paradiso and Nowak 1982).	A wide ranging species that may occur in a variety of habitats while dispersing/traveling. Denning and rendezvous sites in remote areas. Not known to occur in the CRW; may occur in more remote locations. Not expected to occur regularly in the lower CRW due to high road density; not expected to occur regularly on industrial forest lands or within the rural residential area due to high levels of human activity. Not expected to occur in the project vicinity .
Wolverine (*Gulo gulo*)	FC, SM	A true wilderness species requiring large areas of minimally disturbed habitats (Banci 1994).	May occur within the higher elevation areas of the CRW; habitat is lacking in the project area. Not expected to occur in the project vicinity.
FT = federal threatened, FE = federal endangered, FC = federal (USFWS) species of concern, SE = state endangered, ST = state threatened, SC = state candidate, SM = state monitor, and LC = local concern.			

An historic spotted owl sighting occurred on lands owned by the Weyerhaeuser Company. This single owl reported in 1993 was over 0.5 mi. from the proposed Alternative 3 ROW and, therefore, was not within the project area. Suitable nesting habitat is lacking in the vicinity of the historic sighting, although the riparian buffers remaining on the industrial forest lands may provide a dispersal corridor for spotted owls.

Marbled murrelet nesting habitat is lacking within the project area, with the nearest potentially suitable nesting habitat located 1.5 miles to the west of the proposed ROW.

Northern goshawks and pileated woodpeckers may nest in portions of the project area, while **merlins**, and **Vaux's swifts** are unlikely to nest within the project area. Goshawks and pileated woodpeckers are both known to nest in older forest types (Reynolds et al. 1992, Rodrick and Milner 1991). Mature regeneration stands in the project area are approaching conditions that would make them suitable nesting habitat for these species, and although no evidence of nesting was observed during field reconnaissance surveys, these stands may provide nesting habitat for these species, particularly in riparian areas. Pileated woodpeckers may nest in second-growth stands if large downed wood and snags are abundant (Rodrick and Milner 1991). Because many of the managed stands within the CRW were burned following logging, snags and downed wood are generally lacking in these stands (City of Seattle 2000). However, the field reconnaissance survey located a stand south of where Alternative 3 exits the CRW, which contains snags showing signs of woodpecker use. The amount of decay in these snags would preclude use as nesting, however, and this sign is evidence that this is foraging habitat for pileated woodpeckers. All mature regeneration forest types (CFL, DFL) within the project area may be suitable foraging habitat for pileated woodpeckers, and all mid and mature regeneration forest types (CFL, CFM, DFL, DFM, MFE, MFM, MFL) are potential dispersal habitat for both pileated woodpeckers and northern goshawks, and potential foraging habitat for northern goshawks.

Large hollow trees, suitable nesting for Vaux's swift, are also lacking within the project area, although abandoned chimneys in the residential areas (DEV) could potentially provide nesting habitat (Smith et al. 1997). However, all forest types (CFE, CFM, CFL, DFE, DFM, DFL, MFE, MFM, MFL) within the project area are suitable for use as foraging habitat for Vaux's swift, because they are known to feed on flying insects in all forest seral stages (Rodrick and Milner 1991).

Merlins are rare in Washington, and nesting in the Cascades occurs in high-elevation forests, (Smith et al. 1997), outside of the project area. However, forest within the project area (DFE, DFM, DFL, CFE, CFM, CFL, MFE, MFM, MFL) may contain potential dispersal or migratory habitat for merlins.

Mature deciduous regeneration and mature coniferous regeneration (DFL and CFL) within the project area are potential nesting and foraging habitat for **black swifts**, which utilize both coniferous and mixed coniferous/deciduous mid to late seral forests (Smith et al. 1997). Mature regeneration, as used in this document, has characteristics of mid to late seral forest, although no old-growth forest occurs within the project area.

Both **olive-sided flycatchers** and **red-tailed hawks** nest in forested habitat and utilize edges and openings for foraging (Smith et al. 1997). All forested stands (DFE, DFM, DFL, CFE, CFM, CFL, MFE, MFM, MFL) within the project area are potential nesting habitat for these species, and vegetated open areas (GFS, NNF) are potential foraging habitat. Developed areas (DEV) are not included for olive-sided flycatchers because they are not areas of primary use; however such areas are included for the red-tailed hawk, which often occurs near areas of human activity (Smith et al. 1997).

Both **band-tailed pigeons** and **blue grouse** occur in forest habitats ranging from early to late seral (Smith et al. 1997); therefore all forested types (DFE, DFM, DFL, CFE, CFM, CFL, MFM, and MFL) in the project area may be habitat for them. Band-tailed pigeons are migratory and nest at lower elevations, moving upslope with the fruit and berry crops in late summer and then migrating south for the winter (Rodrick and Milner 1991). In the project area, then, band-tailed pigeon habitat would likely be used for nesting. Blue grouse, however, would occur in the project area year-round because they are not migratory (Rodrick and Milner 1991).

Fisher are most commonly associated with late-successional forest with an abundant supply of large downed wood and snags available for breeding and resting, but they will travel through any type of forested habitat and avoid openings (Maser 1998, Johnson and Cassidy 1997). For this reason, all forest types in the project area (CFM, CFL, CFE, DFE, DFM, DFL, MFE, MFM, MFL) were included as potential travel habitat for fisher. These types are also considered potential foraging habitat because the foraging behavior of fisher appears to be largely opportunistic (Maser 1998).

Five species of bats have been identified as potentially occurring in the project area and having a listing status. Four of these are species within the genus myotis and are associated with forested habitat. Three of these species (**Keen's myotis, long-eared myotis, and long-legged myotis**) are also known to utilize structures such as buildings and bridges for roosting (Johnson and Cassidy 1997, Barbour and Davis 1969). For these reasons, all forest types (CFE, CFM, CFL, DFE, DFM, DFL, MFE, MFM, MFL, L/P) and developed (DEV) areas were included as potential habitat. Developed areas were not included for **fringed myotis** because they are less likely to utilize human structures (Johnson and Cassidy 1997). Within forested areas, these bats are most likely to utilize older forest containing snags that are either hollow or have loose bark for roosting or for maternity colonies. Because these characteristics are usually associated with late-successional or old-growth forest, this habitat type is not expected to occur in the project area. Maternity colonies may occur in developed areas, however. The forest types occurring within the project area are potential foraging habitat for these species (Maser 1998).

The fifth species of bat included is the **Townsend's big-eared bat**. This species occurs in forested habitats but is strongly associated with caves, mines, and buildings for roosting, maternity colonies, and hibernation (Christy and West 1993, Johnson and Cassidy 1997, Rodrick and Milner 1991). This species forages in forest habitats, often along edges (Christy and West 1993) and, therefore, all forested types (CFE, CFM, CFL, DFE, DFM, DFL, MFE, MFM, MFL) were included as potential habitat. Developed areas (DEV) were also included due to the association of this species with human structures.

Four species of terrestrial mollusks may occur within the project area: two snails (**Oregon megomphix and Puget Oregonian**) and two slugs (**blue-gray tail-dropper and papillose tail-dropper**). These mollusks are all associated with forested communities, particularly conifer and mixed conifer/deciduous forest and are often found associated either with leaf litter or with woody debris (Frest and Johannes unpub., Frest and Johannes 1993). The Oregon megomphix is most commonly associated with late-successional forest (Frest and Johannes 1993) and, therefore, habitat types DFL and CFL are considered potentially suitable for this species. The other species are found in a wider variety of forest types (Frest and Johannes unpub., Frest and Johannes 1993) and may occur in the DFM, DFL, CFM, CFL, MFM, and MFL types.

One species of butterfly, Johnson's (mistletoe) hairstreak may occur in the project area. This butterfly is associated with mistletoe in the genus *Arceuthobium*, which occurs primarily in low elevation old-growth and late-successional second growth stands containing western hemlock (*Tsuga heterophylla*) (Larsen et al, 1995). Forest stands in the CFL habitat type may provide habitat for this species.

3.3.2.2 Riparian Community Dependent Species

Seven wildlife species were identified as potentially occurring within the project vicinity and having a primary association with riparian community habitat.

Bald eagles are known to occur within the project area, but only as migratory visitors (City of Seattle 2000). This species was proposed for delisting in 1999 (64 FR 36453) and was tentatively scheduled to be delisted in July 2000. To date, the bald eagle has not been delisted and remains a federally-listed threatened species. However, delisting may occur during the lifetime of the proposed project. No bald eagle nests are known to occur within the project area (City of Seattle 2000, WDFW 2000). Nest trees are usually located in uneven-aged stands containing old-growth components and nest trees often have broken or forked tops to support the nest. An uneven canopy is important for allowing flight into and out from both the nest and perch trees located within the nest stand (Rodrick and Milner 1991). Given the predominantly even-aged, closed-canopy structure of the mature regeneration forest stands within the project area, the project area does not contain suitable nesting habitat for bald eagles.

Mid and mature regeneration forest stands (CFM, CFL, DFM, DFL, MFM, MFL) may provide perch sites for bald eagles foraging along rivers within the project area. However, this use is limited by the availability of fish and so is most likely to occur in the Raging River area, where the proposed project crosses industrial forest lands with riparian buffers, and along the Cedar River in the CRW. Migratory or dispersing bald eagles potentially passing through the project area are also more likely to occur within the forested riparian areas.

Great blue herons are not known to nest within the project area (City of Seattle 2000, WDFW 2000). However, potential nesting habitat occurs in forested (CFM, CFL, DFM, DFL, MFM, MFL) riparian areas adjacent to wetlands and streams or rivers. Foraging habitat also occurs within the project area, within wetlands and streams or rivers (WET and L/P).

Osprey nesting habitat is similar to that of the bald eagle, usually occurring near a large body of water in snag or a tree with a broken top (Smith et al. 1997). Potential nesting habitat within the project area occurs in mid to mature regeneration forest types (CFL, DFL, MFL) within riparian areas. Mid regeneration forest stands (MFD, MFC, MFM) may also be utilized for perching during foraging activity or dispersal and migration.

Willow flycatchers may occur in the project area and are known to nest in wetlands containing shrubs or young trees (WET), in shrub or forested areas containing appropriate wetland microhabitats (GFS, DFE, CFE), and in developed areas (DEV) (Smith et al. 1997). Potential nesting habitat occurs in wetlands in and surrounding shrub or early seral habitat. Migratory willow flycatchers may also occur in wetlands and early seral habitat types in the project area (WET, CFE, DFE, GFS).

Harlequin ducks nest in forested habitats along fast-moving streams and rivers; therefore all forested (CFE, CFM, CFL, DFE, DFM, DFL, MFM, MFL) riparian habitat in the project area may be suitable nesting habitat for this species.

Mink occur in all vegetation types within the riparian areas of streams, lakes, rivers, ditches and wetlands (Johnson and Cassidy 1997); therefore all riparian habitats in the project area may be year-round habitat for this species.

Van Dyke's salamanders are terrestrial salamanders usually found near the edges of streams in association with large woody debris (Corkran and Thoms 1996). Potential habitat for this species occurs in the project area where mature regeneration forest types (CFL, DFL, MFL) occur in riparian areas.

3.3.2.3 Aquatic Community Dependent Species

Seven wildlife species were identified as potentially occurring within the project vicinity and having a primary association with aquatic community habitat.

The **Cascades frog** is found in the Olympic and Cascade Mountains of Washington and Oregon; above 2,600 ft. in elevation, and in montane meadows, slow-moving streams, lakes, and ponds. It has also been recorded at elevations as low as 1,600 feet in the CRW. The **northern red-legged frog** is found in wetlands and forests at lower elevations west of the Cascade Mountains. Both require ponds or wetlands for egg laying and development of tadpoles (Leonard et al. 1993). These species are common and would be expected to occur in wetlands (WET) in the project area, although the Cascades frog is unlikely to be found except at the highest elevations of the project area.

The **Cascade torrent salamander** lives in small streams and seeps in moist conifer forests or in nearby splash zones. They require cold, moving water but may move short distances into forests in wet weather. Stream habitat (STR) for torrent salamanders exists in the project area and they may occur there, although the northern limit of their range is reported to be south of Mount Rainier (Larsen 1997, Leonard et al. 1993).

The **Oregon spotted frog** is highly aquatic, breeding in shallow emergent wetlands and remaining in wetland and riparian areas as adults. The Oregon spotted frog was once common in the lowlands of western Washington but is found only at three sites in southwest Washington (Nordstrom and Milner 1997). Wetlands (WET) within the project area may be potential habitat for the spotted frog.

The **tailed frog** is endemic to the Pacific Northwest, occurring in Washington in fast-flowing mountain streams on the west side of the Cascades. The adults generally stay in or near streams but may use nearby forests in wet weather (Leonard et al. 1993). The species appears to be associated with mature forest habitats that can produce cold streams free of fine sediment, and is considered susceptible to loss of old-growth forests (Blaustein et al. 1995). Watershed alterations such as road building and timber harvest are suspected to have caused declines in some areas (Leonard et al. 1993). Tailed frogs are known to occur in the CRW and would be expected to occur in the project area because of the presence of stream and forest habitat (STR, CFL).

The **western toad** is widely distributed over all but the most arid regions of the western United States, and it can utilize a wide variety of habitats from sea level to over 7,000 ft. (Blaustein et al. 1995, Leonard et al. 1993). The adults can disperse through forest, grass, and shrub habitats but are most common near lakes, ponds, and wetlands (L/P and WET). They require open water ponds or wetlands for breeding. Toads can be very abundant locally but have appeared to decline in overall population, especially in the lowlands of western Washington and some high-elevation habitats (Leonard et al. 1993). They are known to occur in the CRW and would be expected to occur in wetlands and forests in the project area.

Fender's soliperlan stonefly is endemic to western Washington. The nymphs are largely predatory and live in seeps and small streams with clean, clear water. The adults are poor fliers and live in riparian zones of small streams, feeding on algae and vegetation. They may occur in and near streams (STR) in the CRW and the project area, although the only confirmed sightings have been in Pierce and Skamania Counties (Pacific Biodiversity Institute 2000).

3.3.2.4 Species Dependent upon Unique Habitats

Two wildlife species, the **Larch Mountain salamander** and the **peregrine falcon**, were identified as potentially occurring within the project vicinity and having a primary association with unique habitat types.

The Larch Mountain salamander is associated with forested and talus environments that provide cool, moist conditions. The species occupies forests with late seral characteristics, early to late seral forests, non-forested talus, caves, and occasionally seeps. (Crisafulli 1998). Its core distribution is along the Columbia River Gorge at elevations ranging from 2,000 to 4,000 ft., but because Survey and Manage requirements have been in place, scattered additional populations of this species have been found on the Mount Baker-Snoqualmie National Forest in the Green River Watershed and on the Wenatchee National Forest, Cle Elum Ranger District. The species may occur in the project area where suitable talus habitat (C/T) is present. Within the project area, no reliable estimate of the amount of talus habitat is available, because it generally occurs in small patches within other habitat types and is not mapped separately. Mature coniferous regeneration forest (CFL) may be utilized by this species if an adequate down wood component exists.

Peregrine falcons are associated with cliffs, which they utilize for nesting habitat. Peregrines forage on other species of birds, and forage primarily in areas where there are large concentrations of waterfowl or flocking birds (Johnsgard 1990). Within the project vicinity, potential nesting habitat for peregrine falcons occurs in the area of Rattlesnake Ridge in the lower CRW, although peregrines have not been documented as occurring in the vicinity (City of Seattle 2000, WDFW 2000). This potential nesting habitat is approximately 2 miles from the proposed alignment of Alternative 3 and approximately 4 miles from the other proposed alignments. Because peregrines are known to have hunting territories that extend up to 15 miles from nest sites, peregrines may use the project area as foraging habitat.

3.3.2.5 Early Seral Community Dependent Species

Three wildlife species were identified as potentially occurring within the project vicinity and having a primary habitat association with early seral community habitat types: elk, black-tailed deer, and western bluebirds.

Elk are known to occur throughout the project area (City of Seattle 2000, WDFW 2000) and are expected to utilize all the different habitat types within the project area during some part of the year. Mid and mature regeneration forest types (CFL, CFM, DFL, DFM, MFM, MFL) provide potential cover, including hiding and thermal cover, during all seasons and provide foraging habitat where an understory is present. Early seral types (GFS, DFE, CFE, NNF) provide foraging habitat and wetlands (WET) provide both foraging and cover habitat. Calving is likely to occur in areas away from human disturbance where hiding cover is available, with wetlands and early seral habitats being the most likely areas for calving to occur (Thomas and Toweill 1982).

Black-tailed deer are more closely associated with forested habitats than elk, and are expected to utilize all forested habitat types (DFE, DFM, DFL, CFE, CFM, CFL, MFE, MFM, MFL) within the project area. They may also utilize the early seral types (GFS and NNF) but prefer smaller openings or edges (Johnson and Cassidy 1997).

Western bluebirds are cavity-nesting birds that forage in open habitats (Rodrick and Milner 1991). Habitat for this species is limited in the project area by the lack of snags containing cavities, as documented in the HCP prepared for the CRW (City of Seattle, 2000). Potential habitat occurs where late forest types are beginning to contain snags and in areas where remnant snags remain. However, no reliable estimate of acreages exists for this habitat type.

3.4 Transmission Line Alternatives

3.4.1 Wildlife Habitats

The amount of each type of wildlife habitat present along the transmission line ROW varies by alternative, as shown in Table 4.

Table 4. Wildlife Habitat Present along Transmission Line ROW by Alternative

Habitat type	Habitat Present (acres)				
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Forested Communities					
Mid-regeneration, closed deciduous canopy	183	154	26	154	154
Mature deciduous regeneration	110	108	0	110	110
Early regeneration, open coniferous canopy	77	205	91	137	137
Mid-regeneration, closed coniferous canopy	41	56	440	54	47
Mature coniferous regeneration	1,467	1,406	1,943	1,583	1,766
Early-regeneration, mixed canopy	157	157	319	157	157
Mid-regeneration, mixed canopy	319	319	319	319	319
Totals	2,354	2,405	3,138	2,514	2,690
Riparian Communities					
Managed grass/forb/shrub	43	68	29	68	68
Developed	2	2	0	2	3
Mid-regeneration, closed deciduous canopy	19	19	4	19	19

Habitat type	Habitat Present (acres)				
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Mature deciduous regeneration	11	11	0	11	11
Early regeneration, open coniferous canopy	10	20	13	20	20
Mid-regeneration, closed coniferous canopy	5	7	62	8	7
Mature coniferous regeneration	143	161	215	161	156
Early-regeneration, mixed canopy	16	16	45	16	16
Mid-regeneration, mixed canopy	26	26	58	26	26
Totals	275	330	426	331	326
Aquatic Communities					
Lakes/ponds	6	7	20	10	6
Wetlands	141	142	27	142	142
Streams (miles)*	13	15	22	16	15
Totals	147	149	47	152	148
Unique Habitats					
Cliff/talus	0	0	0	0	0
Developed	80	27	30	33	28
Totals	80	27	30	33	28
Early Seral Communities					
Managed grass/forb/shrub	425	439	197	463	475
Natural non-forest	0	0	1	1	1
Totals	425	439	198	464	476
*Streams are reported as the number of miles of stream occurring within the area of potential disturbance.					

3.4.1.1 Alternative 1: Preferred Alternative

Alternative 1 parallels the existing Raver-Echo Lake transmission line and therefore the 0.25-mi.-wide project area along the Alternative 1 ROW contains the least amount of forested community habitat of all the action alternatives. However, the most abundant type of forested community habitat within the Alternative 1 ROW is mature coniferous regeneration forest, which is potential dispersal and/or foraging habitat for forest community dependent species.

The second most abundant habitat type within the Alternative 1 ROW is managed grass, forb, or shrub. Much of this type occurs within the existing Raver-Echo Lake transmission line ROW, and it is also a common type in the rural residential area that the southern portion of the ROW passes through. This is potential habitat for early seral community dependent species.

The Alternative 1 ROW contains the least amount of forested riparian habitat but is comparable to Alternatives 2, 4a, and 4b in the amount of wetland habitat it contains. The Alternative 1 ROW also contains the most developed areas.

3.4.1.2 Alternative 2

Alternative 2 also parallels the existing Raver-Echo Lake transmission line for much of its length, although to a lesser extent than Alternative 1. Habitat types within the Alternative 2 ROW are, therefore, similar to those for Alternative 1. The 0.25-mi.-wide project area along the Alternative 2 ROW contains a greater amount of forested community habitat but less mature coniferous regeneration forest than Alternative 1. It also contains a greater amount of forested riparian habitat. The amount of wetland area in the Alternative 2 ROW is similar to that for Alternatives 1, 4a, and 4b. Alternative 2 crosses more early seral communities, due largely to the placement of the ROW in the rural residential area in the southern portion of the project area.

3.4.1.3 Alternative 3

The 0.25-mi.-wide project area along the Alternative 3 ROW contains the greatest amount of forested community habitat of all alternatives, largely due to the fact that none of this alternative parallels the existing Raver-Echo Lake transmission line and, therefore, a new ROW must be cleared on both sides of the Alternative 3 corridor. As under Alternative 1, the most abundant forest type for this alternative is mature coniferous regeneration forest, and Alternative 3 crosses the greatest amount of this habitat type of all of the alternatives.

The Alternative 3 ROW also contains the most forest riparian habitat, which is dominated by mature coniferous regeneration forest. It contains the least amount of wetlands, however, as well as the least amount of early seral habitat.

3.4.1.4 Alternative 4a

Alternative 4a parallels the existing Raver-Echo Lake transmission line for much of its length and so is similar to Alternatives 1 and 2. It contains slightly more forested community habitat than Alternatives 1 and 2, as well as slightly more early seral community habitat. The amount of forested riparian habitat within the Alternative 4a ROW is similar to Alternative 2, and the amount of wetlands is similar for all alternatives except Alternative 3.

3.4.1.5 Alternative 4b

Alternative 4b is similar to 4a, containing slightly more forested community habitat and early seral community habitat, and slightly less forested riparian habitat. The amount of wetlands is similar to Alternatives 1, 2, and 4a.

3.5 Access Roads

Because Alternative 1 parallels the existing Raver-Echo Lake transmission line, it would require the least amount of new access roads. New roads would generally be short spurs off of existing access roads. New roads would be constructed in the mature coniferous regeneration forest and early regeneration, mixed forest habitat types.

The majority of Alternatives 2, 4a, and 4b also parallel the existing transmission line. However, most new roads associated with these alternatives would be constructed in the portion of the

ROW that does not parallel the existing line. Under Alternative 2, most new roads constructed in the portion of the ROW not paralleling the existing line would be in the managed grass/forb/shrub, mature coniferous regeneration forest, or early regeneration, coniferous forest habitat types. Under Alternatives 4a and 4b, most new roads constructed in the portion of the ROW not paralleling the existing line would be in the mature coniferous regeneration forest habitat type.

Alternative 3 would require the greatest amount of new road construction. In the southern portion of the Alternative 3 ROW, within the rural residential area crossing into the CRW, these roads would be constructed primarily within the managed grass/forb/shrub or early regeneration, coniferous forest habitat types. Within the CRW, most new roads would be constructed in the mature coniferous regeneration forest habitat type. On the industrial forest lands in the northern portion of the ROW, roads would be primarily constructed in the mid-regeneration, coniferous forest, mid-regeneration, mixed forest, and early regeneration, mixed forest habitat types.

3.6 Substation

The proposed expansion of the Echo Lake Substation would be located east of the existing substation. Habitat types in this area are early regeneration, coniferous forest and early regeneration, mixed forest; and so are most likely to provide habitat for early seral community dependent species or forest community dependent species that utilize early seral forest. A portion of this area is already developed as a road accessing lands beyond the substation. The substation expansion would require the relocation of this road. Given the amount of human activity in this area, associated with both the existing substation and the presence of the access road, wildlife species sensitive to human disturbance would not be expected to utilize the area.

4.0 Environmental Consequences and Mitigation

BPA defines environmental impact levels in three categories: high, moderate, and low.

High-level impacts on wildlife would occur when an action creates an adverse change in wildlife populations or habitats. Adverse changes include impacts that would:

- Create an unavoidable adverse effect on a species federally-listed as threatened or endangered;
- Reduce the quantity or quality of a regionally or nationally important wildlife population or habitat;
- Reduce the quantity or quality of habitat critical for local animal populations, such as big-game winter range; or
- Adversely affect rare or declining species or other species with high public profiles, values or appeal, such as elk, gray wolves, or bald eagles.

Moderate-level impacts on wildlife occur if the actions would:

- Create an effect on a threatened or endangered species that could be partially mitigated through an interagency consultation with the USFWS under Section 7 of the ESA;
- Cause a local reduction in the quality or quantity of wildlife habitats; or

- Marginally reduce the productivity of adjacent wildlife habitats or resources (such as nest sites).

Low-level impacts occur when an action would:

- Create an effect that could be largely mitigated;
- Reduce the quality or quantity of wildlife habitat or species confined to the site of the action;
- Cause no major effect on productivity of adjacent wildlife habitat;
- Temporarily disturb common wildlife species;
- Reduce habitat that is very common in the project vicinity;
- Adversely affect relatively common species at a local level; or
- Cause temporary effects that can be minimized by site planning or by placing seasonal restrictions on activities.

A project may also have no impact.

Impacts could result either from construction of the facilities or from ongoing operation and maintenance. In addition, these impacts could be either temporary or permanent. Impacts may consist of the physical loss of habitat, or disturbance of wildlife from the construction activities or ongoing facility use and maintenance.

4.1 Construction Impacts

Permanent construction impacts would occur when an area is modified and maintained in the modified state. Examples include clearing for transmission lines, building sites, and roads. An example of permanent loss of wildlife habitat would be where vegetation removal is associated with facility development.

Temporary construction impacts would be associated with noise and human presence. Temporary construction impacts would result from tower installation involving the use of heavy equipment, helicopters, and blasting, and intense levels of human activity around the construction site; construction of substation addition and roads; clearing ROWs; and pulling conductors. These types of activities would occur only during the construction phase and would not be long term.

4.1.1 Impacts Common to All Transmission Line Alternatives

4.1.1.1 Impacts

The types of impacts that would occur as a result of project implementation would be the same for all the action alternatives, with differences occurring in the magnitude of the impacts. The following types of impacts would occur under all alternatives.

Impacts on Threatened, Endangered, and other Sensitive Species - Potential impacts to threatened, endangered, and other sensitive species could occur as a result of habitat loss or alteration, disturbance, or collision with transmission lines, and are discussed in subsequent sections.

Habitat Loss - Impacts would occur to all of the wildlife habitat types described in Section 3.0 of this document under all action alternatives. Impacts would differ in magnitude and location, as is discussed under each alternative later in this section. Habitat for species dependent upon forested communities, riparian communities, aquatic communities, and unique habitats would be reduced while habitat for early seral dependent or edge species would be increased. Based upon the definitions above, this would be a moderate-level impact.

Within the CRW there would also be a loss of recruitment habitat for late-successional forest dependent species. The CRW has in place a HCP which prescribes management of forested stands in the watershed so that they develop late successional characteristics. Permanent conversion of these stands from a forested condition to either being maintained in an early seral condition (within the ROW) or a developed conditions (new access roads) would cause a permanent loss of recruitment habitat. The amount of forested habitat lost is described by alternative in Section 4.1.2.

Habitat Fragmentation—Under all of the alternatives, the amount of habitat fragmentation within the project vicinity would increase, resulting in a moderate-level impact. Fragmentation can affect wildlife habitat in three ways:

- It can cause an increase in the amount of edge habitat in an area.
- It can cause a decrease in the size of habitat patches leading to decrease in interior habitat.
- It can create barriers to travel and/or dispersal for species which utilize forested habitats.

The first two impacts are related in that, in general, as habitats are fragmented the amount of edge habitat increases and the amount of interior habitat decreases. Edge effect (the distance into the stand that an edge impacts such features as microclimate) varies by the types of vegetation structure which abut one another, with early seral or developed types abutting late seral habitat being the most extreme. Changes in microclimate can be expected to occur 60 to 80 m. into the stand adjacent to roads and 120-240 m. into the stand adjacent to regeneration harvest, depending on site conditions (Jones 1999).

New edge habitat would be created under all alternatives in association with both clearing the transmission line ROW and construction of new access roads. The amount of new edge habitat created would vary by alternative, with Alternative 1 creating the least and alternative 3 the most.

Information on new access road construction is available only for Alternative 1. Under Alternative 1, the majority of new access road construction would occur within the area of the cleared transmission line ROW and so would not, in itself, contribute to an increase in edge habitat. Road construction outside of the cleared transmission line ROW would lead to an approximate 13-acre increase in edge habitat, all within the mid-regeneration, closed coniferous canopy type. The amount of new edge habitat would be expected to be greater for Alternatives 2, 4a, and 4b since the portions of these alternatives that do not parallel the existing ROW would create a new opening and would likely require an increased amount of new road construction. The amount of new edge habitat created would be expected to be highest for Alternative 3 which would create a new opening along it's entire length and would likely require the greatest amount of new access road construction. Increases in edge habitat would be beneficial to species that utilize edges, such as elk and bats. However, increases in edge would reduce the quantity and quality of habitat present for species that utilize interior habitats, such as spotted owls and goshawks.

Since Alternative 1 would be expected to create the least amount of new edge habitat, it would also be expected to have the least impact on the amount of interior habitat available. Alternatives 2, 4a, and 4b would be expected to have a greater impact on the amount of interior habitat due to clearing of new ROW corridors in the areas where these alternatives do not parallel the existing ROW and new road construction. Alternative 3 would be expected to have the greatest impact on interior habitat since it would require clearing along the entire length of the transmission line and construction of new access roads.

Habitat fragmentation can also impact the suitability of the landscape for migratory or wide-ranging animals. This can take the form of limiting the amount of habitat available to species that avoid crossing large openings, such as fisher, or an increase in the potential for predation for species that may cross openings but are more susceptible to predation while doing so, such as spotted owl. If an opening creates a disperal barrier for a given species, it can lead to otherwise suitable habitat being unoccupied, or can lead to isolation of segments of a population and possible local extinctions. It could also limit the amount of habitat available for establishment of home ranges, limiting the ability of a species to populate an area. If an opening creates a travel barrier for a given species, it would limit the available habitat within a home range and could lead to creating home ranges that are too small to support individuals. If the potential increase in predation on individuals crossing an opening were to occur, it could limit the potential for a species to repopulate an area. Since one of the goals of the HCP for the CRW is to manage forested habitat so that it develops into habitat suitable for late successional species, and to have these species utilize this habitat, creating an opening that could limit the potential for these species to utilize the habitat could affect the probability of these goals being reached.

For some species, allowing brush to revegetate the site and providing large down wood within the cleared ROW may provide enough cover to allow individuals to cross the ROW. This would be most effective for small bodied animals, such as small mammals.

Alternative 1 would widen an opening than currently exists and so create more of a barrier to animals moving through the area. Alternatives 2, 4a, and 4b would create a wider opening along those portions of the ROW that parallel the existing transmission line ROW, and would create new openings in those areas that do not parallel it. Alternative 3 would create a second corridor through the project vicinity, creating a second barrier for animals that avoid openings.

Because habitat fragmentation reduces habitat quantity and quality for some species and also reduces productivity of adjacent habitat for interior forest species, this would be a moderate-level impact.

In addition, under all action alternatives the proposed transmission line would cross wildlife linkage corridors identified in the King County Comprehensive Plan (King County 2000). Under Alternative 3, one corridor would be crossed and under all other action alternatives, two corridors would be crossed. Creating openings with early seral vegetation may reduce the effectiveness of these corridors for species dependent upon cover for travel habitat. The corridor crossed by all alternatives follows the Cedar River, however, and because the riparian vegetation in this area is expected to remain intact, with the transmission line spanning the riparian zone, impacts to this corridor would be low-level. The second corridor would be bisected by the new ROW where it parallels the existing Raver-Echo Lake ROW under Alternatives 1, 2, 4a, and 4b, and so would double the size of an existing opening in the network corridor. This gap would result in a moderate-level impact to low-mobility species for which such an opening may be a barrier.

Bird Collision or Electrocution—The risk of bird mortality from either collision with transmission lines or electrocution would be similar under all alternatives. Historically, raptors were known to have a high incidence of mortality associated with power lines, primarily from electrocution, however current design standards have greatly reduced the probability of this occurring, as described in Section 4.1.1.2. Raptor collisions with powerlines are relatively rare, although they do occur. Keen eyesight and a tendency to avoid flying in inclement weather are believed to reduce the risk of powerline collisions by raptors (Olendorff and Lehman 1986). If raptor mortality were to occur, particularly to a bald eagle, this would be a high-level impact.

Species that are at greatest risk of collision with powerlines are waterfowl, particularly near wetlands or open water and during conditions of low visibility (Stout 1976, Arend 1970, Anderson 1978). Within the project vicinity, small wetlands occur that may be utilized by waterfowl, and collisions may occur when these birds are traveling between areas.

Other species may also collide with transmission lines, including marbled murrelets potentially flying up the Cedar River enroute to suitable nesting habitat in the upper CRW. The risk of this occurring is unknown, however the risk would be related to the height at which murrelets fly above the canopy while traveling to nest sites, which is not well documented. Peregrine falcons foraging in the vicinity of the transmission lines may also be at risk for collision. If mortality of either of these species were to occur to it would be a high level impact.

According to the Avian Powerline Interaction Committee (APLIC 1994) four factors contribute to the level of risk of collision with powerlines: the current level of risk; the type of power line; the amount of avian use in the area; and the inherent tendency of a species to collide with overhead wires. Because the proposed transmission line would be built entirely adjacent to the existing line under Alternative 1, this alternative would have the least increase in the current level of risk. Because the proposed transmission lines would have a ground wire, which is located at the top of the lines and is usually a smaller diameter than the transmission lines, the level of risk is higher than if there wasn't a ground wire. The level of use of species susceptible to collision in the project area is not known, however some use is expected to occur and the susceptibility of different species is described above. Although measures would be taken to prevent collisions, as described in section 4.1.1.2, it is likely that some level of mortality due to powerline collision would occur.

Disturbance of Wildlife—Noise associated with construction of the proposed transmission line could disturb wildlife potentially occurring within the project area. Construction activities with the potential to cause noise disturbance include use of chainsaws, heavy equipment, helicopters, and explosives. Because potential disturbance would be confined to the site of the action, would be temporary, and could be limited by seasonal restrictions if a high-priority resource such as a bald eagle nest were discovered in the area, this would be a low-level impact.

Noise from blasting would be audible over a larger area than the other potential disturbance mechanisms; however, blasting would be infrequent and of short duration and so would result in a low-level impact. The exception to this would be blasting that occurred during the nesting season of species sensitive to noise, such as raptors, which could cause disturbance impacts up to a mile from the blasting site. Measures to avoid these impacts are described in Section 4.1.1.2.

Construction of Alternative 3 has the highest potential for causing disturbance because it would be constructed through habitats currently receiving the least amount of human use. Construction of Alternative 1 would have the least potential impact because it would occur entirely adjacent to the current transmission line and, therefore, within an area with ongoing regular human activity in the form of maintenance and monitoring activities. Disturbance from construction activities associated with Alternatives 2, 4a, and 4b would be greatest in the segments not parallel to the existing transmission line.

4.1.1.2 Mitigation

Impacts on Threatened, Endangered, and other Sensitive Species—Potential mitigation for habitat alteration or removal includes:

- Minimize the amount of forest vegetation clearing by clearing only as much as necessary. Along ROW edges, selectively cut only those trees with sufficient height to damage the transmission line if they should fall, leaving shorter trees in place.

- Improve forest habitat conditions outside of the ROW through stand manipulations such as precommercial thinning, in cooperation with the landowner.

- Where trees must be felled along the ROW edges, fell and leave some trees in the adjacent stand to provide coarse woody debris. Larger trees would be the most valuable in providing this function.

Habitat Fragmentation—Potential mitigation for habitat fragmentation includes:

- Clear only as much vegetation as necessary.

- Provide coarse woody debris within the cleared ROW for cover for small mammals and for connectivity of habitat for invertebrates. This can be accomplished by either leaving some logs in place during clearing operations or by placing logs within the ROW following construction. Large logs have the highest value for this purpose.

- Span riparian corridors to the extent possible, leaving riparian vegetation across the cleared ROW for use as travel corridors.

Bird Collision or Electrocution—To minimize the risk of mortality from electrocution or collision:

- Base design and construction of the new transmission line on guidelines described in the publication, Suggested Practices for Raptor Protection on Power Lines: The State of the Art in 1996 ((APLIC 1996). Guidelines to decrease the risk of electircution include:

    1. Insulating ground wires.

    2. Maintaining a minimum spacing of 60 inches between conductors.

- Line markers would be installed where the transmission line crosses riparian corridors in order to make the transmission line more visible and reduce the potential for collision.

Disturbance of Wildlife—To minimize or avoid the risk of disturbance to wildlife:

- Prior to construction, verify that no new bald eagle nests have been constructed within 1 mile of the proposed ROW. If any are found, avoid construction within 2,600 ft. of the nest during the nesting period (January 1 through August 15), or within 1 mile for blasting. Survey techniques are to be determined and would be included in the mitigation action plan to be prepared for this project.

- Prior to construction, verify that no other special status raptor nests occur within 1 mile of the proposed ROW. If any are found, avoid construction within 0.25 mile of the nest during the nesting season (varies by species), or within 1 mile for blasting. Survey techniques are to be determined and would be included in the mitigation action plan to be prepared for this project.

- Plan flight paths for helicopters used during construction so that they do not fly over potential nesting habitat for either northern spotted owls or marbled murrelets in the project vicinity during their nesting seasons, or maintain a minimum altitude of 500 ft. over these stands if they are unavoidable. The nesting season for spotted owls is March 1 through July 31; for marbled murrelets it is April 1 through September 15.

- Plan flight paths for helicopters used during construction so that they do not fly over potential nesting habitat for peregrine falcons in the project vicinity during their nesting season or maintain a minimum altitude of 1,500 feet above the habitat if it is unavoidable. The nesting season for peregrine falcons is March 1 through June 30.

4.1.1.3 Unavoidable, Irreversible, or Irretrievable Impacts

Permanent alteration of forested habitat types to managed early seral habitat types would occur under all alternatives. The amount of alteration would vary by alternative, as discussed below. Permanent impacts to both wetland and riparian habitat may also occur.

4.1.2 Alternative Transmission Line Impacts

Table 5 shows the habitat changes that would occur under each alternative, assuming that a 150-ft. ROW is cleared for each alternative with the currently identified centerline, as shown in Figure 3.

Riparian vegetation clearing is likely overestimated since stream corridors will be spanned, where possible, making it unnecessary to clear the riparian corridor.

Changes in vegetation types represent vegetation clearing for the proposed new ROW. This clearing would result in a permanent conversion of vegetation type for all types except the managed grass/forb/shrub. Vegetation types cleared would be permanently converted to the managed grass/forb/shrub type, while vegetation that is currently grass/forb/shrub would be temporarily impacted and then allowed to regenerate. Therefore, the acres lost represent a temporary loss and the acres gained represent a permanent gain.

Table 5. Habitat Impacts within the Alternative Transmission Line Alignments

Habitat Type	Change in Amount of Each Habitat Type (acres)				
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Forested Communities					
Mid-regeneration closed deciduous forest	-9	-9	-<1	-9	-9
Mature deciduous regeneration	-3	-3	0	-3	-3
Early regeneration, open coniferous forest	0	-8	-3	-4	-4
Mid-regeneration, closed coniferous forest	-1	-1	-27	-1	-1
Mature coniferous regeneration	-86	-85	-113	-96	-107
Early regeneration, open mixed canopy	-4	-4	-20	-4	-4
Mid-regeneration, open mixed canopy	-17	-17	-14	-17	-17
Totals	-120	-127	-178	-134	-145
Riparian Communities					
Managed grass/forb/ shrub	-5, +10	-5, +10	-2, +26	-5, +11	-5, +11
Developed	0	0	-<1	0	0
Mid-regeneration closed deciduous forest	-<1	-<1	-0	-<1	-<1
Mature deciduous regeneration	0	0	0	0	0
Early regeneration, open coniferous canopy	0	-1	-1	-1	-1
Mid-regeneration, closed coniferous canopy	-<1	-<1	-4	-<1	-<1
Mature coniferous regeneration	-5	-5	-12	-5	-5
Early regeneration, open mixed canopy	-<1	-<1	-4	-<1	-<1
Mid-regeneration, open mixed canopy	-2	-<1	-4	-2	-2
Totals*	-15	-15	-28	-16	-16
Aquatic Communities					
Lakes /ponds	0	0	0	0	0
Wetlands	-11	-11	-2	-11	-11
Streams (miles)**	1	1	1	1	<1
Totals	-11	-11	-2	-11	-11
Unique Habitats					
Cliff/talus	0	0	0	0	0

Habitat Type	Change in Amount of Each Habitat Type (acres)				
	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Developed	-11	-4	-3	-4	-4
Totals	-11	-4	-3	-4	-4
Early Seral Communities					
Managed grass/forb/shrub	-24, +142	-25, +142	-7, +182	-26, +149	-26, +160
Natural non-forest	0	0	0	0	0
Totals*	-24	-25	-7	-26	-26

* Totals do not reflect the increase in managed grass/forb/shrub acreage resulting from conversion of other habitat types. Impacts on managed grass/forb/shrub are temporary since these areas will continue to be managed in their current state.

**Streams are reported as the number of miles of stream occurring within the area of potential disturbance.

4.1.2.1 Alternative 1: Preferred Alternative

In order to assess potential impacts to wildlife habitat, the vegetation cover developed for the proposed project area (Figure 3) was used, with the assumption that a 150-ft. ROW centered on the proposed transmission line would be cleared. The changes in habitat discussed below are calculated from converting vegetation within the cleared ROW to a managed grass/forb/shrub condition.

Forest Community Dependent Species: Construction of Alternative 1 would result in clearing 120 acres (ac.) of forested community habitat, including 86 ac. of mature coniferous regeneration forest. This alternative would require the least amount of clearing of forest community habitat of all action alternatives and would result in low-level impacts on forest community dependent species. Clearing this habitat type would reduce the amount of foraging habitat available to spotted owls potentially utilizing the area, as well as for goshawks, merlins, pileated woodpeckers, and Vaux's swifts. It would also reduce the amount of recruitment habitat available for these species, and for marbled murrelet, in the CRW. Under the current management plan (City of Seattle 2000), this habitat would develop into potentially suitable nesting habitat for these species.

Clearing of forested communities would also reduce the amount of potential nesting habitat available for both olive-sided flycatchers and red-tailed hawks in the project area, but would increase the amount of foraging habitat available for them. Similarly, it would decrease potential roosting and foraging habitat for the four species of *Myotis* bats potentially occurring in the project area. Construction of Alternative 1 would also decrease potential roosting habitat for Townsend's big-eared bat but, because it would not substantially increase the amount of edge habitat available, it would not increase the amount of foraging habitat for this species.

Clearing of forested communities would reduce the amount of potential nesting habitat available for both band-tailed pigeon and blue grouse and would also reduce the amount of winter foraging and cover habitat for blue grouse.

Clearing of forested habitat would also decrease the amount of travel and foraging habitat available for fisher. Because Alternative 1 would parallel the existing Raver-Echo Lake transmission line, it would not represent a new barrier to fishers potentially moving through the area, but it would increase the width of the current barrier.

Clearing of forested habitat would also decrease the amount of habitat for the four mollusk species of concern, particularly reductions in the amount and distribution of coarse woody debris available for these species.

Clearing of mature coniferous regeneration would decrease the amount of potentially suitable habitat available for Johnson's (mistletoe) hairstreak (butterfly). If individuals in the larval form are present during project implementation, mortality of individuals may also occur. Permanent conversion of forested habitat to managed grass/forb/shrub would also decrease future potential habitat for this species.

The 120 ac. of forested community habitat that would be cleared for Alternative 1 represents 5% of the 2,354 ac. of forested community habitat present in the project area. Because this habitat type is common in the project area and the amount of reduction is relatively small, construction of Alternative 1 would result in low-level impacts on forest community dependent species.

Riparian Community Dependent Species: Construction of Alternative 1 would result in the clearing of 15 ac. of riparian vegetation, of which 10 ac. is forested riparian habitat. This would reduce potential habitat for bald eagle, great-blue heron, harlequin duck, and mink. Forested riparian vegetation in the mature coniferous regeneration forest type totaling 5 ac. would be cleared, reducing the amount of habitat available for Van Dyke's salamander. Habitat for willow flycatchers would potentially increase due to conversion of current forested habitat to the managed grass/forb/shrub habitat type.

The removal of 10 ac. of forested riparian habitat represents 4% of the total present (230 ac.) in the project area, and removal of 5 ac. of mature coniferous regeneration riparian forest represents 3.5% of the total present (143 ac.) in the project area under Alternative 1. Because this vegetation removal could result in a loss of productivity in adjacent aquatic habitat and would cause a local reduction in the quantity of wildlife habitat, this would represent a moderate- level impact.

Aquatic Community Dependent Species: Because construction of Alternative 1 could cause a reduction in the quantity of wetland habitat and in the quality of both wetland and stream habitat, this alternative would have a moderate-level impact on aquatic community dependent species. Construction of Alternative 1 would potentially impact 11 ac. of wetlands. This is potential habitat for Cascades frog, red-legged frog, Oregon spotted frog, and western toad. Construction of this alternative would also impact 1 mi. of stream, which is potential habitat for tailed frog, Cascade torrent salamander, and Fender's soliperlan stonefly.

Potential impacts would occur within 8% of total wetland habitat within the Alternative 1 project area (141 ac.). There are 13 mi. of stream within the project area for Alternative 1, and 8% of these would potentially be impacted by construction of this alternative.

Species Dependent upon Unique Habitats: Two species were identified that are primarily associated with unique habitats and may occur within the project area, the Larch Mountain salamander and the peregrine falcon. The Larch Mountain salamander is associated with talus habitat, a type that has not been mapped in the project area. Talus habitat may occur, however, in small, localized areas within the project area. It is not expected to be an abundant habitat type within the project area, however, given the relatively gentle terrain and well developed soil layer. Potential impacts to this habitat type within the project area from construction of Alternative 1 are unknown.

The Larch Mountain salamander is also known to occur in association with large woody debris as described in Section 3.3.2.4. This habitat type is most likely to occur in the mature coniferous regeneration forest habitat type, which has been mapped. Construction of Alternative 1 would result in removal of 86 ac. of this habitat type, approximately 6% of the total amount present in the project area. As described under forest communities, this removal of mature coniferous regeneration forest habitat would result in a low-level impact.

Construction of Alternative 1 would not impact nesting habitat for peregrine falcons. By creating a larger opening in the canopy, it may increase available foraging habitat. However, the risk of collision with the power lines, as discussed in Section 4.1.1.2, would negate any benefit to creating openings.

Early Seral Community Dependent Species: Construction of Alternative 1 would result in an increase in early seral habitat, increasing the amount of managed grass/forb/shrub habitat by 142 ac. This would benefit species dependent upon this habitat type, particularly elk and deer. Given the lack of suitable nesting habitat for western bluebirds in the project area, the increase in foraging habitat for this species would not appreciably benefit western bluebirds and so the project would have little or no impact on them.

Mitigation—Mitigation measures to minimize or reduce potential impacts to forested community dependent species include:

- Minimize the amount of forest vegetation removed by clearing only as much as necessary. Along ROW edges, selectively cut only those trees with sufficient height to damage the transmission line if they should fall, leaving shorter trees in place.

- Improve forest habitat conditions outside of the ROW through stand manipulations such as precommercial thinning, in cooperation with the landowner.

- Within the cleared ROW, clear only as much vegetation as necessary.

- Provide coarse woody debris within the cleared ROW for cover for small mammals and for connectivity of habitat for invertebrates. This can be accomplished by either leaving some logs in place during clearing operations or by placing logs within the ROW following construction. Large logs have the highest value for this purpose.

- Where trees must be felled along the ROW edges, fell some trees into the adjacent stand and leave them for coarse woody debris. Larger trees have the most value in this function.

Mitigation measures to minimize or reduce potential impacts to riparian community dependent species include:

- Span riparian corridors to the extent possible, leaving riparian vegetation across the cleared ROW for use as travel corridors.

Mitigation measures to minimize or reduce potential impacts to aquatic community dependent species include:

- Avoid placing tower footings within or adjacent to wetlands to the extent possible.

- Minimize soil disturbance within or adjacent to wetlands and stream banks to the extent possible.

Mitigation measures to minimize or reduce potential impacts to species dependent upon unique habitats include:

- Provide coarse woody debris within the cleared ROW for cover for small mammals and for connectivity of habitat for invertebrates. This can be accomplished by either leaving some logs in place during clearing operations or by placing logs within the ROW following construction. Large logs have the highest value for this purpose.

- Where trees must be felled along the ROW edges, fell some trees into the adjacent stand and leave them for coarse woody debris. Larger trees having the most value in this function.

Mitigation measures to minimize or reduce potential impacts to species dependent upon early seral habitats:

- Create snags along the edges of the cleared ROW to create potential nesting habitat for western bluebirds.

Unavoidable, Irreversible, or Irretrievable Impacts—Under Alternative 1, there would be a permanent conversion of forested habitats, riparian habitats, and wetland habitats to a managed early seral habitat type, as shown in Table 5.

4.1.2.2 Alternative 2

Forest Community Dependent Species: Construction of Alternative 2 would result in clearing 127 ac. of forested community habitat, representing 5% of the forest community habitat in the Alternative 2 project area. A total of 85 ac. of mature coniferous regeneration forest would be cleared, representing 6% of the amount present in the project area. This also represents a reduction in the amount of recruitment habitat available for late successional forest dependent species in the CRW. Under the current management plan (City of Seattle 2000), this habitat would develop into potentially suitable nesting habitat for these species. Under Alternative 2, impacts to forest community dependent species are expected to be comparable to those described under Alternative 1, and, therefore, would be low-level impacts.

Riparian Community Dependent Species: Construction of Alternative 2 would result in the clearing of 15 ac. of riparian vegetation (4.5% of that present in the project area). Of this total, 10 ac. would be forested riparian habitat (4% of the amount present in the project area). Under Alternative 2, impacts to riparian community dependent species are expected to be comparable to those described under Alternative 1, and, therefore, would be moderate- to low-level impacts.

Aquatic Community Dependent Species: Construction of Alternative 2 would potentially impact 11 ac. of wetlands and 1 mi. of streams, representing 8% and 7% of the amount present in the project area, respectively. Under Alternative 2, impacts to aquatic community dependent species are expected to be comparable to those described under Alternative 1, and, therefore, would be moderate-level impacts.

Species Dependent upon Unique Habitats: Under Alternative 2, impacts to species dependent on unique habitat types would be similar to those described under Alternative 1 (potential disturbance of unmapped talus habitat and clearing of mature coniferous regeneration forest habitat). The amount of mature coniferous regeneration forest habitat cleared under Alternative 2 would be 85 ac., or 6% of the amount in the project area. As described under forest communities, this removal of mature coniferous regeneration forest habitat would result in a low-level impact.

Construction of Alternative 2 would not impact nesting habitat for peregrine falcons. By creating a larger opening in the canopy it may increase available foraging habitat, however the risk of collision with the power lines, as discussed in Section 4.1.1.2, ould negate any benefit to creating openings.

Early Seral Community Dependent Species: Construction of Alternative 2 would result in an increase in early seral habitat (managed grass/forb/shrub) of 142 ac. This would benefit species dependent upon this habitat type, particularly elk and deer. Given the lack of suitable nesting habitat for western bluebirds in the project area, the increase in foraging habitat for this species would not appreciably benefit western bluebirds and so the project is expected to have little or no impact on them.

Mitigation—Mitigation measures to minimize or reduce potential impacts under Alternative 2 would be the same as described under Alternative 1.

Unavoidable, Irreversible, or Irretrievable Impacts—Under Alternative 2, there would be a permanent conversion of forested habitats, riparian habitats, and wetland habitats to a managed early seral habitat type, as shown in Table 5.

4.1.2.3 Alternative 3

Construction impacts for Alternative 3, described below, are based on the assumption that the transmission line would be constructed in the currently mapped location. There is the possibility that this alternative, if chosen, could be shifted up to 250 ft. to the east or west of the currently mapped location, depending upon site-specific conditions and construction constraints. If this were to occur, the impacts to wildlife habitat types may differ to some extent from those described below but, given the overall uniformity of the vegetation within the project area, the level of impact to the vegetation types is not expected to change.

Forest Community Dependent Species: Construction of Alternative 3 would result in clearing 178 ac. of forested community habitat, with 113 ac. of this total in the mature coniferous regeneration forest type. This alternative would result in the most clearing of forested habitat of all the action alternatives (6% of the total forest community habitat present within the project area and 6% of the amount of mature coniferous regeneration forest present within the project area). This also represents a reduction in the amount of recruitment habitat available for late successional forest dependent species in the CRW. Under the current management plan (City of Seattle 2000), this habitat would develop into potentially suitable nesting habitat for these species. Under Alternative 3, impacts to forest community dependent species would be comparable to those described under Alternative 1, and, therefore, would be low level.

Riparian Community Dependent Species: Construction of Alternative 3 would result in the clearing of 28 ac. of riparian vegetation, 25 ac. of which is forested riparian habitat. This alternative would result in the most riparian vegetation clearing of all action alternatives (6.5% of total riparian vegetation present in the project area and 6.5% of the forested riparian vegetation present in the project area). Under Alternative 3, impacts to riparian community dependent species are expected to be comparable to those described under Alternative 1, and, therefore, would be moderate- to low-level impacts.

Aquatic Community Dependent Species: Construction of Alternative 3 would potentially impact 2 ac. of wetlands and 1 mi. of streams, representing 7% and 5% of the amount present in the project area, respectively. Alternative 3 would result in the least amount of potential impact to wetlands of all action alternatives. Under Alternative 3, impacts to aquatic community dependent species would be comparable to those described under Alternative 1, and, therefore, would be moderate-level impacts.

Species Dependent upon Unique Habitats: Under Alternative 3, impacts to species dependent on unique habitat types would be similar to those described under Alternative 1 (that is, potential disturbance of unmapped talus habitat and clearing of mature coniferous regeneration forest habitat). The amount of mature coniferous regeneration forest habitat cleared under Alternative 3 would be 113 ac., or 6% of the amount present in the project area. As described under forest communities, this removal of mature coniferous regeneration forest habitat would result in a low-level impact.

Construction of Alternative 3 would not impact nesting habitat for peregrine falcons. By creating a new opening in the canopy, it may increase available foraging habitat. However the risk of collision with the power lines, as discussed in Section 4.1.1.2, would negate any benefit to creating openings.

Early Seral Community Dependent Species: Construction of Alternative 3 would result in an increase in early seral habitat (managed grass/forb/shrub) of 182 ac., the largest increase of any of the action alternatives. This would benefit species that depend upon this habitat type, particularly elk and deer. Given the lack of suitable nesting habitat for western bluebirds in the project area, the increase in foraging habitat for this species would not appreciably benefit western bluebirds and so the project is expected to have little or no impact on them.

Mitigation—Mitigation measures to minimize or reduce potential impacts under Alternative 3 would be the same as described under Alternative 1.

Unavoidable, Irreversible, or Irretrievable Impacts—Under Alternative 3, there would be a permanent conversion of forested habitats, riparian habitats, and wetland habitats to a managed early seral habitat type, as shown in Table 5.

4.1.2.4 Alternative 4a

Forest Community Dependent Species: Construction of Alternative 4a would result in clearing 134 ac. of forested community habitat (5% of the amount present in the project area), of which 96 ac. is the mature coniferous regeneration forest type (6% of the amount present in the project area). This also represents a reduction in the amount of recruitment habitat available for late successional forest dependent species in the CRW. Under the current management plan (City of Seattle 2000), this habitat would develop into potentially suitable nesting habitat for these species. Under Alternative 4a, impacts to forest community dependent species would be comparable to those described under Alternative 1, and, therefore, would be low-level impacts.

Riparian Community Dependent Species: Construction of Alternative 4a would result in the clearing of 16 ac. of riparian vegetation (5% of the amount present in the project area), of which 11 ac. is forested riparian habitat (4% of the amount present in the project area). Under Alternative 4a, impacts to riparian community dependent species would be comparable to those described under Alternative 1, and, therefore, would be moderate- to low-level impacts.

Aquatic Community Dependent Species: Construction of Alternative 4a would potentially impact 11 ac. of wetlands and 1 mi. of streams, representing 8% and 6% of the amount present in the project area, respectively. Under Alternative 4a, impacts to aquatic community dependent species would be comparable to those described under Alternative 1, and, therefore, would be moderate-level impacts.

Species Dependent upon Unique Habitats: Under Alternative 4a, impacts to species dependent on unique habitat types would be similar to those described under Alternative 1 (that is, potential disturbance to unmapped talus habitat and clearing of mature coniferous regeneration forest habitat). The amount of mature coniferous regeneration forest habitat cleared under Alternative 4a would be 96 ac., or 6% of the amount present in the project area. As described under forest communities, this removal of mature coniferous regeneration forest habitat would result in a low-level impact.

Construction of Alternative 4a would not impact nesting habitat for peregrine falcons. By creating a larger opening in the canopy, it may increase available foraging habitat. However the risk of collision with the power lines, as discussed in Section 4.1.1.2, would negate any benefit to creating openings.

Early Seral Community Dependent Species: Construction of Alternative 4a would result in an increase in early seral habitat (managed grass/forb/shrub) of 149 ac. This would benefit species dependent upon this habitat type, particularly elk and deer. Given the lack of suitable nesting habitat for western bluebirds in the project area, the increase in foraging habitat for this species would not appreciably benefit western bluebirds and so the project would have little or no impact on them.

Mitigation—Mitigation measures to minimize or reduce potential impacts under Alternative 4a would be the same as described under Alternative 1.

Unavoidable, Irreversible, or Irretrievable Impacts—Under Alternative 4a, there would be a permanent conversion of forested habitats, riparian habitats, and wetland habitats to a managed early seral habitat type, as shown in Table 5.

4.1.2.5 Alternative 4b

Forest Community Dependent Species: Construction of Alternative 4b would result in clearing 145 ac. of forested community habitat (5% of the amount present in the project area), of which 107 ac. is the mature coniferous regeneration forest type (6% of the amount present in the project area). This also represents a reduction in the amount of recruitment habitat available for late successional forest dependent species in the CRW. Under the current management plan (City of Seattle 2000), this habitat would develop into potentially suitable nesting habitat for these species. Under Alternative 4b, impacts to forest community dependent species would be comparable to those described under Alternative 1, and, therefore, would be low-level impacts.

Riparian Community Dependent Species: Construction of Alternative 4b would result in the clearing of 16 ac. of riparian vegetation (5% of the amount present in the project area), of which 11 ac. is forested riparian habitat (4% of the amount present). Under Alternative 4b, impacts to riparian community dependent species are expected to be comparable to those described under Alternative 1, and, therefore, would be moderate- to low-level impacts.

Aquatic Community Dependent Species: Construction of Alternative 4b would potentially impact 11 ac. of wetlands and 0.5 mi. of streams, representing 8% and 3% of the amount present in the project area, respectively. Under Alternative 4b, impacts to aquatic community dependent species would be comparable to those described under Alternative 1, and, therefore, would be moderate-level impacts.

Species Dependent upon Unique Habitats: Under Alternative 4b, impacts to species dependent on unique habitat types would be similar to those described under Alternative 1 (that is, potential disturbance of unmapped talus habitat and clearing of mature coniferous regeneration forest habitat). The amount of mature coniferous regeneration forest habitat cleared under Alternative 4a would be 107 ac., or 6% of the amount present in the project area. As described under forest communities, this removal of mature coniferous regeneration forest habitat would result in a low-level impact.

Construction of Alternative 4b would not impact nesting habitat for peregrine falcons. By creating a larger opening in the canopy, it may increase available foraging habitat. However the risk of collision with the power lines, as discussed in Section 4.1.1.2, would negate any benefit to creating openings.

Early Seral Community Dependent Species: Construction of Alternative 4b would result in an increase in early seral habitat (managed grass/forb/shrub) of 160 ac. This would benefit species dependent upon this habitat type, particularly elk and deer. Given the lack of suitable nesting habitat for western bluebirds in the project area, the increase in foraging habitat for this species would not appreciably benefit western bluebirds and so the project would have little or no impact on them.

Mitigation—Mitigation measures to minimize or reduce potential impacts under Alternative 4a would be the same as described under Alternative 1.

Unavoidable, Irreversible, or Irretrievable Impacts—Under Alternative 4b, there would be a permanent conversion of forested habitats, riparian habitats, and wetland habitats to a managed early seral habitat type, as shown in Table 5.

4.1.3 Access Roads

4.1.3.1 Impacts

Because Alternative 1 parallels the existing transmission line, it would require the least amount of new road. Under Alternative 1, vegetation totaling 2 ac. would be removed in the construction of new access roads, predominantly in the mature coniferous regeneration forest and early regeneration, mixed forest habitat types. A portion of this clearing would coincide with clearing for the transmission ROW and so is not additive. The additional clearing for new roads would not alter the impact level in forested habitat as described under Alternative 1.

The majority of Alternatives 2, 4a, and 4b also parallel the existing Raver-Echo Lake transmission line. However, most new roads associated with these alternatives would be constructed in the portion of the alignment that does not parallel the existing line.

Under Alternative 2, new road construction would require clearing 7 ac., primarily within the managed grass/forb/shrub, mature coniferous regeneration forest, or early regeneration, coniferous habitat types. Alternatives 4a and 4b would each require 6 ac. of vegetation clearing for new access road construction, with the majority in the mature coniferous regeneration forest habitat type. Clearing associated with road construction is not expected to change the impact level for any of the alternatives as described earlier.

Alternative 3 would require the greatest amount of clearing for new road construction, totaling 16 ac in the managed grass/forb/shrub, early regeneration, coniferous forest, mature coniferous regeneration forest, mid-regeneration, coniferous forest, mid-regeneration, mixed forest, and early regeneration, mixed forest habitat types. This clearing would not alter the level of impact expected for forest community dependent species as described under Alternative 3.

Construction of new roads may also lead to disturbance of wildlife, as described under the discussion of impacts common to all alternatives. Disturbance from road construction would result from use of power saws to clear the new ROW, heavy equipment used to construct the road, and use of the road following construction. Potential disturbance is expected to be lowest under Alternative 1 because it would be located adjacent to an area that currently receives a relatively high level of human use, and greatest for Alternative 3, which would be constructed in an area currently receiving the least amount of human use.

New road construction through areas of uniform habitat type would also increase the amount of edge habitat in the stand, contributing to habitat fragmentation for low-mobility species such as mollusks.

4.1.3.2 Mitigation

Mitigation measures to reduce or minimize impacts from new road construction include:

- Avoid building new roads within or adjacent to wetlands.

4.1.3.3 Unavoidable, Irreversible, or Irretrievable Impacts

Construction of access roads would result in permanent removal of potential wildlife habitat. Although roads can be decommissioned and so are not an irreversible impact in general, construction of roads in association with the proposed project is considered permanent because there is no plan in place to later close these roads, and the intention is to maintain them as a permanent feature.

4.1.4 Substation Impacts

4.1.4.1 Impacts

The proposed expansion of the Echo Lake Substation would occur east of the existing substation. Habitat types in the area are early regeneration, coniferous forest and early regeneration, mixed forest, types that are most likely to provide habitat for early seral community dependent species or forest community dependent species that utilize early regeneration forest. Given the large amount of this habitat type available in the surrounding area and the existing disturbed nature of the site, impacts associated with expansion of the substation are expected to be low-level.

4.1.4.2 Mitigation

No mitigation measures would be required for substation expansion.

4.1.4.3 Unavoidable, Irreversible, or Irretrievable Impacts

Expansion of the Echo Lake Substation would result in a permanent conversion of land capable of supporting forested habitat types to a developed condition.

4.1.5 Cumulative Impacts

Construction impacts resulting from the proposed new transmission line, associated access roads, and the substation expansion would occur in conjunction with the current land management activities on the properties that the proposed new ROW would cross. Therefore, impacts in these areas would not be limited to those resulting only from the proposed transmission project. By definition, cumulative impacts are meant to consider other reasonably foreseeable actions in the project area.

Within rural residential areas, residential development can be expected to continue, following the trend in the greater Puget Sound region. Vegetation removal and habitat alteration would not be confined to that occurring in conjunction with the proposed project but would also include vegetation removal associated with residential development.

Within the CRW, vegetation removal and thus habitat alteration is expected to be minimal, as described in the HCP (City of Seattle 2000). For this reason, clearing associated with the proposed project would be the greatest foreseeable impact in this portion of the project area. The HCP also outlines plans to close certain roads within the CRW, making this a reasonably foreseeable action which could potentially offset or reduce impacts from proposed new access roads that would be constructed in conjunction with the proposed project.

Industrial forest lands crossed by the northern portion of the proposed project would continue to be managed for timber production, and so impacts to vegetation described earlier would be additive to impacts caused by timber management activities. The exception would be within forested riparian areas, which would be maintained as riparian buffers on industrial forest lands.

4.1.6 No Action Alternative

4.1.6.1 Impacts

Under the No Action Alternative, wildlife and wildlife habitats within the CRW would be managed as described in the HCP (City of Seattle 2000) prepared for the CRW. Forest stands would be retained and allowed to develop as wildlife habitat. Industrial forest lands within the project area would continue to be managed for timber production under the provisions of the Washington Forest Practices Act. Rural residential areas would continue to be occupied, and development in these areas is likely to increase, given the population trend in the greater Puget Sound area.

4.1.6.2 Mitigation

No mitigation would be required under the No Action Alternative.

4.1.6.3 Unavoidable, Irreversible, or Irretrievable Impacts

Unavoidable, irreversible, or irretrievable impacts would not occur under the No Action Alternative.

4.2 Operation and Maintenance Impacts

Operation and maintenance impacts would be associated with the transmission line and substation. Impacts associated with operations tend to be disturbance impacts, potentially leading to avoidance of areas by wildlife even if habitat in the area has not been altered in a way that would make it otherwise unsuitable. Operational impacts tend to be less intense but are long term and may influence wildlife use of an area to a greater extent than shorter term, more intense construction activities. Such impacts could result from activities such as road maintenance, repair of towers or conductors, and vegetation removal within or adjacent to the ROW.

4.2.1 Impacts Common to all Transmission Line Alternatives

4.2.1.1 Impacts

Under all action alternatives, vegetation within the cleared transmission line ROW would be maintained in the managed early seral grass/forb/shrub habitat type. Associated impacts include the potential for noise disturbance to wildlife in adjacent forest habitats during maintenance activities, and the long-term maintenance of a cleared ROW with associated edge habitat and potential barriers to wildlife travel.

As the stands adjacent to the cleared ROW continue to develop, the potential for use by forest community dependent species would increase. As this occurs, the presence of a cleared ROW and associated edge habitat would have an increasing impact on the quality of forested habitat in the project area. For species that utilize interior habitat, the maintenance of edge habitat may preclude the use of otherwise suitable habitat in the future.

Maintaining a cleared ROW through stands that are developing late successional characteristics may also maintain a barrier between patches of suitable habitat for both low-mobility species, such as mollusks, and species that avoid openings, such as fisher. This would reduce the quality of the habitat in the project area. Because of the long, linear nature of the proposed project, this would be a moderate-level impact on these species.

Noise associated with the operation of the line, including constant humming and crackling during rain showers, has the potential to cause noise disturbance in the immediate vicinity of the line. Since this noise would be constant, wildlife in the vicinity would be expected to acclimate to it. Also, only the area immediately adjacent to the line would be impacted. For these reasons, noise impacts during project operation would be low level.

4.2.1.2 Mitigation

Mitigation measures to reduce or minimize potential impacts from noise disturbance include:

- Prior to maintenance activities, verify that no new bald eagle nests have been constructed in the project area. If any are found, limit activities within 2,600 ft. of the nest between the dates of January 1 through August 15.

Mitigation measures to reduce or minimize potential impacts from habitat fragmentation include:

- Clear only as much vegetation as necessary. Where possible, limit clearing to overstory removal and leave shrubs and small trees.

- Provide coarse woody debris within the cleared ROW for cover for small mammals, such as chipmunks, mice and shrews, and for connectivity of habitat for invertebrates, such as mollusks species included in this document. This can be accomplished by either leaving some logs in place during clearing or by placing logs within the ROW following construction. Large logs have the highest value for this purpose.

- Span riparian corridors to the extent possible, leaving riparian vegetation across the cleared ROW for use as travel corridors.

4.2.1.3 Unavoidable, Irreversible, or Irretrievable Impacts

The long-term maintenance of the proposed ROW in a managed early seral condition would be considered irreversible because it is intended to be maintained this way indefinitely.

4.2.2 Access Roads

4.2.2.1 Impacts

Impacts from maintenance of access roads would be similar to those described for the transmission lines, although access roads would present a lesser barrier to wide-ranging species.

4.2.2.2 Mitigation

Mitigation measures to reduce or minimize impacts from access road maintenance include:

- Prior to maintenance activities, verify that no new bald eagle nests have been constructed in the project area. If any are found, limit activities within 2,600 ft. of the nest between the dates of January 1 through August 15.

4.2.2.3 Unavoidable, Irreversible, or Irretrievable Impacts

The long-term maintenance of the proposed ROW in a managed early seral condition would be considered irreversible because it is intended to be maintained this way indefinitely.

4.2.3 Substation

4.2.3.1 Impacts

Impacts from maintenance and operation of the expanded Echo Lake Substation would not differ from the existing condition. The site would continue to be of low quality as wildlife habitat, and wildlife use of the area is not expected to change.

4.2.3.2 Mitigation

No mitigation measure would be required for operation and maintenance of the expanded substation.

4.2.3.3 Unavoidable, Irreversible or Irretrievable Impacts

No unavoidable, irreversible, or irretrievable impacts would occur.

4.2.4 Cumulative Impacts

Maintenance of the proposed new ROW in an early seral condition, along with new access roads and the expanded substation, would occur in conjunction with other current land management activities on properties where the new ROW would cross. Therefore impacts in these areas would not be limited to those of the proposed project.

Maintenance activities would consist primarily of vegetation maintenance under the transmission lines, resulting in potential disturbance of wildlife in adjacent habitats. Within the rural residential areas, this would occur simultaneously with a high level of human activity and so would not be appreciably different from the existing condition. The same is true for industrial forest lands.

Within the CRW, maintenance activities would have a greater potential to cause noise disturbance to wildlife because human activity is limited in this area. Activities that do occur include some road use, road maintenance, and vegetation management along roads. Thinning may also occur in the future, as described in the HCP (City of Seattle 2000), which could compound potential impacts from ROW maintenance if they are in the same general vicinity.

4.2.5 No Action Alternative

4.2.5.1 Impacts

There would be no operation or maintenance impacts associated with the proposed project under the No Action Alternative.

4.2.5.2 Mitigation

There would be no mitigation required for the proposed project under the No Action Alternative.

4.2.5.3 Unavoidable, Irreversible or Irretrievable Impacts

Unavoidable, irreversible, or irretrievable impacts would not occur under the No Action Alternative.

5.0 Environmental Consultation, Review, and Permit Requirements

Several federal laws and administrative procedures must be met by the alternatives. This section lists and briefly describes requirements that would apply to wildlife elements of this project.

5.1 Federal

5.1.1 National Environmental Policy Act

This report was prepared according to NEPA (42 USC 4321 et seq.). NEPA is a national law for protection of the environment. NEPA applies to all federal projects or projects that require federal involvement. BPA would take into account potential environmental consequences and would take action to protect, restore, and enhance the environment prior to making a decision on the proposed action.

5.1.2 Endangered Species Act

The ESA of 1973 (16 USC 1536) provides for conserving endangered and threatened species of fish, wildlife, and plants. Federal agencies must determine whether proposed actions would adversely affect any endangered or threatened species. When conducting an environmental impact analysis for specific projects, agencies must identify practicable alternatives to conserve or enhance such species.

The ESA protects species whose populations are declining to the point where they are now at risk of extinction, or are likely to be in the future. The ESA prohibits "taking" any species listed as endangered. The prohibition against taking can be extended to threatened species under regulations promulgated by the USFWS and National Marine Fisheries Service (NMFS). Under the Act, "to take" is defined as "to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 USC 1532(18)). "Harming" includes any action that reduces an individual species' ability to feed, breed, or seek shelter and can include major habitat modifications that result in killing or injuring wildlife by significantly impairing behavioral patterns.

Section 7 of the ESA requires federal agencies to consult with the USFWS and/or the NMFS on actions leading to activities that might affect listed species. Consultation typically involves preparing a Biological Assessment that describes the expected effects of a proposed action on a listed species. If the Biological Assessment indicates that the action is likely to adversely affect a listed species, then formal consultation with the USFWS or NMFS is required. Formal consultation results in the issuance of a Biological Opinion – a formal determination on whether or not an action will jeopardize the continued existence of the species or destroy or adversely modify a species' critical habitat, and if so whether there are reasonable and prudent alternatives that avoid such a result (50 CFR 17.3).

Under Section 10 of the ESA, as amended in 1982, incidental takes (those that are incidental to otherwise lawful activity) of listed species may be authorized through voluntary agreements including HCPs. HCPs must be approved by the Secretary of the listing department. When approving a plan, the Secretary must find that:

1. the plan will minimize and mitigate the impacts of the incidental take to the maximum extent possible;

2. the incidental take will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

3. adequate funding for the plan is provided.

HCP agreements must also satisfy consultation requirements specified in Section 7 of the ESA.

5.1.3 Designated Critical Habitat for Listed Species

The ESA requires that, to the maximum extant determinable, NMFS and USFWS must designate critical habitat for federally-listed species at the time of their listing. Critical habitat designation establishes areas that are to be given special consideration in Section 7 consultations. The project area does not contain any designated critical habitat for wildlife.

5.1.4 Migratory Bird Treaty Act

The Migratory Bird Treaty Act protects birds defined as migratory, which includes many songbirds, waterfowl, and raptors. This Act prohibits the killing, harming, or capture of migratory birds, bird parts, nests, and eggs, unless permitted by regulation.

5.1.5 Bald Eagle Protection Act

The Bald Eagle Protection Act prohibits the taking of both bald and golden eagles or any parts, nests, or eggs. This Act prohibits killing, collection, and disturbance of these species. Project activities that caused direct mortality of these species or removal or alteration of a nest site would likely not be in compliance with this Act; however, such consequences are not expected to occur.

5.2 State

Washington State-listed threatened and endangered species are not protected in the same way as federally-listed species, where a "taking" is generally prohibited unless authorized by an Incidental Take Permit or an Incidental Take Statement. Instead, the State uses these classifications to assist with agency management programs and decision making. The State also defines Priority Habitats as those habitats having unique or significant value to species because they contain a unique vegetation type or a specific habitat element that is key to fish and wildlife. Priority habitats occurring or potentially occurring within the project area include riparian areas, areas containing down logs and snags, wetlands, and talus.

5.2.1 Washington Forest Practices Act

The Washington Forest Practices Act has provisions for managing riparian and wetland vegetation and wildlife habitats in areas where timber harvest is planned. It requires landowners to consult with the WDFW to protect critical habitats; to preserve wildlife reserve trees; and to avoid disturbance to both spotted owls and marbled murrelets during their nesting seasons.

5.3 Local

5.3.1 King County Comprehensive Plan

Key objectives of the King County Comprehensive Plan include conserving wildlife resources and maintaining biodiversity within the county. To accomplish these objectives, the county has identified areas of important wildlife habitat and linkage corridors between these habitats. The comprehensive plan also requires that species listed as threatened or endangered, either federally or by the state, and species listed as sensitive by the state be considered in project planning and protected. This level of consideration is also extended to species that are not listed either federally or by the state, but that are considered to be of local importance in the county. The project area contains habitat linkage corridors and either known or potential habitat for species included under the comprehensive plan. The HCP provides for long-term management of forested habitat intended to benefit forest dependent species in the watershed.

5.3.2 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by SPU to establish a comprehensive management plan for long-term management of the CRW. The HCP includes numerous provisions intended to maintain the quality of wildlife habitat and the health of wildlife populations in the CRW. Objectives of the HCP include meeting the legal requirements of the ESA, contributing to the conservation of unlisted species as appropriate, providing a net benefit over current conditions to both listed and unlisted species, and developing conservation strategies for at-risk species and their habitats.

6.0 Individuals and Agencies Consulted

- U.S. Fish and Wildlife Service, species request letter.

- Dwayne Paige, Wildlife Biologist, City of Seattle, Cedar River Watershed.

7.0 List of Preparers

Leigh Kienker, CAD/GIS Specialist
Thirteen years of experience in the CAD/GIS and photogrammetry industries.
M.U.P., Urban Planning, University of Washington, expected 2001.

Gregory Poremba, Project Manager
Twenty years of experience managing and preparing EISs.
Ph.D., Sociology, Washington State University, 1990.

Sean Robertson, CAD/GIS Specialist
Two years of experience in GIS mapping and evaluations.
B.S., Environmental and Resource Sciences, University of California – Davis, 1999.

Heidi Tate, Wildlife Biologist
Nine years of experience in natural resources management, threatened and endangered species, and preparing biological assessments.
B.S., Wildlife Biology, Washington State University, 1990.

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9.0 Glossary and Acronyms

This chapter contains a list of acronyms, abbreviations, and technical terms used in this report. Words that would be defined in a desk-size dictionary (for example, the College Edition of the American Heritage Dictionary) are not included.

Access roads are constructed to each structure site first to build the tower and line and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, short spurs are built to the structure site. Access roads are maintained after construction, except where they pass through cultivated land where the road is restored for crop production after construction is completed.

Alternatives refer to different choices or means to meet the need for action.

Aquifers are water-bearing rock or sediments below the surface of the earth.

Best Management Practices are a practice or a combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Biological Assessments are documents prepared to fulfill the implementing regulations of the Endangered Species Act, found at 50 CFR, part 402, which require an assessment of potential effects on listed species and critical habitat prior to implementing a proposed action. A proposed action is defined as any activity authorized, funded, or carried out by a federal agency (50 CFR 402.10).

Culverts are corrugated metal or concrete pipes used to carry or divert runoff water from a discharge. Culverts are usually installed under roads to prevent washouts and erosion.

Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Cut and fill is the process by which a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (filled).

CWA signifies the Clean Water Act, a federal law intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters and secure water quality.

Danger trees or high-growing brush occur in or alongside the project right-of-way and are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the right-of-way is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A contains any tree that in 15 years will grow within about 5 m (18 ft.) of conductors when the conductor is at maximum sag (100° C or 212° F) and is swung by 30 kg per sq/m (6 lb per sq/ft.) of wind (93 kph or 58 mph); Category B represents any tree or high-growing bush that after 8 years of growth will fall within about 2 m (8 ft.) of the conductor when it reaches maximum sag (80° C or 176° F) in a static position.

Dead ends are heavy towers designed for use where the transmission line loads the tower primarily in tension rather than compression. Dead ends are used in turning large angles along a line or in bringing a line into a substation.

Easement is a grant of certain rights to use a piece of land, which then becomes a "right-of-way." BPA normally acquires easements for its transmission lines. Easement includes the right to enter the ROW to build, maintain, and repair facilities.

Emergent plants have their bases submerged in water.

Endangered species are those species listed as endangered either by the Federal Government or the State of Washington. Federally-listed Endangered Species are those officially designated by the U.S. Fish and Wildlife Service as being in danger of extinction throughout all or a significant portion of their range. These species receive full protection under the Endangered Species Act. State-listed Endangered Species are those species native to the State of Washington that are seriously threatened with extinction throughout all or a significant portion of their range within the state, as designated in Washington Administrative Code 232-12-014.

Floodplain refers to a portion of a river valley adjacent to the stream channel that is covered with water when the stream overflows its banks during flood stage.

Footings are the supporting base for the transmission towers. They are usually steel assemblies buried in the ground for lattice-steel towers.

Forb is any herbaceous plant that is not a grass or grasslike.

Ford is a travelway across a stream where water depth does not prevent vehicle movement. Ford construction can include grading and stabilizing streambanks at the approaches and adding coarse fill material within the channel to stabilize the roadbed.

GIS signifies Geographic Information System, a computer system that analyzes graphical map data.

Ground wire (overhead) is wire strung from the top of one tower to the next; it shields the line against lightning strikes.

Hydrology addresses properties, distribution, and circulation of water.

Insulators are ceramic or other nonconducting materials used to keep electrical circuits from jumping to ground.

Intermittent refers to periodic water flow in creeks or streams.

Jurisdictional wetlands are areas that are consistently inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Kilovolt is one thousand volts.

Lattice steel refers to a transmission tower constructed of multiple steel members that are connected together to make up the tower's frame.

Low-gradient refers to gentle slopes.

Mitigation is the step(s) taken to lessen the potential environmental effects predicted for each resource impacted by the transmission project. Mitigation may reduce the impact, avoid it completely, or compensate for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is enacted during the design and location process. Other mitigation, such as reseeding access roads with desirable grasses and avoiding weed proliferation, is taken after construction.

Monitor species are those species for which the State of Washington monitors status and distribution either because they have been listed as State threatened, endangered or sensitive within the previous 5 years; they require a habitat that has limited availability during at least some portion of their life cycle; they are environmental indicators; or their taxonomy is in question and it is unclear whether they should be included as listed species.

Montane areas refer to those occurring in the biogeographic zone of relatively moist, cool upland slopes below timberline dominated by large coniferous trees.

National Environmental Policy Act (NEPA) requires an environmental impact statement on all major Federal actions significantly affecting the quality of the human environment. (42 U.S.C. 4332 2(2)(C))

Noxious weeds are plants that are injurious to public health, crops, livestock, land, or other property.

100-year floodplains are areas that have a 1% chance of being flooded in a given year.

Perennial streams and creeks have year-round water flows.

Permeability refers to the capability of various materials to transport liquids.

Pulling site is a staging area for machinery used to string conductors.

Revegetation is reestablishment of vegetation on a disturbed site.

Right-of-way (ROW) is an easement for a certain purpose over the land of another owner, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Riparian habitat is a zone of vegetation that extends from the water's edge landward to the edge of the vegetative canopy. The term is associated with watercourses such as streams, rivers, springs, ponds, lakes, or tidewater.

Sensitive species are those species native to Washington State that are vulnerable or declining and are likely to become endangered or threatened in a significant portion of their range within the state without cooperative management or removal of threats, as defined in Washington Administrative Code 232-12-011.

Silt is a designation referring to individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05mm).

Sole source aquifer is designated by the U.S. Environmental Protection Agency as an aquifer providing at least half of an area's drinking water.

Substation is the fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Substation dead ends are towers within the confines of the substation where incoming and outgoing transmission lines end. Dead ends are typically the tallest structures in a substation.

Survey and manage is a mitigation measure adopted as a standard and guideline within the Northwest Forest Plan Record of Decision that is intended to mitigate impacts of land management efforts on species that are closely associated with late-successional or old-growth forests whose long-term persistence is a concern. (U.S. Department of Agriculture, Forest Service, and U.S. Department of Interior, Bureau of Land Management 2000)

Take is to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct (Federal Endangered Species Act, Section 3(18)).

Threatened species are those species listed as threatened either by the Federal Government or the State of Washington. Federally-listed threatened species are those officially designated by the U.S. Fish and Wildlife Service as being in danger of becoming endangered throughout all or a significant portion of their range. These species receive full protection under the Endangered Species Act. State listed threatened species are those species native to the State of Washington that are likely to become endangered within the foreseeable future throughout all or a significant portion of their range within the state without cooperative management or removal of threats, as designated in Washington Administrative Code 232-12-011.

Transmission dead end towers are the last transmission line towers on both the incoming and outgoing sides of the substation. These towers are structurally reinforced to reduce conductor tension on substation dead ends and provide added reliability to the substation.

Transmission line includes the structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Water bars are smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

Wetlands are areas where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Abbreviations and Acronyms

ac.	acre or acres
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
CRW	Cedar River Watershed
CWA	Clean Water Act
FR	Federal Register
ft.	foot or feet
EIS	environmental impact statement
ESA	Endangered Species Act
GIS	Geographic Information System
HCP	Habitat Conservation Plan
in.	inch or inches
kV	kilovolt
mi.	mile or miles
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NMFS	National Marine Fisheries Service
ROW	right-of-way
SPU	Seattle Public Utilities
USC	U.S. Code
USFWS	U.S. Fish and Wildlife Service
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources

Appendix C Final Vegetation Technical Report

Final Vegetation Technical Report

Bonneville Power Administration
Kangley-Echo Lake Transmission Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97208-3621

Prepared by:

Jones & Stokes
11820 Northup Way, Suite E300
Bellevue, Washington 98005-1946

April 2002

The analysis in this technical report is generally based on typical construction activities and impacts for transmission lines. Detailed information for this project has been updated as much as possible. However, the most current information about this project is in the Final Environmental Impact Statement.

This document should be cited as:

Jones & Stokes. 2002. Bonneville Power Administration Kangley-Echo Lake Transmission Project. Final vegetation technical report. April 2. (JSA 0P005.00.) Bellevue, WA. Prepared for Bonneville Power Administration, Portland, OR.

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List of Tables and Figures

1.0 Executive Summary

This report describes the existing conditions and potential impacts on vegetation from the proposed Bonneville Power Administration (BPA) Kangley-Echo Lake Transmission Line Project. This report serves as the primary basis for the vegetation discussion in the National Environmental Policy Act (NEPA) environmental impact statement (EIS) prepared for the project.

1.1 Alternatives

This EIS evaluates five alternative routes for constructing a new 500-kilovolt (kV) electrical transmission line intended to increase the reliability of the Seattle metropolitan area's transmission system. This increased reliability would reduce the potential for rolling brownouts or blackouts that could transpire by the winter of 2002-2003 if the current rate of development continues and if severe winter weather were to cause inordinate power demand.

The transmission line would start at the Schultz-Raver No. 2 500-kV transmission line near the unincorporated community of Kangley in central King County, Washington and travel approximately 9 miles (mi.) to the Echo Lake Substation, located north of the Kangley area and southwest of North Bend (Figure 1).

1.1.1 Construction Methods

BPA would construct all of the action alternatives using the existing practices described below for building transmission lines and substations. BPA would build or improve access roads as necessary. If additional easements for right-of-way (ROW) or access roads were needed, additional rights would be obtained from landowners. BPA typically uses existing, cleared staging areas in which to store and assemble materials or structures.

After the structures are in place and conductors are strung between the structures, BPA would restore disturbed areas.

The following sections describe in greater detail the sequential steps that BPA typically takes to construct a transmission line.

1.1.1.1 Right-of-Way Requirements

BPA would obtain easements from landowners for the new transmission line ROW, and easements for the access roads outside of the transmission line ROW easements. The easements give BPA the right to construct, operate, and maintain the line and access roads. A 150-foot (ft.) ROW width is assumed for the 500-kV line.

Fee title to the land comprising the easement generally remains with the owner, subject to the provisions of the easement. The easement prohibits large structures, tall trees, storing of flammable materials, and other activities that could be hazardous to people or could endanger the transmission line. Activities that do not interfere with the transmission line or endanger people are usually not restricted.

Rights (usually easements) for new access roads would be acquired from property owners, as necessary. A 50-ft. ROW easement generally would be acquired for new access roads measuring about 16 ft. wide, and 20 ft. of ROW would be required for any existing access roads.

1.1.1.2 Clearing

The height of vegetation within the ROW would be restricted to provide safe and reliable operation of the line. Trees would be cleared within the ROW as well as outside of the ROW to prevent trees from falling onto the lines. A clearing advisory would be generated using ground information from cross section data. This clearing advisory would specify a safe vegetation height along and at varying distances from the line. The amount of vegetation removed would be based on this clearing advisory and local knowledge of regional conditions such as weather patterns, storm frequency and severity, general tree health, and soils. Other factors that influence the amount of clearing along the line are the line voltage; vegetation species, height, and growth rates; ground slope; conductor elevation above the ground; and clearance distance required between the conductors and other objects.

Merchantable timber purchased from private owners would be marketed and non-merchantable timber would be left lopped and scattered, piled, chipped, or would be taken off-site. Contractors would be required to use equipment that leave low-growing vegetation in place instead of dirt blades on bulldozers for clearing. Other specialized brushing/mulching equipment may also be required. Additional best management practices (BMPs) for timberland would also be used.

At the tower sites, all trees, brush, and snags would be felled. Stumps would be removed at these sites only if they interfered with tower and guy installation. The site would be graded to provide a relatively level work surface. The total amount of clearing required for this project is unknown at this time.

An additional amount of land would be cleared for roads that are needed off the ROW and for roads determined to be in poor condition and requiring upgrading by BPA.

1.1.1.3 Access Road Construction and Improvement

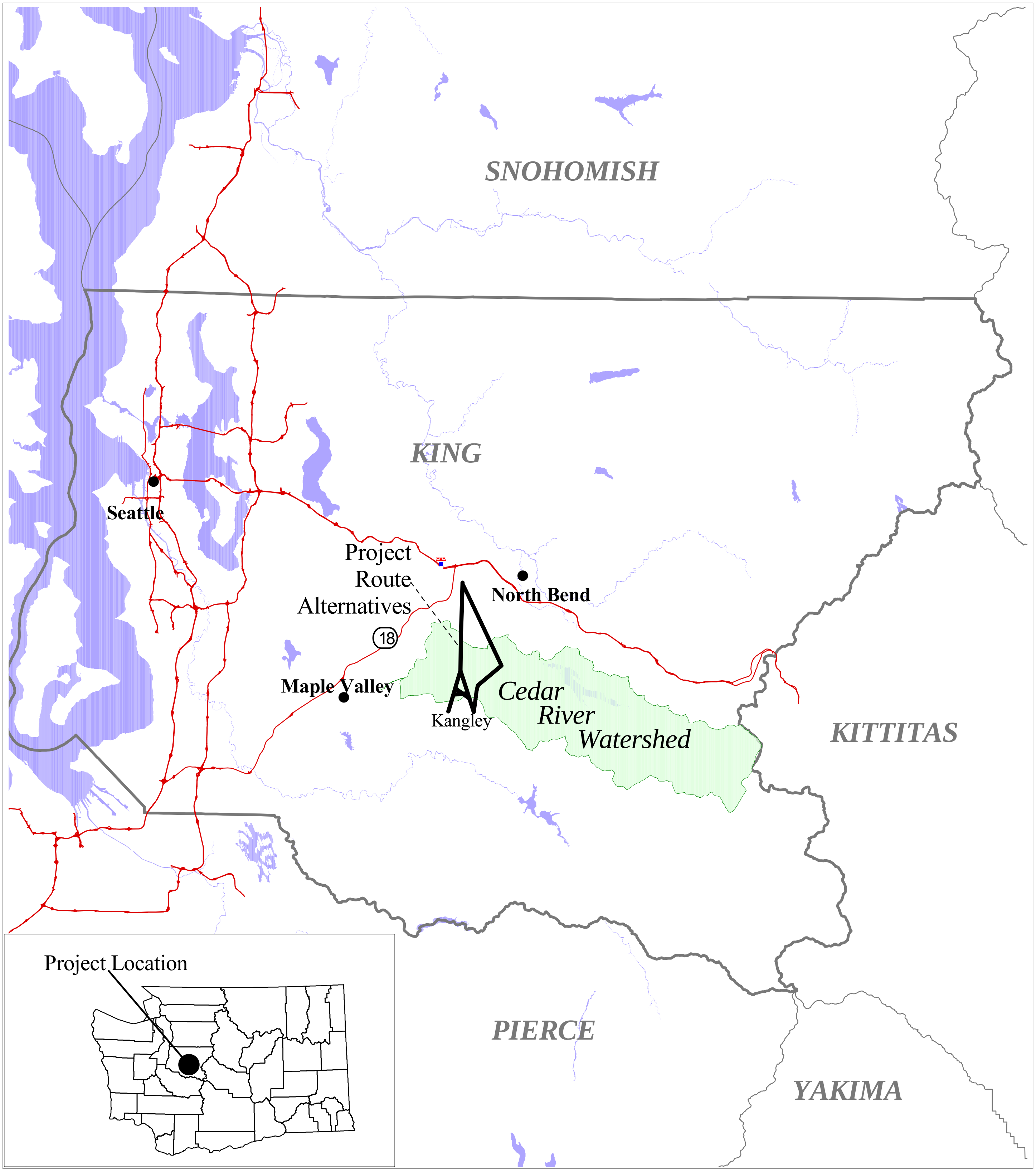
An access road system within and outside of the ROW would be used to construct and maintain a new line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. Roads generally would be surfaced with gravel, and appropriately designed for drainage and erosion control. The access roads would generally have grades of 6% or less for erodible soils and 10% or less for resistant soils. The maximum grades would be 15% for trunk roads and 18% for spur roads. No permanent access road construction would be allowed in cultivated or fallow fields.

Clearing and construction activities for new access roads would disturb an area about 20 ft. wide, depending on terrain. New roads would be constructed within the ROW wherever possible, but where conditions dictate otherwise, roads would be constructed and used outside of the ROW.

Dips, culverts, and waterbars would be installed within the roadbed to provide drainage. Fences, gates, cattle guards, and additional rock would be added to access roads as necessary.

Where temporary roads are used, any disturbed ground would be repaired and, where land use permits, the road would be reseeded with grass or other appropriate seed mixtures. After construction, access roads would be used for line maintenance. Where ground must be disturbed for maintenance activities, the roadbed would be repaired and reseeded as necessary.

The amount of new roads required for this project would vary depending on the alternative chosen and the feasibility of using existing roads along the line.



LOCATION MAP

County, contour data, King County, 2000.

Transmission line alternatives

Counties

Highway

Cedar River Watershed

Waterbodies

BONNEVILLE POWER ADMINISTRATION

GEOGRAPHIC INFORMATION SYSTEM

N

0ft 50000ft 100000ft

0mi 5mi 10mi 15mi 20mi

Figure 1

Path/apr: S:\Temp\BPA Kangley 0P005\GIS\Projects\intro1.apr (Date:2001-10-25) rpe

Figure 1. Location Map

1.1.1.4 Storage, Assembly, and Refueling Areas

Construction contractors usually establish storage areas near the transmission line where they can stockpile materials for structures, spools of conductor, and other construction materials. These areas would be accessible from major highways. Structural steel would be delivered in pieces on flatbed trucks and would be assembled on-site. A mobile crane may be needed to handle the bundles. If the terrain were too steep at the actual tower site, general assembly yards would be used to erect the tower in pieces. The structure would then be transported to the tower site by truck or helicopter. Because trucks and helicopters need to refuel often, these construction areas could also be used for refueling.

1.1.1.5 Tower Site Preparation

Site preparation begins with removing all vegetation from a tower site. In areas of uneven topography, the site would be graded to provide a level work area. An average area of 30,000 square feet (150 by 200 ft.) would be disturbed at each tower site. Additional areas that could be disturbed include the site where the conductor is strung and pulled. These disturbances could be as large as a 370-ft. radius from the tower center.

Bulldozers would be used to clear and construct any new access roads to the transmission line towers and any new tower site landings. Manual methods, including chainsaws and brush hogs, would be used to clear the new ROW. BMPs would be used during clearing and construction to reduce impacts.

In addition to clearing the ROW for the transmission line towers, construction crews would remove selected trees outside of the ROW. This additional clearing would be done to reduce the possibility of blowdown. Blowdown occurs when newly exposed trees fall after the initial clearing process because they have not developed the root structure to remain standing once they become more fully exposed to strong winds.

1.1.1.6 Towers and Tower Construction

Steel lattice towers would be erected to support the transmission line conductors. The new towers would be similar in design to those used in the existing Schultz-Raver No. 2 500-kV transmission line. The height of each tower would vary by location and surrounding land forms. Towers would average 135 ft. high and would be spaced about 1,100 to 1,200 ft. apart. Under Alternatives 1 and 2 (described in the next section), where the new line would parallel a portion of the existing Raver-Echo Lake transmission line, towers would be staggered so that a tower from one line would not contact a tower from the other line in the unlikely event that a tower falls.

Most towers used on the proposed line would be “tangent” or “suspension” towers. This type of tower is designed to support conductors strung along a virtually straight line with only small turns or angles. “Deadend” towers would also be used on a limited basis where stresses on the transmission line conductors would have to be equalized because of changes in direction, because of the need to support an excessively long span, or where a span crossing is needed for extremely steep or rugged terrain or a river. Deadend towers use more insulators and heavier steel than tangent or suspension towers, thus making them more visible. Deadend towers also are more costly to build than suspension towers.

The towers would usually be constructed from the ground, rather than using helicopters. The equipment used depends on the weight and size of the towers and such site conditions as weather and soil characteristics. Most 500-kV lines would be built using mobile cranes; helicopter tower erection could be used if access was not available or if sensitive resources would be encountered.

Steel towers would be assembled in sections near the tower site. Each tower contains three components: the legs, body, and bridge. The bridge is the uppermost portion of the tower and serves as the attachment point for the insulators that support the conductors.

Steel towers are anchored to the ground by footings. Each tower requires four footings placed in holes that have been excavated, augered, or blasted. Large machinery, such as backhoes or truck-mounted augers, would be used to excavate the footings. Topsoil would be stockpiled during excavation. The design of the footings would vary based upon soil properties, bedrock depth, and the soundness of the bedrock at each site. Typically, towers would be attached to steel plates or grillages placed within the excavated area. The areas would then be backfilled with excavated material or concrete. Topsoil would then be replaced to restore the original ground surface.

Typical footings for single-circuit towers include 4- by 4-ft. plates placed 10 to 12 ft. deep for suspension towers and 12.5- by 12.5-ft. grillage placed 14 to 16 ft. deep for heavy dead-end towers. On average, for an entire transmission line project, each footing would occupy an area about 10 by 10 ft. to a depth of 15 ft. if bedrock was not encountered. The holes in which the plates and grillage would be installed must be large enough to provide about 1 ft. of clearance on each side of the plate or grillage. If bedrock were encountered and had properties that allowed anchor borings, holes would be drilled and steel rods grouted into the rock. These rods would either be attached to a concrete footing or welded directly to a tower member and embedded in compacted backfill. If rock properties were not suitable for anchor rods, the rock may be blasted to obtain adequate footing depth.

As the towers were built, heavy machinery would disturb the ground surface and/or compact soils at the tower site and along access roads. Noise and dust also would be generated by the machinery.

1.1.1.7 Conductors, Overhead Ground Wires, and Insulators

The wires or lines that carry the electrical current in a transmission line are called conductors. Alternating-current transmission lines such as the proposed line require three wires or sets of wires, each of which is referred to as a “phase.” Three 1.3-in. Bunting conductors would be included for each phase. Each bundle is 16 by 20 in.

Conductors are not covered with insulating material. Instead, air is used for insulation. Conductors are physically separated by insulators on transmission towers.

After the transmission towers are in place, workers would attach a smaller steel cable to the towers and then pull the conductor under tension through the towers. Conductors would be attached to the structure using glass, porcelain, or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors on the tower, the tower itself, and the ground. As the conductors are strung, the ground surface would be disturbed at the tensioning sites, and noise and dust would be generated by the machinery.

Transmission towers elevate conductors to provide safe clearance for people and structures within the ROW. The National Electrical Safety Code (NESC) establishes minimum conductor heights.

The minimum conductor-to-ground clearance for a 500-kV line is a little more than 29 ft. Greater clearances would be provided by BPA over county roads and highways, railroads, and river crossings.

One or two smaller wires, called overhead ground wires, would also be attached to the top of the transmission towers. Overhead ground wires would protect the transmission line against lightning damage. The diameter of the wire would vary from 0.375 to 0.625 in.

1.1.1.8 Substation Additions

Under the current proposal, the Echo Lake Substation would be expanded to the east on land owned in fee title by BPA. The size of the expansion would be 300 by 750 ft. The site would be cleared in the same manner as the ROW for the transmission line. The site would include a fenced yard and a graded and graveled parking lot. The existing road around the substation would be realigned to the east to accommodate this expansion. New transformers, switches, and other equipment would be installed in the expanded area. A continuous ground wire would also be installed.

1.1.1.9 Site Restoration and Clean-up

Disturbed areas around the towers, conductor reels, and pull site locations would be reshaped and contoured to be consistent with their original condition. Access roads would be repaired.

Disturbed areas would be reseeded with grass or an appropriate seed mixture to prevent erosion. The seed mixture would include native plant species and would be free of noxious weeds. All solid waste from construction would be removed and properly disposed offsite, and equipment would be removed from the ROW.

1.1.2 Alternative Rights-of-Way

A portion of the action alternatives would be located within the Cedar River Municipal Watershed. The alternatives would begin at the Schultz-Raver No. 2 500-kV transmission line and generally travel northward to the Echo Lake Substation. (See Figure 2.) Under all alternatives, the transmission line ROW would be 150 ft. wide. Miles of new access roads were calculated for a 20-ft. ROW within a 0.25-mile buffer on each transmission line alternative.

1.1.2.1 Alternative 1

The alignment for Alternative 1 would be immediately adjacent and parallel to a portion of the existing 12-mi. Raver-Echo Lake transmission line from a point approximately 3 mi. north of Raver (S26, T22N, R7E) to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 0.8 mi. of new access roads. The existing 150-ft. ROW would be widened to 300 ft., with the widening and new line located east of the existing corridor.

1.1.2.2 Alternative 2

Alternative 2 would originate from tap point #2 (Figure 2) located approximately 2 mi. east of the tap point #1 for Alternative 1 (S25, T22N, R7E). The line would traverse approximately 3 mi. to S11, T22N, R7E before continuing north along the same alignment as Alternative 1, paralleling the existing Raver-Echo Lake transmission line, and terminating at the Echo Lake Substation

(S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 2.8 mi. of new access roads.

1.1.2.3 Alternative 3

Alternative 3 would begin at the tap point #2 (S25, T22N, R7E); traverse northeast to S8, T22N, R8E; and then turn north-northwesterly to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 10.2 mi. long and would require about 6.4 mi. of new access roads.

1.1.2.4 Alternative 4a

Alternative 4a would begin about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverse northwest to connect with Alternative 1 over 1 mi. (S23, T22N, R7E) further south from where Alternative 2 reconnects (S11, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.5 Alternative 4b

Alternative 4b would begin slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverse west to connect with Alternative 1 further south from where Alternative 4a reconnects (S23, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.6 No Action Alternative

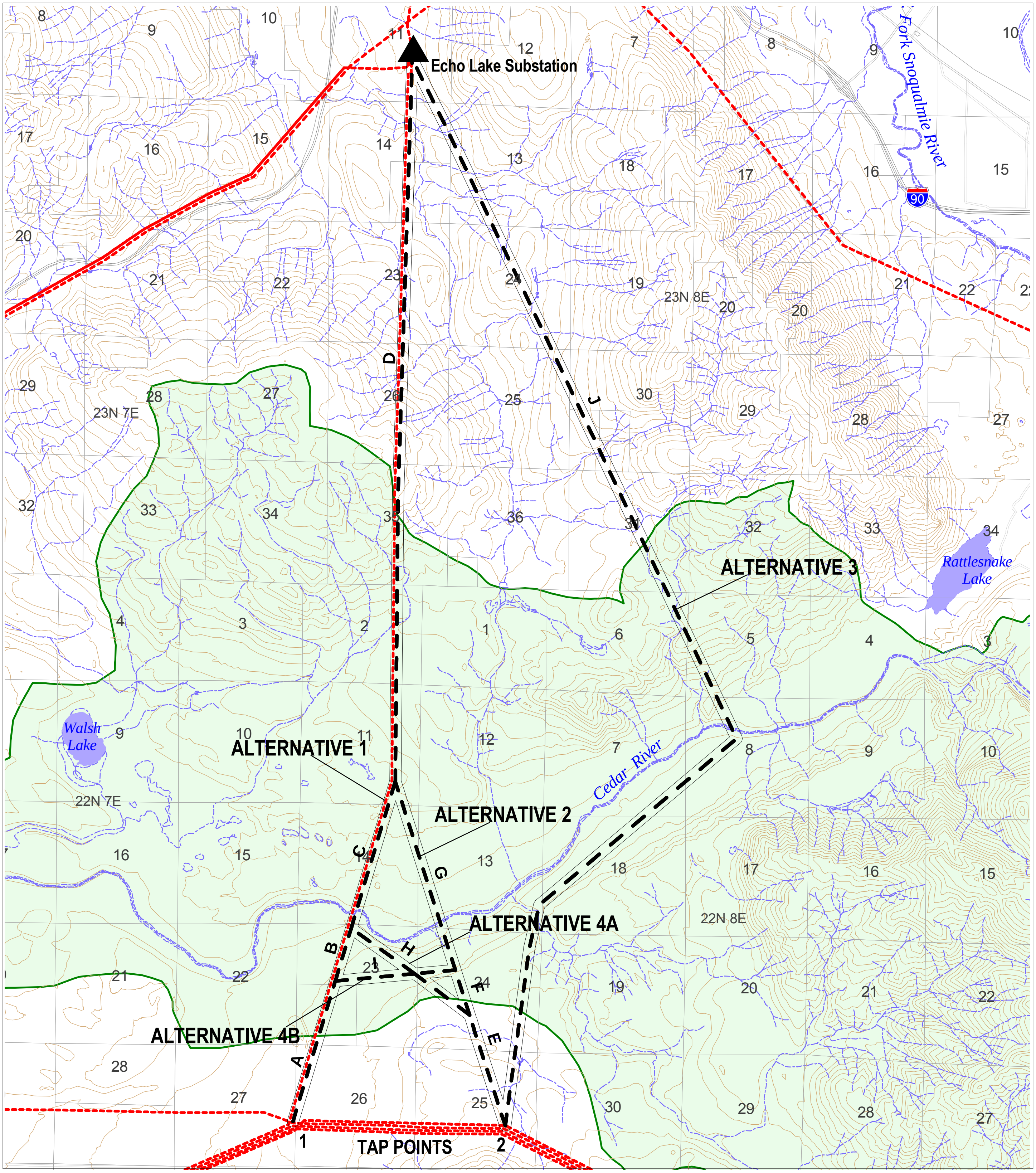
Under the No Action Alternative, a new 500-kV electrical transmission line would not be built. As a result, transmission line capacity could be reached or exceeded as early as 2002-2003 if a cold winter were to occur in the Seattle metropolitan area and the existing Raver-Echo Lake transmission line were to go out of service. Relying upon the existing transmission system during periods of increased demand and compromised reliability could result in brownouts or rolling blackouts in the area. Thus, residents, businesses, and government agencies could experience as much as several days without electricity. Loss of electricity for lights and heating could halt business and government activities. Residents would have to rely upon other energy sources for heating, cooking, and lighting, such as wood and gas fireplaces, stoves and barbecues, oil lamps and candles, etc.

1.2 Key Issues for Vegetation

Key vegetation issues were developed from public comments collected during the scoping process for this project; from issues developed in the Cedar River Watershed (CRW) Habitat Conservation Plan (HCP); and from consultation with federal and state agencies.

1.2.1 Impacts on Threatened, Endangered, and other Sensitive Species

The project area could provide habitat or potential habitat for several plant species that are listed either federally under the Endangered Species Act (ESA) or by the State of Washington. Habitat conditions and availability within the project area and potential impacts from the proposed project to these species and their habitats have been identified as issues.



ROUTE ALTERNATIVES

Transmission line alternatives
E Segment of alternative
150ft Clearing area
Existing transmission lines
Highway
Primary roads
Public land survey sections
Cedar River Watershed
Fish-bearing streams
100 Ft contours

0ft 6000ft 12000ft
0mi 1mi 2mi 3mi

N

Figure 2.
Existing Transmission Lines and Proposed ROW Alternatives

Figure 2

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1.2.2 Vegetation Removal, Alteration, and Fragmentation

Implementation of the proposed project would require varying amounts of vegetation clearing, depending upon the alternative selected. Moreover, the project would require the permanent conversion of certain areas from managed forest to non-forest use. The ratio of forested to non-forested vegetative cover would decrease. Under certain alternatives being considered, the project would also increase the amount of forest edge.

1.2.3 Removal of Forest within the Cedar River Watershed

The project would require removal of forest from the CRW. Forests play an important role in determining hydrologic regimes and water quality within a watershed. The HCP for the CRW proposes strict limitation of logging and other forest conversion within the watershed.

1.2.4 Introduction and Management of Non-Native Species

Removal of relatively large tracts of tree and understory species native to Washington could favor colonization of the cleared areas by non-native species. Most non-native species are adapted to disturbance, and they frequently out-compete and displace the native species that have been removed.

1.3 Major Conclusions

Major conclusions were derived from review of the available data, additional field surveys, and analysis of new collected data.

1.3.1 Uniformity of Vegetation Communities Between Alternatives

Review of available data and additional data collected for this report shows that vegetation community composition is similar among the five action alternatives being considered. Because most of the project area is second-growth forest that has been actively managed since around 1920, the existing forest stands are more or less uniform, with only slight variation in age and size classes between stands. As a result, the potential impacts generated by each action alternative are very similar.

1.3.2 Removal of Coniferous Forest

All five action alternatives would require removal of at least 84 acres (ac.) of coniferous forest. Regardless of the alternative selected, removal of coniferous forest would come predominantly from the 36- to 75-year-old age class, and from stands dominated by Douglas-fir. These stands average 18 to 36 in. diameter at breast height (dbh) and are 100 to 130 ft. tall.

1.3.3 Conversion to Non-Forest Use

Under all five action alternatives, at least 77% of the affected land would be permanently converted from forest to non-forest use.

1.3.4 Threatened, Endangered, and Other Special-Status Species

According to consultation with the U.S. Fish and Wildlife Service (USFWS), and based on additional field surveys, there are no listed plant species present on any of the alternative alignments. Also, because the land to be used is not federal land, Survey and Manage protocols do not apply to this project.

2.0 Study Scope and Methodology

2.1 Data Sources and Study Methods

This technical report assesses existing vegetation, potential impacts to vegetation, and management of vegetation during construction, operation, and maintenance of the proposed transmission line. The majority of the project area has been extensively studied. Data sources consulted for this report include:

- The HCP for the CRW (City of Seattle 2000).
- Geographic Information System (GIS) data provided by BPA and the U.S. Geological Survey (USGS).
- Examination and interpretation of 1:24,000-scale USGS topographic maps and 1:24,000-scale color aerial photographs flown on July 20, 1999.
- Washington Department of Natural Resources (WDNR) Natural Heritage Program (NHP) lists of threatened, endangered, and other special-status plant species.
- Helicopter reconnaissance conducted October 25, 2000.
- Field surveys conducted October 26 and 27, and November 1, 2000.
- Interviews with agency personnel.

Analysis of existing vegetation relied primarily on aerial photo interpretation and review of GIS databases. A study area was defined that extended 0.25 mi. in either direction from the alignment of each alternative. Initial analyses were field-verified by visiting representative stands. At each stand visited, sample trees were chosen for dbh, age, and height measurement. Sampled stands were then checked against preliminary estimates of age class and cover type made from the aerial photographs and GIS database.

GIS data for the north end of the project area were not as comprehensive as those available for the CRW. In the north end of the project area, aerial photograph interpretation and field verification were used to extend the GIS age class and cover type information. In this manner, uniform age class and cover type classifications were applied to the entire project area.

For impact analysis, it was assumed that the action alternatives would require clearing vegetation over a 150-ft. wide area along the entire project area. For Alternative 3, it was initially decided to review a 500-ft. wide area, because the actual alignment of that alternative would vary with the placement and configuration of angle structures. However, due to the uniformity of vegetation within the Alternative 3 study area, this wider analysis was not undertaken. It was also assumed, for all alternatives, that vegetation in an additional 75-ft. zone on either side of the cleared area would be partially cleared to ensure the reliable operation of the transmission line. The actual extent of this "low vegetation area" would vary in the completed project.

2.2 Agencies Contacted

The following agencies were contacted during the preparation of this report:

- Seattle Public Utilities (SPU), Watershed Management Division.
- King County Department of Development and Environmental Services (DDES).
- WDNR,NHP.
- USFWS, North Pacific Ecoregion, Western Washington Office.

3.0 Affected Environment

3.1 Regional Overview

The project area lies almost entirely within second-growth forests that have been maintained in timber production for most of the last 150 years. Vegetation within this part of Washington is characterized on the basis of physiographic provinces and vegetation zones. According to this classification system, the project area is within the Southern Washington Cascade Province and the Western Hemlock Zone (Franklin and Dyrness 1973).

Another general description of the predominant vegetation within the project area utilizes vegetation classification methods developed by the U.S. Forest Service (USFS) for the Mount Baker-Snoqualmie National Forest (Henderson et al. 1992). Under this methodology, the project area is classified as part of the Western Hemlock Series. The most prevalent Plant Associations within the project area are Western Hemlock/Swordfern-Foamflower (TSHE/POMU-TITR), Western Hemlock/Swordfern-Salal (TSHE/POMU-GASH), and Western Hemlock/Foamflower-Oakfern (TSHE/TITR-GYDR). (See Appendix A for scientific names of plant species mentioned in the text.) These associations are based upon the potential natural vegetation (i.e., climax) of a given stand. The use of these associations to characterize a stand does not mean that the climax species is currently dominant or that it ever would be. Instead, the use of these associations relates to the presence of environmental conditions that favor the establishment and eventual dominance of the climax species (Logan et al. 1987). Therefore, while Douglas-fir is currently the dominant species in the project area, the environmental conditions present favor the eventual establishment and dominance of western hemlock.

The project area is divided into three general sections. Proceeding from the southern end of the project area, these are (1) the towns of Selleck and Kangley, and their surrounding rural residential areas; (2) the CRW; and (3) the private and state timberlands. Of these three sections, the CRW is the largest area and contains the best-developed forest. Its designation as a protected watershed favors the development, over time, of this forest into mature and old-growth stands. The towns and rural areas at the southern end of the project area are disturbed, with little natural native vegetation. The private timberlands at the northern end are also disturbed, but they have been replanted with native tree species and are intensively managed.

Vegetation in the project area is dominated by Douglasfir. Based on measurements of stumps found across the CRW, trees within the forest reached diameters of over 82 in. dbh, and were probably over 200 ft. prior to the initiation of logging in the region. However, such mature trees are no longer found in the project area.

3.2 Regulations, Standards, and Guidelines

Federal, state, and county laws, regulations, and rules pertaining to vegetation management and forest practices were consulted in the preparation of this report.

The WDNR Forest Practices Rules (Washington Administrative Code [WAC] 222) describe the types of forest practices allowed under the State of Washington Forest Practices Act (Revised Code of Washington [RCW] 76.09). They divide forest practices into four classes and outline the processes for permitting of each class.

The King County DDES Conversion Option Harvest Plan (COHP) is a voluntary timber harvesting plan developed by the landowner and approved by King County, indicating limits of timber harvest, road locations, sensitive areas, and vegetation management practices. A COHP defines the local government standards and regulations that the landowner must follow.

Section 7(c) of the ESA of 1973 gives guidance for assessing the effect of development activities on listed species.

Section 404 of the Clean Water Act (CWA) of 1977 regulates activities in wetlands and other waters of the United States. Additional guidance on wetland delineation and classification is provided in the U.S. Army Corps of Engineers (Corps) Wetland Delineation Manual (Environmental Laboratory 1987) and the Washington State Wetlands Identification and Delineation Manual (Washington Department of Ecology 1997).

The CRW HCP outlines proposed regulation of activities within the watershed.

The BPA Transmission Vegetation Management Program defines mitigation measures and management practices for BPA transmission facilities.

3.3 Project Area and Approach

The project area for vegetation is a 0.5-mi. corridor centered on the ROWs of the proposed alternatives. This project area includes areas within the ROW where vegetation would be cleared for construction, and areas beyond the ROW where vegetation would be maintained in low-growing condition to prevent "danger trees" from interfering with the safe and reliable operation of the line, facilities (e.g., substation), or access roads. For Alternatives 1, 2, 4a, and 4b, the ROW would be 150 ft. wide. For Alternative 3, the ROW width would also be 150 ft.

In this report, vegetation is classified by vegetative cover type and by age class. Vegetation cover type, for the purposes of this report, is a description of the type and average size of the plants growing on a specific site. An age class distribution was utilized to reflect the project area's long history of timber production.

Vegetation cover types were determined by the type of dominant plants (e.g., tree, grass, shrub), the species of dominant plants (e.g., Douglas-fir, alder, and maple) and the stage of succession of a given forested stand. Vegetation cover types in the CRW HCP database were reviewed and consolidated into 12 categories. A 0.5-mi. wide corridor was then superimposed over GIS mapping of vegetation cover types within the watershed. Cover types and age classes within the 0.5-mi. corridor were derived from the GIS database, and from examination of 1:24,000-scale color aerial photographs. Field surveys were conducted to ground-verify the information obtained from these sources. In areas outside of the CRW GIS database, 1:24,000-scale color aerial photographs were examined. Preliminary age class and cover type polygons were drawn on mylar sheets laid over the aerials. Field surveys were conducted to verify this information. The polygons were then digitized and added to the existing CRW GIS. Areas for age classes and cover types were obtained from this database.

3.4 Transmission Line Alternatives

Two general characterizations can be made of the study areas for all five action alternatives. First, moving south to north, vegetative cover type tends to change from conifer-dominated stands to mixed conifer-deciduous stands. Second, stand age tends to fall as one proceeds north along the alternative ROWs.

Twelve major vegetation cover types were defined and mapped for this project (Figure 3). Cover types include forested and non-forested areas. The forested stands within the project area have been managed for timber production in the recent past. Timber production has recently been discontinued over much of the project area, especially within the Cedar River Watershed. Nevertheless, the forested stands found in the project area can still be differentiated by recent timber management practices. As a result, the definitions of cover types are based primarily upon the state of regeneration in formerly managed forested stands. The relative areas of each cover type are shown in Figure 4. The 12 cover types are described below:

- **Early regeneration, open coniferous canopy** cover types are young plantations of Douglas-fir, in sufficient densities to preclude more than 30% hardwood coverage. Stands are generally less than 20 years old and range in height from 15 to 30 ft. Understory herb and shrub coverage is generally low, due to the stand density.

- **Mid-regeneration, closed coniferous canopy** cover types are comprised of medium-age coniferous stands dominated by Douglas-fir, with occasional hemlock and western red cedar. Understory trees are dominated by western hemlock. Herb and shrub coverage is dominated by sword fern and salal, with occasional vine maple. Individual canopy trees in this cover type range in size from 12 to 20 in. dbh and average 40 to 80 ft. Ages of these stands are generally in the range of 20 to 35 years. This cover type, found throughout the project area, is most prevalent along Pole Line Road and the central

- **Mature coniferous regeneration** cover types are the most prevalent cover type in the project area. Within the ROW and the adjacent quarter-mile area, this cover type represents a late stage of regenerative growth in a managed stand, and tends to be 36 to 75 years old. Older trees are present but uncommon. This type represents late second-growth stands of conifers. If the CRW were still in active timber production, this cover type represents stands that would be at or near typical harvest age. This cover type is represented primarily by stands dominated by Douglas-fir, with occasional western hemlock and western red-cedar. In some cases, especially near drainages, stands are co-dominated by Douglas-fir and Sitka spruce. Western hemlock is the dominant species in the understory. The forest floor is dominated by salal and sword fern, with vine maple occasionally present. Individual trees in this cover type range in size from 18 to over 36 in. and average 100 to 130 ft. This cover type also includes coniferous stands that have matured, but do not yet have the complex canopy structure, dense down woody material, and other attributes of old-growth forest. These stands tend to be clustered along major drainages such as the Cedar River and the Raging River, especially in steep, remote stretches. In addition to the drainages mentioned, this cover type is found north of the Cedar River, southeast of Segment C. There are also areas of mature regenerated coniferous stands west of Segment D, near the top of Taylor Mountain.

- **Mid-regeneration, closed deciduous canopy** cover types are dominated by sapling to pole-size hardwoods. Hardwood coverage is over 70%. Within the project area, the dominant species is red alder, with occasional co-dominance by black cottonwood and/or big-leaf maple. Stand ages are in the 10 to 30 year range and heights average 25 to 40 ft.

- **Mature deciduous regeneration** cover types are stands dominated by mature hardwoods. Hardwood coverage is over 70%. Within the project area, the dominant species is red alder. Black cottonwoods are occasionally co-dominant and are usually the largest trees present, often over 25 in. dbh. Big-leaf maple is also an occasional co-dominant. Stand ages are generally over 30 years old and heights average 40 to 80 ft.

- **Early regeneration, open mixed canopy** cover types are primarily stands that have been harvested within the last 10 years. Most of these areas are clearcuts. This type differs from the coniferous early regeneration stage by having more than 30% cover of hardwood trees present. Some also have up to 20% retention of mature trees, especially those areas with drainages. The dominant coniferous species is Douglas-fir. Hardwood species, including red alder, vine maple, and willows, are also present, often in higher percent coverages than the conifers. Heights of these stands range from 8 to 15 ft., with the hardwood species frequently overtopping the young conifers. Shrub species are dominated by trailing blackberry, salal, and red huckleberry.

- **Mid-regeneration, closed mixed canopy** cover types are another of the more prevalent cover types in the study area. These are stands comprised of roughly even coverages of conifers and hardwoods. The dominant conifer is Douglas-fir, though in many areas western hemlock co-dominates. The dominant hardwood is red alder, with occasional black cottonwood and big-leaf maple. Conifers average 5 to 8 in. dbh and are between 10 and 25 years old. Heights of these stands range from 35 to 45 ft.

- **Managed grass/forb/shrub** cover types are characterized by mixed grasses and forbs, mostly non-native species. They also include areas of low- to medium-height shrub thickets. These areas are managed to maintain their existing condition and are not allowed to continue typical ecological succession for a western hemlock association. This is the dominant cover type found under the existing transmission line.

- **Wetlands** are areas that meet the Corps and State of Washington criteria for jurisdictional wetlands. The majority of the wetlands present in the project area are palustrine forested sites dominated by red alder, with salmonberry-dominated shrub strata. They range in size from 1 to 5 ac. Sources of wetland hydrology include surface runoff, shallow subsurface flow, and, occasionally, hillside seeps. Wetlands are discussed in depth in the Wetland Technical Report.

- **Natural non-forested** cover types are areas dominated by meadows or dense shrub thickets. These communities tend to have a higher percentage of native species.

- **Lakes, rivers, streams** includes lakes, ponds or other natural impoundments of water, and drainages with perennial flows.

- **Developed** cover types include any area cleared for the building of residential, commercial, or industrial structures. Within the project area, this cover type includes the towns of Selleck and Kangley, the BPA substations at Raver and Echo Lake, and several small quarries and borrow pits.

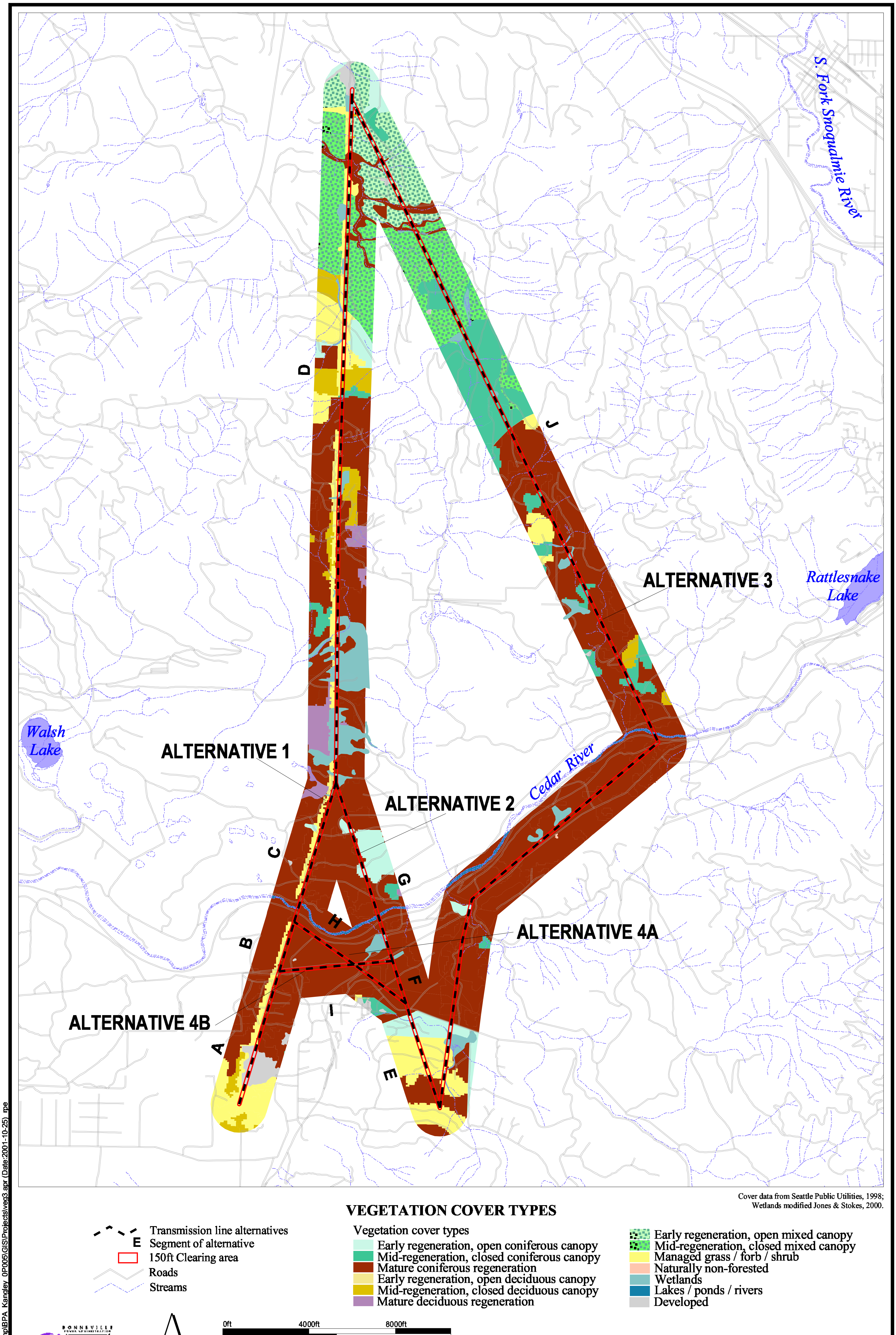

Figure 3.
Vegetation Cover Types, Potential Clearing, and Affected Habitat within 0.25-mi. of the Action Alternatives

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Figure 4. Acreage of Vegetative Cover Type by Alternative

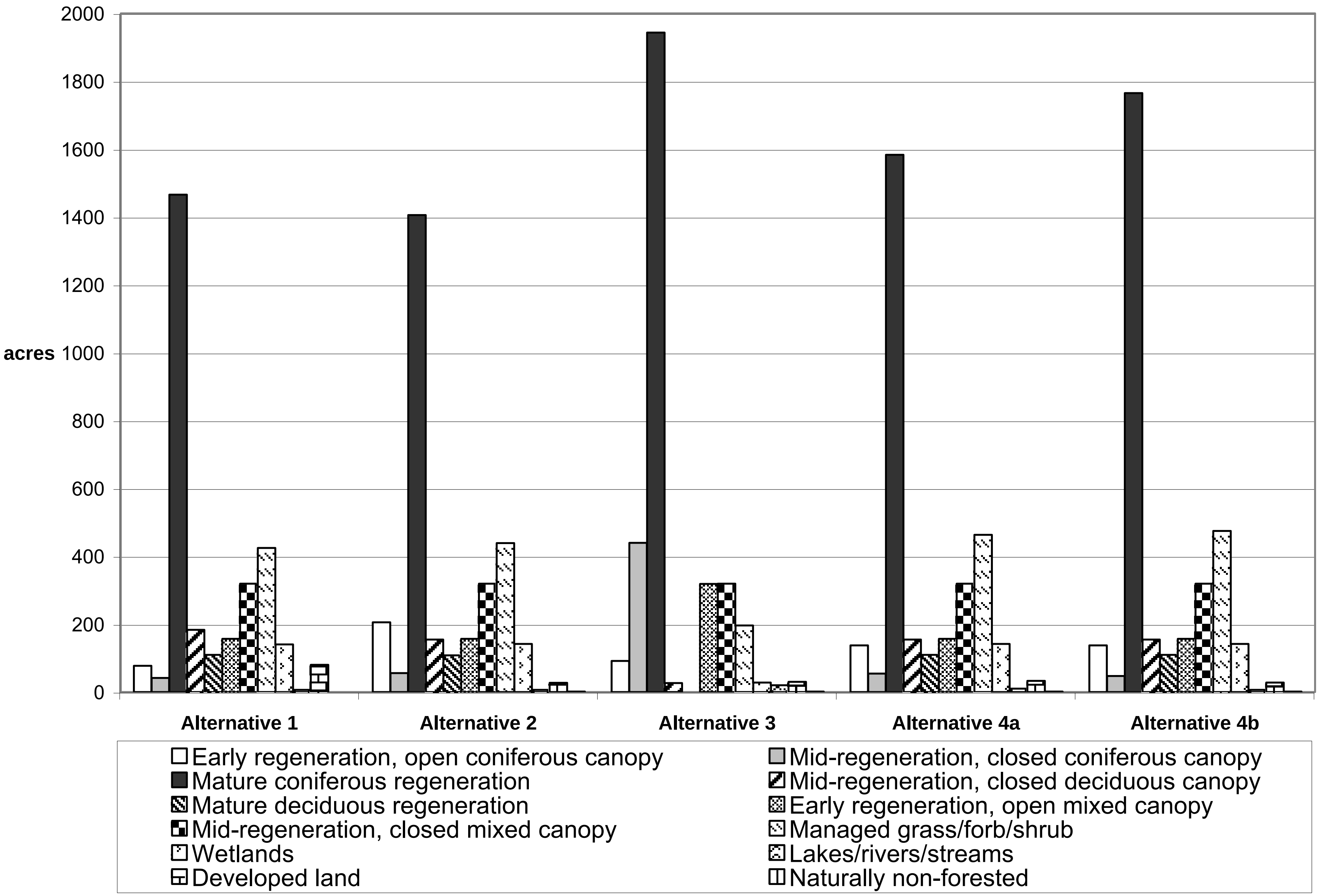


Table 1 lists the 12 major vegetation cover types and charts them in terms of acreages across the five action alternatives.

Table 1. Acreage of Vegetative Cover Types by Alternative

Vegetative Cover Type	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Early regeneration, open coniferous canopy	77	205	92	137	137
Mid-regeneration, closed coniferous canopy	41	56	440	54	47
Mature coniferous regeneration	1,466	1,406	1,943	1,583	1,765
Mid-regeneration, closed deciduous canopy	183	154	26	154	154
Mature deciduous regeneration	110	108	0	110	110
Early regeneration, open mixed canopy	157	157	319	157	157
Mid-regeneration, closed mixed canopy	319	319	320	319	319
Managed grass/forb/shrub	425	439	196	463	475
Wetlands	141	142	28	142	142
Lakes/rivers/streams	6	7	20	10	6
Developed land	80	27	30	33	28
Naturally non-forested	0	1	1	1	1
Total	**3,005**	**3,021**	**3,415**	**3,163**	**3,341**

Two additional cover types were initially described during the data review and preparation for field surveys. These types were described because of their potential habitat value for wildlife. Review of the GIS database and surveys in the field suggest that neither cover type is found within the project area; however, small pockets of either type may be present within the project area, including:

- **Cliff/talus** are areas of extensive exposed rock and aggregations of fractured rock at the base of cliffs and slopes. There are no natural cliffs or talus fields within the project area.

- **Naturally non-vegetated** areas contain bare soil, slope failures, or other eroded-soils features.

3.4.1 Alternative 1: Preferred Alternative

The project area for Alternative 1 covers just over 3,000 ac. It is dominated by coniferous forest stands in the mature coniferous regeneration cover type. Alternative 1 parallels a portion of the existing transmission line ROW, to the Echo Lake Substation. As a result, the developed land area is greater than for other alternatives. The north leg of Alternative 1 tends to be mixed coniferous-deciduous forest. The south leg of Alternative 1 has more conifer-dominated stands.

A thin riparian strip along the Raging River contains several large old conifers, including Douglas-fir and western red cedar trees over 35 in. dbh.

3.4.2 Alternative 2

The project area for Alternative 2 covers approximately 3,020 ac. It is dominated by coniferous forest stands in the mature coniferous regeneration cover type. The extreme southern end of Alternative 2 passes through a young Douglas-fir plantation. Alternative 2 also passes through young Douglas-fir plantations just southeast of the point where it joins Segment D along the existing transmission line ROW.

The project area for Alternative 2 includes the least mature coniferous regeneration cover type.

As with Alternative 1, the portion of Alternative 2 that follows Segment D tends to have more mixed forest to the west and more conifers to the east. This alternative crosses a thin stand of older Douglas-fir and western red cedar at the Raging River.

3.4.3 Alternative 3

The project area for Alternative 3 is over 3,400 ac. Alternative 3 has no segments in common with any of the other alternatives. As a result, it is somewhat different from the other alternatives in vegetative cover type composition. In general, it passes through older, more mature coniferous regeneration and mid-regeneration, closed coniferous canopy stands, and less non-forested area. There are no mature deciduous stands on this alternative alignment. The project area of Alternative 3 includes approximately 28 ac. of wetlands, compared to at least 140 ac. of wetlands in each of the other alternatives. However, the project area for Alternative 3 has twice the area of lakes, rivers, and streams than that of the next largest alternative.

At least two older, mature Douglas-fir stands were found during field studies for Alternative 3. These were off Pole Line Road near Taylor Creek and along Binus Creek Road. Trees in these stands were over 32 in. dbh and averaged 160 ft. in height. Increment cores from these trees showed these stands to be over 70 years old.

3.4.4 Alternative 4a

The project area for Alternative 4a is over 3,160 ac. It is dominated by coniferous forest stands in the mature coniferous regeneration cover type. This alternative also crosses the same young Douglas-fir plantation that is crossed at the south end of Alternative 2. Most of the younger stands within the project area were found along Segment D, toward the north end of the alternative.

The areas north of Selleck and Pole Line Road, where Alternative 4a “crosses” from Segment E to Segment C, are dominated by mature coniferous regeneration stands.

3.4.5 Alternative 4b

The project area for Alternative 4b is 3,341 ac. It is dominated by coniferous forest stands in the mature coniferous regeneration forest cover type. It is similar to Alternative 4a in that it begins in a young, Douglas-fir plantation, then passes through older coniferous areas before joining Segment D. From there, stand age tends to drop and cover type becomes more mixed forest.

3.5 Access Roads

Several dirt and gravel roads exist within the project area. Many of the roads present within the CRW were created in the early 1900s for logging purposes. These roads are currently used for operation and maintenance access by various agencies and concerns, with the permission of the SPU Watershed Management Division. In addition, the abandoned Burlington Northern Railroad ROW is now a frequently used gravel road that runs predominantly parallel to the Cedar River. Some of the old logging roads are not frequently used or maintained, however, and have become impassable due to growth of vegetation.

Similarly, existing roads within the Weyerhaeuser portion of the project area were created for either logging or gravel mining purposes. Some are used and maintained more frequently than others.

3.6 Substation

The Echo Lake Substation is the only substation in the project area and is the terminus common to all alternatives. The Echo Lake Substation is approximately 16 ac. The perimeter area to about 100 ft. around the substation is surrounded by gravel and non-native grasses. Beyond that are managed grass/forb/shrub areas, with small mixed coniferous-deciduous stands.

3.7 Special-Status Plant Species

3.7.1 Threatened, Endangered, and Candidate Plant Species

For the purpose of this report, the term "special-status plant species" includes:

- species listed or proposed for listing as threatened or endangered under the federal ESA (50 CFR 17.12 [listed plants] and various notices in the Federal Register [proposed species]);

- species that are candidates for possible future listing as threatened or endangered under the federal ESA (58 FR 188: 51144-51190, September 30, 1993);

- species listed or proposed for listing by the State of Washington as threatened, endangered, or candidate species;

- plants that are identified by the Washington NHP.

Threatened, endangered, and candidate plant species have been identified by the USFWS as plants to be protected under the ESA. The USFWS has published a list of threatened and endangered wildlife and plant species (50 CFR 17.11 and 17.12); a list of proposed threatened, endangered, and candidate species (61 FR 7596, February 28, 1996; 50 CFR 17.12); and a notice of review for candidate or proposed animals and plants (62 FR 182, September 19, 1997).

A letter issued by the USFWS on April 12, 2000 indicated no listed, proposed, or candidate plant species occur within the project area.

3.7.2 Survey and Manage Species

Survey and Manage species, along with the standards and guidelines for management of these species, were designated in Table C-3 of the Record of Decision (ROD) and Standards and

Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest-Related Species Within the Range of the Northern Spotted Owl (USFS and BLM 1994b), commonly called the Northwest Forest Plan. The ROD requires surveys to be conducted on U.S. Forest Service and Bureau of Land Management lands for many of the species that are to be managed. Botanical resources on the Survey and Manage list include bryophytes (e.g., mosses, liverwort, and hornworts), lichens, and fungi**.** According to Neitlich and McCune (1995), many bryophtyes, lichens, and fungi species appear to be closely associated with late-successional habitat, which provides canopy complexity and a greater diversity of trees and shrubs.

The proposed transmission line would be constructed on an easement purchased by BPA and the substation expansion would be on land owned “in fee” by BPA. None of the proposed transmission line would be on U.S. Forest Service or Bureau of Land Management lands. Therefore, Survey and Manage requirements are not applicable to this project.

3.8 Noxious Weeds and Other Undesirable Vegetation

Noxious weeds, which are formally designated at the county level by noxious weed control boards (RCW 17.10.205), and at the federal level (7 CFR 360.200), typically include species that pose a major threat of spreading or interfering with agriculture or natural plant communities, and whose growth can be managed. Noxious weed species present within the project area include Scotch broom, Himalayan blackberry, cut-leaf blackberry, Canada thistle, knapweeds, orange hawkweed, St. Johnswort, tansy ragwort, and small amounts of English holly.

Scotch broom is one of the most pervasive weed species in the project area. It commonly occurs in the highly disturbed areas of clear-cuts, as well as along the existing transmission line from the Raver Substation to the Echo Lake Substation. Several other species of noxious or undesirable vegetation occur in the project area.

4.0 Environmental Consequences and Mitigation

BPA defines environmental impact levels in four categories: high-level impacts, moderate-level impacts, low-level impacts, and minimal or no impacts.

High-level impacts on vegetation occur when an action would:

- create an unavoidable adverse effect on a federally listed threatened or endangered plant species;
- significantly reduce the quantity or quality of a regionally or nationally important botanical reserve, plant population, or similar botanical habitat area;
- spread noxious weeds due to construction or maintenance; or
- adversely affect rare or declining species at the regional level. For this project, the regional level is considered the Washington Western Cascade Province.

Moderate-level impacts on vegetation occur if the impacts:

- create an effect on threatened or endangered plant species that could be mitigated partially through interagency consultation with the USFWS under Section 7 of the ESA;

- temporarily disturb sensitive plants during construction but not affect the viability of local populations;
- cause a local reduction in the quantity or quality of vegetation communities (as opposed to regional reductions); or
- marginally reduce the productivity of adjacent vegetation communities or resources (such as wetland plant communities or botanical reserves).

Low-level impacts occur when an action would:

- create an effect that could be largely mitigated;
- reduce the quantity or quality of vegetation communities confined to the site of the action;
- cause no major effect on productivity of adjacent vegetation communities;
- temporarily disturb common plant species;
- reduce plant communities that are very common in the project vicinity;
- adversely affect relatively common species at a local level (i.e., occurring within the immediate vicinity of the project and not affecting regional populations); or
- cause temporary effects or those that can be minimized by site planning or by placing seasonal restrictions on construction activities.

Minimal or no impacts occur when an action creates no impacts or fewer impacts than the low impact level.

4.1 Construction Impacts

4.1.1 Impacts Common to All Transmission Line Alternatives

4.1.1.1 Impacts

Construction impacts include those associated with clearing, those that may affect listed plant species, and those that affect noxious weed coverage and propagation. Given the impact levels defined above, all five action alternatives would have moderate impacts to coniferous forested communities, and potentially high impacts due to noxious weed colonization in disturbed areas.

Impacts on vegetation could occur through direct clearing for the transmission line and for construction of roads, transmission-line footings, substations, and other facilities. Additional impacts could occur from the effects of heavy equipment use on local soils, including compaction and physical movement of soils. Compaction of soils could inhibit precipitation from infiltrating over plant root zones. Compaction could also inhibit germination of seeds residing in the upper soil horizon, and it could favor the development of bare-soil areas. Physical movement of soils could disrupt the seed bank in the upper soil horizon, inhibiting regeneration of desirable species. Physical movement of soils at greater depths could damage the fine root zones of shrubs and trees. Additionally, the temporary storage of soils and cleared vegetation could compact soils beneath the storage piles. Decomposition of vegetation within the storage piles could generate sufficient heat to inhibit germination of desirable species in the seed bank of the upper soil horizon beneath the piles.

Forested areas are the most affected by placement of a transmission line, because these areas must be cut to keep trees from interfering with the line. Plant communities that are naturally low growing are often unaffected by placement of a transmission line. Construction of the transmission line would involve clearing a 150-ft.-wide ROW.

Table 2 shows the acreage of vegetation that would be impacted for each alternative from each vegetative cover type within the 150-ft. ROW. Relative areas of cover type impacts are shown in Figure 5.

Table 2. Acreage of Vegetative Cover Types Impacted by Alternative

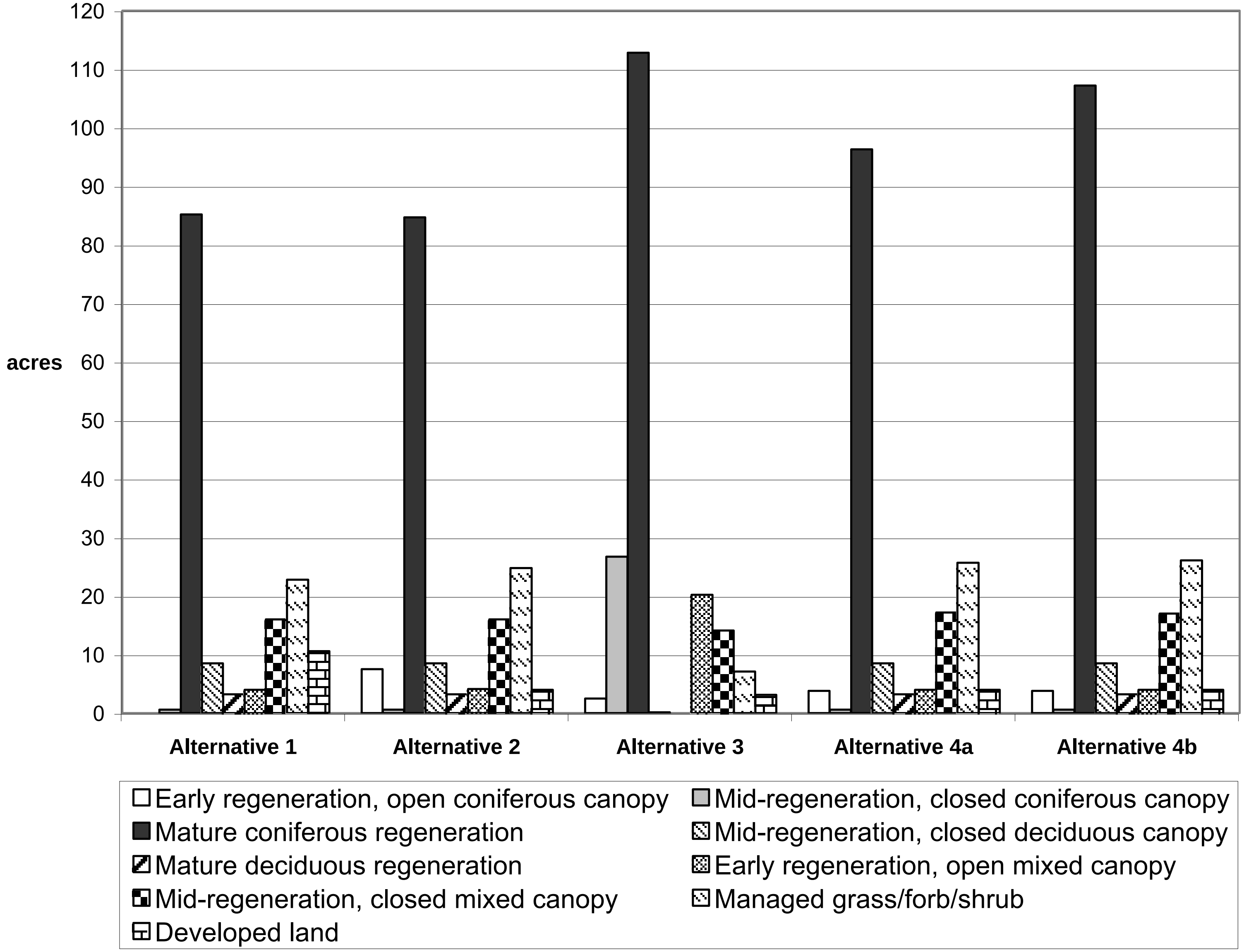
Vegetative Cover Type	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Early regeneration, open coniferous canopy	0	8	3	4	4
Mid-regeneration, closed coniferous canopy	1	1	27	1	1
Mature coniferous regeneration	85	85	113	96	107
Mid-regeneration, closed deciduous canopy	9	9	0	9	9
Mature deciduous regeneration	3	3	0	3	3
Early regeneration, open mixed canopy	4	4	20	4	4
Mid-regeneration, open mixed canopy	16	16	14	17	17
Managed grass/forb/shrub	23	25	7	26	26
Developed land	11	4	3	4	4
Total	**152**	**155**	**187**	**164**	**175**

Additional clearing would be needed at various locations beyond the 150-ft. ROW to remove danger trees. This additional clearing would be required whenever the height of trees, in combination with the topography and maximum swing of the conductors during heavy winds, could represent a danger to electrical transmission line reliability. Outside the ROW, the taller trees would be cut, and most shrubs and lower vegetation would be left in place. Subsequently, trees would be allowed to grow back outside the 150-ft. ROW. We have used 75 ft. on either side of the ROW as an assumption for the analysis.

Trees that grow within the protection of a group of trees (with relatively little exposure to wind) would be exposed when the trees around them were removed, making them vulnerable to wind throw. However, trees that were already growing in the open would have become “wind hardened” and much less likely to fall. Therefore, trees that grow back within the initial cleared area, but outside of the 150-ft. maintained ROW, would not be as likely to fall because they would have grown adjacent to the maintained ROW and become wind-hardened.

It is important to note that the additional clearing widths outside of the 150-ft. ROW would vary, based on the type and height of vegetation and terrain crossing. In some cases, forested stands, even within the maintained ROW, would not require clearing. This is because the transmission lines could span narrow, deep draws and stream channels.

Figure 5. Direct Impact Acreage on Vegetative Cover Types by Alternative



Soil disturbance resulting from construction of the line, towers, roads, and related facilities could change the ability of some plant communities to reestablish. Additionally, trees immediately adjacent to the cleared areas could be injured or killed if large portions of the plant roots or above-ground shoots were cut or damaged, or if soils were excessively compacted by equipment.

For all of the action alternatives, there is a potential for impacts to special-status plants during construction and maintenance, with higher potential along some segments than others. Impacts to special-status plants could occur while clearing vegetation within the 150-ft. ROW and additional low-vegetation areas. Impacts could also occur during clearing of vegetation for staging and materials storage, clearing vegetation for work areas, and clearing and grubbing for construction of tower footings. Potential impacts to listed plant species are discussed here in the event that individuals or small populations of listed plant species actually occur within the project area. It is important to note that the USFWS has indicated that no listed plant species occur within the project area.

The project has a potentially high impact resulting from the spread of noxious weeds. Noxious weeds are plant species designated by federal or state law. Disturbed areas such as transmission line ROWs often become infested with undesirable or non-native plant species. These species take advantage of disturbed soils and the lack of competing vegetation in areas recently cleared. Construction would disrupt vegetation and disturb soils, increasing the potential for noxious weeds invading new areas. Vehicles could inadvertently transport seeds from infested areas to locations along the ROW and access roads. Without proper mitigation measures in place, the spread of noxious weeds would likely increase.

4.1.1.2 Mitigation

Standard mitigation measures to minimize impacts to vegetation along the selected transmission line alternative would include the following:

- Locate the proposed project adjacent to existing ROWs as much as possible to keep clearing to a minimum.

- Keep incidental vegetation clearing to the minimum needed to maintain safety and operational standards. Flag and/or clearly mark clearing limits, and include clear descriptions of clearing limits and place requirements as part of construction contracts.

- Ensure that adequate topsoil depth (minimum of 4 in.) and texture are in place. Promptly reseed or revegetate disturbed areas with native seed mix as soon as construction is completed in an area. However, in many cases, locally adapted native plant materials are not available. Many native species available for restoration are actually from other areas, representing different genetics than existing vegetation. BPA would consult with the WDNR, SPU, and other agencies about the appropriate seed mixtures to use.

- Develop and implement aggressive vegetation management programs to limit colonization by non-native species and eradicate noxious weeds within the transmission line ROW Policies and procedures adopted by BPA in the May 2000 Final EIS for the BPA Transmission System Vegetation Management Program and its July 2000 ROD provide adequate mitigation for potential noxious weed invasion along the proposed transmission line.

- Use only certified weed-free straw, where straw is used as mulch or for erosion control.

4.1.1.3 Unavoidable, Irreversible or Irretrievable Impacts

Unavoidable, irreversible, and irretrievable impacts associated with this project include the effects of short-term uses of resources on long-term productivity, limitations placed upon the growth of vegetation in and around the transmission line and substation, and use of non-renewable resources such as minerals and petroleum-based fuels.

Short-term uses associated with the project area include the clearing of vegetation for the construction of the transmission line and the creation of a low-growing vegetation zone. Long-term productivity refers to the capability of the land to provide resources for future generations. Construction of any of the alternatives under consideration would decrease the amount of land that could be used for other purposes, including various types of production or resource conservation.

Construction of any of the transmission line alternatives would require the permanent conversion of existing forest types to the managed grass/forb/shrub type. Lakes, rivers, and streams would be spanned and, therefore, not converted. Wetlands would be avoided to the extent possible. Existing managed grass/forb/shrub and developed types would be only temporarily impacted, and they would not be converted. New access roads and the Echo Lake Substation would also be permanently converted to the developed cover type. Table 3 shows the area and percent conversion of forested types to managed grass/forb/shrub cover. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, is a low impact.

Forested stands growing in the areas that BPA would maintain as low-growing vegetation zones would not be allowed to grow beyond a height that would endanger the reliable operation of the transmission line. Periodic clearing in these areas would be unavoidable.

Construction of the transmission line would require the use of non-renewable resources such as petroleum-based fuels. Mineral resources would also be expended with construction of the project.

4.1.2 Substation Impacts

4.1.2.1 Impacts

Clearing totaling 13 ac. would be required to accommodate the 5.2-ac. Echo Lake Substation expansion. This clearing would take place in an early regeneration, closed mixed canopy cover type, with trees approximately 10 to 30 years old. As defined at the beginning of Section 4.0, reduction in quantity of a vegetation community, confined to the site of the action, would be a low impact.

A young (10 to 25 year) Douglas-fir-dominated stand located immediately east of the proposed expansion could also be temporarily impacted by construction activities. Movement of the disturbed area edge eastward to the young Douglas-fir stand would encourage colonization of the stand's edge by non-native species and/or noxious weeds. Without proper mitigation measures in place, this would be a high impact.

Table 3. Area and Percentage of Converted and Non-Converted Vegetative Cover Types by Alternative

Cover Type	Alt 1	Alt 2	Alt 3	Alt 4a	Alt 4b
Converted Cover Types (acres)					
Early regeneration, open coniferous canopy	0	8	3	4	4
Mid-regeneration, closed coniferous canopy	1	1	27	1	1
Mature coniferous regeneration	85	85	113	96	107
Mid-regeneration, closed deciduous canopy	9	9	0	9	9
Mature deciduous regeneration	3	3	0	3	3
Early regeneration, open mixed canopy	4	4	20	4	4
Mid-regeneration, open mixed canopy	16	16	14	17	17
Total Area of Converted Cover Types	118	126	177	134	145
Total Impacted Area	152	155	187	164	175
Percent of Impacted Area	78	81	95	82	83
Non-Converted Cover Types					
Managed grass/forb/shrub	23	25	7	26	26
Developed land	11	4	3	4	4
Total Area of Non-Converted Cover Types	34	29	10	30	30
Total Impacted Area	152	155	187	164	175
Percent of Impacted Area	22	19	5	18	17

4.1.2.2 Mitigation

Mitigation measures to minimize the impacts to vegetation could include:

- Plant shrubs and trees to provide a buffer between the substation and surrounding vegetated areas, and to enhance the diversity of vegetation in the area.

- Use native plant species in buffer areas around the expanded substation to discourage colonization of the substation perimeter by non-native species.

- BPA could undertake an aggressive noxious weed management program to discourage further colonization of these species around the substation. Management practices regarding noxious weed control, and general vegetation management practices, have been defined in the BPA Transmission System Vegetation Management Program.

4.1.2.3 Unavoidable, Irreversible or Irretrievable Impacts

Vegetation would have to be cleared from the land east of the Echo Lake Substation to expand the facility. This would be a permanent use that would affect long-term productivity of that area. Long-term productivity refers to the capability of the land to provide resources for future generations. Expansion of the Echo Lake Substation would preclude the use of this land for any other purpose, including various types of production or resource conservation.

Construction of the expanded substation would result in the permanent conversion of 5.2 ac. of young forested area into developed land. In addition, the young Douglas-fir stand east of the substation expansion would likely be taken out of its current status as a timber-producing stand.

Non-renewable resources such as petroleum-based fuels and certain mineral resources would be used for the construction of the substation.

4.1.3 Alternative Transmission Line Impacts

4.1.3.1 Alternative 1: Preferred Alternative

Impacts—Please refer to Section 4.1.1 for discussion of impacts common to all action alternatives. Alternative 1 would result in impacts to 152 ac. Over half (56%) of this impact would occur in mature coniferous regeneration and mid-regeneration, closed coniferous canopy cover types. These stands are dominated by Douglas-fir, and average 100 to 130 ft. in height. As a result, the clearing of adjacent areas to ensure the reliable operation of the transmission line would be expanded out to approximately 120 ft. where the line passes through these stands. As defined at the beginning of Section 4.0, reduction in quantity of a vegetation community, confined to the site of the action, would be a low impact.

Alternative 1 parallels a portion of the existing transmission line and would be constructed to the east of the existing ROW. As a result, there would be no impact to forested communities west of the existing transmission line ROW.

Mitigation—Please refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives. Additional mitigation for Alternative 1 could include:

- Locating all construction staging, soil stockpiles, and cleared vegetation piles within the existing cleared transmission line ROW. This would minimize impacts caused by these activities in forested areas to the east of the existing ROW.

Unavoidable, Irreversible, or Irretrievable Impacts—Alternative 1 would result in the conversion of 118 ac. of forested stands to the managed grass/forb/shrub vegetation types, as found under the existing Raver-Echo Lake transmission line (see Table 3). This represents 78% of the total Alternative 1 impact permanently converted to non-forested use. An additional 34 ac. of non-forested land would be temporarily impacted and would remain in non-forested use.

4.1.3.2 Alternative 2

Impacts—Please refer to Section 4.1.1 for discussion of impacts common to all action alternatives. Alternative 2 would result in impacts to 155 ac. Over half (55%) of this impact would occur in mature coniferous regeneration and mid-regeneration, closed coniferous canopy cover types. These stands are dominated by Douglas-fir, and average 100 to 130 ft. in height. As a result, the clearing of adjacent areas to ensure the reliable operation of the transmission line would be expanded out to approximately 120 ft. where the line passes through these stands. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, would be a low impact.

Under Alternative 2, construction of Segments E, F, and G would require clearing on both sides of the proposed centerline. Segment D would parallel a portion of the existing cleared ROW, however, and so new clearing along this segment would occur only to the east of the proposed centerline.

Mitigation—Please refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives. Additional mitigation for Alternative 2 could include:

- Minimizing locations of construction staging areas in the newly cleared ROW. Locate equipment storage, soils storage, and cleared vegetation piles in the existing Raver –Echo Lake transmission line ROW (Segment D).

Unavoidable, Irreversible, or Irretrievable Impacts—Alternative 2 would result in the conversion of 126 ac. of forested stands to the managed grass/forb/shrub vegetation type, as found under the existing Raver-Echo Lake transmission line (see Table 3). This represents 81% of the total Alternative 2 impact permanently converted to non-forested use. An additional 29 ac. of non-forested land would be temporarily impacted and would remain in non-forested use.

4.1.3.3 Alternative 3

Impacts—Please refer to Section 4.1.1 for discussion of impacts common to all action alternatives. Alternative 3 would be an entirely new cleared ROW, and would, therefore, result in greater impacts to forested areas. Adjustments to the ROW would have a low effect on the overall impacts of Alternative 3 because the area that Alternative 3 passes through contains relatively uniform vegetation. Alternative 3 would result in impacts to 187 ac. Regardless of the ultimate placement of Alternative 3, over half (60%) of this impact would occur in mature coniferous regeneration and mid-regeneration, closed coniferous canopy cover types. These stands are dominated by Douglas-fir, and average 100 to 130 ft. in height. As a result, the clearing of adjacent areas to ensure the reliable operation of the transmission line would be expanded out to approximately 120 ft. where the line passes through these stands. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, would be a low impact.

Alternative 3 would result in greater impacts to early regeneration, open coniferous canopy and early regeneration, open mixed canopy cover types as well.

Certain stands within Alternative 3 are somewhat taller than the average tree height in the project area. These stands range from 140 to 170 ft. in height, and they may be close enough to the Alternative 3 transmission line ROW to pose a threat to the line, once constructed. In these areas, the additional clearing area would be expanded beyond what has been proposed to ensure the reliable operation of the transmission line.

Mitigation—Please refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives. The final ROW of Alternative 3 would depend on topographic and sensitive resource constraints.

Unavoidable, Irreversible, or Irretrievable Impacts—Alternative 3 would result in the conversion of 177 ac. of forested stands to the managed grass/forb/shrub vegetation type, as found under the existing transmission line (see Table 3). This represents 95% of the total Alternative 3 impact permanently converted to non-forested use. An additional 10 ac. of non-forested land would be temporarily impacted and would remain in non-forested use.

The conversion of 95% of the impacted area in Alternative 3 from forested to non-forested use is the highest percentage of all of the action alternatives evaluated.

4.1.3.4 Alternative 4a

Impacts—Please refer to Section 4.1.1 for discussion of impacts common to all action alternatives. Alternative 4a would result in impacts to 164 ac. Over half (59%) of this impact would occur in mature coniferous regeneration and mid-regeneration, closed coniferous canopy cover types. These stands are dominated by Douglas-fir, and average 100 to 130 ft. in height. As a result, the clearing of adjacent areas to ensure the reliable operation of the transmission line would be expanded to approximately 120 ft. where the line passes through these stands. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, would be a low impact.

Under Alternative 4a, construction of Segments E, F, and H would require clearing on both sides of the proposed centerline. Segment D would parallel the existing cleared ROW, however, and so new clearing along this segment would occur only to the east of the proposed centerline.

Mitigation—Please refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives. Additional mitigation for Alternative 4a could include:

- Minimizing locations of construction staging areas in the newly cleared ROW. Locate equipment storage, soils storage, and cleared vegetation piles in the existing transmission line ROW (Segment D).

Unavoidable, Irreversible or Irretrievable Impacts—Alternative 4a would result in the conversion of 134 ac. of forested stands to the managed grass/forb/shrub vegetation type as found under the existing transmission line (see Table 3). This represents 82% of the total Alternative 4a impact permanently converted to non-forested use. An additional 30 ac. of non-forested land would be temporarily impacted and would remain in non-forested use.

4.1.3.5 Alternative 4b

Impacts—Please refer to Section 4.1.1 for discussion of impacts common to all action alternatives. Alternative 4b would result in impacts to 175 ac. Over half (61%) of this impact would occur in mature coniferous regeneration and mid-regeneration, closed coniferous canopy cover types. These stands are dominated by Douglas-fir, and average 100 to 130 ft. in height. As a result, the clearing of adjacent areas to ensure the reliable operation of the transmission line would be expanded out to approximately 120 ft. where the line passes through these stands. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, would be a low impact.

Under Alternative 4b, construction of Segment I would require clearing on both sides of the proposed centerline. Segment D would parallel the existing cleared ROW, however, and so new clearing along this segment would occur only to the east of the proposed centerline.

Mitigation—Please refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives. Additional mitigation for Alternative 4b could include:

- Minimizing locations of construction staging areas in the newly cleared ROW. Locate equipment storage, soils storage, and cleared vegetation piles in the existing Raver-Echo Lake transmission line ROW (Segment D).

Unavoidable, Irreversible or Irretrievable Impacts—Alternative 4b would result in the conversion of 145 ac. of forested stands to the managed grass/forb/shrub vegetation type as found under the existing transmission line (see Table 3). This represents 83% of the total Alternative 2 impact permanently converted to non-forested use. An additional 30 ac. of non-forested land would be temporarily impacted and would remain in non-forested use.

4.1.3.6 Access Roads

Impacts—New access roads would be built for the construction, operation, and maintenance of the transmission line. New roads, including the roadbed and embankments, would be built as spurs from existing roads where possible. For the purposes of assessing new access road impacts, a 20-ft. road cross section was assumed. Existing access roads are generally 24 ft. across, and the actual new access road width would be 16 ft. Table 4 lists the acreages of clearing for new access roads for each alternative.

Table 4. Acreage of New Access Roads by Alternative

Alternative	Acres Cleared
1	7
2	9
3	16
4a	8
4b	8

Alternative 1 would follow the existing transmission line ROW and, therefore, has the least impact with regard to new access roads. Conversely, Alternative 3 would be an entirely new ROW and would, therefore, have greater impact from new access roads. Alternatives 2, 4a, and 4b would utilize both a portion of the existing ROW (Segment D) and areas where new access roads would be constructed. Therefore, Alternatives 2, 4a, and 4b would result in intermediate impacts associated with new access roads. For all five alternatives, new access roads would have low impact, as defined at the beginning of Section 4.0.

Mitigation—Mitigation measures for construction of new access roads include:

- Keep incidental vegetation clearing to the minimum needed to maintain safety and operational standards. Flag and/or mark clearing limits. Describe clearing limits and applicable buffer requirements as part of construction contracts.

- Promptly reseed or revegetate disturbed areas with native seed mix as soon as construction in an area is completed. However, in many cases, locally adapted native plant materials are not available. Many native species available for restoration are actually from other areas, representing different genetics than existing vegetation. BPA would consult with the WDNR, SPU, and others to determine appropriate seed mixtures.

Develop and implement aggressive vegetation management programs to limit colonization by non-native species and eradicate noxious weeks along new access roads.

- Policies and procedures adopted by BPA in the May 2000 Final EIS for the BPA Transmission System Vegetation Management Program and its July 2000 ROD provide adequate mitigation for potential noxious weed invasion along new access roads.

- Use only certified weed-free straw, where straw is used as mulch or for erosion control.

Cumulative Impacts—Construction of new access roads would add to the area already converted to existing access roads.

Unavoidable, Irreversible or Irretrievable Impacts—Construction of new access roads would have irreversible impacts similar to construction of the transmission line, but to a lesser degree due to the smaller area involved. These impacts include the effects of short-term uses of resources on long-term productivity, limitations placed upon the growth of vegetation in and around the access roads, and use of non-renewable resources such as minerals and petroleum-based fuels.

Short-term uses associated with construction of new access roads include the clearing of vegetation for the roadbed and the maintenance of a low-vegetation fringe along the road. Long-term productivity refers to the capability of the land to provide resources for future generations. Construction of new access roads would decrease the amount of land that could be used for other purposes, including various types of production or resource conservation.

Construction of new access roads would require the permanent conversion of certain existing vegetative cover types to the developed type. Types to be converted include all forested types and managed grass/forb/shrub areas. Streams and rivers may be culverted or bridged where necessary. Wetlands would be avoided where practical; otherwise they would be spanned or mitigated (see the Wetlands Technical Report for details). Developed vegetation types would be only temporarily impacted and would not be converted. As defined at the beginning of Section 4.0, reduction in the quantity of a vegetation community, confined to the site of the action, would be a low impact.

Construction of the new access roads would require the use of non-renewable resources such as petroleum-based fuels. Mineral resources would also be consumed in the construction of the roads.

4.1.3.7 Cumulative Impacts

Cumulative impacts associated with construction of the transmission line include loss of forested area within the CRW, additional road construction, and increased colonization by non-native species. For all alternatives except Alternative 1, there would be increased fragmentation of forested stands and an increase in the number of trees prone to windfall along forest edges.

4.1.3.8 No Action Alternative

Impacts—Under the No Action Alternative, there would be no loss of vegetation and no conversion from forested to non-forested types. There would be no additional potential for the spread of noxious weeds. Expansion of low-growing vegetation zones for the reliable operation of the transmission line would not occur. Areas adjacent to the Echo Lake Substation would remain in their existing condition. New access roads would not be constructed.

Mitigation—No additional impacts would occur under the No Action Alternative. Therefore, no additional mitigation measures would be required. Existing vegetation management practices, especially those associated with noxious weed control, would be maintained in the existing transmission line ROW.

Cumulative Impacts—The No Action Alternative would not contribute additional impacts to the project area. There would be no additional clearing of forested areas or conversion of forested land to non-forested use related to the proposed transmission line project.

Unavoidable, Irreversible, or Irretrievable Impacts—Under the No Action Alternative, there would be no unavoidable, irreversible, or irretrievable impacts related to the proposed transmission line project. Long-term potential productivity within the project area would remain as it currently exists, with much of the project area committed to timber production and watershed management.

There would be no additional use of petroleum-based fuels or mineral resources related to the proposed transmission line project.

4.2 Operation and Maintenance Impacts

4.2.1 Impacts Common to All Transmission Line Alternatives

4.2.1.1 Impacts

Impacts associated with operation and maintenance of the transmission line would include continued clearing and trimming of vegetation beneath and adjacent to the transmission line, and continued disturbance of vegetation and soils during maintenance activities.

Vegetation beneath the transmission line would be converted to a managed grass/forb/shrub type. However, trees would regrow in this area, and they would either be removed immediately, or cleared as they attain heights that could interfere with the operation of the transmission line. The continued removal and/or suppression of tree growth would be a low-level impact as defined at the beginning of Section 4.0.

Routine and emergency maintenance activities would require visits to tower sites and movement of personnel and vehicles along the transmission line ROW. These activities could result in additional disturbance to soils. This in turn would favor colonization by non-native and/or noxious plant species. This is a low-level impact because it could be mitigated.

4.2.1.2 Mitigation

Mitigation measures for impacts associated with operation and maintenance of BPA transmission line systems would follow policies and procedures adopted by BPA in the May 2000 Final EIS for the BPA Transmission System Vegetation Management Program and its July 2000 ROD. In order to reduce the frequency and intensity of maintenance, low-growing plant communities would be favored. A combination of methods would be used where vegetation must be removed, including manual, mechanical, and biological techniques.

4.2.1.3 Unavoidable, Irreversible, or Irretrievable Impacts

Unavoidable, irreversible, or irretrievable impacts associated with the operation and maintenance of the transmission line could include the continued loss of long-term timber productivity, and the use of non-renewable resources. Moreover, vehicles used to transport vegetation management personnel to the transmission line ROW would also use petroleum-based fuels.

4.2.2 Access Roads

4.2.2.1 Impacts

Impacts associated with the operation and maintenance of access roads would include periodic clearing of vegetation; disturbance of soils; and potential spills of fuels, oils, or other compounds toxic to vegetation.

Vegetation within and adjacent to access roads would need to be cleared periodically to allow passage of maintenance vehicles. This would be a low-level impact. Species cleared would include trees and shrubs.

Driving on access roads would disturb soils in the path of the maintenance vehicle. Soil disturbance would favor colonization by non-native and/or noxious plant species. In extreme cases, soil disturbance would preclude growth of vegetation entirely. This would be a low-level impact.

While driving and parking maintenance vehicles along access roads, occasional small fuel and oil leaks could occur. In addition, petroleum-based compounds being transported by vehicles could spill or leak, especially on rough or uneven terrain. Any such spills or leaks could kill or injure vegetation in the immediate vicinity of the spill. This would be a low-level impact.

4.2.2.2 Mitigation

Mitigation measures for impacts associated with access roads would be similar to those described in Section 4.2.1.2 for the transmission line. No herbicides would be used in the CRW.

4.2.2.3 Unavoidable, Irreversible or Irretrievable Impacts

Unavoidable, irreversible, or irretrievable impacts associated with operation and maintenance of access roads would include long-term damage to soils and the use of non-renewable resources.

Operation of vehicles on access roads could denude and compact soils. This impact would be greatest on access roads that are most frequently used. In extreme cases, these soils would lose their ability to support vegetation communities altogether, without restoration. This would be a low-level impact.

Vehicles used in the operation and maintenance of access roads along the transmission ROW would use petroleum-based fuels. This use of a non-renewable resource would be a low-level impact.

4.2.3 Substation

4.2.3.1 Impacts

Impacts associated with the operation and maintenance of the expanded Echo Lake Substation would include periodic clearing of vegetation and potential spills of fuels, oils, or other compounds toxic to vegetation.

4.2.3.2 Mitigation

Mitigation measures for impacts associated with substation operation would be the same as those adopted by BPA in the May 2000 Final EIS for the BPA Transmission System Vegetation Management Program and its July 2000 ROD. Areas would be maintained using a combination of manual methods (hoes, saws, pulling) and herbicides, primarily a pre-emergent herbicide that would be applied to the ground to keep vegetation from germinating.

4.2.3.3 Unavoidable, Irreversible, or Irretrievable Impacts

Unavoidable, irreversible, or irretrievable impacts associated with operation and maintenance of the Echo Lake Substation would include the loss of long-term productivity, and the use of non-renewable resources.

Long-term productivity refers to the capability of the land to provide resources for future generations. Expansion of the Echo Lake Substation would preclude the use of this land for any other purpose, including various types of production or resource conservation. Historically, this land has been suitable for timber production, although not operated as such. Preclusion of use would be a low-level impact.

Operation and maintenance of the substation may require use of petroleum-based fuels, for maintenance activities around the substation. This use of a non-renewable resource is a low-level impact.

4.2.4 Cumulative Impacts

Cumulative impacts associated with operation and maintenance of the transmission line would include loss of forested area within the CRW and increased colonization by non-native species.

4.2.5 No Action Alternative

4.2.5.1 Impacts

Under the No Action Alternative, no new operation or maintenance activities would be involved and there would be no additional impacts associated with current operation and maintenance activities.

4.2.5.2 Mitigation

Mitigation measures would not be required due to the absence of additional operation and maintenance activities under the No Action Alternative.

4.2.5.3 Cumulative Impacts

Because there would be no new operation and/or maintenance activities involved, the No Action Alternative would not contribute additional cumulative impacts to the project area.

4.2.5.4 Unavoidable, Irreversible or Irretrievable Impacts

There would be no unavoidable, irreversible, or irretrievable impacts under the No Action Alternative. Long-term timber productivity would remain at its current level. No non-renewable resources would be used.

5.0 Environmental Consultation, Review and Permit Requirements

Several federal laws and administrative procedures must be met by the alternatives. This section lists and briefly describes requirements that would apply to the vegetation elements of this project.

5.1 National Environmental Policy Act

This report was prepared according to NEPA (42 USC 4321 et seq.). NEPA is a national law for protection of the environment. NEPA applies to all federal projects or projects that require federal involvement. BPA would take into account potential environmental consequences and would take action to protect, restore, and enhance the environment prior to making a decision on the proposed action.

5.2 Endangered and Threatened Species

5.2.1 Federal

The Endangered Species Act of 1973 (16 USC 1536) provides for conserving endangered and threatened species of fish, wildlife, and plants. Federal agencies must determine whether proposed actions would adversely affect any endangered or threatened species. When conducting an environmental impact analysis for specific projects, agencies must identify practicable alternatives to conserve or enhance such species.

The ESA protects species whose populations are declining to the point where they are now at risk of extinction, or are likely to be in the future. The ESA prohibits "taking" any species listed as endangered. The prohibition against taking can be extended to threatened species under regulations promulgated by USFWS and the National Marine Fisheries Service (NMFS). Under the ESA, "to take" is defined as "to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct" (16 USC 1532(18)). "Harming" includes any action that reduces an individual species' ability to feed, breed, or seek shelter and can include major habitat modifications that result in killing or injuring wildlife by materially impairing behavioral patterns.

Section 7 of the ESA requires federal agencies to consult with the USFWS and/or the NMFS on actions leading to activities that might affect listed species. Consultation typically involves preparing a Biological Assessment that describes the expected effects of a proposed action on a listed species. If the Biological Assessment indicates that the action is likely to adversely affect a listed species, then formal consultation with the USFWS or NMFS is required. Formal consultation results in the issuance of a Biological Opinion – a formal determination on whether or not an action will jeopardize the continued existence of the species or destroy or adversely modify a species' critical habitat, and if so whether there are reasonable and prudent alternatives that avoid such a result (50 CFR 17.3).

Under Section 10 of the ESA, as amended in 1982, incidental takes (those that are incidental to otherwise lawful activity) of listed species may be authorized through voluntary agreements including HCPs. HCPs must be approved by the Secretary of the listing department. When approving a plan, the Secretary must find that:

1. the plan will minimize and mitigate the impacts of the incidental take to the maximum extent possible;

2. the incidental take will not appreciably reduce the likelihood of the survival and recovery of the species in the wild; and

3. adequate funding for the plan is provided.

HCP agreements must also satisfy consultation requirements specified in Section 7 of the ESA.

A letter issued by the USFWS on April 12, 2000 indicated no plant species listed, proposed, or candidate for designation under the ESA occur within the project area.

5.2.1.1 Designated Critical Habitat for Listed Species

The ESA requires that, to the maximum extent determinable, NMFS and USFWS must designate critical habitat for federally listed species at the time of their listing. Critical habitat designation establishes areas that are to be given special consideration in Section 7 consultations. The project area does not contain any designated critical habitat for plant species.

5.2.2 State

Washington State-listed threatened and endangered species are not protected in the same way as federally listed species, where a "taking" is generally prohibited unless authorized by an Incidental Take Permit or an Incidental Take Statement. Instead, the state uses these classifications to assist with agency management programs and decision making. The state also defines Priority Habitats as those habitats having unique or significant value to species because they contain a unique vegetation type or a specific habitat element that is key to fish and wildlife.

According to the WDNR Natural Heritage Program, there are no state-listed threatened or endangered plant species present within the project area.

5.3 Federal, State, Areawide, and Local Plan and Program Consistency

BPA would work with agency planners to minimize conflicts between proposed activities and the land use plans of King County and the City of Seattle.

5.4 Floodplain/Wetlands Assessment

In accordance with the Department of Energy regulations on compliance with floodplains/ wetlands environmental review requirements (10 CFR 1022.12), and Executive Orders 11988 and 11990, BPA has prepared an assessment of the impacts of the alternatives on floodplains and wetlands.

5.5 Discharge Permits Under the Clean Water Act

The CWA regulates discharges into waters of the United States and comprises three primary sections.

5.5.1 Section 401

Section 401 of the CWA, the State Water Quality Certification program, requires that states certify compliance of federal permits and licenses with state water quality requirements. A federal permit to conduct an activity that results in discharges into waters of the United States, including wetlands, is issued only after the affected state certifies that existing water quality standards would not be violated if the permit were issued.

5.5.2 Section 402

This section authorizes storm water discharges associated with industrial activities under the National Pollutant Discharge Elimination System (NPDES). BPA would comply with the appropriate conditions for this project, such as issuing a Notice of Intent (NOI) to obtain coverage under the U.S. Environmental Protection Agency general permit and preparing a Storm Water Pollution Prevention Plan (SWPPP). The SWPPP helps to ensure that erosion control measures would be implemented and maintained during construction. The SWPPP would address BMPs for stabilization, storm water management, and other controls.

5.5.3 Section 404

Authorization from the Corps is required in accordance with the provisions of Section 404 of the CWA when there is a discharge of dredge or fill material into waters of the United States, including wetlands. This includes excavation activities that result in the discharge of dredged material that could destroy or degrade waters of the United States..

5.5.4 King County Sensitive Areas Ordinance

Wetlands are also protected under the King County Sensitive Areas ordinance and related regulations (King County Code 21.24). Standards have been established for Class 1, 2, and 3 wetlands. Other habitats that are protected under the ordinance include streamside (riparian) vegetation and other important wildlife habitats. King County Code 21A.14.260 also defines specific wildlife habitat corridors. These corridors are to be maintained at a width, wherever possible, of 300 ft. and at a minimum of 150 ft.

5.5.5 King County Drainage Requirements

The King County Code requires a drainage review for projects requiring a grading permit. King County Code 9.04.050 lists core drainage requirements, including discharge at the natural location, off-site analysis, runoff control, temporary erosion and sedimentation control, maintenance and operation of surface water management features, and bonds and liability. Drainage design in conformance with King County's Surface Water Design Manual is required.

5.6 Other Standards and Guidelines

5.6.1 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by SPU to establish a comprehensive plan for long-term management of the CRW. The HCP includes numerous provisions intended to maintain the quality of fish habitat and the health of fish populations in the CRW. Many of these provisions apply to management procedures such as fish hatchery operation or manipulation of instream flows and thus are not directly relevant to this analysis. Other provisions address the effects on fish and their habitat that can result from forest removal and forest road construction and maintenance.

5.6.2 King County Department of Development and Environmental Services Conversion Option Harvest Plan

The King County DDES COHP is a voluntary timber harvesting plan developed by the landowner and approved by King County, indicating limits of timber harvest, road locations, sensitive areas, and vegetation management practices. A COHP defines the local government standards and regulations which the landowner must follow.

5.6.3 Washington Forest Practices Act

The Washington Forest Practices Act has provisions for managing riparian and wetland vegetation and wildlife habitats in areas where timber harvest is planned. It requires landowners to consult with the Washington Department of Fish and Wildlife to protect critical habitats; to preserve wildlife reserve trees; and to avoid disturbance to both spotted owls and marbled murrelets during their nesting seasons.

5.6.4 Washington Department of Natural Resources Forest Practices Rules

The WDNR Forest Practices Rules (WAC 222) describe the types of forest practices allowed under the State of Washington Forest Practices Act (RCW 76.09). They divide forest practices into four classes, based on potential impact to public resources, and outline the processes for permitting of each class.

5.6.5 Washington Department of Natural Resources Habitat Conservation Plan

The WDNR HCP establishes a comprehensive management plan for long-term management of all WDNR-managed timberlands within the range of the northern spotted owl in Washington. The HCP also includes numerous provisions to maintain the quality of fish habitat and the health of fish populations.

6.0 Individuals and Agencies Contacted

Sandy Swope Moody, Environmental Coordinator
Washington Natural Heritage Program
Washington Department of Natural Resources
November 11, 2000

Yvonne Dettlaff
U.S. Department of the Interior
Fish and Wildlife Service
North Pacific Coast Ecoregion
Western Washington Office
November 9, 2000

7.0 List of Preparers

Melissa Chaun, Vegetation and Wetlands Biologist
Four years of experience in vegetation identification and wetlands delineations, assessments, permitting, and monitoring.
M.A., Marine Science (Resource Management and Policy), Virginia Institute of Marine Science, College of William and Mary, 1995.

Daniel Jones, Vegetation and Wetlands Biologist
Thirteen years of experience in plant taxonomy, fungal taxonomy, vegetation sampling methodology, and wetland delineation.
M.S., Biology (Ecology and Evolution), University of Oregon, 1997.

Leigh Kienker, CAD/GIS Specialist
Thirteen years of experience in the CAD/GIS and photogrammetry industries.
M.U.P., Urban Planning, University of Washington, expected 2001.

Gregory Poremba, Project Manager
Twenty years of experience managing and preparing EISs.
Ph.D., Sociology, Washington State University, 1990.

Sean Robertson, CAD/GIS Specialist
Two years of experience in GIS mapping and evaluations.
B.S., Environmental and Resource Sciences, University of California – Davis, 1999.

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9.0 Glossary and Acronyms

This chapter contains a list of acronyms, abbreviations, and technical terms used in this report. Words that would be defined in a desk-size dictionary (for example, the College Edition of the American Heritage Dictionary) are not included.

Glossary

Access roads are constructed to each structure site first to build the tower and line and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, short spurs are built to the structure site. Access roads are maintained after construction, except where they pass through cultivated land where the road is restored for crop production after construction is completed.

Alternatives refer to different choices or means to meet the need for action.

Aquifers are water-bearing rock or sediments below the surface of the earth.

Best Management Practices are a practices or a combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Climax species is the species that eventually comes to dominance and remains dominant as the end result of the natural process of succession in undisturbed plant communities.

Culverts are corrugated metal or concrete pipes used to carry or divert runoff water from a discharge. Culverts are usually installed under roads to prevent washouts and erosion.

Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Cut and fill is the process by which a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (filled).

CWA signifies the Clean Water Act, a federal law intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters and secure water quality.

Danger trees or high-growing brush occur in or alongside the project right-of-way and are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the right-of-way is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A contains any tree that in 15 years will grow within about 5 m (18 ft.) of conductors when the conductor is at maximum sag (100^o C or 212^o F) and is swung by 30 kg per sq/m (6 lb per sq/ft.) of wind (93 kph or 58 mph); Category B represents any tree or high-growing bush that after 8 years of growth will fall within about 2 m (8 ft.) of the conductor when it reaches maximum sag (80^o C or 176^o F) in a static position.

Dead ends are heavy towers designed for use where the transmission line loads the tower primarily in tension rather than compression. Dead ends are used in turning large angles along a line or in bringing a line into a substation.

Easement is a grant of certain rights to use a piece of land, which then becomes a "right-of-way." BPA normally acquires easements for its transmission lines. Easement includes the right to enter the ROW to build, maintain, and repair facilities.

Emergent plants have their bases submerged in water.

Endangered species are those officially designated by the USFWS and/or the NMFS as being in danger of extinction throughout all or a significant portion of their range.

Floodplain refers to a portion of a river valley adjacent to the stream channel that is covered with water when the stream overflows its banks during flood stage.

Footings are the supporting base for the transmission towers. They are usually steel assemblies buried in the ground for lattice-steel towers.

Forb is any herbaceous plant that is not a grass or grasslike.

Ford is a travelway across a stream where water depth does not prevent vehicle movement. Ford construction can include grading and stabilizing streambanks at the approaches and adding coarse fill material within the channel to stabilize the roadbed.

GIS signifies Geographic Information System, a computer system that analyzes graphical map data.

Ground wire (overhead) is wire strung from the top of one tower to the next; it shields the line against lightning strikes.

Hydrology addresses properties, distribution, and circulation of water.

Insulators are ceramic or other nonconducting materials used to keep electrical circuits from jumping to ground.

Intermittent refers to periodic water flow in creeks or streams.

Jurisdictional wetlands are areas that are consistently inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Kilovolt is one thousand volts.

Lattice steel refers to a transmission tower constructed of multiple steel members that are connected together to make up the tower's frame.

Low-gradient refers to gentle slopes.

Low vegetation area is the area where vegetation is kept below a maximum reliable operation height.

Mitigation is the step(s) taken to lessen the potential environmental effects predicted for each resource impacted by the transmission project. Mitigation may reduce the impact, avoid it completely, or compensate for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is enacted during the design and location process. Other mitigation, such as reseeding access roads with desirable grasses and avoiding weed proliferation, is taken after construction.

National Environmental Policy Act (NEPA) requires an environmental impact statement on all major federal actions significantly affecting the quality of the human environment.
(42 U.S.C. 4332 2(2)(C))

Noxious weeds are plants that are injurious to public health, crops, livestock, land, or other property.

100-year floodplains are areas that have a 1% chance of being flooded in a given year.

Perennial streams and creeks have year-round water flows.

Permeability refers to the capability of various materials to transport liquids.

Pulling site is a staging area for machinery used to string conductors.

Regeneration is the re-establishment and growth of a given tree species in a forested stand that has been harvested. Regeneration also refers to the establishment and growth of seedlings of a given species during the natural shift in the species composition of a plant community through succession.

Revegetation is reestablishment of vegetation on a disturbed site.

Right-of-way (ROW) is an easement for a certain purpose over the land of another owner, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Riparian habitat is a zone of vegetation that extends from the water's edge landward to the edge of the vegetative canopy. The term is associated with watercourses such as streams, rivers, springs, ponds, lakes, or tidewater.

Sensitive species are those plants and animals identified by the USFWS for which population viability is a concern. This classification is evidenced by major current or predicted downward trends in populations or density and significant or predicted downward trends in habitat capability.

Silt is a designation referring to individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05 mm).

Sole source aquifer is designated by the U.S. Environmental Protection Agency as an aquifer providing at least half of an area's drinking water.

Substation is the fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Substation dead ends are towers within the confines of the substation where incoming and outgoing transmission lines end. Dead ends are typically the tallest structures in a substation.

Survey protocols are interagency documents describing the survey techniques needed to have a reasonable chance of locating a species when it is present on a site, or needed to make an "equivalent effort" of locating the species when it is present on the site. Survey protocols also identify habitats needing surveys and may identify habitats or circumstances not needing surveys. (U.S. Department of Agriculture, Forest Service, and U.S. Department of Interior, Bureau of Land Management 2000)

Threatened species are those officially designated by the USFWS as likely to become endangered within the foreseeable future throughout all or a major portion of their range.

Transmission dead end towers are the last transmission line towers on both the incoming and outgoing sides of the substation. These towers are structurally reinforced to reduce conductor tension on substation dead ends and provide added reliability to the substation.

Transmission line includes the structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Water bars are smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

Wetlands are areas where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Abbreviations and Acronyms

ac.	acre or acres
BLM	Bureau of Land Management
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
COHP	Conversion Option Harvest Plan
Corps	U.S. Army Corps of Engineers
CRW	Cedar River Watershed
CWA	Clean Water Act
dbh	diameter at breast height
DDES	Department of Development and Environmental Services (King County)
FR	Federal Register
ft.	foot or feet
EIS	environmental impact statement
ESA	Endangered Species Act
GIS	Geographic Information System
HCP	Habitat Conservation Plan
in.	inch or inches
kV	kilovolt
mi.	mile or miles
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NHP	Natural Heritage Program
NMFS	National Marine Fisheries Service
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
ROD	Record of Decision
ROW	right-of-way
SPU	Seattle Public Utilities
SWPPP	Storm Water Pollution Prevention Plan
USC	U.S. Code
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington Department of Natural Resources

Appendix A.

Common and Scientific Names of Plants Discussed in the Vegetation Technical Report

Appendix A.

Common and Scientific Names of Plants Discussed in the Vegetation Technical Report

Scientific Name	Common Name
Acer circinatum	Vine maple
Acer macrophyllum	Big-leaf maple
Alnus rubra	Red alder
Centaurea spp	Knapweeds
Cirsium arvense	Canada thistle
Cytisus scoparius	Scotch broom
Gaultheria shallon	Salal
Gymnocarpium dropteris	Oakfern
Hieracium aurantiacum	Orange hawkweed
Hypericum perforatum	St. Johnswort
Ilex aquifolium	English holly
Picea sitchensis	Sitka spruce
Polystichum munitum	Sword fern
Populus balsaminifera trichocarpa	Black cottonwood
Pseudotsuga menziesii	Douglas fir
Rubus armeniacus	Himalayan blackberry
Rubus laciniatus	Cut-leaf blackberry
Rubus spectabilis	Salmonberry
Rubus ursinus	Trailing blackberry
Senecio jacobaea	Tansy ragwort
Thuja plicata	Western red cedar
Tiarella trifoliata	Foamflower
Tsuga heterophylla	Western hemlock
Vaccinium parvifolium	Red huckleberry

Appendix D Final Wetlands Technical Report

Final Wetlands Technical Report

Bonneville Power Administration Kangley-Echo Lake Transmission Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97208-3621

Prepared by:

Jones & Stokes
2820 Northup Way, Suite 100
Bellevue, Washington 98004-1419

December 2002

The analysis in this technical report is generally based on typical construction activities and impacts for transmission lines. Detailed information for this project has been updated as much as possible. However, the most current information about this project is in the Final Environmental Impact Statement.

This document should be cited as:

Jones & Stokes. 2002. Bonneville Power Administration Kangley-Echo Lake Transmission Project. Final wetlands technical report. December. (JSA 0P005.00.) Bellevue, WA. Prepared for Bonneville Power Administration, Portland, OR.

Table of Contents

List of Tables and Figures

1.0 Executive Summary

This report describes the existing conditions and potential impacts on vegetation from the proposed Bonneville Power Administration (BPA) Kangley-Echo Lake Transmission Line Project. This report serves as the primary basis for the vegetation discussion in the National Environmental Policy Act (NEPA) environmental impact statement (EIS) prepared for the project.

1.1 Alternatives

This EIS evaluates five alternative routes for constructing a new 500-kilovolt (kV) electrical transmission line intended to increase the reliability of the Seattle metropolitan area's transmission system. This increased reliability would reduce the potential for rolling brownouts or blackouts that could transpire by the winter of 2002-2003 if the current rate of development continues and if severe winter weather were to cause inordinate power demand.

The transmission line would start at the Schultz-Raver No. 2 500-kV transmission line near the unincorporated community of Kangley in central King County, Washington and travel approximately 9 miles (mi.) to the Echo Lake Substation, located north of the Kangley area and southwest of North Bend (Figure 1).

1.1.1 Construction Methods

BPA would construct all of the action alternatives using the existing practices described below for building transmission lines and substations. BPA would build or improve access roads as necessary. If additional easements for right-of-way (ROW) or access roads were needed, additional rights would be obtained from landowners. BPA typically uses existing, cleared staging areas in which to store and assemble materials or structures.

After the structures are in place and conductors are strung between the structures, BPA would restore disturbed areas.

The following sections describe in greater detail the sequential steps that BPA typically takes to construct a transmission line.

1.1.1.1 Right-of-Way Requirements

BPA would obtain easements from landowners for the new transmission line ROW, and easements for the access roads outside of the transmission line ROW easements. The easements give BPA the right to construct, operate, and maintain the line and access roads. A 150-foot (ft.) ROW width is assumed for the 500-kV line.

Fee title to the land comprising the easement generally remains with the owner, subject to the provisions of the easement. The easement prohibits large structures, tall trees, storing of flammable materials, and other activities that could be hazardous to people or could endanger the transmission line. Activities that do not interfere with the transmission line or endanger people are usually not restricted.

Rights (usually easements) for new access roads would be acquired from property owners, as necessary. A 50-ft. ROW easement generally would be acquired for new access roads measuring about 16 ft. wide, and 20 ft. of ROW would be required for any existing access roads.

1.1.1.2 Clearing

The height of vegetation within the ROW would be restricted to provide safe and reliable operation of the line. Trees would be cleared within the ROW as well as outside of the ROW to prevent trees from falling onto the lines. A clearing advisory would be generated using ground information from cross section data. This clearing advisory would specify a safe vegetation height along and at varying distances from the line. The amount of vegetation removed would be based on this clearing advisory and local knowledge of regional conditions such as weather patterns, storm frequency and severity, general tree health, and soils. Other factors that influence the amount of clearing along the line are the line voltage; vegetation species, height, and growth rates; ground slope; conductor elevation above the ground; and clearance distance required between the conductors and other objects.

Merchantable timber purchased from private owners would be marketed and non-merchantable timber would be left lopped and scattered, piled, chipped, or would be taken off-site. Contractors would be required to use equipment that leaves low-growing vegetation in place instead of dirt blades on bulldozers for clearing. Other specialized brushing/mulching equipment may also be required. Additional best management practices (BMPs) for timberland would also be used.

At the tower sites, all trees, brush, and snags would be felled. Stumps would be removed at these sites only if they interfere with tower and guy installation. The site would be graded to provide a relatively level work surface. The total amount of clearing required for this project is unknown at this time.

An additional amount of land would be cleared for roads that are needed off the ROW and for roads determined to be in poor condition and requiring upgrading by BPA.

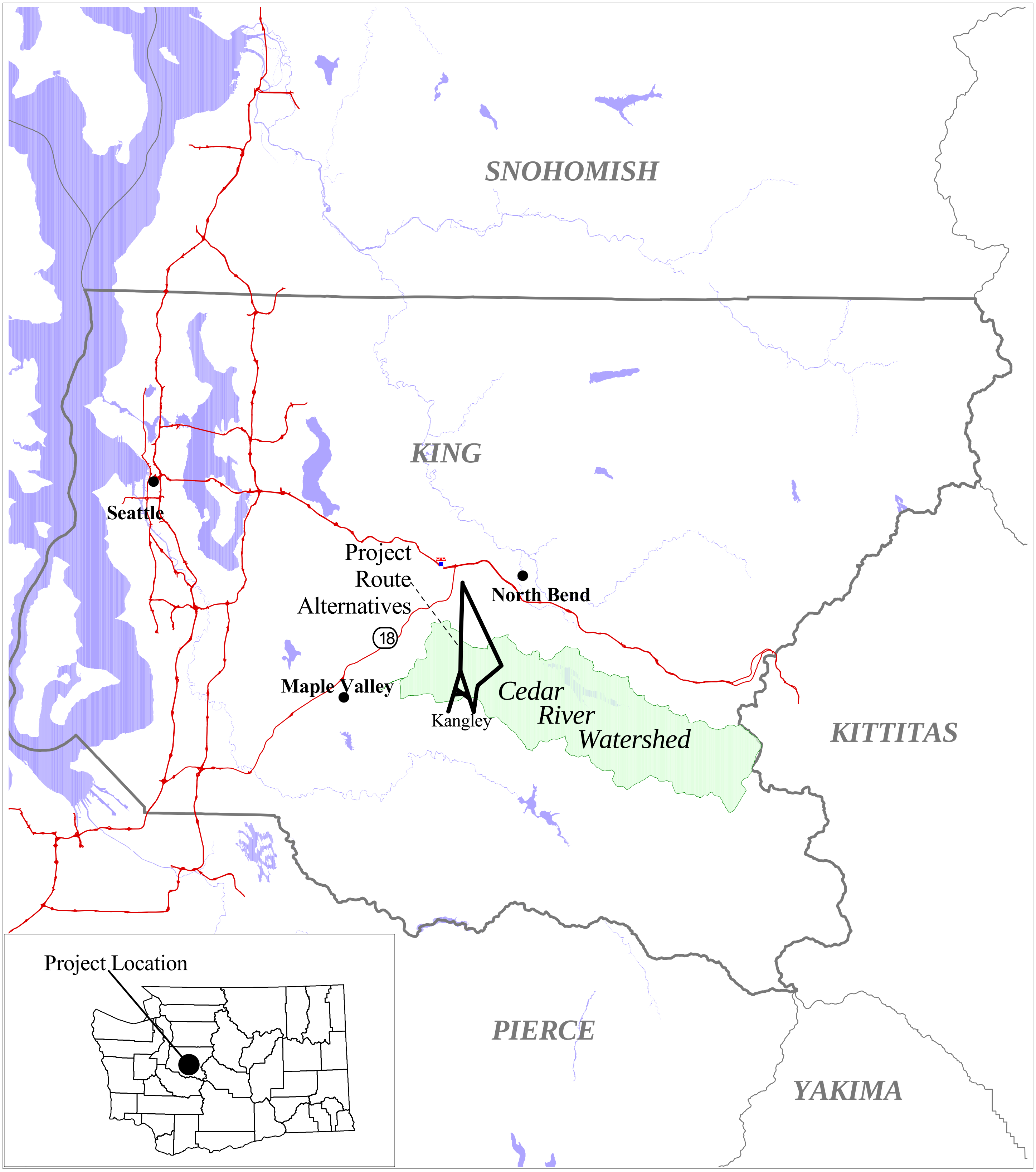
1.1.1.3 Access Road Construction and Improvement

An access road system within and outside of the ROW would be used to construct and maintain a new line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. Roads generally would be surfaced with gravel, and appropriately designed for drainage and erosion control. The access roads would generally have grades of 6% or less for erodible soils and 10% or less for resistant soils. The maximum grades would be 15% for trunk roads and 18% for spur roads. No permanent access road construction would be allowed in cultivated or fallow fields.

Clearing and construction activities for new access roads would disturb an area about 20 ft. wide, depending on terrain. New roads would be constructed within the ROW wherever possible, but where conditions dictate otherwise, roads would be constructed and used outside of the ROW. Construction of new roads is recommended only to access new towers to avoid greater wetland or stream impacts. In several places, new access roads would be constructed in uplands within the new transmission line corridor to avoid wetlands that occur within the existing alignment.

Dips, culverts, and waterbars would be installed within the roadbed to provide drainage. Fences, gates, cattle guards, and additional rock would be added to access roads as necessary.

Where temporary roads are used, any disturbed ground would be repaired and, where land use permits, the road would be reseeded with grass or other appropriate seed mixtures. After construction, access roads would be used for line maintenance. Where ground must be disturbed for maintenance activities, the roadbed would be repaired and reseeded as necessary.



County, contour data, King County, 2000.

LOCATION MAP

Transmission line alternatives

Counties
Highway

Cedar River Watershed
Waterbodies

BONNEVILLE POWER ADMINISTRATION
GIS GEOGRAPHIC INFORMATION SYSTEM

N

0ft 50000ft 100000ft
0mi 5mi 10mi 15mi 20mi

Figure 1

Figure 1.
Location Map

Path/apr: S:\Temp\BPA Kangley 0P005\GIS\Projects\intro1.apr (Date:2001-10-25) rpe

The amount of new roads required for this project would vary depending on the alternative chosen and the feasibility of using existing roads along the line.

1.1.1.4 Storage, Assembly, and Refueling Areas

Construction contractors usually establish storage areas near the transmission line where they can stockpile materials for structures, spools of conductor, and other construction materials. These areas would be accessible from major highways. Structural steel would be delivered in pieces on flatbed trucks and would be assembled on-site. A mobile crane may be needed to handle the bundles. If the terrain were too steep at the actual tower site, general assembly yards would be used to erect the tower in pieces. The structure would then be transported to the tower site by truck or helicopter. Because trucks and helicopters need to refuel often, these construction areas could also be used for refueling.

1.1.1.5 Tower Site Preparation

Site preparation begins with removing all vegetation from a tower site. In areas of uneven topography, the site would be graded to provide a level work area. An average area of 30,000 square feet (150 by 200 ft.) would be disturbed at each tower site. Additional areas that could be disturbed include the site where the conductor is strung and pulled. These disturbances could be as large as a 370-ft. radius from the tower center.

Bulldozers would be used to clear and construct any new access roads to the transmission line towers and any new tower site landings. Manual methods, including chainsaws and brush hogs, would be used to clear the new ROW. BMPs would be used during clearing and construction to reduce impacts.

In addition to clearing the ROW for the transmission line towers, construction crews would remove selected trees outside of the ROW. This additional clearing would be done to reduce the possibility of blowdown. Blowdown occurs when newly exposed trees fall after the initial clearing process because they have not developed the root structure to remain standing once they become more fully exposed to strong winds.

1.1.1.6 Towers and Tower Construction

Steel lattice towers would be erected to support the transmission line conductors. The new towers would be similar in design to those used in the existing Schultz-Raver No. 2 500-kV transmission line. The height of each tower would vary by location and surrounding land forms. Towers would average 135 ft. high and would be spaced about 1,100 to 1,200 ft. apart. Under Alternatives 1 and 2 (described in the next section), where the new line would parallel a portion of the existing Raver-Echo Lake transmission line, towers would be staggered so that a tower from one line would not contact a tower from the other line in the unlikely event that a tower falls.

Most towers used on the proposed line would be “tangent” or “suspension” towers. This type of tower is designed to support conductors strung along a virtually straight line with only small turns or angles. “Deadend” towers would also be used on a limited basis where stresses on the transmission line conductors would have to be equalized because of changes in direction, because of the need to support an excessively long span, or where a span crossing is needed for extremely steep or rugged terrain or a river. Deadend towers use more insulators and heavier steel than tangent or suspension towers, thus making them more visible. Deadend towers also are more costly to build than suspension towers.

The towers would usually be constructed from the ground, rather than using helicopters. The equipment used depends on the weight and size of the towers and such site conditions as weather and soil characteristics. Most 500-kV lines would be built using mobile cranes; helicopter tower erection could be used if access was not available or if sensitive resources would be encountered.

Steel towers would be assembled in sections near the tower site. Each tower contains three components: the legs, body, and bridge. The bridge is the uppermost portion of the tower and serves as the attachment point for the insulators that support the conductors.

Steel towers are anchored to the ground by footings. Each tower requires four footings placed in holes that have been excavated, augered, or blasted. Large machinery, such as backhoes or truck-mounted augers, would be used to excavate the footings. Topsoil would be stockpiled during excavation. The design of the footings would vary based upon soil properties, bedrock depth, and the soundness of the bedrock at each site. Typically, towers would be attached to steel plates or grillages placed within the excavated area. The areas would then be backfilled with excavated material or concrete. Topsoil would then be replaced to restore the original ground surface.

Typical footings for single-circuit towers include 4- by 4-ft. plates placed 10 to 12 ft. deep for suspension towers and 12.5- by 12.5-ft. grillage placed 14 to 16 ft. deep for heavy dead-end towers. On average, for an entire transmission line project, each footing would occupy an area about 10 by 10 ft. to a depth of 15 ft. if bedrock was not encountered. The holes in which the plates and grillage would be installed must be large enough to provide about 1 ft. of clearance on each side of the plate or grillage. If bedrock were encountered and had properties that allowed anchor borings, holes would be drilled and steel rods grouted into the rock. These rods would either be attached to a concrete footing or welded directly to a tower member and embedded in compacted backfill. If rock properties were not suitable for anchor rods, the rock may be blasted to obtain adequate footing depth.

As the towers were built, heavy machinery would disturb the ground surface and/or compact soils at the tower site and along access roads. Noise and dust also would be generated by the machinery.

1.1.1.7 Conductors, Overhead Ground Wires, and Insulators

The wires or lines that carry the electrical current in a transmission line are called conductors. Alternating-current transmission lines such as the proposed line require three wires or sets of wires, each of which is referred to as a “phase.” Three 1.3-in. Bunting conductors would be included for each phase. Each bundle is 16 by 20 in.

Conductors are not covered with insulating material. Instead, air is used for insulation. Conductors are physically separated by insulators on transmission towers.

After the transmission towers are in place, workers would attach a smaller steel cable to the towers and then pull the conductor under tension through the towers. Conductors would be attached to the structure using glass, porcelain, or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors on the tower, the tower itself, and the ground. As the conductors are strung, the ground surface would be disturbed at the tensioning sites, and noise and dust would be generated by the machinery.

Transmission towers elevate conductors to provide safe clearance for people and structures within the ROW. The National Electrical Safety Code (NESC) establishes minimum conductor heights. The minimum conductor-to-ground clearance for a 500-kV line is a little more than 29 ft. Greater clearances would be provided by BPA over county roads and highways, railroads, and river crossings.

One or two smaller wires, called overhead ground wires, would also be attached to the top of the transmission towers. Overhead ground wires would protect the transmission line against lightning damage. The diameter of the wire would vary from 0.375 to 0.625 in.

1.1.1.8 Substation Additions

Under the current proposal, the Echo Lake Substation would be expanded to the east on land owned in fee title by BPA. The size of the expansion would be 300 by 750 ft. The site would be cleared in the same manner as the ROW for the transmission line. The site would include a fenced yard and a graded and graveled parking lot. The existing road around the substation would be realigned to the east to accommodate this expansion. New transformers, switches, and other equipment would be installed in the expanded area. A continuous ground wire would also be installed.

1.1.1.9 Site Restoration and Clean-up

Disturbed areas around the towers, conductor reels, and pull site locations would be reshaped and contoured to be consistent with their original condition. Access roads would be repaired.

Disturbed areas would be reseeded with grass or an appropriate seed mixture to prevent erosion. The seed mixture would include native plant species and would be free of noxious weeds. All solid waste from construction would be removed and properly disposed offsite, and equipment would be removed from the ROW.

1.1.2 Alternative Rights-of-Way

A portion of the action alternatives would be located within the Cedar River Municipal Watershed. The alternatives would begin at the Schultz-Raver No. 2 500-kV transmission line and generally travel northward to the Echo Lake Substation. (See Figure 2.) Under all alternatives, the transmission line ROW would be 150 ft. wide. Miles of new access roads were calculated for a 20-ft. ROW within a 0.25-mile buffer on each transmission line alternative.

1.1.2.1 Alternative 1: Preferred Alternative

The alignment for Alternative 1 would be immediately adjacent and parallel to a portion of the existing 12-mi. Raver-Echo Lake transmission line from a point approximately 3 mi. north of Raver (S26, T22N, R7E) to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 0.8 mi. of new access roads. The existing 150-ft. ROW would be widened to 300 ft., with the widening and new line located east of the existing corridor.

1.1.2.2 Alternative 2

Alternative 2 would originate from tap point #2 (Figure 2) located approximately 2 mi. east of the tap point #1 for Alternative 1 (S25, T22N, R7E). The line would traverse approximately 3 mi. to

S11, T22N, R7E before continuing north along the same alignment as Alternative 1, paralleling the existing Raver-Echo Lake transmission line, and terminating at the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 9 mi. long and would require about 2.8 mi. of new access roads.

1.1.2.3 Alternative 3

Alternative 3 would begin at the tap point #2 (S25, T22N, R7E); traverse northeast to S8, T22N, R8E; and then turn north-northwesterly to the Echo Lake Substation (S11, T23N, R7E). This alternative would be approximately 10.2 mi. long and would require about 6.4 mi. of new access roads.

1.1.2.4 Alternative 4a

Alternative 4a would begin about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverse northwest to connect with Alternative 1 over 1 mi. (S23, T22N, R7E) further south from where Alternative 2 reconnects (S11, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

1.1.2.5 Alternative 4b

Alternative 4b would begin slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverse west to connect with Alternative 1 further south from where Alternative 4a reconnects (S23, T22N, R7E). This alternative would be approximately 9.5 mi. long and would require about 2.3 miles of new access roads.

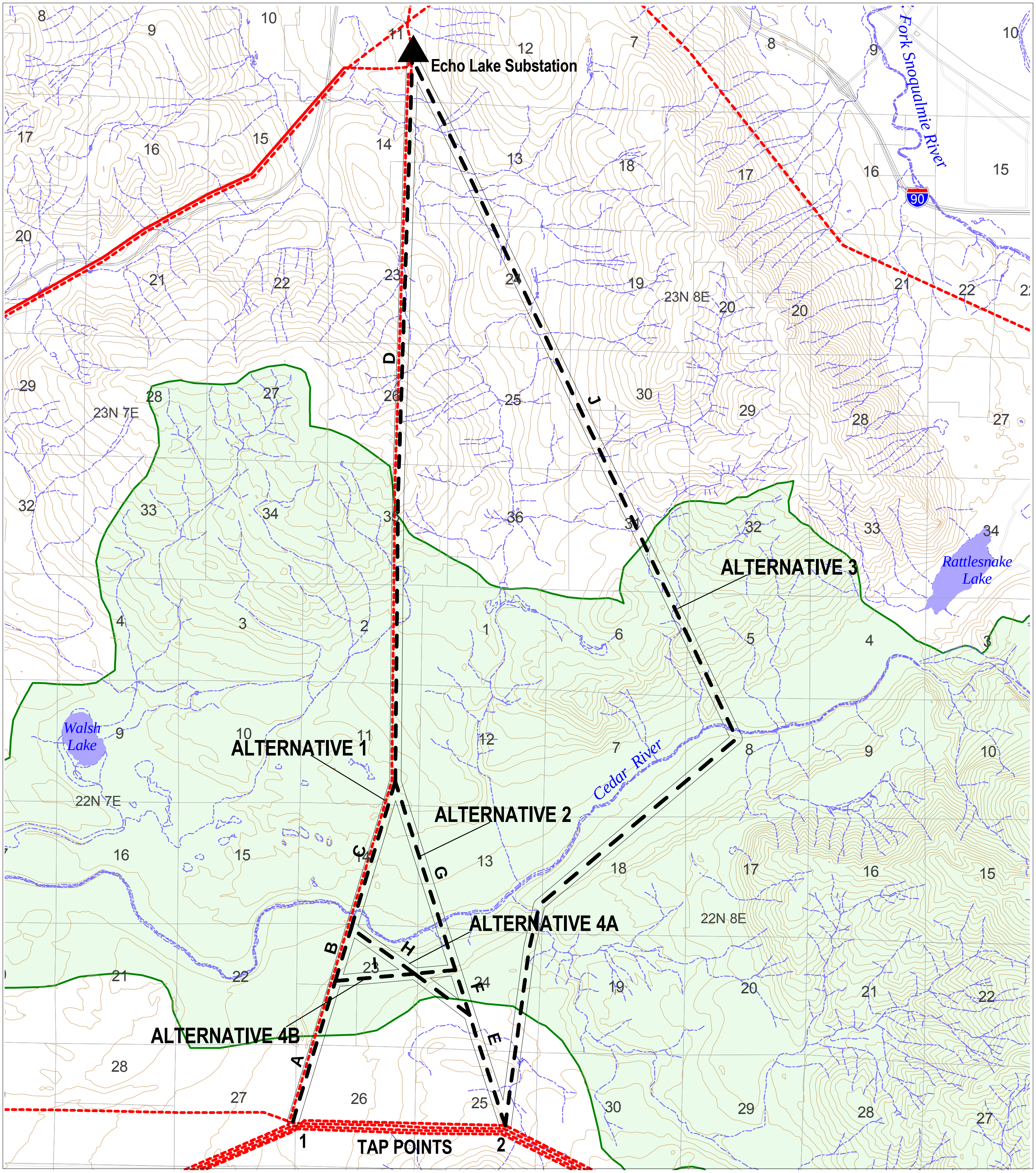
1.1.2.6 No Action Alternative

Under the No Action Alternative, a new 500-kV electrical transmission line would not be built. As a result, transmission line capacity could be reached or exceeded as early as 2002-2003 if a cold winter were to occur in the Seattle metropolitan area and the existing Raver-Echo Lake transmission line were to go out of service. Relying upon the existing transmission system during periods of increased demand and compromised reliability could result in brownouts or rolling blackouts in the area. Thus, residents, businesses, and government agencies could experience as much as several days without electricity. Loss of electricity for lights and heating could halt business and government activities. Residents would have to rely upon other energy sources for heating, cooking, and lighting, such as wood and gas fireplaces, stoves and barbecues, oil lamps and candles, etc.

1.2 Key Issues for Wetlands

Wetlands are susceptible to degradation from excavation, fill, and clearing. Federal, state, and local agencies require the disclosure of potential impacts to wetlands associated with the construction and maintenance of the transmission line.

The majority of wetlands that would be affected are associated with forested habitats that would be permanently altered, by removal of trees and construction of access roads, with construction of the transmission line. Moderate to high levels of impact to wetlands would occur with the construction of any of the proposed transmission line alternatives.



Watershed data from City of Seattle.
Road data from King County GIS, 1999.

ROUTE ALTERNATIVES

Transmission line alternatives
E Segment of alternative
150ft Clearing area
Existing transmission lines
Highway
Primary roads
Public land survey sections
Cedar River Watershed
Fish-bearing streams
100 Ft contours

BONNEVILLE POWER ADMINISTRATION GIS GEOGRAPHIC INFORMATION SYSTEM

N

0ft 6000ft 12000ft
0mi 1mi 2mi 3mi

Figure 2.
Existing Transmission Lines and Proposed ROW Alternatives

Figure 2

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Impacted wetland functions associated with vegetation clearing and access road construction are wildlife habitat, water quality improvement, flood storage, moderation of flood flow, and groundwater discharge and recharge. In forested wetlands, permanent impacts would occur where herbaceous vegetation and trees are removed. These wetlands would be permanently maintained as scrub-shrub or emergent wetlands. Minimizing the disturbance to soil structure during clearing would reduce impacts to water quality, flood storage, and flood flow moderation functions.

Where possible, BPA would place new roads and tower structures outside of wetland areas to avoid permanently altering wetland hydrology and soils through excavation or fill.

1.3 Major Conclusions

A total of 23 wetlands were identified within the project area during the October 2000 site reconnaissance. An additional 31 wetlands were identified during the reconnaissance of the preferred Alternative 1 in April 2001. Alternative 3 would result in the least impact to wetlands with a total of 6 acres (ac.) of clearing impacts. Impacts to wetlands associated with the construction of the transmission line would be limited to the clearing of vegetation and construction of access roads. Operation and maintenance impacts would be similar except with less severity. Potential fill and excavation impacts from the construction of towers would be avoided by strategically locating towers outside of wetland areas and by spanning wetlands.

The majority of wetlands within the proposed ROWs are forested. Permanent impacts to wetland functions would occur from the removal of trees and the maintenance of shrub communities within the 150-ft. transmission line ROW. Key wetland functions that would be degraded from construction of the transmission line are wildlife habitat, flood storage and flood flow moderation, and water quality. Identifying and avoiding wetland resources before and during construction, and limiting disturbance to the minimum necessary when working in and immediately adjacent to wetlands, would minimize wetland impacts. New road construction could carry sediment into wetlands, affecting water quality and biological productivity; however, use of erosion control devices would minimize these indirect impacts.

2.0 Study Scope and Methodology

2.1 Data Sources and Study Methods

The collection of wetland data for the project area focused on two tasks:

- Habitat-Based Evaluation
- Field Verification

The habitat-based evaluation was initiated by reviewing existing data and literature applicable to the project area. Background review of wetlands data for the project area was based on:

- U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) maps (USDI 1987 map series).
- Wetland maps and other information from the Cedar River Watershed (CRW) Habitat Conservation Plan (HCP) (City of Seattle 2000).

- 1:24,000-scale orthophotos.
- U.S. Geological Survey (USGS) 7.5-minute series quadrangle topographic maps.

A basemap of potential wetland locations was created by superimposing the transmission alternatives over the wetlands location data provided by the aforementioned data sources. This map was used to aid the field survey of wetlands within the ROWs. The wetlands reconnaissance conducted in October 2000 focused on field-verifying selected areas of the wetland basemap that may be impacted. The approximate wetland boundaries were then field-mapped on the orthophotos provided by BPA.

Jones & Stokes wetland biologists located wetlands within a 500-ft. survey corridor during the week of October 23 to 27, 2000. Wetlands previously identified by King County were located. In addition, several other wetlands not identified by King County or other sources were located. A global positioning system was used to field-verify the location of each wetland. No waters of the United States were "delineated"; subsequently no jurisdictional wetland boundaries were established for the purposes of the Draft Environmental Impact Statement. Wetland biologists located wetlands, including waters of the United States, using criteria for jurisdictional wetland identification developed by the U.S. Army Corps of Engineers (Environmental Laboratory 1987), the Washington State Department of Ecology (Ecology 1997). Wetland class, rating, and size were determined at each wetland location. Wetlands were classified following the standardized national system established in Cowardin et al. (1979). Wetlands were rated and buffer widths were assigned based on the King County Environmentally Sensitive Areas Ordinance (King County Code 21A.24.320). Due to the size of the wetlands and their readily apparent signature on the aerial photographs, the boundaries were sketched on 1:24,000-scale aerial photographs and subsequently digitized electronically to the aerial orthophotos using the ArcView mapping program.

Wetlands within the 500-ft. corridor were mapped by alternative consecutively from south to north. Wetlands were numbered based upon their association with a primary alternative and the order from south to north. For example, the southernmost wetland located on Alternative 2 is wetland 2-1. Alternatives 1, 2, 4a, and 4b share portions of the same ROWs; thus, some wetlands are common to several alternatives.

In April 2001, a reconnaissance of wetlands and streams within the preferred Alternative 1 was conducted to map the locations of jurisdictional waters of the United States. The purpose of this reconnaissance was to provide BPA tower and road engineers flagged locations of jurisdictional waters in the field to better site access roads and towers to avoid impacts to the resources. Wetland biologists walked the entire 150-ft wide ROW of the preferred Alternative 1 and flagged the boundaries of waters of the United States, using criteria for jurisdictional wetland identification developed by the U.S. Army Corps of Engineers (Environmental Laboratory 1987), the Washington State Department of Ecology (Ecology 1997). Within each wetland encountered vegetation, hydrology, and soils data was recorded. Approximate wetland boundaries were sketched on the 1:24,000-scale orthophotos provided by BPA. Wetlands within the 150-foot Alternative 1 corridor were labeled according to the proposed transmission line tower moving south to north. For example, the southernmost wetland located on Alternative 1 is wetland 78/5-1. Thus, this wetland is the first wetland north of proposed tower 78/5.

Wetland impacts were calculated for Alternatives 2, 3, 4a, and 4b using the ArcView mapping program by overlaying each 150-ft. ROW on the October 2000 surveyed wetlands. The sum of potential wetland impacts from vegetation clearing was then calculated for each alternative. In

September 2001, BPA provided a map of proposed towers and access roads locations associated with the preferred Alternative 1. This map was used to calculate potential impacts to the April 2001 reconnaissance wetlands, from the vegetation clearing for the 150-foot wide proposed transmission line corridor to wetlands associated with Alternative 1. As the access road network was developed, further field reconnaissances conducted during summer 2001 resulted in hand-measured approximate impacts to wetlands from the proposed access road construction (e.g., new roads, road upgrade, culvert installation). See Section 4.0 for potential impacts on wetlands.

2.2 Agencies Contacted

Agencies contacted include the U.S. Army Corps of Engineers (Corps) and the City of Seattle.

3.0 Affected Environment

3.1 Regional Overview

The project area is located within the Cascade foothills of western Washington, between the City of North Bend and the Kangley area. A major portion of each proposed ROW passes through the CRW and private timberlands. Within the area, primary land holders, including "in fee" ROWs and easements, include BPA, Weyerhaeuser Timber Company, Washington Department of Natural Resources (WDNR), City of Seattle, and private residential landowners.

Water Resource Inventory Areas (WRIAs) designated by the Washington Department of Ecology that are crossed by the proposed ROWs include Lake Washington (#8), Snohomish River (#7), and Green River (#9).

Wetlands within the region are typical of the Puget Lowland and western Cascade Mountain foothills. Wetland soils are often formed in porous gravels, sands, and clay and silt tills derived from glacial deposits. Mixed deciduous and coniferous-forested wetlands with pockets of shrub, emergent, and open water communities are common. Wetland water sources include hillside seeps, perched water tables, overland runoff, precipitation, and flows from adjacent streams.

3.2 Regulations, Standards, and Guidelines

3.2.1 Federal

The Clean Water Act (CWA) Section 404 requires the avoidance of development in wetlands wherever practicable. Wetlands are important natural communities that deserve special consideration because of historical and current regional and statewide losses, and because of the federal laws and policies that pertain to their protection. Wetland communities in the project ROWs play a vital role in groundwater discharge, supporting stream baseflow, capturing sediment and nutrient runoff, and providing habitat for wildlife and plant species.

Under Section 404 of the CWA, the Corps and the U.S. Environmental Protection Agency (EPA) regulate the placement of dredge and fill material into waters of the United States, which include jurisdictional wetlands. Although the CWA protects wetlands, filling of wetlands can occur after a Section 404 permit is issued by the Corps.

For regulatory purposes, the federal agencies define wetlands as follows:

Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (CFR 328.3, CFR 230.3).

Other waters of the United States include seasonal or perennial surface water features, such as streams and drainages, that are not considered wetlands because they do not meet one or more of the three mandatory technical criteria that characterize jurisdictional wetlands (i.e., hydrophytic vegetation, hydric soil, and wetland hydrology), as defined by the Corps Wetlands Delineation Manual (1987). Please see the Fisheries Technical Report for a complete discussion of these other surface water features within the project area.

3.2.2 State

Section 401 of the federal CWA requires that proposed dredge and fill activities permitted under Section 404 be reviewed by the Washington Department of Ecology (Ecology) for compliance with state water quality standards. Certification ensures that federally permitted activities comply with the federal CWA, state water quality laws, and any other state aquatic protection requirements (unless certified by the state, the federal Section 404 permit is considered invalid).

3.2.3 Local

Compliance with King County Sensitive Areas Ordinance (Ordinance #9614) is required whenever proposing a project located near or in critical areas wetlands. Wetlands within the project ROWs were rated using the criteria defined in the King County Sensitive Areas Ordinance. This ordinance categorizes wetlands into Class 1, 2, and 3 based on the size, the presence of species listed as threatened or endangered, and the number of vegetation classes present.

The King County Sensitive Areas Ordinance requires minimum buffer widths for wetlands, as determined by the wetland category. Wetland buffers are measured from the wetland edge. The King County Sensitive Areas Ordinance provides for permanent protection of wetlands and their buffers by regulation of development and other activities. Minimum buffer requirements are:

- Class 1: 100 ft.
- Class 2: 50 ft.
- Class 3: 25 ft.

In addition, and unless otherwise specified, a minimum building setback of 15 ft. is required from the edge of a wetland buffer.

3.3 Study Area

The study area for wetlands included a 500-ft. wide corridor along all of the transmission line alternatives. The primary focus of the wetlands analysis was on identifying wetlands within the proposed 150-ft. ROW centerline of each transmission line corridor. The wetlands within the 150-ft. ROW were judged most vulnerable to impacts resulting from construction and maintenance of the transmission lines, because the ROW would be cleared of vegetation and would include access roads and transmission line towers. Figure 3 presents the location of all wetlands surveyed within the ROWs during the October 2000 reconnaissance. Table 1 presents the wetland identification numbers and vegetation classes by alternative as surveyed in October 2000.

Table 1. Summary of Wetlands Present within 150-ft. ROW by Transmission Line Alternative

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
Alternative 1				
1-1	PFO	Class 2	9	#8 – Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO	Class 1	8	#7 - Snohomish River
Total			242	
Alternative 2				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-2	PFO	Class 2	3	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 – Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO	Class 2	8	#7 - Snohomish River
Total			261	
Alternative 3				
3-1	PFO/PSS	Class 2	22	#8 - Lake Washington
3-2	PFO/POW	Class 2	6	#8 - Lake Washington

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
3-3	PFO	Class 2	10	#9 - Green River
3-4	PFO	Class 2	12	#8 - Lake Washington
3-5	PFO	Class 2	10	#8 - Lake Washington
3-6	PFO/PSS	Class 2	2	#7 - Snohomish River
3-7	PFO/POW	Class 2	6	#7 - Snohomish River
3-8	PFO	Class 2	6	#7 - Snohomish River
3-9	PSS	Class 3	1	#7 - Snohomish River
Total			75	
Alternative 4a				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 - Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River
1-10	PFO/POW	Class 1	8	#7 - Snohomish River
Total			258	
Alternative 4b				
2-1	PSS/PFO	Class 2	1	#8 - Lake Washington
2-2	PFO	Class 2	3	#8 - Lake Washington
2-3	PFO	Class 2	15	#9 - Green River
1-1	PFO	Class 2	9	#8 - Lake Washington
1-2	PFO	Class 2	67	#8 - Lake Washington
1-3	PFO	Class 2	87	#8 - Lake Washington
1-4	PFO	Class 2	51	#8 - Lake Washington
1-5	PFO	Class 2	1	#8 - Lake Washington
1-6	PFO	Class 2	8	#8 - Lake Washington
1-7	POW/PFO	Class 2	7	#7 - Snohomish River
1-8	PFO/PSS	Class 2	3	#7 - Snohomish River
1-9	PSS/PFO	Class 2	1	#7 - Snohomish River

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 500-foot Study Corridor	WRIA
1-10	PFO	Class 2	8	#7 - Snohomish River
Total			261	
Substation				
Echo 1	PEM/PSS	Class 2	7	#7 - Snohomish River

*Vegetation class definitions (as defined by Cowardin et al. 1979, Classification of Wetlands and Deepwater Habitats. U.S. Fish and Wildlife Service):
PEM – Palustrine Emergent
PFO – Palustrine Forested
PSS – Palustrine Scrub-Shrub
POW – Palustrine Open Water

** King County ratings are explained in Appendix B.

A total of 23 wetlands were identified within the ROWs during the October 2000 reconnaissance for wetlands. Additional wetlands were identified during the reconnaissance of the 150-foot-wide preferred Alternative 1 in April 2001. Figure 3 illustrates the relationship between wetlands identified during the October 2000 field reconnaissance and the 500-ft. transmission line ROW. Figure 4 details the wetlands identified during the April 2001 reconnaissance of the preferred Alternative 1 within the proposed 150-ft transmission line ROW. Discrepancies between the size and shape of wetlands presented in Figures 3 and 4 are attributed to survey methods. Wetlands boundaries surveyed in April 2001 reflect the detail necessary to site access roads and towers to avoid and minimize impacts to waters of the United States, including wetlands within the preferred Alternative 1 ROW. Thus, additional wetlands were inventoried and boundaries of wetlands presented in 4 were adjusted (see Figure 4).

Wetland vegetation classes in the proposed ROWs included palustrine emergent, scrub-shrub, open water, and forested wetlands as defined by Cowardin et al. (1979). Commonly wetlands on flat bench areas were associated with depressional areas that receive water from overland runoff and precipitation. Wetlands on the north and south side of Brew Hill (Alternative 1) and wetlands generally located on slopes were fed by groundwater discharge seeps. Most wetlands were generally greater than 1 ac. in size and included a mosaic of wetland and upland areas following small variations in topography. Several wetlands were also found to be associated with the riparian strips of streams.

The majority of wetlands within the CRW have been protected from recent timber harvest and have intact mixed conifer and deciduous forested components. However, the existing roads system does cross wetlands in places, thereby reducing vegetation cover and altering surface and subsurface flows within these wetlands. The majority of wetlands located north of the CRW have been impacted by timber harvest and are currently dominated by deciduous trees and shrubs, or sapling conifers rather than the mixed deciduous/coniferous tree dominated wetlands common to the CRW. Common dominant wetland plant species included red alder, western hemlock, western red cedar, salmonberry, Douglas' spirea, skunk cabbage, piggy-back plant, and slough sedge. (Please see Appendix A for scientific names of dominant plant species surveyed within the project area.)

Wetland buffers within the 150-ft ROW of each of the alternatives were generally intact and forested within the CRW. Wetland buffers extending within the cleared existing alignment associated with Alternative 1 have been cut to allow conductor span, and generally maintain low shrub and herbaceous cover. Wetland buffers within the private timberlands to the north of the watershed reflect the mosaic past and recent timber harvest, and are generally intact and dominated by a mix of shrubs, and young deciduous and coniferous trees.

The wetlands in the ROWs provide many functions and values that directly or indirectly benefit society. Many of the depressional and seep discharge wetlands in the ROWs are forested, located within the upper third of their respective watershed, and connected to drainages, all of which are factors that increase the flood storage and flood flow moderation wetland functions. Several wetlands are associated with the riparian fringe of streams, a factor that plays an important role in filtering pollutants and sediments before they reach the waterway. High vegetative structural complexity within the wetlands and adjacent intact forested upland communities may provide foraging, breeding, cover, and rearing habitat for many wildlife species.

Wetland buffers provide important functions, including protection of wetland functions and values, water quality improvement, wildlife habitat, and deterrence of human access and associated impacts. Vegetated buffers may reduce impacts to water quality in wetlands by controlling soil erosion and filtering out pollutants. Vegetated buffers provide essential life needs for birds and mammals that are considered to be dependent on wetlands.

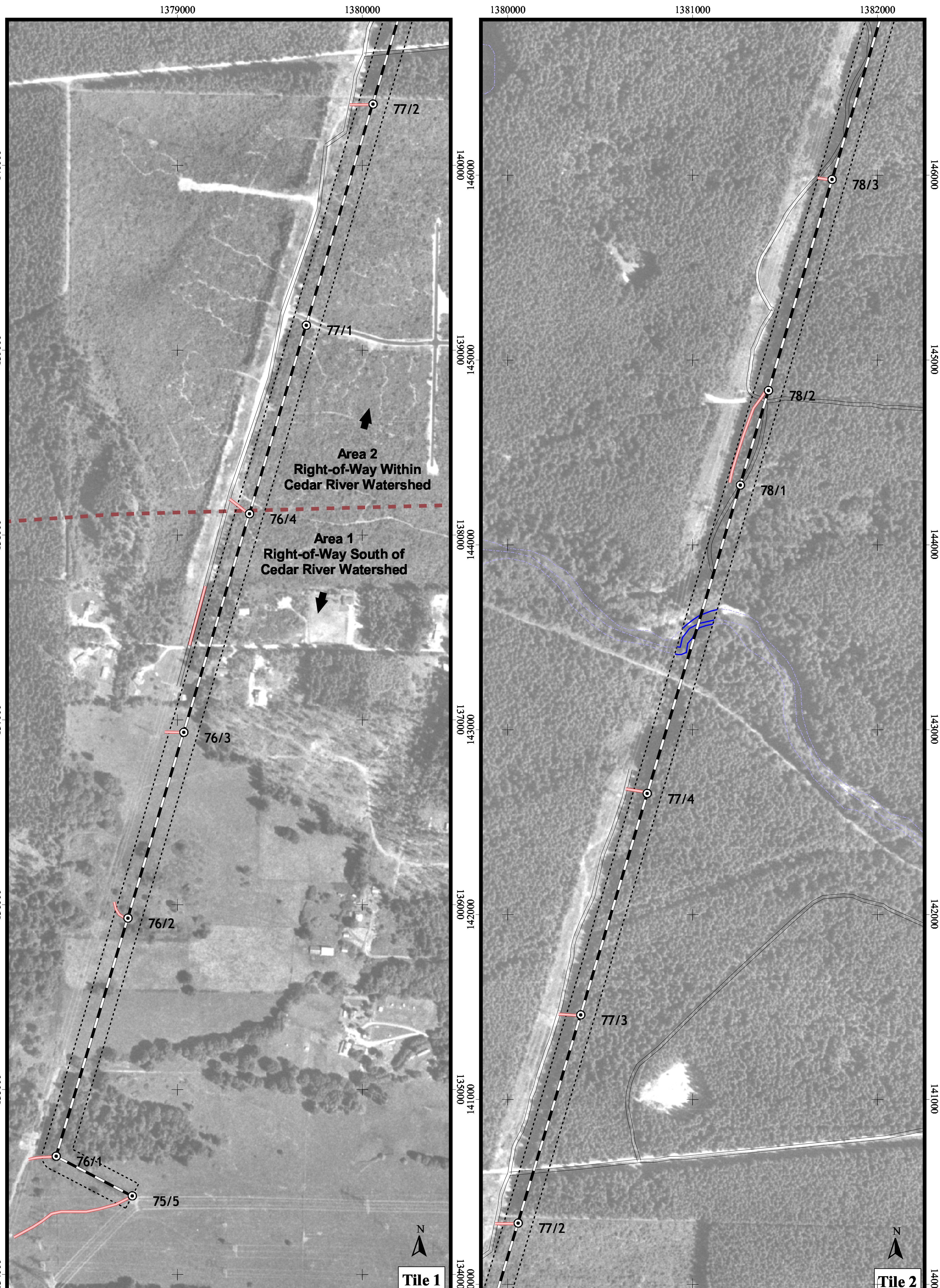
3.4 Transmission Line Alternatives

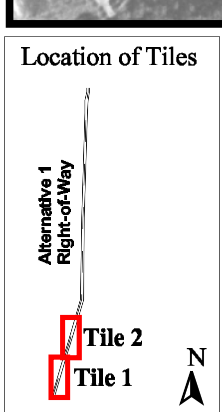
3.4.1 Alternative 1: Preferred Alternative

A total of 10 wetlands, totaling 242 ac., were identified within the 500-ft. transmission line study corridor for Alternative 1 during the October 2000 reconnaissance (see Table 1). All of the wetlands identified within the 500-ft. corridor would be crossed by the proposed 150-ft. ROW centerline. The April 2001 reconnaissance of the 150-foot preferred Alternative 1 corridor identified 31 wetlands totaling 13.9 acres. Table 2 lists the 31 wetlands surveyed during the April 2001 reconnaissance (please refer to Figure 4 for wetland locations within Alternative 1). The discrepancy between the two surveys is attributable to the survey methods described in Chapter 2.1.

Table 2. Alternative 1 Wetlands Surveyed During the April 2001 Reconnaissance of the 150-Ft.-Wide Corridor

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 150-Foot Study Corridor	WRIA
78/5-1	PFO	2	0.5	#8 – Lake Washington
78/5-2	PFO	2	0.5	#8 – Lake Washington
79/1-1	PFO	2	0.4	#8 – Lake Washington
79/2-1	PFO	2	0.5	#8 – Lake Washington
79/3-1	PFO	2	0.5	#8 – Lake Washington
79/3-2	PFO	2	0.1	#8 – Lake Washington
79/5-1	PFO	2	1.1	#8 – Lake Washington





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Wetlands (Field Inventory)
- Stream (Field Inventory)
- Stream

500 0 500 Feet

Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4a.
Preferred Alternative 1 Wetlands, Access Roads, and Tower Locations
Tiles 1 & 2

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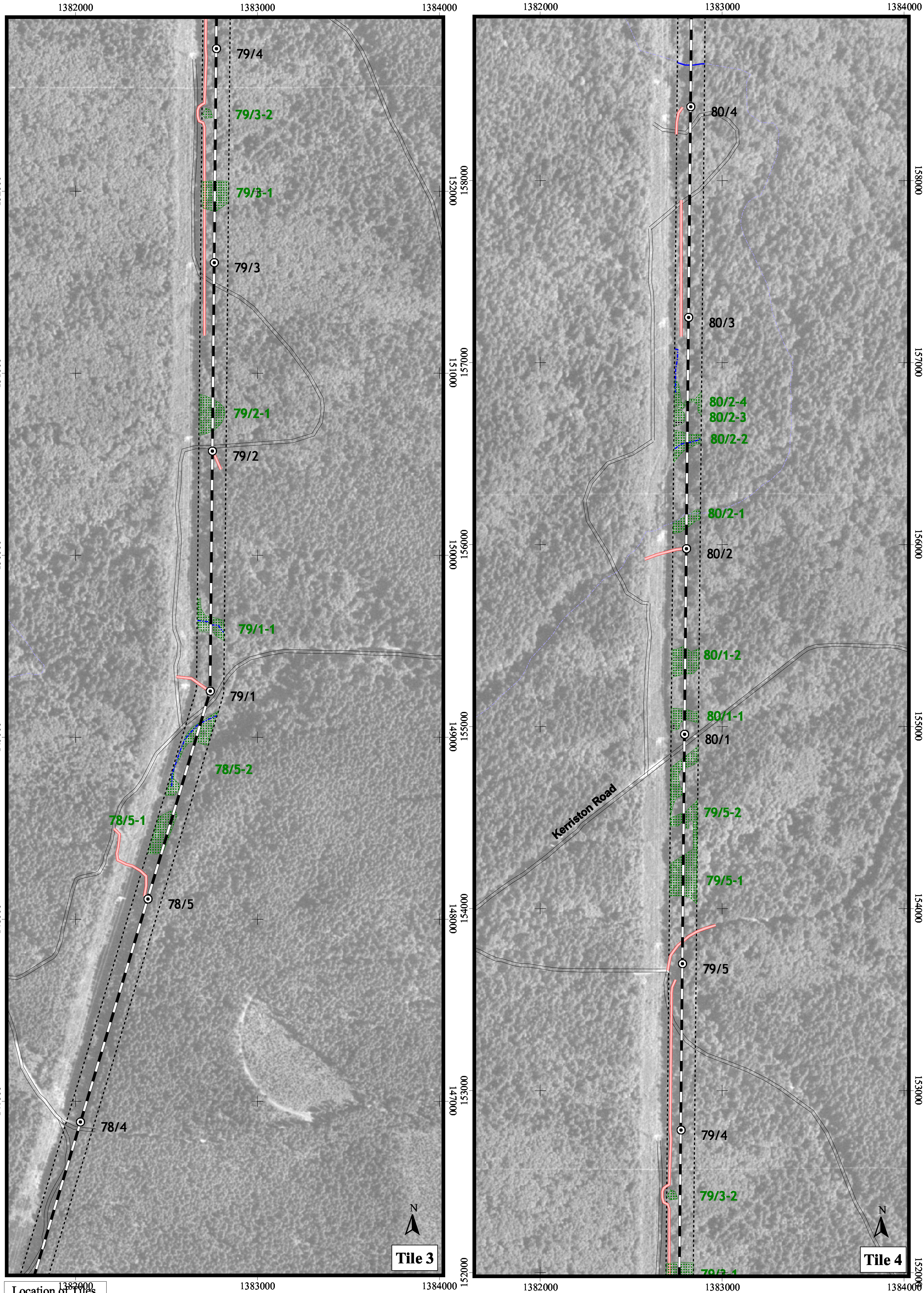
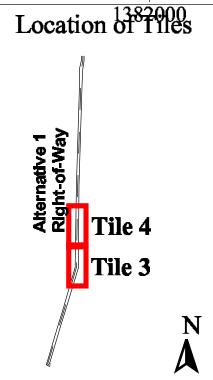
Wet5





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Wetlands (Field Inventory)
- Stream (Field Inventory)
- Stream

500 0 500 Feet
Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4b.
Preferred Alternative 1 Wetlands, Access Roads, and Tower Locations
Tiles 3 & 4

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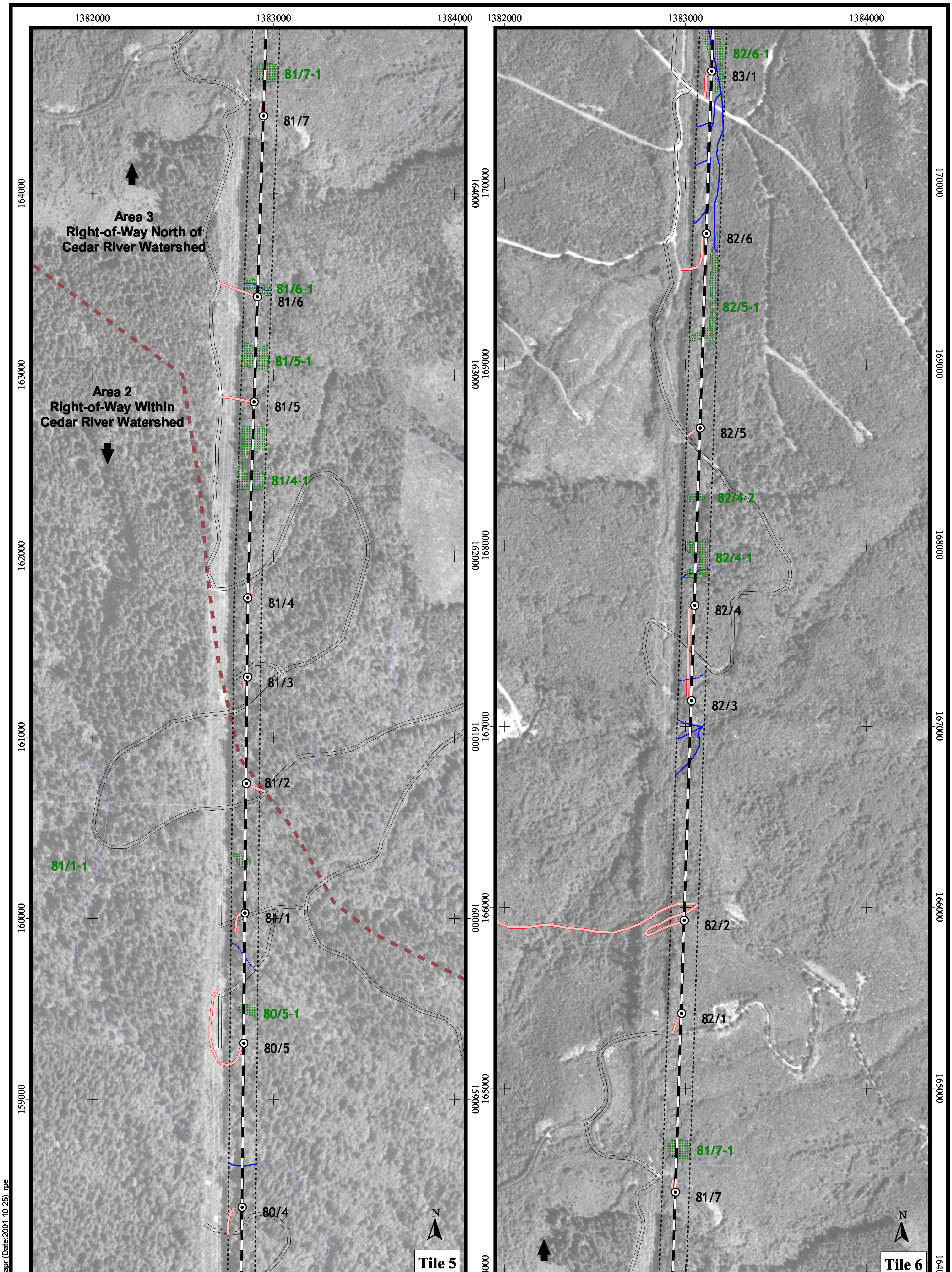
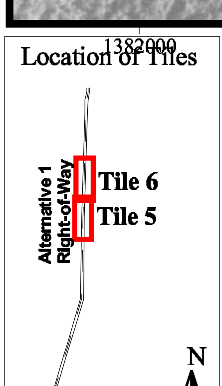
Wet5





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Wetlands (Field Inventory)
- Stream (Field Inventory)
- Stream

500 0 500 Feet
Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4c.
Preferred Alternative 1 Wetlands, Access Roads, and Tower Locations
Tiles 5 & 6

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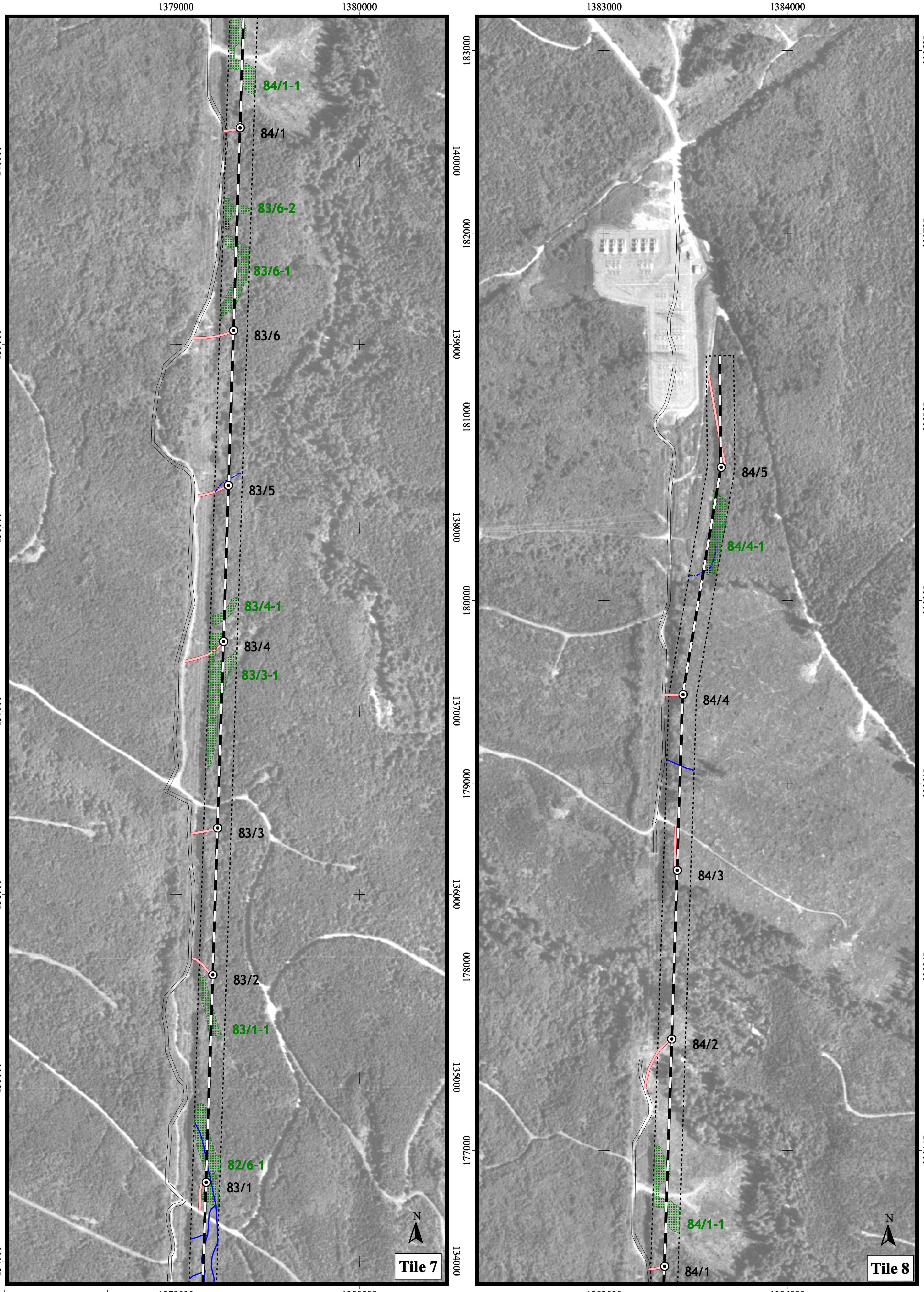
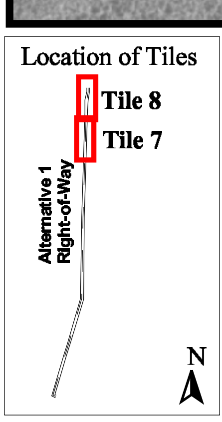
Wet5





LEGEND

- New Tower Locations
- New Transmission Line
- Transmission Line Right-of-Way
- New Access Roads
- Existing Roads
- Wetlands (Field Inventory)
- Stream (Field Inventory)
- Stream

500 0 500 Feet

Scale 1" = 500'

Source:
Tower locations, right-of-way, centerline, access roads - BPA, 2001
Streams - Seattle Public Utilities, 1997
Wetlands - Jones & Stokes Field Survey, 2001

Projection: Washington State Plane, North Zone, NAD83 Datum, Feet

Figure 4d.
Preferred Alternative 1 Wetlands, Access Roads, and Tower Locations
Tiles 7 & 8

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Wet5

Wetland ID	Vegetation Class*	King Co. Rating**	Total Acres Within 150-Foot Study Corridor	WRIA
79/5-2	PFO	2	0.4	#8 – Lake Washington
80/1-1	PFO	2	0.3	#8 – Lake Washington
80/1-2	PFO	2	0.5	#8 – Lake Washington
80/2-1	PFO	2	0.2	#8 – Lake Washington
80/2-2	PFO	2	0.3	#8 – Lake Washington
80/2-3	PFO	2	0.1	#8 – Lake Washington
80/2-4	PFO	2	0.2	#8 – Lake Washington
80/5-1	PFO	2	0.1	#8 – Lake Washington
81/1-1	PSS	3	0.1	#8 - Lake Washington
81/4-1	PSS	2	0.9	#7 - Snohomish River
81/5-1	PFO	2	0.4	#7 - Snohomish River
81/6-1	PFO	2	0.2	#7 - Snohomish River
81/7-1	PSS	3	0.3	#7 - Snohomish River
82/4-1	PFO	2	0.5	#7 - Snohomish River
82/4-2	PFO	2	0.1	#7 - Snohomish River
82/5-1	PFO	2	0.7	#7 - Snohomish River
82/6-1	PFO	2	1.0	#7 - Snohomish River
83/1-1	PFO	2	0.4	#7 - Snohomish River
83/3-1	PFO	2	1.1	#7 - Snohomish River
83/4-1	PFO	2	0.2	#7 - Snohomish River
83/6-1	PFO/POW	1	0.7	#7 - Snohomish River
83/6-2	PSS	2	0.2	#7 - Snohomish River
84/1-1	PSS	2	0.7	#7 - Snohomish River
84/4-1	PSS/PEM	2	0.7	#7 - Snohomish River
Total			13.9	

*Vegetation class definitions (as defined by Cowardin et al. 1979, Classification of Wetlands and Deepwater Habitats. U.S. Fish and Wildlife Service):
PEM – Palustrine Emergent
PFO – Palustrine Forested
PSS – Palustrine Scrub-Shrub
POW – Palustrine Open-Water

** King County ratings are explained in Appendix B.

Large depressional wetlands occupy flat benches on the north and south slopes of Brew Hill and are often fed by groundwater seeps. Several wetlands are also associated with the riparian area of tributaries to the Raging River to the north and Rock Creek to the south of Brew Hill, within the watershed and within private lands. Many of the wetlands continue outside of the 150-ft corridor into the existing transmission line corridor and onto adjacent lands.

A majority of wetlands in this alternative have a palustrine forested vegetation community component dominated by red alder. The red alder forest is often associated with western red cedar and western hemlock in the canopy. Salmonberry, and Douglas' spirea are common wetland shrub species, with piggy-back plant, meadow buttercup, and skunk cabbage often dominating the herbaceous layer. The depressional wetlands occupying the south and north bench areas of Brew Hill provide important groundwater discharge and recharge functions, while serving as the headwaters for Rock Creek and the Raging River. These forested wetland communities also provide bird, mammal, fish, amphibian, and invertebrate habitat for a variety of species that use seasonally and perennially saturated wetlands and riparian areas for feeding, nesting, and rearing.

No wetlands were identified south of the Cedar River crossing within the Alternative 1 ROW.

3.4.2 Alternative 2

A total of 13 wetlands, totaling 261 ac., were identified within the 500-ft. study corridor for Alternative 2. Three wetlands were identified south of the junction with Alternative 1. North of this junction (which is within Alternative 1), within the CRW, there are 10 wetlands (described under Alternative 1 above).

All three of the wetlands identified within the southern portion of this alternative are located south of the Cedar River, and all three wetlands are within the proposed 150-ft. ROW. All are depressional wetlands with palustrine forested vegetation community components and areas of surface water inundation. Two of these wetlands have been altered. Tree harvesting has impacted the buffer associated with wetland 2-1, while the location of Pole Line Road has altered the hydrology of wetland 2-2. Wetland 2-3 is located within mid-seral coniferous forest and, like the other two wetlands, is associated with a depressional area within relatively flat topography.

3.4.3 Alternative 3

A total of nine wetlands, totaling 75 ac., were identified within the 500-ft. study corridor along Alternative 3. Wetlands are located to the north and south of the CRW, as well as within the watershed. Seven of nine wetlands identified within the study corridor would be crossed by the proposed 150-ft. ROW.

Most of the wetlands are associated with depressions that collect overland flows and precipitation and hold this water over prolonged periods. These wetlands provide water quality, flood storage, and flood water retention functions. Vegetation communities are predominantly palustrine forested with components of palustrine scrub-shrub with low diversity. Wetlands 3-8 and 3-4 contain open water surrounded by red alder-dominated, palustrine forested wetland.

Several wetlands are associated with the riparian fringe of streams that provide wildlife habitat and wildlife travel corridors, as well as water quality improvement, flood storage, and floodwater retention. Wetland 3-9 is a palustrine forested wetland paralleling the north and south sides of Canyon Creek. Wetland 3-5 fringes an unnamed tributary to Raging River. Wetland 3-4 contains a large open water component forming the headwaters to Steele Creek, a tributary to the Cedar River.

3.4.4 Alternative 4a

A total of 12 wetlands, totaling 258 ac., were identified along the entire length of the Alternative 4a 500-ft. study corridor. Wetland 2-3 was identified along the portion of Alternative 4a that begins about one-third of the way along Alternative 2 (S24, T22N, R7E) and traverses northwest to connect with Alternative 1, over 1 mi. (S23, T22N, R7E) further south than where Alternative 2 reconnects (S11, T22N, R7E).

Ten of the 12 wetlands identified within the Alternative 4a 500-ft. study corridor were previously described in Section 3.4.1 for Alternative 1. The remaining two wetlands (2-1 and 2-3) are described in Section 3.4.2 for Alternative 2. However, wetland 2-3 is not within the proposed 150-ft. ROW and would not be directly impacted.

3.4.5 Alternative 4b

A total of 13 wetlands, totaling 261 ac., were identified along the entire length of Alternative 4b. Wetlands 2-2 and 2-3 were identified along the portion of Alternative 4b that begins slightly north of Alternative 4a (S24, T22N, R7E), along Alternative 2, and traverses west to connect with Alternative 1 further south than where Alternative 4a reconnects (S23, T22N, R7E).

Ten of the 13 wetlands identified within Alternative 4a were previously described in Section 3.4.1 for Alternative 1. The remaining wetlands are described in Section 3.4.2 for Alternative 2. However, wetland 2-3 is not within the proposed 150-ft. ROW and would not be directly impacted.

3.5 Access Roads

An access road system within and outside of the ROW would be used to construct and maintain the new transmission line. Access roads would be 16 ft. wide, with additional road widths of up to 20 ft. for curves. In addition to new access roads, existing access roads may need to be improved. New and improved roads generally would be surfaced with gravel, with appropriate design for drainage and erosion control.

Access roads would be located to avoid the identified wetlands where possible.

3.6 Substation

One wetland of about 7 ac. size is located within the footprint of the Echo Lake Substation expansion. Wetland E-1 is located at the base of the hillslope within a depressional area to the east and south of the current Echo Lake Substation. The wetland is a mixture of palustrine scrub-shrub and palustrine emergent vegetation communities. Water emerges within the proposed expansion area as a seep, draining over the surface to the west of the proposed substation expansion area into the existing Raver-Echo Lake transmission line ROW.

4.0 Environmental Consequences

For all transmission line alternatives, impacts to wetlands would occur during construction and operation (maintenance). Impacts to wetlands could occur during construction of new roads or widening of existing access roads, clearing vegetation within the 150-ft. wide ROW, preparation and clearing vegetation for staging and materials storage areas, clearing vegetation for work areas, and clearing and grubbing for construction of tower footings. Operational impacts to wetlands could include the periodic removal of vegetation within or adjacent to wetlands to ensure proper clearance to conductors.

A **high impact** to wetlands would occur if the project:

- Permanently altered wetland hydrology, vegetation, and/or soils by excavation or fill, and the ecological integrity of a wetland was impaired; or

- Completely filled a wetland or destroyed a wetland function.

A moderate impact would occur if the project:

- Partially filled a wetland or degraded a wetland function. Recovery generally would require restoration and monitoring.

A **low impact** would occur if the project:

- Changed vegetation or soils for the short term but did not change hydrology; or

- Caused a short-term disruption of a wetland function.

No impact would occur if the project avoids wetlands and their buffers; if new or widened access roads do not affect wetlands and buffers; if construction, operation, and maintenance of facilities does not affect wetlands and buffers; or if the size, quality, and functions of existing wetlands are not reduced.

4.1 Construction Impacts

4.1.1 Impacts Common to All Action Alternatives

4.1.1.1 Impacts

Each transmission line ROW would cross stream channels, valleys, and other landforms supporting wetlands. The conductor would span wetlands, and new structures and roads would be sited to avoid wetlands wherever possible. A 150-ft. wide ROW generally would be cleared of all trees, except when crossing steep, deep drainages or in other locations where conductor clearance was sufficient.

Direct construction impacts within wetlands would occur from hand-clearing the ROW for conductor span, and from permanent fill resulting from access road construction. No towers would be placed in wetland areas. Although clearing of forested wetland areas would impair the ecological integrity of the wetland, no mechanical land clearing would occur in forested wetlands within the transmission line corridor. To minimize soil disturbance within forested wetlands, trees would be hand felled and stumps would remain in place. Additionally, no new access roads or towers would be placed within mature forested wetlands (as defined in Washington State Department of Ecology's Washington State Wetlands Rating System for Western Washington, Second Editions [August 1993, Publication 93-74]). Clearing activities would result in the loss of vegetation and other habitat features such as stumps, downed logs, and snags. Soil disturbance from these activities could injure or kill plants if large portions of the plant roots or aboveground shoots were cut or damaged. Soil disturbance from land clearing would result in an increase of sedimentation within wetlands and promote erosion on steep slopes common to the Brew Hill area. The removal of forested vegetation would also effect evapotranspiration rates and would increase soil and water temperatures due to the lack of shading.

The majority of new roads would be short spurs from the existing tower locations to the new adjacent tower locations. However, new road segments would be constructed within the new corridor to avoid potential wetland impacts that would occur from constructing roads within the existing corridor. Wetlands located directly adjacent to the existing roads would be filled during widening of the road prism. On average, existing roads are 10-feet wide, and need to be widened to 16-feet wide. Road widening would consist of grading the current road surface and adding crushed rock 4 to 6 feet beyond the current road edge. Existing drainage devices such as water bars, and roadside ditches need to be replaced or repaired. Several culverts would be installed with the construction of new roads crossing either wetland areas or streams. The placement of impervious road surface in wetlands would impair the function to infiltrate surface water and discharge groundwater, alter surface and subsurface flows, destroy wildlife habitat, and result in increases in sedimentation and pollutants entering the adjacent wetland area.

Indirect impacts to wetlands could occur from construction activities adjacent to wetlands such as staging and material storage areas, work areas, the placement of tower footings, and construction or widening of access roads and spurs. Indirect impacts to wetlands and water resources from construction activities adjacent to wetlands could result in short-term increases in sedimentation and pollutants from ground disturbance and machinery operation, the removal of upland wildlife habitat, increases in surface water temperatures from the lack of vegetative shading, and the introduction of invasive plant species such as reed canarygrass and Douglas' spirea which already grow within the existing transmission line corridor.

Wetland Impact Avoidance and Minimization—Ecology and NEPA guidelines prioritize first reducing impacts through avoidance and minimization and then rectifying and compensating for unavoidable impacts. Criteria used by BPA to select the alternative ROW included avoiding known high-quality natural resources such as wetlands and streams. Any wetlands identified along the selected transmission line ROW would be avoided where feasible. Feasibility would be determined by land ownership, road configuration, spanning to avoid wetlands, construction costs, reducing sharp angles and bends in the ROW, and access.

Vegetation Impacts—Vegetation impacts from construction would include clearing shrubs, trees, and herbaceous vegetation from wetlands and wetland buffers. Vegetation within the construction ROW would be cut and removed, leaving roots intact where possible. Trees cut within and adjacent to forested wetlands would result in a permanent modification of that wetland type to either an emergent or shrub-scrub condition. Forested wetlands where vegetation would be permanently altered to shrub-scrub and emergent communities would experience greater impacts than other wetland areas. The low-growing vegetation within herbaceous and scrub-shrub wetlands is generally compatible with the vegetation height requirements for conductor clearance.

Hydrology Impacts—Construction-related activities could impact the hydrology of wetlands within and immediately adjacent to the cleared ROW and substation facilities. Construction could affect wetland hydrology by:

- Filling wetlands for road access or widening for tower construction;

- Altering the subbasin that drains to a particular wetland by diverting surface and subsurface flows from grading and road construction;

- Altering evapotranspiration by modifying vegetation; and
- Increasing soil and water temperatures as a result of less shading.

Construction within or adjacent to wetlands associated with streams or other surface water could also adversely affect those surface water resources. Factors that determine the risk of altering wetland hydrology include the source of water for the wetland (e.g., groundwater, surface runoff, or streamflow), landscape position, size, surface geology, and soils.

Clearing tree cover would cause a high-level impact (as defined in Section 4.0) to forested wetlands. Tower and road construction would generally avoid wetland areas, which would allow hydric soils within forested wetlands within the ROW to be maintained. However, wetland hydroperiod (seasonal occurrence of flooding and/or soil saturation) would change with the removal of trees and resulting reduced evapotranspiration and forest litter; increased storm runoff volumes and delivery rates to adjacent waters would be expected (Reinelt and Taylor 1997).

Water Quality Impacts—The reduction in forested cover within wetlands and construction of new roads could result in degradation of water quality (Horner et al. 1997). Construction activities could introduce sediments into wetlands and thereby degrade the water quality of the wetlands if preventive measures are not taken. The most likely source of sediment would be construction of roads, staging areas, and excavation for tower footings. Construction of tower footings could require dewatering to maintain safe working conditions and conditions suitable for pouring the footings.

Wildlife Impacts—Removal of vegetation within and adjacent to wetlands could affect wildlife habitat and use in those wetlands. Because of the need to maintain low-growing vegetation for safety, the impacts to vegetative cover in forested wetlands would be more dramatic than the impacts to other wetland areas. The change in vegetative cover from trees and snags to low-growing scrub-shrub or emergent vegetation would impact wildlife species. Wildlife that depend on forested wetlands (e.g., cavity-dwelling birds and mammals) would be most impacted by construction due to loss of habitat (Richter and Azous 1997).

4.1.1.2 Mitigation

Standard mitigation measures to minimize wetland impacts include the following:

- Locate structures and new roads to avoid wetlands and buffers.
- Avoid any activities within designated King County wetland buffers (Ordinance #9614).
- Do not perform mechanized clearing within wetlands.
- Use helicopters during construction to minimize the need for use of roads and avoid impacts to wetlands.
- Limit disturbance to the minimum necessary when working in and immediately adjacent to wetlands.
- Locate construction staging areas outside of wetlands and associated buffers.
- Delineate wetlands before final design and flag for avoidance during construction.

- Use erosion control measures when conducting any earth disturbance upslope of wetlands to ensure soil is not washed downhill during storms.
- Ensure that the hydrology of wetlands and associated streams is maintained wherever the ROW crosses these resources. This can be accomplished by ensuring that landforms are regraded to pre-existing conditions, and that connectivity is maintained between streams and wetlands.
- Stockpile wetland topsoil when excavating and redeposit soil in place for restoration following construction.
- Minimize impacts to wetlands as described in WDNR Forest Practices Rules (WAC 222) regulations.
- Return temporary construction roads to their original contours following construction to reestablish pre-project surface water flow patterns.
- Ensure noxious weed infestations do not become a problem in wetlands by washing all construction vehicles and conducting a weed inventory one year after construction to verify that weeds have not been introduced.
- Avoid clearing vegetation within forested wetlands wherever possible.
- Use vehicle crossing mats to support equipment used during construction to minimize wetland soil compaction.

4.1.1.3 Cumulative Impacts

Filling or adverse modification of wetlands would result in the incremental reduction of wetland acreage and function within the watersheds of the project area. This could be offset through mitigation and restoration of degraded wetlands within the affected watersheds.

In the future, the transmission line ROW would be a logical choice for construction of other linear projects, including additional transmission lines, fiber optic cables, or pipelines. The decision to create a new corridor in this area could increase the likelihood of such proposals.

4.1.1.4 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

Unavoidable effects and commitment of wetland resources would be dependent on the final siting decisions for towers, roads, and other facilities. Siting of facilities to avoid wetlands could avoid or reduce the unavoidable, irreversible, or irretrievable effects.

4.1.2 Substation Impacts

4.1.2.1 Impacts

Expansion of the substation would impact less than 1 ac. of wetlands (Table 3).

Table 3. Acreage of Wetland Impact from Vegetation Clearing by Transmission Line Alternatives

Alternative	Acres of Wetland Impact
1	13.81
2	14
3	6
4a	14
4b	15
Substation	< 1
[1]As calculated using wetland boundaries surveyed in April 2001 (Figure 4)	

The wetland that would be affected is composed of a monotypic stand of sapling red alder. Wetland functions related to wildlife habitat, flood storage and flood flow moderation, and water quality improvement are low. Functional impacts to this wetland resulting from clearing would be minimal.

4.1.2.2 Mitigation

Wetland E-1 (Figure 3) is small and could be avoided. Mitigation would be the same as described in Section 4.1.1.2.

4.1.2.3 Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources

High-level impacts to wetlands from towers, roads, and expansion of the substation could be largely avoided.

4.1.3 Alternative Transmission Line Impacts

4.1.3.1 Alternative 1: Preferred Alternative

Impacts—The 150-ft. wide cleared ROW would cross a total of 13.9 ac. of wetlands (Table 3). A total of 13.2 acres of these wetlands have palustrine forested components that would be cleared of deciduous and coniferous trees. The construction of new and improved access roads would fill approximately 0.6 acres of wetlands within the proposed and existing corridor. Wetlands surveyed within the Alternative 1 ROW consisted primarily of palustrine scrub-shrub and palustrine forested types. The majority of wetlands were low-gradient, depressional wetlands, however several seep wetlands are present on the south and north slopes of Brew Hill. Major streams and rivers associated with wetlands within the Alternative 1 ROW include the Raging River, Rock Creek, and Cedar River.

Clearing would cause a high-level impact to forested wetlands and their buffers. The permanent alteration of forested wetland community to scrub-shrub wetland community would degrade wildlife habitat, lower flood flow and flood storage capability, alter hydrology through changes in evapotranspiration rates, lower water quality improvement functions, and increase soil and water temperatures through the reduction of shading. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

An estimated total of 0.6 acres of wetland would be filled by the construction of new access roads and the upgrade of existing access roads supporting Alternative 1. Of the 0.6-acre of wetland to be permanently filled, 0.1-acre of wetland impact would occur within the 150-foot Alternative 1 ROW. Impacts from new access road construction within the proposed ROW would be to young red alder dominated palustrine forested wetlands adjacent to the cleared corridor. The majority of impacts from development of the access roads network would occur to palustrine scrub-shrub and emergent wetlands established within the existing transmission line corridor. Although these wetlands do provide important groundwater discharge and recharge, and water quality functions, they are currently dominated by invasive shrub and herbaceous plant species due to the cutting and suppression of trees under the existing transmission line.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 1 would include:

- Towers should be sited to span the sinkhole associated with wetland 1-9, resulting in no clearing impact.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 1.

4.1.3.2 Alternative 2

Impacts—The 150-ft. wide cleared ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts associated with this alternative would include all of the wetland impacts described for the shared portion of Alternative 1. Additional impacts associated with Alternative 2 would result from the portion of the ROW originating from a tap point located approximately 2 mi. east of the tap point for Alternative 1 (S25, T22N, R7E), traversing approximately 3 mi. to S11, T22N, R7E, before continuing north along the same ROW as Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 2 would include:

- Towers should be sited to span the sinkhole associated with wetland 1-9, resulting in no clearing impact.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 2.

4.1.3.3 Alternative 3

Impacts—Along Alternative 3, wetland impacts were calculated for the 150-ft. wide ROW centerline and also for the remaining 350-ft. within a 500-ft. corridor (including 175 ft. west and 175 ft. east of Alternative 3). The 150-ft. centerline for Alternative 3 would impact a total of 6 ac. of wetlands (Table 2).

In comparison to the Alternative 3 centerline, if the transmission line were located in the corridor west of the centerline, a total of 10 ac. of wetlands would be impacted, 4 ac. more than the centerline. If the transmission line were located in the corridor east of the centerline, a total of 6 ac. of wetlands would also be impacted.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 3 would include:

- Towers should be placed to span wetland 3-9 at the crossing of Canyon Creek and vegetation clearing should be avoided within the wetland.

- Constructing the line in the 150-ft. ROW centerline would minimize clearing in wetlands, compared to placing the line in the western or eastern portions of the 500-ft. corridor.

- Utilizing the existing cleared ROW paralleling Pole Line Road would reduce the amount of tree removal and associated impacts.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 3.

4.1.3.4 Alternative 4a

Impacts—The 150-ft. wide ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts would include those described with the shared portions of the Alternative 1 ROW and the southern portion of the Alternative 2 ROW. Additional impacts associated with Alternative 4a were determined from 1 mi. of the ROW located between Alternatives 1 and 2. This portion of the ROW begins one-third of the way along Alternative 2 (S24, T22N, R7E) and connects with Alternative 1 (S23, T22N, R7E) further south than where Alternative 2 reconnects (S11, T22N, R7E), before continuing north along Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 4a would include:

- Site towers to span the sinkhole associated with wetland 1-9, resulting in no impacts from clearing.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 4a.

4.1.3.5 Alternative 4b

Impacts—The 150-ft. wide ROW would impact a total of 14 ac. of wetlands (Table 2). Wetland impacts would include all of the wetland impacts described with the shared portions of the Alternative 1 ROW and the southern portion of the Alternative 2 ROW. Additional impacts associated with Alternative 4b would result from the portion of the ROW traversing between Alternatives 1 and 2 by paralleling Pole Line Road, before continuing north along Alternative 1.

Clearing would cause a moderate-level impact to forested wetlands. Wildlife habitat, flood flow and flood storage, and water quality functions could be degraded. Scrub-shrub and open water wetlands would experience moderate, low, or no impact assuming the wetlands could be avoided or spanned and that soils, hydrology, and vegetation were maintained.

Mitigation—Mitigation measures specific to the wetland resources along Alternative 4b would include:

- Utilize the existing cleared ROW paralleling Pole Line Road, to reduce the amount of tree removal and associated impacts.

- Site towers to span the sinkhole associated with wetland 1-9, resulting in no impacts from clearing.

- Minimize road construction and strategically site towers to avoid wetlands 1-3 and 1-4 to minimize impacts to wetlands within the headwaters of Rock Creek.

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands are avoided during construction, the project would result in the loss of wetlands from the construction of towers, clearing for the ROW and roads, and construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by Alternative 4b.

4.1.3.6 Access Roads

Impacts—New access roads would be required to construct each of the alternatives. Where possible, new access roads would avoid identified wetlands for any of the proposed transmission line alternatives where practical.

New road construction could carry sediment into wetlands, affecting water quality and biological productivity. However, use of erosion and sediment control devices would minimize these impacts. Wetlands within the ROW and adjacent to access roads would be subject to soil compaction and vegetation damage from vehicles carrying heavy construction machinery and transmission line structures.

Mitigation—Mitigation measures specific to the construction of access roads within the project area would include:

- Utilize existing road systems to access tower locations and for the clearing of the transmission line ROW.

- Maintain properly functioning drainage control devices.

- Avoid construction on steep slopes and geologically unstable areas.

- Avoid constructing steep road grades.

- Construct roads consistent with the WDNR Forest Practices Rules (WAC 222).

Please also refer to Section 4.1.1.2 for discussion of mitigation common to all action alternatives.

Unavoidable Effects, Irreversible, or Irretrievable Commitment of Resources—Unless wetlands were avoided during construction, the project would result in the loss of wetlands from the construction and filling for access roads. This commitment of wetland resources could occur in all watersheds crossed by the preferred alternative.

4.1.3.7 No Action Alternative

Current levels of impacts to wetland resources along the existing Raver-Echo Lake transmission line ROW would continue under the No Action Alternative.

4.2 Operation and Maintenance Impacts

4.2.1 Impacts Common to All Action Alternatives

4.2.1.1 Impacts

Maintenance of the 150-ft. transmission ROW and substations would require the periodic removal of trees to ensure a safe distance to the conductors. Tree clearing would be accomplished as routine maintenance in forested wetlands and their buffers where trees may grow to a height that conflicts with the operation of the transmission line.

Moderate-level wetland impacts would also occur where the forest cover was removed and permanently maintained as scrub-shrub or emergent vegetation.

4.2.1.1 Mitigation

Standard mitigation measures to minimize impacts to wetland resources during operation and maintenance of the transmission line would include:

- Require contractors to use manual methods within wetlands.
- Limit disturbance to the minimum necessary when working in and immediately adjacent to wetlands.
- Use erosion control measures when conducting any earth disturbance upslope of wetlands to ensure that soil is not washed downhill during storm events.
- Minimize impacts to wetlands consistent with the WDNR Forest Practices Rules (WAC 222) regulations.
- Avoid clearing vegetation within forested wetlands wherever possible.

4.2.1.2 Cumulative Impacts

Loss or modification of wetlands would result in an incremental reduction in wetland functions within the watersheds of the project area.

4.2.1.3 Unavoidable, Irreversible, or Irretrievable Impacts

Forested wetlands would be permanently modified through the removal of trees and maintenance of shrub-scrub wetland communities. Wildlife habitat, flood flow and flood storage moderation, and water quality functions would be permanently degraded. This commitment of wetland resources could occur in all watersheds crossed by the preferred alternative.

4.2.2 Access Roads

4.2.2.1 Impacts

Access roads used for maintenance of towers and the vegetation within the transmission line could carry sediment into wetlands, affecting water quality and biological productivity. Truck travel, exposed soil, and malfunctioning drainage control devices could result in low- to moderate-level impacts.

4.2.2.2 Mitigation

Mitigation measures specific to the operation and maintenance of access roads within the project area would include:

- Utilize existing road systems to access tower locations and for the clearing of the transmission line ROW.
- Maintain properly functioning drainage control devices on all roads.
- Repair degraded road surfaces.
- Decommission unused roads.

Please also refer to Section 4.2.1.2 for discussion of mitigation common to all action alternatives.

4.2.3 Substation

No additional wetland impacts would occur from the operation and maintenance of the substation.

4.2.4 No Action Alternative

Current levels of impacts to wetlands along the existing Raver-Echo Lake transmission line ROW would continue under the No Action Alternative. No impacts related to the proposed transmission line project would occur.

5.0 Environmental Consultation, Review and Permit Requirements

Several federal laws and administrative procedures must be met by the alternatives. This section lists and briefly describes requirements that could apply to wetland elements of this project.

5.1 Discharge Permits Under the Clean Water Act

5.1.1 Section 401

Section 401 of the CWA, the State Water Quality Certification program, requires that states certify compliance of federal permits and licenses with state water quality requirements. A federal permit to conduct an activity that results in discharges into waters of the United States, including wetlands, is issued only after the affected state certifies that existing water quality standards would not be violated if the permit were issued.

5.1.2 Section 402

The CWA Section 402 program, also known as the National Pollutant Discharge Elimination System (NPDES) program, regulates the discharge of pollutants from point sources into waters of the United States (other than dredged or fill material, which is covered under Section 404).

5.1.3 Section 404

Authorization from the Corps is required in accordance with the provisions of Section 404 of the CWA when there is a discharge of dredge or fill material into waters of the United States, including wetlands. This includes excavation activities that result in the discharge of dredged material that could destroy or degrade waters of the United States.

This project, with mitigation measures as stated, would meet the standards outlined by the CWA.

5.2 Other Standards and Guidelines

5.2.1 Cedar River Watershed Habitat Conservation Plan

The CRW HCP (City of Seattle 2000) was prepared by Seattle Public Utilities to establish a comprehensive plan for long-term management of the CRW. The HCP includes numerous provisions intended to protect wetlands and riparian habitat from degradation of function and ability to support species addressed in the HCP. Many of these provisions apply management procedures such as the designation of wetland reserve areas, and the establishment of adequate wetland buffers, as part of the Stream and Riparian Conservation Strategy component of the HCP. Specifically, the HCP allows timber harvest and road construction within wetlands and wetland buffers only in limited circumstances. For activities in wetlands and their buffers, the City of Seattle would consult with the state and federal agencies regarding measures to minimize and mitigate the impacts.

5.2.2 Washington Department of Natural Resources

The WDNR Forest Practices Rules (WAC 222) describe the types of forest practices allowed under the State of Washington Forest Practices Act (RCW 76.09). They divide forest practices into four classes based on potential impacts to public resources, and they classify wetlands as either Forested, Nonforested Type A, or Nonforested Type B. Specific wetland management zones and permitted practices within each management zone are applied to each wetland class.

5.2.3 King County Department of Development and Environmental Services

The King County Department of Development and Environmental Services reviews public and private projects under the King County Sensitive Areas Ordinance (Ordinance #9614) to ensure consistency with King County Code for project activities in wetlands and wetland buffers.

6.0 Individuals and Agencies Contacted

Agencies contacted include the Corps and the City of Seattle.

7.0 List of Preparers

David Johnson, Wetland Biologist
Two years of experience in wetland surveys, delineations, and mitigation and regulatory compliance and permitting.
B.S., Biology, University of Minnesota, 1997.

Leigh Kienker, CAD/GIS Specialist
Thirteen years of experience in the CAD/GIS and photogrammetry industries.
M.U.P., Urban Planning, University of Washington, expected 2001.

Gregory Poremba, Project Manager
Twenty years of experience managing and preparing EISs.
Ph.D., Sociology, Washington State University, 1990.

Sean Robertson, CAD/GIS Specialist
Two years of experience in GIS mapping and evaluations.
B.S., Environmental and Resource Sciences, University of California – Davis, 1999.

John Soden, Wetland Biologist
Five years of experience in wetland delineation and assessment of aquatic resources, resource inventory and classification, riparian and wetlands research, and permitting assistance.
M.S., Forestry (Riparian and Wetland Research Program), University of Montana, 1999.

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9.0 Glossary and Acronyms

This chapter contains a list of acronyms, abbreviations, and technical terms used in this report. Words that would be defined in a desk-size dictionary (for example, the College Edition of the American Heritage Dictionary) are not included.

Glossary

Access roads are constructed to each structure site first to build the tower and line and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, short spurs are built to the structure site. Access roads are maintained after construction, except where they pass through cultivated land where the road is restored for crop production after construction is completed.

Alternatives refer to different choices or means to meet the need for action.

Aquifers are water-bearing rock or sediments below the surface of the earth.

Best Management Practices are a practices or a combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

Culverts are corrugated metal or concrete pipes used to carry or divert runoff water from a discharge. Culverts are usually installed under roads to prevent washouts and erosion.

Cumulative impacts are created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Cut and fill is the process by which a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (filled).

CWA signifies the Clean Water Act, a federal law intended to restore and maintain the chemical, physical, and biological integrity of the nation's waters and secure water quality.

Danger trees or high-growing brush occur in or alongside the project right-of-way and are hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owner of danger trees off the right-of-way is compensated for their value. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories: Category A contains any tree that in 15 years will grow within about 5 m (18 ft.) of conductors when the conductor is at maximum sag (100^{o} C or 212^{o} F) and is swung by 30 kg per sq/m (6 lb per sq/ft.) of wind (93 kph or 58 mph); Category B represents any tree or high-growing bush that after 8 years of growth will fall within about 2 m (8 ft.) of the conductor when it reaches maximum sag (80^{o} C or 176^{o} F) in a static position.

Dead ends are heavy towers designed for use where the transmission line loads the tower primarily in tension rather than compression. Dead ends are used in turning large angles along a line or in bringing a line into a substation.

Easement is a grant of certain rights to use a piece of land, which then becomes a "right-of-way." BPA normally acquires easements for its transmission lines. Easement includes the right to enter the ROW to build, maintain, and repair facilities.

Emergent plants have their bases submerged in water.

Endangered species are those officially designated by the USFWS and/or the NMFS as being in danger of extinction throughout all or a significant portion of their range.

Floodplain refers to a portion of a river valley adjacent to the stream channel that is covered with water when the stream overflows its banks during flood stage.

Footings are the supporting base for the transmission towers. They are usually steel assemblies buried in the ground for lattice-steel towers.

Forb is any herbaceous plant that is not a grass or grasslike.

Ford is a travelway across a stream where water depth does not prevent vehicle movement. Ford construction can include grading and stabilizing streambanks at the approaches and adding coarse fill material within the channel to stabilize the roadbed.

GIS signifies Geographic Information System, a computer system that analyzes graphical map data.

Ground wire (overhead) is wire strung from the top of one tower to the next; it shields the line against lightning strikes.

Hydrology addresses properties, distribution, and circulation of water.

Hydroperiod is the seasonal occurrence of flooding and/or soil saturation.

Insulators are ceramic or other nonconducting materials used to keep electrical circuits from jumping to ground.

Intermittent refers to periodic water flow in creeks or streams.

Jurisdictional wetlands are areas that are consistently inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated soil conditions.

Kilovolt is one thousand volts.

Lattice steel refers to a transmission tower constructed of multiple steel members that are connected together to make up the tower's frame.

Low-gradient refers to gentle slopes.

Mitigation is the step(s) taken to lessen the potential environmental effects predicted for each resource impacted by the transmission project. Mitigation may reduce the impact, avoid it completely, or compensate for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is enacted during the design and location process. Other mitigation, such as reseeding access roads with desirable grasses and avoiding weed proliferation, is taken after construction.

National Environmental Policy Act (NEPA) requires an environmental impact statement on all major federal actions significantly affecting the quality of the human environment.
(42 U.S.C. 4332 2(2)(C))

Noxious weeds are plants that are injurious to public health, crops, livestock, land, or other property.

100-year floodplains are areas that have a 1% chance of being flooded in a given year.

Perennial streams and creeks have year-round water flows.

Permeability refers to the capability of various materials to transport liquids.

Pulling site is a staging area for machinery used to string conductors.

Revegetation is reestablishment of vegetation on a disturbed site.

Right-of-way (ROW) is an easement for a certain purpose over the land of another owner, such as a strip of land used for a road, electric transmission line, pipeline, etc.

Riparian habitat is a zone of vegetation that extends from the water's edge landward to the edge of the vegetative canopy. The term is associated with watercourses such as streams, rivers, springs, ponds, lakes, or tidewater.

Sensitive species are those plants and animals identified by the USFWS for which population viability is a concern. This classification is evidenced by significant current or predicted downward trends in populations or density and significant or predicted downward trends in habitat capability.

Silt is a designation referring to individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 mm) to the lower limit of very fine sand (0.05 mm).

Substation is the fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Threatened species are those officially designated by the USFWS as likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Transmission line includes the structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Water bars are smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

Wetlands are areas where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Acronyms and Abbreviations

ac.	acre or acres
BMPs	Best Management Practices
BPA	Bonneville Power Administration
CFR	Code of Federal Regulations
Corps	U.S. Army Corps of Engineers
CRW	Cedar River Watershed
CWA	Clean Water Act
ft.	foot or feet
Ecology	Washington Department of Ecology
EIS	environmental impact statement
EPA	Environmental Protection Agency
GIS	Geographic Information System
HCP	Habitat Conservation Plan
in.	inch or inches
kV	kilovolt
mi.	mile or miles
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NWI	National Wetland Inventory
NPDES	National Pollutant Discharge Elimination System
RCW	Revised Code of Washington
ROW	right-of-way
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WAC	Washington Administrative Code
WDNR	Washington Department of Natural Resources
WRIA	Water Resource Inventory Area

Appendix A.

Common and Scientific Plant Names of Dominant Wetland Plant Species Surveyed within the Project Area

Appendix A.

Common and Scientific Plant Names of Dominant Wetland Plant Species Surveyed within the Project Area

Common Name	**Scientific Name**
Red alder	*Alnus rubra*
Western hemlock	*Tsuga heterophylla*
Western red cedar	*Thuja plicata*
Scouler's willow	*Salix scouleriana*
Salmonberry	*Rubus spectabilis*
Douglas' spirea	*Spiraea douglasii*
Soft rush	*Juncus effusus*
Redtop	*Agrostis alba*
Meadow buttercup	*Ranunculus repens*
Common cattail	*Typha latifolia*
Piggy-back plant	*Tolmiea menziesii*
Skunk cabbage	*Lysichiton americanum*
Slough sedge	*Carex obnupta*
Source: Hitchcock and Cronquist 1973.	

Appendix B.

King County Wetland Rating System

Appendix B.

King County Wetland Rating System

Class 1 Wetlands – “Class 1 wetlands” means wetlands assigned the Unique/Outstanding #1 rating in the King County Wetlands Inventory, 1983; or which meet any of the following criteria.

a. The documented presence of species listed by the federal or state government as endangered, threatened, or the presence of critical or outstanding actual habitat for those species;
b. Wetlands having 40% to 60% permanent open water in dispersed patches with two or more classes of vegetation:
c. Wetlands equal to or greater that ten acres in size and having three or more wetland classes, one of which is open water; or
d. The presence of plant associations of infrequent occurrence.

Class 2 Wetlands – “Class 2 wetlands” means wetlands assigned the Significant #2 rating in the King County Wetlands Inventory, 1983; or any wetlands which meet any of the following criteria:

a. Wetlands greater than one acre in size;
b. Wetlands equal to or less than one acre in size and having three or more wetland classes;
c. Wetlands equal to or less than one acre that have a forested wetland class;
d. Documented presence of heron rookeries or raptor nesting sites.

Class 3 Wetlands – “Class 3 wetlands” means wetlands assigned the Lesser Concern #3 rating in the King County Wetlands Inventory, 1983; or uninventoried wetlands that are equal to or less than one acre in size and that have two or fewer wetland classes.

Appendix E Electrical Effects

<u>KANGLEY – ECHO LAKE PROJECT</u>

APPENDIX E

ELECTRICAL EFFECTS

January 2001

Prepared by

T. Dan Bracken, Inc.

for

Bonneville Power Administration

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ELECTRICAL EFFECTS FROM THE PROPOSED KANGLEY – ECHO LAKE PROJECT

1.0 Introduction

The Bonneville Power Administration (BPA) is proposing to build a 500-kilovolt (kV) transmission line from the Echo Lake Substation near North Bend, Washington, to an existing BPA 500-kV near Kangley, Washington. This proposed line is known as the Kangley – Echo Lake Project. Alternative routes include construction on new right-of-way on a new corridor, on new right-of-way parallel to an existing 500-kV line, and on new right-of-way parallel to an existing 115-kV line. The purpose of this report is to describe and quantify the electrical effects of the proposed Kangley - Echo Lake line. These include the following:

- the levels of 60-hertz (Hz; cycles per second) electric and magnetic fields (EMF) at 3.28 feet (ft.) or 1 meter (m) above the ground,
- the effects associated with those fields,
- the levels of audible noise produced by the line, and
- electromagnetic interference associated with the line.

Electrical effects occur near all transmission lines, including those already present along segments of the proposed route for the Kangley - Echo Lake line. Therefore, the levels of these quantities for the proposed line are computed and compared with those from the existing lines.

The voltage on the conductors of transmission lines generates an electric field in the space between the conductors and the ground. The electric field is calculated or measured in units of volts-per-meter (V/m) or kilovolts-per-meter (kV/m) at a height of 3.28 feet (ft.) (1 meter [m]) above the ground. The current flowing in the conductors of the transmission line generates a magnetic field in the air and earth near the transmission line; current is expressed in units of amperes (A). The magnetic field is expressed in milligauss (mG), and is usually measured or calculated at a height of 3.28 ft. (1 m) above the ground. The electric field at the surface of the conductors causes the phenomenon of corona. Corona is the electrical breakdown or ionization of air in very strong electric fields, and is the source of audible noise, electromagnetic radiation, and visible light.

To quantify EMF levels along the route, the electric and magnetic fields from the proposed and existing lines were calculated using the BPA Corona and Field Effects Program (USDOE, 2000). In this program, the calculation of 60-Hz fields uses standard superposition techniques for vector fields from several line sources: in this case, the line sources are transmission-line conductors. (Vector fields have both magnitude and direction: these must be taken into account when combining fields from different sources.) Important input parameters to the computer program are voltage, current, and geometric configuration of the line. The transmission-line conductors are assumed to be straight, parallel to each other, and located above and parallel to an infinite flat ground plane. Although such conditions do not occur under real lines because of conductor sag and variable terrain, the validity and limitations of calculations using these assumptions have been well verified by comparisons with measurements. This approach was used to estimate fields for the proposed Kangley - Echo Lake line, where minimum clearances were assumed to provide worst-case (highest) estimates for the fields.

Electric fields are calculated using an imaging method. Fields from the conductors and their images in the ground plane are superimposed with the proper magnitude and phase to produce the total field at a selected location.

The total magnetic field is calculated from the vector summation of the fields from currents in all the transmission-line conductors. Balanced currents are assumed; the contribution of image currents in the conductive earth is not included. Peak currents for 500-kV lines were provided by BPA and are based on the projected winter peak power loads in 2006. Peak loads for an existing 115-kV line were provided by Seattle City Light (SCL). In the case of corridors with more than one line, calculations were performed for similar (maximum) current conditions on both lines. Power-flow direction for parallel lines was assumed to be in the same direction unless other information was available.

Electric and magnetic fields for the proposed line were calculated at the standard height (3.28 ft. or 1 m) above the ground (IEEE, 1987). Calculations were performed out to 300 ft. (91 m) from the centerline of the proposed line and out to 200 ft. (61 m) from the centerline of existing lines. The validity and limitations of such calculations have been well verified by measurements. Because maximum voltage, maximum current, and minimum conductor height above-ground are used, ***the calculated values given here represent worst-case conditions:*** i.e., the calculated fields are higher than they would be in practice. Such worst-case conditions would seldom occur.

The corona performance of the proposed line was also predicted using the BPA Corona and Field Effects Program (USDOE, undated). Corona performance is calculated using empirical equations that have been developed over several years from the results of measurements on numerous high-voltage lines (Chartier and Stearns, 1981; Chartier, 1983). The validity of this approach for corona-generated audible noise has been demonstrated through comparisons with measurements on other lines all over the United States (IEEE Committee Report, 1982). The accuracy of this method for predicting corona-generated radio and television interference from transmission lines has also been established (Olsen et al., 1992). Of the methods available for predicting radio interference levels, the BPA empirical equivalent method agrees most closely with long-term data. Important input parameters to the computer program are voltage, current, conductor size, and geometric configuration of the line.

Corona is a highly variable phenomenon that depends on conditions along a length of line. Predictions of the levels of corona effects are performed to account for this statistical nature. Calculations of audible noise and electromagnetic interference levels were made under conditions of an estimated average operating voltage (540 kV for the proposed line) and with the average line height (47.5 ft. or 14 m). Levels of audible noise, radio interference, and television interference are predicted for both fair and foul weather; however, corona is basically a foul-weather phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Along the alternative routes of the proposed Kangley - Echo Lake transmission line, such conditions are expected to occur about 19 percent of the time during a year, based on hourly records for Sea-Tac airport from 1995 to 1999. Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude of 1500 ft. (457 m) was assumed.

2.0 Physical Description

2.1 Proposed Line

The Kangley - Echo Lake line would be a three-phase, single-circuit design with a maximum phase-to-phase voltage of 550 kV. The average voltage of the line would be 540 kV. The maximum electrical current on the line would be 2400 A. The estimated currents in each phase are based on the projected normal winter peak load in 2006, as determined in the case studies prepared under BPA's "Northern Intertie Long Range Planning Study" (USDOE, 2000). These loads assume that 100 percent of BPA's Canadian Entitlement obligations will be delivered into British Columbia. The load factor for these loads is 0.45 (average load = peak load x load factor). BPA and SCL provided the physical and operating characteristics of the proposed and existing lines.

The physical dimensions and electrical characteristics for the configuration of the proposed line are shown in Figure 1, and summarized in Table 1. The three 1.302-inch (in.) (3.31-centimeter (cm)) diameter conductors for each phase (ACSR: steel reinforced aluminum conductors) would be arranged in an inverted triangle bundle configuration with 17-in. (43.3-cm) spacing between conductors. Voltage and current waves are displaced by 120° in time (one-third of a cycle) on each electrical phase. The conductor bundles would be arranged in a delta or triangular configuration on steel towers, as shown in Figure 1. The horizontal phase spacing between the lower conductor bundles would be 40 ft. (12.2 m). The vertical spacing between the upper and lower conductor bundles would be 28.7 ft. (8.8 m). Minimum conductor-to-ground clearance would be 33 ft. (10.1 m) at a conductor temperature of 122°F (50°C), which represents maximum operating conditions and high ambient air temperatures; clearances above ground would be greater under normal operating temperatures. The average clearance above ground will be approximately 47 ft. (14.3 m); this value was used for corona calculations. At road crossings, the ground clearance would be at least 47.5 ft. (14.5 m). The 33-ft. (10.1-m) minimum clearance provided by BPA is greater than the minimum distance of the conductors above ground required to meet the National Electric Safety Code (NESC) (IEEE, 1990). The final design of the proposed line could entail larger clearances. The right-of-way width for the proposed line would be 150 ft. (45.7 m).

2.2 Existing Lines

The proposed Kangley - Echo La—ke 500-kV line could parallel the existing BPA Raver - Echo Lake 500-kV line and/or an SCL 115-kV line along different segments of the alternative routes. Three possible configurations were identified, including the new right-of-way with no parallel line (Table 2). A very short segment of the proposed route on BPA property immediately south of the Echo Lake Substation was not included.

BPA provided information on currents for the Raver - Echo Lake 500-kV line. SCL provided currents information for the Cedar Falls – Fairwood 115-kV line; the information is based on actual currents during 1999. This line is fed by a hydro generation plant; the peak loads for 1999, a high-water year, were assumed to apply for subsequent years.

The physical and electrical characteristics of the corridor configurations that were analyzed are given in Table 1; cross-sections of the corridors are shown in Figure 1. Two almost-equivalent conductor configurations are present for the SCL 115-kV line. The use of one of those configurations and an assumption of the electrical phasing for the SCL 115-kV line does not substantially change the predicted field levels along the corridor.

3.0 Electric Field

3.1 Basic Concepts

An electric field is said to exist in a region of space if an electrical charge, at rest in that space, experiences a force of electrical origin (i.e., electric fields cause free charges to move). Electric field is a vector quantity: that is, it has both magnitude and direction. The direction corresponds to the direction that a positive charge would move in the field. Sources of electric fields are unbalanced electrical charges (positive or negative) and time-varying magnetic fields. Transmission lines, distribution lines, house wiring, and appliances generate electric fields in their vicinity because of unbalanced electrical charge on energized conductors. The unbalanced charge is associated with the voltage on the energized system. On the power system in North America, the voltage and charge on the energized conductors are cyclic (plus to minus to plus) at a rate of 60 times per second. This changing voltage results in electric fields near sources that are also time-varying at a frequency of 60 Hz (a frequency unit equivalent to cycles per second).

As noted earlier, electric fields are expressed in units of volts per meter (V/m) or kilovolts (thousands of volts) per meter (kV/m). Electric- and magnetic-field magnitudes in this report are expressed in root-mean-square (rms) units. For sinusoidal waves, the rms amplitude is given as the peak amplitude divided by the square root of two.

The spatial uniformity of an electric field depends on the source of the field and the distance from that source. On the ground, under a transmission line, the electric field is nearly constant in magnitude and direction over distances of several feet (1 meter). However, close to transmission- or distribution-line conductors, the field decreases rapidly with distance from the conductors. Similarly, near small sources such as appliances, the field is not uniform and falls off even more rapidly with distance from the device. If an energized conductor (source) is inside a grounded conducting enclosure, then the electric field outside the enclosure is zero, and the source is said to be shielded.

Electric fields interact with the charges in all matter, including living systems. When a conducting object, such as a vehicle or person, is located in a time-varying electric field near a transmission line, the external electric fields exert forces on the charges in the object, and electric fields and currents are induced in the object. If the object is grounded, then the total current induced in the body (the "short-circuit current") flows to earth. The distribution of the currents within, say, the human body, depends on the electrical conductivities of various parts of the body: for example, muscle and blood have higher conductivity than bone and would therefore experience higher currents.

At the boundary surface between air and the conducting object, the field in the air and perpendicular to the conductor surface is much, much larger than the field in the conductor itself. For example, the average surface field on a human standing in a 10 kV/m field is 27 kV/m; the internal fields in the body are much smaller: approximately 0.008 V/m in the torso and 0.45 V/m in the ankles.

3.2 Transmission-line Electric Fields

The electric field created by a high-voltage transmission line extends from the energized conductors to other conducting objects such as the ground, towers, vegetation, buildings, vehicles, and people. The calculated strength of the electric field at a height of 3.28 ft. (1 m) above an unvegetated, flat earth is frequently used to describe the electric field under straight parallel transmission lines. The most important transmission-line parameters that determine the electric field at a 1-m height are conductor height above ground and line voltage.

Calculations of electric fields from transmission lines are performed with computer programs based on well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values under these conditions represent an ideal situation. When practical conditions approach this ideal model, measurements and calculations agree. Often, however, conditions are far from ideal because of variable terrain and vegetation. In these cases, fields are calculated for ideal conditions, with the lowest conductor clearances to provide upper bounds on the electric field under the transmission lines. With the use of more complex models or empirical results, it is also possible to account accurately for variations in conductor height, topography, and changes in line direction. Because the fields from different sources add vectorially, it is possible to compute the fields from several different lines if the electrical and geometrical properties of the lines are known. However, in general, electric fields near transmission lines with vegetation below are highly complex and cannot be calculated. Measured fields in such situations are highly variable.

For evaluation of EMF from transmission lines, the fields must be calculated for a specific line condition. The NESC states the condition for evaluating electric-field-induced short-circuit current for lines with voltage above 98 kV, line-to-ground, as follows: conductors are at a minimum clearance from ground corresponding to a conductor temperature of 120°F (49°C), and at a maximum voltage (IEEE, 1990). BPA has supplied the needed information for calculating electric and magnetic fields from the proposed transmission lines: the maximum operating voltage, the estimated peak current in 2006, and the minimum conductor clearances.

There are standard techniques for measuring transmission-line electric fields (IEEE, 1987). Provided that the conditions at a measurement site closely approximate those of the ideal situation assumed for calculations, measurements of electric fields agree well with the calculated values. If the ideal conditions are not approximated, the measured field can differ substantially from calculated values. Usually the actual electric field at ground level is reduced from the calculated values by various common objects that act as shields.

Maximum or peak field values occur over a small area at midspan, where conductors are closest to the ground. As the location of an electric-field profile approaches a tower, the conductor clearance increases, and the peak field decreases. A grounded tower will reduce the electric field considerably by shielding. For the parallel line configurations considered here, minimum conductor clearances were assumed to occur along the same lateral profile for both lines. This condition will not necessarily occur in practice, because the towers for the parallel lines may be offset or located at different elevations. The assumption of simultaneous minimum clearance results in peak fields that may be larger than what occurs in practice.

For traditional transmission lines, such as the proposed line, where the right-of-way extends laterally well beyond the conductors, electric fields at the edge of the right-of-way are not as sensitive as the peak field to conductor height. Computed values at the edge of the right-of-way for any line height are fairly representative of what can be expected all along the transmission-line corridor. However, the presence of vegetation on and at the edge of the right-of-way will reduce actual electric-field levels below calculated values.

3.3 Calculated Values of Electric Fields

Table 3 shows the calculated values of electric field at 3.28 ft. (1 m) above ground for the proposed Kangley - Echo Lake 500-kV transmission-line corridors. The peak value on the right-of-way and the value at the edge of the right-of-way are given for the three proposed corridor configurations and for minimum and average conductor clearances. Figure 2a shows lateral profiles for the electric field from the proposed line for the minimum and average line heights. Figures 2b–c show calculated fields for the two corridors with parallel lines.

The calculated peak electric field expected on the right-of-way of the proposed line is 8.9 kV/m for all configurations. As shown in Figure 2a, the peak values would be present only at locations directly under the line, near mid-span, where the conductors are at the minimum clearance. The conditions of minimum conductor clearance at maximum current and maximum voltage occur very infrequently. The calculated peak levels are rarely reached under real-life conditions, because the actual line height is generally above the minimum value used in the computer model, because the actual voltage is below the maximum value used in the model, and because vegetation within and near the edge of the right-of-way tends to shield the field at ground level. Maximum electric fields under the existing parallel 500-kV and 115-kV transmission lines are 8.4 and 0.5 kV/m, respectively.

The largest values expected at the edge of the right-of-way nearest the proposed line would be 2.1 kV/m. On the other edge of the right-of-way, the field would vary with the line configuration present. The largest fields at the edges of the existing rights-of-way are 1.8 and 0.3 kV/m for the 500- and 115-kV lines, respectively.

3.4 Environmental Electric Fields

The electric fields associated with the Kangley - Echo Lake line can be compared with those found in other environments. Sources of 60-Hz electric (and magnetic) fields exist everywhere electricity is used; levels of these fields in the modern environment vary over a wide range. Electric-field levels associated with the use of electrical energy are orders of magnitude greater than the naturally occurring 60-Hz fields of about 0.0001 V/m, which stem from atmospheric and extraterrestrial sources.

Electric fields in outdoor, publicly accessible places range from less than 1 V/m to 12 kV/m; the large fields exist close to high-voltage transmission lines of 500 kV or higher. In remote areas without electrical service, 60-Hz field levels can be much lower than 1 V/m. Electric fields in home and work environments generally are not spatially uniform like those of transmission lines; therefore, care must be taken when making comparisons between fields from different sources such as appliances and electric lines. In addition, fields from all sources can be strongly modified by the presence of conducting objects. However, it is helpful to know the levels of electric fields generated in domestic and office environments in order to compare commonly experienced field levels with those near transmission lines.

Numerous measurements of residential electric fields have been reported for various parts of the United States, Canada, and Europe. Although there have been no large studies of residential electric fields, sufficient data are available to indicate field levels and characteristics. Measurements of domestic 60-Hz electric fields indicate that levels are highly variable and source-dependent. Electric-field levels are not easily predicted because walls and other objects act as shields, because conducting objects perturb the field, and because homes contain numerous localized sources. Internal sources (wiring, fixtures, and appliances) seem to predominate in producing electric fields inside houses. Average measured electric fields in residences are generally in the range of 5 to 20 V/m. In a large occupational exposure monitoring project that included electric-field measurements at homes, average exposures for all groups away from work were generally less than 10 V/m (Bracken, 1990).

Electric fields from household appliances are localized and decrease rapidly with distance from the source. Local electric fields measured at 1 ft. (0.3 m) from small household appliances are typically in the range of 30 to 60 V/m. Stopps and Janischewskyj (1979) reported electric-field measurements near 20 different appliances; at a 1-ft. (0.3-m) distance, fields ranged from 1 to 150 V/m, with a mean of 33 V/m. In another survey, reported by Deno and Zaffanella (1982), field measurements at a 1-ft. (0.3-m) distance from common domestic and workshop sources were found to range from 3 to 70 V/m. The localized fields from appliances are not uniform, and care should be taken in comparing them with transmission-line fields.

Electric blankets can generate higher localized electric fields. Sheppard and Eisenbud (1977) reported fields of 250 V/m at a distance of approximately 1 ft. (0.3 m). Florig et al. (1987) carried out extensive empirical and theoretical analysis of electric-field exposure from electric blankets and presented results in terms of uniform equivalent fields such as those near transmission lines. Depending on what parameter was chosen to represent intensity of exposure and the grounding status of the subject, the equivalent vertical 60-Hz electric-field exposure ranged from 20 to over 3500 V/m. The largest equivalent field corresponds to the measured field on the chest with the blanket-user grounded. The average field on the chest of an ungrounded blanket-user yields an equivalent vertical field of 960 V/m. As manufacturers have become aware of the controversy surrounding EMF exposures, electric blankets have been redesigned to reduce magnetic fields. However, electric fields from these "low field" blankets are still comparable with those from older designs (Bassen et al., 1991).

Generally, people in occupations not directly related to high-voltage equipment are exposed to electric fields comparable with those of residential exposures. For example, the average electric field measured in 14 commercial and retail locations in rural Wisconsin and Michigan was 4.8 V/m (ITT Research Institute, 1984). Median electric field was about 3.4 V/m. These values are about one-third the values in residences reported in the same study. Power-frequency electric fields near video display terminals (VTDs) are about 10 V/m, similar to those of other appliances (Harvey, 1983). Electric-field levels in public buildings such as shops, offices, and malls appear to be comparable with levels in residences.

Using a small 60-Hz dosimeter, Deadman et al. (1988) measured occupational exposures over a one-week period for 20 utility workers and 16 office workers. The geometric mean of the weekly electric-field exposures during work for the 20 utility workers was 48.3 V/m, compared to 4.9 V/m for the office workers. The transmission linemen (n=2, 420 V/m) had the highest geometric mean exposures. These results are consistent with previous studies that used less sophisticated instrumentation.

In a survey of 1,882 volunteers from utilities, electric-field exposures were measured for 2,082 work days and 657 non-work days (Bracken, 1990). Electric-field exposures for occupations other than those directly related to high-voltage equipment were equivalent to those for non-work exposure.

Thus, except for the relatively few occupations where high-voltage sources are prevalent, electric fields encountered in the workplace are probably similar to those of residential exposures. Even in electric utility occupations where high field sources are present, exposures to high fields are limited on average to minutes per day.

Electric fields found in publicly accessible areas near high-voltage transmission lines can typically range up to 3 kV/m for 230-kV lines, to 10 kV/m for 500-kV lines, and to 12 kV/m for 765-kV lines. Although these peak levels are considerably higher than the levels found in other public areas, they are present only in limited areas on rights-of-way.

The calculated electric fields for the proposed Kangley - Echo Lake 500-kV transmission line are consistent with the levels reported for other 500-kV transmission lines in Washington and elsewhere. The calculated electric fields on the right-of-way of the proposed transmission line would be much higher than levels normally encountered in residences and offices.

4.0 Magnetic Field

4.1 Basic Concepts

Magnetic fields can be characterized by the force they exert on a moving charge or on an electrical current. As with the electric field, the magnetic field is a vector quantity characterized by both magnitude and direction. Electrical currents generate magnetic fields. In the case of transmission lines, distribution lines, house wiring, and appliances, the 60-Hz electric current flowing in the conductors generates a time-varying, 60-Hz magnetic field in the vicinity of these sources. The strength of a magnetic field is measured in terms of magnetic lines of force per unit area, or magnetic flux density. The term "magnetic field," as used here, is synonymous with magnetic flux density and is expressed in units of Gauss (G) or milligauss (mG).

The uniformity of a magnetic field depends on the nature and proximity of the source, just as the uniformity of an electric field does. Transmission-line-generated magnetic fields are quite uniform over horizontal and vertical distances of several feet near the ground. However, for small sources such as appliances, the magnetic field decreases rapidly over distances comparable with the size of the device.

The interaction of a time-varying magnetic field with conducting objects results in induced electric field and currents in the object. A changing magnetic field through an area generates a voltage around any conducting loop enclosing the area (Faraday's law). This is the physical basis for the operation of an electrical transformer. For a time-varying sinusoidal magnetic field, the magnitude of the induced voltage around the loop is proportional to the area of the loop, the frequency of the field, and the magnitude of the field. The induced voltage around the loop results in an induced electric field and current flow in the loop material. The induced current that flows in the loop depends on the conductivity of the loop.

4.2 Transmission-line Magnetic Fields

The magnetic field generated by currents on transmission-line conductors extends from the conductors through the air and into the ground. The magnitude of the field at a height of 3.28 ft. (1 m) is frequently used to describe the magnetic field under transmission lines. Because the magnetic field is not affected by non-ferrous materials, the field is not influenced by normal objects on the ground under the line. The direction of the maximum field varies with location. (The electric field, by contrast, is essentially vertical near the ground.) The most important transmission-line parameters that determine the magnetic field at 3.28 ft. (1 m) height are conductor height above ground and magnitude of the currents flowing in the conductors. As distance from the transmission-line conductors increases, the magnetic field decreases.

Calculations of magnetic fields from transmission lines are performed using well-known physical principles (cf., Deno and Zaffanella, 1982). The calculated values usually represent the ideal straight parallel-conductor configuration. For simplicity, a flat earth is usually assumed. Balanced currents (currents of the same magnitude for each phase) are also assumed. This is usually valid for transmission lines, where loads on all three phases are maintained in balance during operation. Induced image currents in the earth are usually ignored for calculations of magnetic field under or near the right-of-way. The resulting error is negligible. Only at distances greater than 300 ft. (91 m) from a line do such contributions become significant (Deno and Zaffanella, 1982). The clearance for magnetic-field calculations for the proposed line was the same as that used for electric-field evaluations.

Standard techniques for measuring magnetic fields near transmission lines are described in ANSI IEEE Standard No. 644-1987 (1987). Measured magnetic fields agree well with calculated values, provided the currents and line heights that go into the calculation correspond to the actual values for the line. To realize such agreement, it is necessary to get accurate current readings during field measurements (because currents on transmission lines can vary considerably over short periods of time) and also to account for all field sources in the vicinity of the measurements.

As with electric fields, the maximum or peak magnetic fields occur in areas near the centerline and at midspan where the conductors are the lowest. If more than one line is present, the peak field will depend on the relative electrical phasing of the conductors. The magnetic field at the edge of the right-of-way is not very dependent on line height. If more than one line is present, the peak field can depend on the relative electrical phasing of the conductors and the direction of power flow. Phasing information was available for the parallel 500-kV line, but not for the parallel 115-kV line. Assumption of a phasing scheme for the 115-kV line does not affect the calculated field levels on the existing or proposed corridor.

4.3 Calculated Values for Magnetic Fields

Table 4 gives the calculated values of the magnetic field at 3.28 ft. (1 m) height for the proposed 500-kV transmission-line corridors. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents during winter peak load in 2006, for minimum and average conductor clearances. This corresponds to 2400 A on each of the three phases of the proposed line. Figure 3 shows lateral profiles of maximum magnetic field under this current condition for the possible corridors of the proposed 500-kV transmission line. The actual magnetic-field levels would vary, as currents on the lines change daily and seasonally and as ambient temperature changes. Average currents over the year would be about 45 percent of the maximum values. The levels shown in the figures represent the highest magnetic fields expected for the proposed Kangley - Echo Lake 500-kV line. Average fields over a year would be considerably reduced from the peak values, as a result of increased clearances above the minimum value and reduced currents from the maximum value.

The maximum calculated 60-Hz magnetic field expected at 3.28 ft. (1 m) above ground for the proposed line is 408 mG. This field is calculated for the maximum current of 2400 A, with the conductors at a height of 33 ft. (9.1 m). The maximum field would decrease for increased conductor clearance. For an average conductor height over a span of 47 ft. (14.3 m), the maximum field would be 228 mG.

At the edge of the right-of-way of the proposed line, the calculated magnetic field for maximum current load conditions is about 92 mG. If the line were located parallel to an existing line, then the field at the edge of the right-of-way adjacent to the parallel line would depend on that line.

The magnetic field falls off rapidly as distance from the line increases. At a distance of 200 ft. (61 m) from the centerline of the proposed line, the field would be 14 mG for maximum current conditions. The calculated magnetic field for maximum current would be less than 10 mG at about 235 ft. (72 m) from the centerline.

The calculated fields for the two corridors with existing transmission lines that were analyzed are given in Table 4. For the existing lines, the peak magnetic fields on the rights-of-way are 516 mG and 5 mG, for the 500- and 115-kV lines, respectively. Fields at the edges of the existing rights-of-way are 112 mG and 2 mG for the 500- and 115-kV lines, respectively. The edge-of-right-of-way values for magnetic fields will be 48 mG for the existing 500-kV line and 28 mG for the existing 115-kV line, if the proposed line were added.

4.4 Environmental Magnetic Fields

Transmission lines are not the only source of magnetic fields; as with 60-Hz electric fields, 60-Hz magnetic fields are present throughout the environment of a society that relies on electricity as a principal energy source. The magnetic fields associated with the proposed Kangley - Echo Lake 500-kV line can be compared with fields from other sources. The range of 60-Hz magnetic-field exposures in publicly accessible locations such as open spaces, transmission-line rights-of-way, streets, pedestrian walkways, parks, shopping malls, parking lots, shops, hotels, public transportation, and so on range from less than 0.1 mG to about 1 G, with the highest values occurring near small appliances with electric motors. In occupational settings in electric utilities, where high currents are present, magnetic-field exposures for workers can be above 1 G. At 60 Hz, the magnitude of the natural magnetic field is approximately 0.0005 mG.

Several investigations of residential fields have been conducted. Short-term measurements of magnetic fields in 483 residences in the Denver area resulted in mean fields of 0.76 mG (Standard Deviation (SD) = 0.79 mG) under low-power conditions: with all appliances and lights off (Savitz, 1987). Approx- imately six percent of the low-power residences had fields greater than 2.5 mG. The high-power (appliances and lights on) mean fields for 481 residences were 1.05 mG (SD = 1.3 mG) (Savitz, 1987). The average low-power magnetic field for the 133 residences with buried-cable electrical service in the study was 0.49 mG (SD = 0.53 mG).

Kaune et al. (1987) reported on 24-hour magnetic-field measurements made in 43 residences in the Seattle area. The mean for these measurements was 1.0 mG (median = 0.6 mG; SD = 1.2 mG). The magnetic-field data demonstrated a diurnal variation that coincided with utility loads: peak values at 8 am and 6-7 pm, and minimum values very early in the morning. No correlation of magnetic field with individual power consumption in a house was observed. The Denver and Seattle studies both concluded that the predominant sources of residential magnetic fields were external to the home (e.g., transmission and distribution lines). The studies also identified ground-return currents in residences as a possible important source of residential magnetic fields.

In a large study to identify and quantify significant sources of 60-Hz magnetic fields in residences, measurements were made in 996 houses, randomly selected throughout the country (Zaffanella, 1993). The most common sources of residential fields were power lines, the grounding system of residences, and appliances. Field levels were characterized by both point-in-time (spot) measurements and 24-hour measurements. Spot measurements averaged over all rooms in a house exceeded 0.6 mG in 50 percent of the houses and 2.9 mG in 5 percent of houses. Power lines generally produced the largest average fields in a house over a 24-hour period. On the other hand, grounding system currents proved to be a more significant source of the highest fields in a house. Appliances were found to produce the highest local fields; however, fields fell off rapidly with increased distance. For example, the median field near microwave ovens was 36.9 mG at a distance of 10.5 in (0.27 m) and 2.1 mG at 46 in (1.17 m). Across the entire sample of 996 houses, higher magnetic fields were found in, among others, urban areas (vs. rural); multi-unit dwellings (vs. single-family); old houses (vs. new); and houses with grounding to a municipal water system.

In an extensive measurement project to characterize the magnetic-field exposure of the general population, over 1000 randomly selected persons in the United States wore a personal exposure meter for 24 hours and recorded their location in a simple diary (Zaffanella and Kalton, 1998). Based on the measurements of 853 persons, the estimated 24-hour average exposure for the general population is 1.24 mG and the estimated median exposure is 0.88 mG. The average field "at home, not in bed" is 1.27 mG and "at home, in bed" is 1.11 mG. Average personal exposures were found to be largest "at work" (mean of 1.79 mG and median of 1.01 mG) and lowest "at home, in bed" (mean of 1.11 mG and median of 0.49 mG). Average fields in school were also low (mean of 0.88 mG and median of 0.69 mG). Factors associated with higher exposures at home were smaller residences, duplexes and apartments, metallic rather than plastic water pipes, and nearby overhead distribution lines.

As noted above, magnetic fields from appliances are localized and decrease rapidly with distance from the source. Localized 60-Hz magnetic fields have been measured near about 100 household appliances such as ranges, refrigerators, electric drills, food mixers, and shavers (Gauger, 1985). At a distance of 1 ft. (0.3 m), the maximum magnetic field ranged from 0.3 to 270 mG, with 95 percent of the measurements below 100 mG. Ninety-five percent of the levels at a distance of 4.9 ft. (1.5 m) were less than 1 mG. Devices that use light-weight, high-torque motors with little magnetic shielding exhibited the largest fields. These included vacuum cleaners and small hand-held appliances and tools. Microwave ovens with large power transformers also exhibited relatively large fields. Electric blankets have been a much-studied source of magnetic-field exposure because of the length of time they are used and because of the close proximity to the body. Florig and Hoburg (1988) estimated that the average magnetic field in a person using an electric blanket was 15 mG, and that the maximum field could be 100 mG. New "low-field" blankets have magnetic fields at least 10 times lower than those from conventional blankets (Bassen et al., 1991).

In a domestic magnetic-field survey, Silva et al. (1989) measured fields near different appliances at locations typifying normal use (e.g., sitting at a typewriter or standing at a stove). Specific appliances with relatively large fields included can openers (n = 9), with typical fields ranging from 30 to 225 mG and a maximum value up to 2.7 G; shavers (n = 4), with typical fields from 50 to 300 mG and maximum fields up to 6.9 G; and electric drills (n = 2), with typical fields from 56 to 190 mG and maximum fields up to 1.5 G. The fields from such appliances fall off very rapidly with distance and are only present for short periods. Thus, although instantaneous magnetic-field levels close to small hand-held appliances can be quite large, they do not contribute to average area levels in residences.

Although studies of residential magnetic fields have not all considered the same independent parameters, the following consistent characterization of residential magnetic fields emerges from the data:

(1) External sources play a large role in determining residential magnetic-field levels. Transmission lines, when nearby, are an important external source. Unbalanced ground currents on neutral conductors and other conductors, such as water pipes in and near a house, can represent a significant source of magnetic field. Distribution lines per se, unless they are quite close to a residence, do not appear to be a traditional distance-dependent source.

(2) Homes with overhead electrical service appear to have higher average fields than those with underground service.

(3) Appliances represent a localized source of magnetic fields that can be much higher than average or area fields. However, fields from appliances approach area levels at distances greater than 3 ft. (1 m) from the device.

Although important variables in determining residential magnetic fields have been identified, quantification and modeling of their influence on fields at specific locations is not yet possible. However, a general characterization of residential magnetic-field level is possible: average levels in the United States are in the range of 0.5 to 1.0 mG, with the average field in a small number of homes exceeding this range by as much as a factor of 10 or more. Average personal exposure levels are slightly higher, possibly due to use of appliances and varying distances to other sources. Maximum fields can be much higher.

Magnetic fields in commercial and retail locations are comparable with those in residences. As with appliances, certain equipment or machines can be a local source of higher magnetic fields. Utility workers who work close to transformers, generators, cables, transmission lines, and distribution systems clearly experience high-level fields. Other sources of fields in the workplace include motors, welding machines, computers, and VDTs. In publicly accessible indoor areas, such as offices and stores, field levels are generally comparable with residential levels, unless a high-current source is nearby.

Because high-current sources of magnetic field are more prevalent than high-voltage sources, occupational environments with relatively high magnetic fields encompass a more diverse set of occupations than do those with high electric fields. For example, in occupational magnetic-field measurements reported by Bowman et al. (1988), the geometric mean field from 105 measurements of magnetic field in "electrical worker" job locations was 5.0 mG. "Electrical worker" environments showed the following elevated magnetic-field levels (geometric mean greater than 20 mG): industrial power supplies, alternating current (ac) welding machines, and sputtering systems for electronic assembly. For secretaries in the same study, the geometric mean field was 3.1 mG for those using VDTs (n = 6) and 1.1 mG for those not using VDTs (n = 3).

In a Canadian study, the geometric mean of the time-weighted average field for the weekly work exposure of 20 utility workers was 16.6 mG, compared to 1.6 mG for 16 office workers (Deadman et al., 1988). The geometric mean field for the office environment was comparable to that observed during non-work periods for office workers and comparable to that for both groups during sleep (when the exposure meter was not worn).

Measurements of personal exposure to magnetic fields were made for 1,882 volunteer utility workers for a total of 4,411 workdays (Bracken, 1990). Median workday mean exposures ranged from 0.5 mG for clerical workers without computers to 7.2 mG for substation operators. Occupations not specifically associated with transmission and distribution facilities had median workday exposures less than 1.5 mG, while those associated with such facilities had median exposures above 2.3 mG. Magnetic-field exposures measured in homes during this study were comparable with those recorded in offices.

Magnetic fields in publicly accessible outdoor areas seem to be, as expected, directly related to proximity to electric-power transmission and distribution facilities. Near such facilities, magnetic fields are generally higher than indoors (residential). Higher-voltage facilities tend to have higher fields. Typical maximum magnetic fields in publicly accessible areas near transmission facilities can range from less than a few milligauss up to 300 mG or more, near heavily loaded lines operated at 230 to 765 kV. The levels depend on the line load, conductor height, and location on the right-of-way. Because magnetic fields near high-voltage transmission lines depend on the current in the line, they can vary daily and seasonally. To characterize fields from the distribution system, Heroux (1987) measured 60-Hz magnetic fields with a mobile platform along 140 mi. (223 km) of roads in Montreal. The median field level averaged over nine different routes was 1.6 mG, with 90 percent of the measurements less than about 5.1 mG. Spot measurements indicated that typical fields directly above underground distribution systems were 5 to 19 mG. Beneath overhead distribution lines, typical fields were 1.5 to 5 mG on the primary side of the transformer, and 4 to 10 mG on the secondary side. At the surface of distribution poles, the magnetic field ranged from 10 to 100 mG, depending on structure type. Near ground-based transformers used in residential areas, fields were 80 to 1000 mG at the surface and 10 to 100 mG at a distance of 1 ft. (0.3 m).

The magnetic fields from the proposed 500-kV transmission line would be less than those from the existing 500-kV line in the same corridor. Thus, near the proposed line, magnetic fields would be well above average residential levels. However, the fields from the line would decrease rapidly and approach common ambient levels at distances greater than a few hundred feet from the line. Furthermore, the fields at the edge of the right-of-way would not be above those encountered during normal activities near common sources such as hand-held appliances.

5.0 Electric and Magnetic Field (EMF) Effects

Possible effects associated with the interaction of EMF from transmission lines with people on and near a right-of-way fall into two categories: short-term effects that can be perceived and may represent a nuisance, and possible long-term health effects. Only short-term effects are discussed here. The issue of whether there are long-term health effects associated with transmission-line fields is controversial. In recent years, considerable research on possible biological effects of EMF has been conducted. A review of these studies and their implications for health-related effects is provided in a separate technical report for the environmental impact statement for the proposed Kangley - Echo Lake 500-kV transmission line.

5.1 Electric Fields: Short-term Effects

Short-term effects from transmission-line electric fields are associated with perception of induced currents and voltages or perception of the field. Induced current or spark discharge shocks can be experienced under certain conditions when a person contacts objects in an electric field. Such effects occur in the fields associated with transmission lines that have voltages of 230-kV or higher. These effects could occur infrequently under the proposed Kangley - Echo Lake 500-kV line.

Steady-state currents are those that flow continuously after a person contacts an object and provides a path to ground for the induced current. The amplitude of the steady-state current depends on the induced current to the object in question and on the grounding path. The magnitude of the induced current to vehicles and objects under the proposed line will depend on the electric-field strength and the size and shape of the object. When an object is electrically grounded, the voltage on the object is reduced to zero, and it is not a source of current or voltage shocks. If the object is poorly grounded or not grounded at all, then it acquires some voltage relative to earth and is a possible source of current or voltage shocks.

The responses of persons to steady-state current shocks have been extensively studied, and levels of response documented (Keesey and Letcher, 1969; IEEE, 1978). Primary shocks are those that can result in direct physiological harm. Such shocks will not be possible from induced currents under the existing or proposed lines, because clearances above ground required by the NESC preclude such shocks from large vehicles and grounding practices eliminate large stationary objects as sources of such shocks.

Secondary shocks are defined as those that could cause an involuntary and potentially harmful movement, but no direct physiological harm. Secondary shocks could occur under the proposed 500-kV line when making contact with ungrounded conducting objects such as vehicles or equipment. However, such occurrences are anticipated to be very infrequent. Shocks, when they occur under the 500-kV line, are most likely to be at a nuisance level. Induced currents are extremely unlikely to be perceived off the right-of-way of the proposed line.

Induced currents are always present in electric fields under transmission lines and will be present near the proposed line. However, during initial construction, BPA routinely grounds metal objects that are located on or near the right-of-way. The grounding eliminates these objects as sources of induced current and voltage shocks. Multiple grounding points are used to provide redundant paths for induced current flow. After construction, BPA would respond to any complaints and install or repair grounding to mitigate nuisance shocks.

Unlike fences or buildings, mobile objects such as vehicles and farm machinery cannot be grounded permanently. Limiting the possibility of induced currents from such objects to persons is accomplished in several ways. First, required clearances for above-ground conductors tend to limit field strengths to levels that do not represent a hazard or nuisance. The NESC (1990) requires that, for lines with voltage exceeding 98 kV line-to-ground (170 kV line-to-line), sufficient conductor clearance be maintained to limit the induced short-circuit current in the largest anticipated vehicle under the line to 5 milliamperes (mA) or less. This can be accomplished by limiting access or by increasing conductor clearances in areas where large vehicles could be present. BPA and other utilities design and operate lines to be in compliance with the NESC.

For the proposed line, conductor clearances (50°C conductor temperature) would be increased to at least 47.5 ft. (14.5 m) over road crossings along the route, resulting in a maximum field of 4.4 kV/m or less at the 3.28 ft. (1 m) height. The largest truck allowed on roads in Washington without a special permit is 14 feet high by 8.5 feet wide by 75 feet long (4.3 x 2.6 x 22.9 m). The induced currents to such a vehicle oriented perpendicular to the line in a maximum field of 4.4 kV/m (at 3.28-foot height) would be 3.9 mA (Reilly, 1979). For smaller trucks, the maximum induced currents for perpendicular orientation to the proposed line would be less than this value. (Larger special-permitted trucks, such as triple trailers, can be up to 105 feet in length. However, because they average the field over such a long distance, the maximum induced current to a 105-foot vehicle oriented perpendicular to the 500-kV line at a road crossing would be 3.7 mA.) Thus, the NESC 5-mA criterion would be met for perpendicular road crossings of the proposed line. These large vehicles are not anticipated to be off highways or oriented parallel to the proposed line. As discussed below, these are worst-case estimates of induced currents at road crossings; conditions for their occurrence are rare. The conductor clearance at each road crossing would be checked during the design stage of the line to ensure that the NESC 5-mA criterion is met.

Furthermore, it is BPA policy to limit the maximum induced current from vehicles to 2 mA in commercial parking lots. Line clearances would also be increased in accordance with the NESC, such as over railroads and water areas suitable for sailboating.

Several factors tend to reduce the levels of induced current shocks from vehicles:

(1) Activities are distributed over the whole right-of-way, and only a small percentage of time is spent in areas where the field is at or close to the maximum value.

(2) At road crossings, vehicles are aligned perpendicular to the conductors, resulting in a substantial reduction in induced current.

(3) The conductor clearance at road crossings may not be at minimum values because of lower conductor temperatures and/or location of the road crossing away from midspan.

(4) The largest vehicles are permitted only on certain highways.

(5) Off-road vehicles are in contact with soil or vegetation, which reduces shock currents substantially.

Induced voltages occur on objects, such as vehicles, in an electric field where there is an inadequate electrical ground. If the voltage is sufficiently high, then a spark discharge shock can occur as contact is made with the object. Such shocks are similar to "carpet" shocks that occur, for example, when a person touches a doorknob after walking across a carpet on a dry day. The number and severity of spark discharge shocks depend on electric-field strength. Based on the low frequency of complaints reported by Glasgow and Carstensen (1981) for 500-kV ac transmission lines (one complaint per year for each 1,500 mi. or 2400 km of 500-kV line), nuisance shocks, which are primarily spark discharges, do not appear to be a serious impediment to normal activities under 500-kV lines.

In high electric fields, it is theoretically possible for a spark discharge from the induced voltage on a large vehicle to ignite gasoline vapor during refueling. The probability for exactly the right conditions to occur for ignition is extremely remote. The additional clearance of conductors provided at road crossings reduces the electric field in areas where vehicles are prevalent and reduces the chances for such events. Vehicles should not be refueled under the proposed line unless specific precautions are taken to ground the vehicle and the fueling source.

Under certain conditions, the electric field can be perceived through hair movement on an upraised hand or arm of a person standing on the ground under high-voltage transmission lines. The median field for perception in this manner was 7 kV/m for 136 persons; only about 12 percent could perceive fields of 2 kV/m or less (Deno and Zaffanella, 1982). In areas under the conductors at midspan, the fields at ground level would exceed the levels where field perception normally occurs. In these instances, field perception could occur on the right-of-way of the proposed line. It is unlikely that the field would be perceived beyond the edge of the right-of-way. Where vegetation provides shielding, the field would not be perceived.

Conductive shielding reduces both the electric field and induced effects such as shocks. Persons inside a vehicle cab or canopy are shielded from the electric field. Similarly, a row of trees or a lower-voltage distribution line reduces the field on the ground in the vicinity. Metal pipes, wiring, and other conductors in a residence or building shield the interior from the transmission-line electric field.

Thus, potential impacts of electric fields can be mitigated through grounding policies, adherence to the NESC, and increased clearances above the minimums specified by the NESC. Worst-case levels are used for safety analyses but, in practice, induced currents and voltages are reduced considerably by unintentional grounding. Shielding by conducting objects, such as vehicles and vegetation, also reduces the potential for electric-field effects.

5.2 Magnetic Field: Short-term Effects

Magnetic fields associated with transmission and distribution systems can induce voltage and current in long conducting objects that are parallel to the transmission line. As with electric-field induction, these induced voltages and currents are a potential source of shocks. A fence, irrigation pipe, pipeline, electrical distribution line, or telephone line forms a conducting loop when it is grounded at both ends. The earth forms the other portion of the loop. The magnetic field from a transmission line can induce a current to flow in such a loop if it is oriented parallel to the line. If only one end of the fence is grounded, then an induced voltage appears across the open end of the loop. The possibility for a shock exists if a person closes the loop at the open end by contacting both the ground and the conductor. The magnitude of this potential shock depends on the following factors: the magnitude of the field; the length of the object (the longer the object, the larger the induced voltage); the orientation of the object with respect to the transmission line (parallel as opposed to perpendicular, where no induction would occur); and the amount of electrical resistance in the loop (high resistance limits the current flow).

Magnetically induced currents from power lines have been investigated for many years; calculation methods and mitigating measures are available. A comprehensive study of gas pipelines near transmission lines developed prediction methods and mitigation techniques specifically for induced voltages on pipelines (Dabkowski and Taflove, 1979; Taflove and Dabkowski, 1979). Similar techniques and procedures are available for irrigation pipes and fences. Grounding policies employed by utilities for long fences reduce the potential magnitude of induced voltage.

The magnitude of the coupling with both pipes and fences is very dependent on the electrical unbalance (unequal currents) among the three phases of the line. Thus, a distribution line where a phase outage may go unnoticed for long periods of time can represent a larger source of induced currents than a transmission line where the loads are well-balanced (Jaffa and Stewart, 1981).

Knowledge of the phenomenon, grounding practices, and the availability of mitigation measures mean that magnetic-induction effects from the proposed 500-kV transmission line will be minimal.

Magnetic fields from transmission and distribution facilities can interfere with certain electronic equipment. Magnetic fields can cause distortion of the image on VDTs and computer monitors. The threshold field for interference depends on the type and size of monitor and the frequency of the field. Interference has been observed for certain monitors at fields at or below 10 mG (Baishiki et al., 1990; Banfai et al., 2000). Generally, the problem arises when computer monitors are in use near electrical distribution facilities in large office buildings. Fields from the proposed line would fall below this level at approximately 235 ft. (71.6 m) from the centerline.

Interference from magnetic fields can be eliminated by shielding the affected monitor or moving it to an area with lower fields. Similar mitigation methods could be applied to other sensitive electronics, if necessary. Interference from 60-Hz fields with computers and control circuits in vehicles and other equipment is not anticipated at the field levels found under and near the proposed 500-kV transmission line.

6.0 Regulations

Regulations that apply to transmission-line electric and magnetic fields fall into two categories. Safety standards or codes are intended to limit or eliminate electric shocks that could seriously injure or kill persons. Field limits or guidelines are intended to limit electric- and magnetic-field exposures that can cause nuisance shocks or might cause health effects. In no case has a limit or standard been established because of a known or demonstrated health effect.

The proposed line would be designed to meet the NESC (IEEE, 1990), which specifies how far transmission-line conductors must be from the ground and other objects. The clearances specified in the code provide safe distances that prevent harmful shocks to workers and the public. In addition, people who live and work near transmission lines must be aware of safety precautions to avoid electrical (which is not necessarily physical) contact with the conductors. For example, farmers should not up-end irrigation pipes under a transmission or other electrical line. In addition, as a matter of safety, the NESC specifies that electric-field-induced currents from transmission lines must be below the 5 mA ("let go") threshold deemed a lower limit for primary shock. BPA publishes and distributes a brochure that describes safe practices to protect against shock hazards around power lines (USDOE, 1987).

Field limits or guidelines have been adopted in several states and countries and by national and international organizations. Electric-field limits have generally been based on minimizing nuisance shocks or field perception. The intent of magnetic-field limits has been to limit exposures to existing levels, given the uncertainty of their potential for health effects.

There are currently no national standards in the United States for 60-Hz electric and magnetic fields. Several states have been active in establishing mandatory or suggested limits on 60-Hz electric and (in two cases) magnetic fields. Six states have specific electric-field limits that apply to transmission lines: Florida, Minnesota, Montana, New Jersey, New York, and Oregon. These regulations are summarized in Table 5, adapted from TDHS Report (1989). Florida and New York have established regulations for magnetic fields. The state of Washington does not have limits for either electric or magnetic fields from transmission lines.

Electric-field limits for the states have been given in terms of maximum field or edge-of-right-of-way field, or both. Except for Florida, regulations have not explicitly stated the operating conditions under which the limits apply. The Florida regulation, adopted after extensive public hearings and controversy, states: "Although there is no conclusive evidence that there is any danger or hazard to public health at levels of existing 60-hertz electric and magnetic fields found in Florida, there is evidence of a potential for adverse health effects on the public. Further research is needed to determine if there are effects and the exposure levels at which effects may occur" (Florida Department of Environmental Regulation, 1989: Chapter 17-274:2). The Florida electric-field strength standard is based on 1) the avoidance of perception of the field at the edge or on the right-of-way, and 2) the levels near existing facilities. The electric-field strength limit in Florida has been set at 2 kV/m at the edge of the right-of-way and 8 kV/m on the right-of-way for 230-kV or smaller lines. For 500-kV lines, the electric field shall not exceed 10 kV/m on the right-of-way and 2 kV/m at the edge.

The Florida magnetic-field limit at the edge of the right-of-way is 150 mG for lines of 230 kV or less, and 200 mG for 500-kV lines. There is no stated limit on the right-of-way.

The Minnesota 8-kV/m maximum field limit is applied on a case-by-case basis by the Minnesota Environmental Quality Board (MEQB), which has jurisdiction over lines of nominal voltage 200 kV and higher. The limit is included in Construction Permits granted by the MEQB rather than in a formal rule (e.g., MEQB, 1977). Minnesota does not have an edge-of-right-of-way field limit.

The Montana Board of Natural Resources and Conservation (BNRC) imposed a 1 kV/m electric-field limit at the edge of the right-of-way in residential and subdivided areas for the BPA Garrison-Spokane 500-kV Transmission Project (BNRC, 1983). The administrative rules incorporating this requirement were adopted in 1984 (Jamison, 1986). These rules apply to lines designed for operation at 69 kV and higher, as the BNRC has routing authority over them. (An affected landowner may waive the 1 kV/m requirement.) At road crossings, a 7-kV/m limit must be observed. The 1-kV/m electric-field limit was adopted because of the degree of protection and assurance to the public it provided and because of the small amount of additional right-of-way required (Jamison, 1986). Although Montana does not have a magnetic-field limit, the imposition of the 1-kV/m electric-field limit ensures that edge-of-right-of-way magnetic fields will be less than 50 mG (Jamison, 1986).

In New Jersey, the Department of Environmental Protection (NJDEP), Bureau of Radiation Protection, established interim guidelines for maximum field levels at the edge of the right-of-way (NJDEP, 1981). Their 3-kV/m limit is in the form of a resolution and is not enforced, but serves rather as a guideline for evaluating complaints.

The New York edge-of-right-of-way electric-field limit resulted from the extensive public hearings on 765-kV lines before the New York Public Service Commission (NYPSC) from 1975 to 1977. The opinions issued by the NYPSC in this case required that the interim edge-of-right-of-way electric-field limit be equivalent to that for 345-kV lines (NYPSC, 1978b; 1978a). This resulted in an edge-of-right-of-way limit of approximately 1.6 kV/m. This limit was explicitly implemented by specification of a 350-ft. (107-m) right-of-way width for 765-kV lines. In addition, electric fields on public roads, private roads, and other terrain were limited to 7, 11, and 11.8 kV/m, respectively. These values were intended to limit the induced current to 4.5 mA for the largest anticipated vehicle. The NYPSC also required that the utilities involved fund additional research in the area of biological effects of EMF. The final report of the New York State Scientific Advisory Program was issued in 1987 (Ahlbom et al., 1987). New York adopted an edge-of-right-of-way magnetic-field standard of 200 mG in August 1990 (TDHS Report, 1990).

Oregon's formal rule in its transmission line siting procedures specifically addresses field limits. The Oregon limit of 9 kV/m for electric fields is applied to areas accessible to the public (Oregon, 1980). The Oregon rule also addresses grounding practices, audible noise, and radio interference.

Government agencies and utilities operating transmission systems have established design criteria that include EMF levels. BPA has maximum allowable electric fields of 9 and 5 kV/m on and at the edge of the right-of-way, respectively (USDOE, 1996). BPA also has maximum-allowable electric field strengths of 5 kV/m, 3.5 kV/m, and 2.5 kV/m for road crossings, shopping center parking lots, and commercial/ industrial parking lots, respectively. These levels are based on limiting the maximum short-circuit currents from anticipated vehicles to less than 1 mA in shopping center lots and to less than 2 mA in commercial parking lots.

Electric-field limits for overhead power lines have also been established in other countries (Maddock, 1992). Limits for magnetic fields from overhead power lines have not been explicitly established anywhere except in Florida and New York. However, general guidelines and limits on EMF have been established for occupational and public exposure in several countries and by national and international organizations.

The American Conference of Governmental Industrial Hygienists (ACGIH) sets guidelines (Threshold Limit Values or TLV) for occupational exposures to environmental agents (ACGIH, 2000). In general, a TLV represents the level below which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. For EMF, the TLVs represent ceiling levels. For 60-Hz electric fields, occupational exposures should not exceed the TLV of 25 kV/m. However, the ACGIH also recognizes the potential for startle reactions from spark discharges and short-circuit currents in fields greater than 5-7 kV/m, and recommends implementing grounding practices. They recommend the use of conductive clothing for work in fields exceeding 15 kV/m. The TLV for occupational exposure to 60-Hz magnetic fields is a ceiling level of 10 G (10,000 mG) (ACGIH, 2000).

Electric and magnetic fields from various sources (including automobile ignitions, appliances and, possibly, transmission lines) can interfere with implanted cardiac pacemakers. In light of this potential problem, manufacturers design devices to be immune from such interference. However, research has shown that these efforts have not been completely successful and that a few models of pacemakers could be affected by 60-Hz fields from transmission lines. There were also numerous models of pacemakers that were not affected by fields even larger than those found under transmission lines. Because of the known potential for interference with pacemakers by 60-Hz fields, field limits for pacemaker wearers have been established by the ACGIH. They recommend that wearers of pacemakers and similar medical-assist devices limit their exposure to electric fields of 1 kV/m or less and to magnetic fields to 1 G (1,000 mG) or less (ACGIH, 2000).

The International Committee on Non-ionizing Radiation Protection (ICNIRP), working in cooperation with the World Health Organization (WHO) has developed guidelines for occupational and public exposures to EMF (ICNIRP, 1998). For occupational exposures at 60 Hz, the recommended limits to exposure are 8.3 kV/m for electric fields and 4.2 G (4,200 mG) for magnetic fields. The electric-field level can be exceeded, provided precautions are taken to prevent spark discharge and induced current shocks. For the general public, the ICNIRP guidelines recommend exposure limits of 4.2 kV/m for electric fields and 0.83 G (830 mG) for magnetic fields (ICNIRP, 1998).

ICNIRP has also established guidelines for contact currents, which could occur when a grounded person contacts an ungrounded object in an electric field. The guideline levels are 1.0 mA for occupational exposure and 0.5 mA for public exposure.

The electric fields from the proposed 500-kV line would meet the ACGIH standards, provided wearers of pacemakers and similar medical-assist devices are discouraged from unshielded right-of-way use. (A passenger in an automobile under the line would be shielded from the electric field.) The electric fields in limited areas on the right-of-way would exceed the ICNIRP guideline for public exposure. The magnetic fields from the proposed line would be below the ACGIH and IRPA/INIRC limits. The electric fields present on the right-of-way could induce currents in ungrounded vehicles that exceeded the ICNIRP level of 0.5 mA.

The estimated peak electric fields on the right-of-way of the proposed transmission line would meet limits set in Florida, New York, and Oregon, but not those of Minnesota and Montana (see Table 5). The edge of right-of-way electric fields from the proposed line would be below limits set in Florida and New Jersey, but above those in Montana and New York.

The magnetic field at the edge of the right-of-way from the proposed line would be below the regulatory levels of states where such regulations exist.

7.0 Audible Noise

7.1 Basic Concepts

Audible noise (AN), as defined here, represents an unwanted sound, as from a transmission line, transformer, airport, or vehicle traffic. Sound is a pressure wave caused by a sound source vibrating or displacing air. The ear converts the pressure fluctuations into auditory sensations. AN from a source is superimposed on the background or ambient noise that is present before the source is introduced.

The amplitude of a sound wave is the incremental pressure resulting from sound above atmospheric pressure. The sound-pressure level is the fundamental measure of AN; it is generally measured on a logarithmic scale with respect to a reference pressure. The sound-pressure level (SPL) in decibels (dB) is given by:

$$SPL = 20 \log (P/P_o) dB$$

where P is the effective rms (root-mean-square) sound pressure, P_o is the reference pressure, and the logarithm (log) is to the base 10. The reference pressure for measurements concerned with hearing is usually taken as 20 micropascals (Pa), which is the approximate threshold of hearing for the human ear. A logarithmic scale is used to encompass the wide range of sound levels present in the environment. The range of human hearing is from 0 dB up to about 140 dB, a ratio of 10 million in pressure (EPA, 1978).

Logarithmic scales, such as the decibel scale, are not directly additive: to combine decibel levels, the dB values must be converted back to their respective equivalent pressure values, the total rms pressure level found, and the dB value of the total recalculated. For example, adding two sounds of equal level on the dB scale results in a 3 dB increase in sound level. Such an increase in sound pressure level of 3 dB, which corresponds to a doubling of the energy in the sound wave, is barely discernible by the human ear. It requires an increase of about 10 dB in SPL to produce a subjective doubling of sound level for humans. The upper range of hearing for humans (140 dB) corresponds to a sharply painful response (EPA, 1978).

Humans respond to sounds in the frequency range of 16 to 20,000 Hz. The human response depends on frequency, with the most sensitive range roughly between 2000 and 4000 Hz. The frequency-dependent sensitivity is reflected in various weighting scales for measuring audible noise. The A-weighted scale weights the various frequency components of a noise in approximately the same way that the human ear responds. This scale is generally used to measure and describe levels of environmental sounds such as those from vehicles or occupational sources. The A-weighted scale is also used to characterize transmission-line noise. Sound levels measured on the A-scale are expressed in units of dB(A) or dBA.

AN levels and, in particular, corona-generated audible noise (see below) vary in time. In order to account for fluctuating sound levels, statistical descriptors have been developed for environmental noise. Exceedence levels (L levels) refer to the A-weighted sound level that is exceeded for a specified percentage of the time. Thus, the L_5 level refers to the noise level that is exceeded only 5 percent of the time. L_{50} refers to the sound level exceeded 50 percent of the time. Sound-level measurements and predictions for transmission lines are often expressed in terms of exceedence levels, with the L_5 level representing the maximum level and the L_{50} level representing a median level.

Table 6 shows AN levels from various common sources. Clearly, there is wide variation. Noise exposure depends on how much time an individual spends in different locations. Outdoor noise generally does not contribute to indoor levels (EPA, 1974). Activities in a building or residence generally dominate interior AN levels. The amount of sound attenuation (reduction) provided by buildings is given in Table 7. Assuming that residences along the line route fall in the "warm climate, windows open" category, the typical sound attenuation provided by a house is about 12 dBA.

The BPA design criterion for corona-generated audible noise (L_{50}, foul weather) is 50 ±2 dBA at the edge of the right-of-way (Perry, 1982). The Washington Administrative Code provides noise limitations by class of property, residential, commercial or industrial (Washington State, 1975). Transmission lines are classified as industrial and may cause a maximum permissible noise level of 60 dBA to intrude into residential property. During nighttime hours (10:00 pm to 7:00 am), the maximum permissible limit for noise from industrial to residential areas is reduced to 50 dBA. This latter level applies to transmission lines that operate continuously. The state of Washington Department of Ecology accepts the 50 dBA level at the edge of the right-of-way for transmission lines, but encouraged BPA to design lines with lower audible noise levels (WDOE, 1981).

King County, Washington, has noise regulations for maximum permissible sound levels that include the state levels but add an additional category for districts receiving or sending noise. In addition to Industrial, Commercial, and Residential areas, the county defines a Rural area where the maximum sound arising/affecting from an Industrial area (say, a transmission line) is limited to 57 dBA, with a reduction to 47 dBA during the hours of 10 pm and 7 am weekdays and 10 pm and 9 am weekends and holidays (King County, 1992).

The EPA has established a guideline of 55 dBA for the annual average day-night level (L_{dn}) in outdoor areas (EPA, 1978). In computing this value, a 10 dB correction (penalty) is added to night-time noise between the hours of 10 pm and 7 am.

7.2 Transmission-line Audible Noise

Corona is the partial electrical breakdown of the insulating properties of air around the conductors of a transmission line. In a small volume near the surface of the conductors, energy and heat are dissipated. Part of this energy is in the form of small local pressure changes that result in audible noise. Corona-generated audible noise can be characterized as a hissing, crackling sound that, under certain conditions, is accompanied by a 120-Hz hum.

Corona-generated audible noise is of concern primarily for contemporary lines operating at voltages of 345 kV and higher during foul weather. The conductors of high-voltage transmission lines are designed to be corona-free under ideal conditions. However, protrusions on the conductor surface—particularly water droplets on or dripping off the conductors—cause electric fields near the conductor surface to exceed corona onset levels, and corona occurs. Therefore, audible noise from transmission lines is generally a foul-weather (wet-conductor) phenomenon. Wet conductors can occur during periods of rain, fog, snow, or icing. Based on meteorologic records near the route of the proposed transmission line, such conditions are expected to occur less than 19 percent of the time during the year. For a few months after line construction, residual grease or oil on the conductors can cause water to bead up on the surface. This results in more corona sources and slightly higher levels of audible noise and electromagnetic interference if the line is energized. However, the new conductors "age" in a few months, and the level of corona activity decreases to the predicted equilibrium value. During fair weather, insects and dust on the conductor can also serve as sources of corona. The proposed line has been designed with three subconductors per phase to yield acceptable corona levels.

7.3 Predicted Audible Noise Levels

The predicted levels of corona-generated audible noise for the proposed line operated at a voltage of 540 kV are given in Table 8 and plotted in Figure 4. For comparison, Table 8 also gives the calculated levels for the existing parallel lines. Audible noise levels are calculated for average voltage and average conductor heights for fair- and foul-weather conditions. The calculated median level (L_{50}) during foul weather at the edge of the proposed Kangley - Echo Lake right-of-way is about 50 dBA, which is comparable with levels at the edges of existing 500-kV lines in Washington and lower than the levels from the existing Raver - Echo Lake line in the same corridor. The proposed Kangley - Echo Lake line would increase the level at the edge of the existing lines by about 1 dB for the 500-kV line and by about 23 dBA for the 115 kV line. This increase at the edge of 500-kV line would be barely discernible. During fair-weather conditions, which occur about 81 percent of the time, audible noise levels would be about 20 dBA lower (if corona were present). These lower levels could be masked by ambient noise on and off the right-of-way.

7.4 Discussion

The calculated foul-weather corona noise levels for the proposed line would be comparable to or less than those from existing 500-kV lines in Washington. During fair weather, noise from the conductors might be perceivable on the right-of-way, but beyond the right-of-way it will likely be masked or so low as to not be perceived.

Off the right-of-way, the levels of audible noise from the proposed line would be well below the 55 dBA level that can produce interference with speech outdoors. Since residential buildings provide significant sound attenuation (-12 dBA with windows open; -24 dBA with windows closed), the noise levels off the right-of-way would be well below the 45 dBA level required for interference with speech indoors. It is also highly unlikely that indoor noise levels from the line would exceed the 35 dBA level where sleep interference can occur (EPA, 1973; EPA, 1978). Since corona is a foul-weather phenomenon, people tend to be inside with windows possibly closed, providing additional attenuation when corona noise is present. In addition, ambient noise levels can be high during such periods (due to rain hitting foliage or buildings), and can mask corona noise.

The 50-dBA level would meet Washington Administrative Code limits for transmission lines. It would not meet the requirements of the King County Code for sound from an industrial area into a rural area. Noise levels near the existing Echo Lake – Raver 500-kV line exceed the limits of both these jurisdictions and presumably are allowed because of the age of the line. The incremental noise contributed by the proposed line to this existing source would only be about 1 dBA at the edge of the proposed right-of-way and beyond, and would not be discernible.

The computed annual L_{dn} level for transmission lines operating in areas with about 19 percent foul weather is about $L_{dn} = L_{50} + 1$ dB (Bracken, 1987). Therefore, assuming such conditions in the Kangley-Echo Lake area, the estimated L_{dn} at the edge of the right-of-way would be approximately 51 dBA, which is below the EPA L_{dn} guideline of 55 dBA.

7.5 Conclusion

Along the proposed line route, there would be an increase in the perceived noise above ambient levels during foul weather at the edges of new right-of-way. Along those sections of the proposed route where new right-of-way parallels the existing 500-kV right-of-way, changes in line noise levels during foul weather would be barely discernible. Where the proposed line would parallel the existing 115-kV line, noise levels would be increased above the ambient, as at the edge of a new right-of-way. Along new and existing corridors, the corona-generated noise during foul weather might be masked to some extent by naturally occurring sounds such as wind and rain on foliage. During fair weather, the noise off the right-of-way would probably not be detectable above ambient levels. The noise levels from the proposed line would be below levels identified as causing interference with speech or sleep. The audible noise from the transmission line would be below EPA guideline levels and would meet the BPA design criterion that complies with the Washington state noise regulations. However, noise levels from the proposed line will not comply with King County noise regulations in rural areas.

8.0 Electromagnetic Interference

8.1 Basic Concepts

Corona on transmission-line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. The noise can cause radio and television interference (RI and TVI). In certain circumstances, corona-generated electromagnetic interference (EMI) can also affect communications systems and other sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345 kV or higher. This is especially true of interference with television signals. The three-conductor bundle design of the proposed 500-kV line is intended to mitigate corona generation and thus keep radio and television interference levels at acceptable levels.

Spark gaps on distribution lines and on low-voltage wood-pole transmission lines are a more common source of RI/TVI than is corona from high-voltage electrical systems. This gap-type interference is primarily a fair-weather phenomenon caused by loose hardware and wires. The proposed transmission line would be constructed with modern hardware that eliminates such problems and therefore minimizes gap noise. Consequently, this source of EMI is not anticipated for the proposed line.

No state has limits for either RI or TVI. In the United States, electromagnetic interference from power transmission systems is governed by the Federal Communications Commission (FCC) Rules and Regulations presently in existence (Federal Communications Commission, 1988). A power transmission system falls into the FCC category of "incidental radiation device," which is defined as "a device that radiates radio frequency energy during the course of its operation although the device is not intentionally designed to generate radio frequency energy." Such a device "shall be operated so that the radio frequency energy that is emitted does not cause harmful interference. In the event that harmful interference is caused, the operator of the device shall promptly take steps to eliminate the harmful interference." For purposes of these regulations, harmful interference is defined as: "any emission, radiation or induction which endangers the functioning of a radio navigation service or of other safety services or seriously degrades, obstructs or repeatedly interrupts a radio communication service operating in accordance with this chapter" (Federal Communications Commission, 1988: Vol II, part 15. 47CFR, Ch. 1).

Electric power companies have been able to work quite well under the present FCC rule because harmful interference can generally be eliminated. It has been estimated that more than 95 percent of power-line sources that cause interference are due to gap-type discharges. These can be found and completely eliminated, when required to prevent interference (USDOE, 1980). Complaints related to corona-generated interference occur infrequently. This is especially true with the advent of cable television and satellite television, which are not subject to corona-generated interference. Mitigation of corona-generated interference with conventional radio and television receivers can be accomplished in several ways, such as use of a directional antenna or relocation of an existing antenna (USDOE, 1977; USDOE, 1980; Loftness et al., 1981).

8.2 Radio Interference (RI)

Radio reception in the AM broadcast band (535 to 1605 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near to transmission lines can be affected by RI. The IEEE Radio Noise Design Guide identifies an acceptable limit of fair-weather RI as expressed in decibels above 1 microvolt per meter (dBμV/m) of about 40 dBμV/m at 100 ft. (30 m) from the outside conductor (IEEE Committee Report, 1971). As a general rule, average levels during foul weather (when the conductors are wet) are 16 to 22 dBμV/m higher than average fair-weather levels.

8.3 Predicted RI Levels

Table 9 gives the predicted fair- and foul-weather RI levels at 100 ft. (30 m) from the outside conductor for the proposed 500-kV line in the three corridor configurations. Median foul-weather levels would be about 17 dB higher than the fair-weather levels. The predicted L_{50} fair-weather level at the edge of the right-of-way is 46 dBμV/m for 540-kV line operation; at 100 ft. (30 m) from the outside conductor, the level is 39 dBμV/m. Predicted fair-weather L_{50} levels are comparable with those for other existing 500-kV lines and lower than that from the existing 500-kV Raver – Echo Lake line. Predictions indicate that fair-weather RI will meet the IEEE 40 dBμV/m criterion at distances greater than about 100 ft. (30 m) from the outside conductor of the proposed line.

8.4 Television Interference (TVI)

Corona-caused TVI occurs during foul weather and is generally of concern for transmission lines with voltages of 345 kV or above, and only for conventional receivers within about 600 ft. (183 m) of a line. As is the case for RI, gap sources on distribution and low-voltage transmission lines are the principal observed sources of TVI. The use of modern hardware and construction practices for the proposed line would minimize such sources.

8.5 Predicted TVI Levels

Table 10 shows TVI levels predicted at 100 ft. (30 m) from the outside conductor of the proposed line operating at 540 kV and from existing lines. At this distance, the foul-weather TVI level predicted for the proposed line is 25 dBμV/m. This is comparable with TVI levels from other existing BPA 500-kV lines, and lower than that from the existing 500-kV Raver – Echo Lake line.

There is a potential for interference with television signals at locations very near the proposed line in fringe reception areas. However, several factors reduce the likelihood of occurrence. Corona-generated TVI occurs only in foul weather; consequently, signals will not be interfered with most of the time, which is characterized by fair weather. Because television antennas are directional, the impact of TVI is related to the location and orientation of the antenna relative to the transmission line. If the antenna were pointed away from the line, then TVI from the line would affect reception much less than if the antenna were pointed towards the line. Since the level of TVI falls off with distance, the potential for interference becomes minimal at distances greater than several hundred feet from the centerline.

Other forms of TVI from transmission lines are signal reflection (ghosting) and signal blocking caused by the relative locations of the transmission structure and the receiving antenna with respect to the incoming television signal. Television systems that operate at higher frequencies, such as satellite receivers, are not affected by corona-generated TVI. Cable television systems are similarly unaffected.

Interference with television reception can be corrected by any of several approaches: improving the receiving antenna system; installing a remote antenna; installing an antenna for TV stations less vulnerable to interference; connecting to an existing cable system; or installing a translator (cf. USDOE, 1977). BPA has an active program to identify, investigate, and mitigate legitimate RI and TVI complaints. It is anticipated that any instances of TVI caused by the proposed line could be effectively mitigated.

8.6 Interference with Other Devices

Corona-generated interference can conceivably cause disruption on other communications bands such as the citizen's (CB) and mobile bands. However, mobile-radio communications are not susceptible to transmission-line interference because they are generally frequency modulated (FM). Similarly, cellular telephones operate at a frequency of about 900 MHz, which is above the frequency where corona-generated interference is prevalent. In the unlikely event that interference occurs with these or other communications, mitigation can be achieved with the same techniques used for television and AM radio interference.

8.7 Conclusion

Predicted EMI levels for the proposed 500-kV transmission line are comparable to those from existing 500-kV lines. If interference should occur, there are various methods for correcting it; BPA has a program to respond to legitimate complaints. Therefore, the anticipated impacts of corona-generated interference on radio, television, or other reception would be minimal.

9.0 Other Corona Effects

Corona is visible as a bluish glow or as bluish plumes. On the proposed 500-kV line, corona levels would be low, so that corona on the conductors would be observable only under the darkest conditions and probably only with the aid of binoculars. Without a period of adaptation for the eyes and without intentional looking for the corona, it probably would not be noticeable.

When corona is present, the air surrounding the conductors is ionized and many chemical reactions take place, producing small amounts of ozone and other oxidants. Ozone is approximately 90 percent of the oxidants, while the remaining 10 percent is composed principally of nitrogen oxides. The national primary ambient air quality standard for photochemical oxidants, of which ozone is the principal component, is 235 micrograms/cubic meter) or 120 parts per billion. The maximum incremental ozone levels at ground level produced by corona activity on the proposed transmission line during foul weather would be much less than 1 part per billion. This level is insignificant when compared with natural levels and fluctuations in natural levels.

10.0 Summary

Electric and magnetic fields from the proposed transmission line have been characterized using well-known techniques accepted within the scientific and engineering community. The expected electric-field levels from the proposed line at minimum design clearance would be comparable to those of other 500-kV lines in Washington and elsewhere. The expected magnetic-field levels from the proposed line would be comparable to or less than those from other 500-kV lines in Washington and elsewhere.

The peak electric field expected under the proposed line would be 8.9 kV/m; the maximum value at the edge of the right-of-way would be about 2.0 kV/m. Clearances at road crossings would be increased to reduce the peak electric-field value to 4.8 kV/m.

Under maximum current conditions, magnetic-field levels would be as follows:

- the maximum magnetic fields under the proposed line would be 408 mG;

- at the edge of the right-of-way nearest to the proposed 500-kV line, the magnetic field would be 92 or 97 mG, depending on the configuration.

The electric fields from the proposed line would meet regulatory limits for public exposure in some states, but could exceed the regulatory limits or guidelines for peak fields established in other states and by ICNIRP. The magnetic fields from the proposed line would be within the regulatory limits of the two states that have established them and within guidelines for public exposure established by ICNIRP. Washington does not have any electric- or magnetic-field regulatory limits or guidelines.

Short-term effects from transmission-line fields are well understood and can be mitigated. Nuisance shocks arising from electric-field induced currents and voltages could be perceivable on the right-of-way of the proposed line. It is common practice to ground permanent conducting objects during and after construction to mitigate against such occurrences.

Corona-generated audible noise from the line would be perceivable during foul weather. The levels would be comparable to those near existing 500-kV transmission lines in Washington, would be in compliance with noise regulations in Washington but not in King County, and would be below levels specified in EPA guidelines.

Corona-generated electromagnetic interference from the proposed line would be comparable to or less than that from existing 500-kV lines in Washington. Radio interference levels would be below limits identified as acceptable. Television interference, a foul-weather phenomenon, is anticipated to be comparable to or less than that from existing 500-kV lines in Washington; if legitimate complaints arise, BPA has a mitigation program.

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List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 27 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment and project management. Joseph Dudman of T. Dan Bracken, Inc., provided data entry, graphics, and clerical support in the preparation of the report.

Judith H. Montgomery of Judith H. Montgomery/Communications served as technical editor for the report. She holds an A.B. degree in English literature from Brown University, 1966; and a Ph.D. degree in American literature from Syracuse University, 1971. Dr. Montgomery has provided writing, editing, and communications services to government and industry for 20 years. Her experience includes preparation of National Environmental Policy Act documents and technical papers dealing with transmission-line environmental impact assessment and other utility-related activities.

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Table 1: Physical and electrical characteristics of Kangley - Echo Lake Project corridors.

	New Line	Existing Corridors	
Configuration	**I**	**II**	**III**
Description	**Kangley - Echo Lake 500-kV**	**Raver - Echo Lake 500-kV**	**Seattle City Light 115-kV**
Voltage, kV Maximum/Average[1]	550/540	550/540	121/115
Peak Current, A Existing/Proposed	2400	2915/991	89/89
Electric Phasing	ABC	ABC	ABC
Clearance, ft. Minimum/Average[1]	33/47	33/47	32/34
Centerline Distance from Kangley - Echo Lake, ft.	-	150	110
Centerline distance to edge of ROW, ft.	75	75	35
Tower configuration	Delta	Delta	Delta
Phase spacing, ft.	40 H, 28.7 V	40 H, 27.5 V	8.46 H, 7.9 V
Conductor: #/Diameter, in.	3/1.302	2/1.602	1/0.743

1 Average voltage and average clearance used for corona calculations.

Table 2: Possible corridors for Kangley - Echo Lake Project

Configuration	Description of other lines in corridor with Kangley - Echo Lake 500-kV line	Possible segments with same configuration	Miles
I	Kangley - Echo Lake 500-kV line only	E, F, G, H, J	14.38
II	BPA Raver - Echo Lake 500-kV line	A, B, C, D	8.9
III	Seattle City Light 115-kV line	I	1.0

Table 3: Calculated electric fields for configurations of the proposed Kangley - Echo Lake 500-kV line operated at maximum voltage. Configurations are described in Tables 1 and 2.

a) Configuration I: Kangley - Echo Lake 500-kV line only

Configuration	Proposed I		Existing	
ROW width, ft. (m)	150 (46)		—	
Line	Kangley - Echo Lake 500-kV		—	
Clearance	min.	avg.	—	—
Peak field, kV/m	8.9	4.9	—	—
Edge of ROW, kV/m	2.0	2.0	—	—

b) Configuration II: Kangley - Echo Lake and Raver - Echo Lake 500-kV lines

Configuration	Proposed II				Existing	
ROW width, ft. (m)	300 (91)				150 (45)	
Line	Kangley - Echo Lake 500-kV		Raver - Echo Lake 500-kV		Raver - Echo Lake 500-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	8.9	4.9	8.4	4.6	8.4	4.6
Edge of ROW, kV/m	2.1	2.0	1.9	1.9	1.8	1.8

c) Configuration III: Kangley - Echo Lake 500-kV and Seattle City Light 115-kV lines

Configuration	Proposed III				Existing	
ROW width, ft. (m)	220 (67)				70 (21)	
Line	Kangley - Echo Lake 500-kV		SCL 115-kV		SCL 115-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	8.9	4.9	1.6	1.6	0.5	0.5
Edge of ROW, kV/m	2.0	2.0	0.5	0.5	0.3	0.3

Table 4: Calculated magnetic fields for configurations of the proposed Kangley - Echo Lake 500-kV line operated at maximum current. Configurations are described in Tables 1 and 2.

a) Configuration I: Kangley - Echo Lake 500-kV line only

Configuration	Proposed I		Existing	
ROW width, ft. (m)	150 (46)		—	
Line	Kangley - Echo Lake 500-kV		—	
Clearance	min.	avg.	—	—
Peak field, mG	408	228	—	—
Edge of ROW, mG	92	77	—	—

b) Configuration II: Kangley - Echo Lake and Raver - Echo Lake 500-kV lines

Configuration	Proposed II				Existing	
ROW width, ft. (m)	237.5 (72)				125 (38)	
Line	Kangley - Echo Lake 500-kV		Raver - Echo Lake 500-kV		Raver - Echo Lake 500-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	399	221	157	84	516	287
Edge of ROW, mG	96	80	48	40	112	94

c) Configuration III: Kangley - Echo Lake 500-kV and Seattle City Light 115-kV lines

Configuration	Proposed III				Existing	
ROW width, ft. (m)	225 (69)				100 (30)	
Line	Kangley - Echo Lake 500-kV		SCL 115-kV		SCL 115-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	408	228	91	75	5	4
Edge of ROW, mG	92	77	28	26	2	2

Table 5: States with transmission-line field limits

STATE AGENCY	WITHIN RIGHT-OF-WAY	AT EDGE OF RIGHT-OF-WAY	COMMENTS
a. 60-Hz ELECTRIC FIELD LIMIT, kV/m			
Florida Department of Environmental Regulation	8 (230 kV) 10 (500 kV)	2	Codified regulation, adopted after a public rulemaking hearing in 1989.
Minnesota Environmental Quality Board	8	—	12-kV/m limit on the HVDC nominal electric field.
Montana Board of Natural Resources and Conservation	7[1]	1[2]	Codified regulation, adopted after a public rulemaking hearing in 1984.
New Jersey Department of Environmental Protection	—	3	Used only as a guideline for evaluating complaints.
New York State Public Service Commission	11.8 (7,11)[1]	1.6	Explicitly implemented in terms of a specified right-of-way width.
Oregon Facility Siting Council	9	—	Codified regulation, adopted after a public rulemaking hearing in 1980.
b. 60-Hz MAGNETIC FIELD LIMIT, mG			
Florida Department of Environmental Regulation	—	150 (230 kV) 200 (500 kV)	Codified regulations, adopted after a public rulemaking hearing in 1989.
New York State Public Service Commission	—	200	Adopted August 29, 1990.

1 At road crossings
2 Landowner may waive limit

Sources: TDHS Report, 1989;TDHS Report, 1990

Table 6: Common noise levels

Sound Level, dBA	Noise Source or Effect
128	Threshold of pain
108	Rock-and-roll band
80	Truck at 50 ft. (15.2 m)
70	Gas lawnmower at 100 ft. (30 m)
60	Normal conversation indoors
50	Moderate rainfall on foliage
50	Edge of proposed 500-kV right-of-way during rain
40	Refrigerator
25	Bedroom at night
0	Hearing threshold

Adapted from: USDOE, 1996.

Table 7: Typical sound attenuation (in decibels) provided by buildings

	Windows opened	Windows closed
Warm climate	12	24
Cold climate	17	24

Source: EPA, 1978.

Table 8: Predicted foul-weather audible noise (AN) levels at edge of right-of-way (ROW) for proposed Kangley - Echo Lake 500-kV line. AN levels expressed in decibels on the A-weighted scale (dBA). L_{50} and L_5 denote the levels exceeded 50 and 5 percent of the time, respectively. For the parallel-line configurations[1], the AN level at the edge of the proposed Kangley - Echo Lake Project ROW is given first.

	Foul-weather AN					
	Proposed			Existing		
Configuration[1]	ROW ft. (m)	L_{50}, dBA	L_5, dBA	ROW ft. (m)	L_{50}, dBA	L_5, dBA
I	150 (45.7)	50	53	–	–	–
II	300 (91.4)	55, 59	59, 62	150 (45.7)	58	62
III	220 (67.1)	50, 47	53, 50	70(21.3)	24	28

1 Configurations are described in Tables 1 and 2.

Table 9: Predicted fair-weather radio interference (RI) levels at 100 feet (30.5 m) from the outside conductor of the proposed Kangley - Echo Lake 500-kV line. RI levels given in decibels above 1 microvolt/meter (dBμV/m) at 1.0 MHz. L_{50} denotes level exceeded 50 percent of the time. For the parallel-line configurations the RI level on the side of the proposed Kangley - Echo Lake ROW is given first.

Configuration[1]	Fair-weather RI	
	Proposed	Existing
	L_{50}, dBμV/m	L_{50}, dBμV/m
I	39	–
II	39, 46	46
III	39, 32	12

1 Configurations are described in Tables 1 and 2.

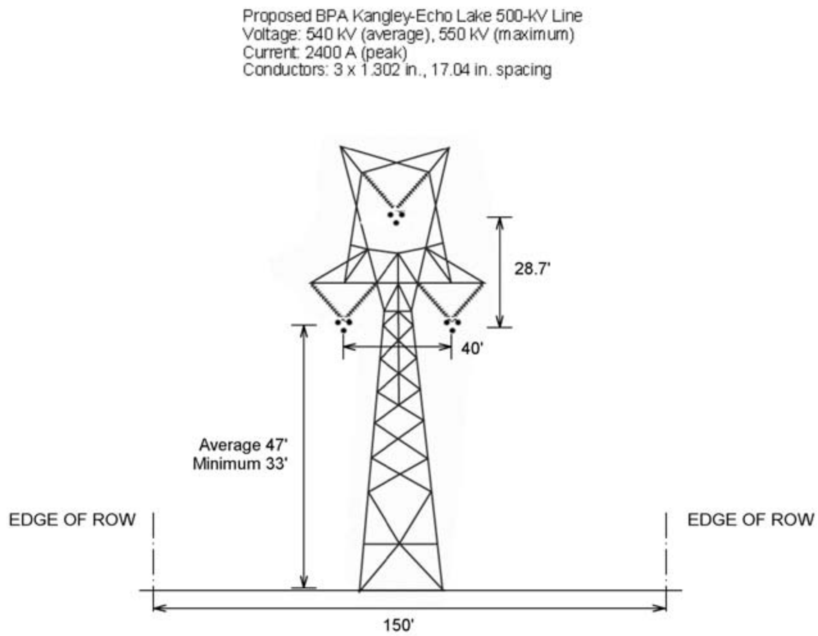
Table 10: Predicted maximum foul-weather television interference (TVI) levels predicted at 100 feet (30.5 m) from the outside conductor of the proposed Kangley - Echo Lake 500-kV line. TVI levels given in decibels above 1 microvolt/meter (dBμV/m) at 75 MHz. For the parallel-line configurations, the TVI level on the side of the proposed Kangley - Echo Lake ROW is given first.

Configuration[1]	Foul-weather TVI	
	Proposed	Existing
	L_5 (foul), dBμV/m	L_5 (foul), dBμV/m
I	25	–
II	25, 32	32
III	25, 15	-

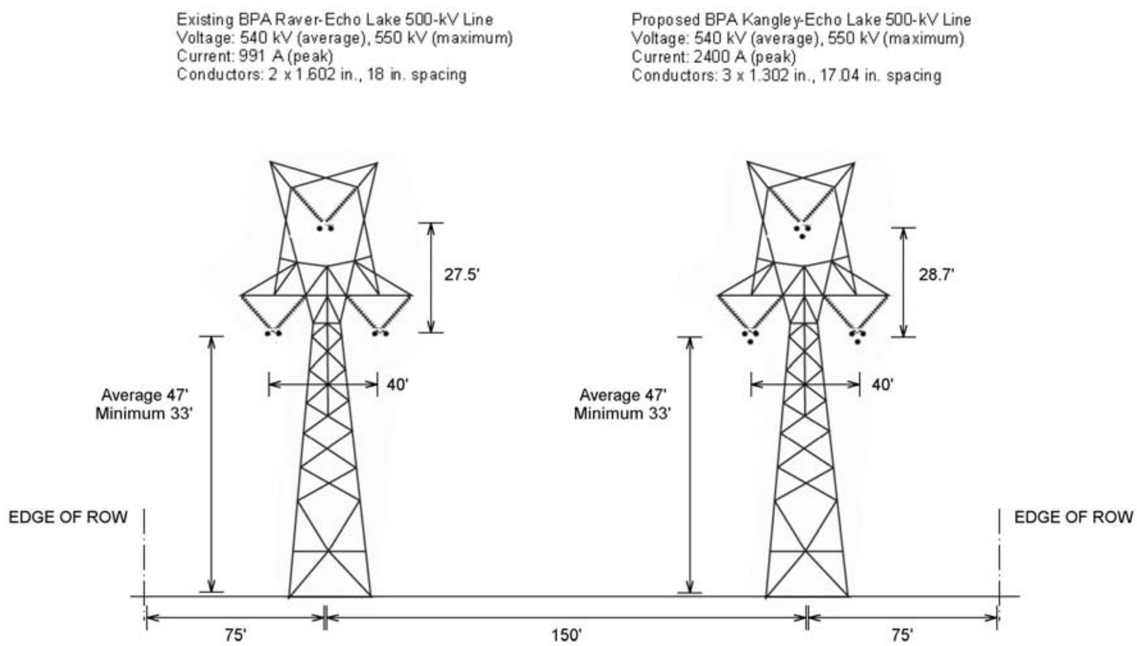
1 Configurations are described in detail in Tables 1 and 2.

Figure 1: Configurations for proposed Kangley - Echo Lake 500-kV line
a) Proposed line with no parallel lines (Configuration I);
b) Proposed line with parallel 500-kV line (Configuration II); and
c) proposed line with parallel 115-kV line (Configuration III).

a) Proposed line with no parallel lines (Configuration I) (not to scale)



b) Proposed line with parallel 500-kV line (Configuration II) (not to scale)



c) Proposed line with parallel 115-kV line (Configuration III) (not to scale)

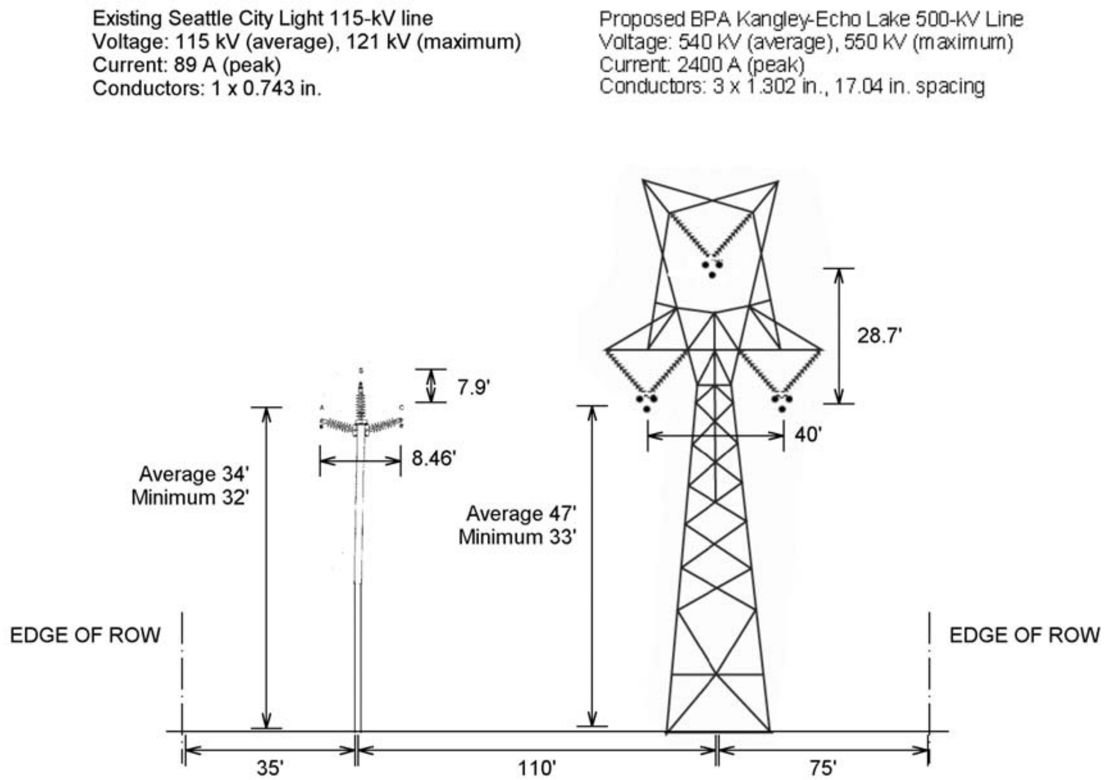
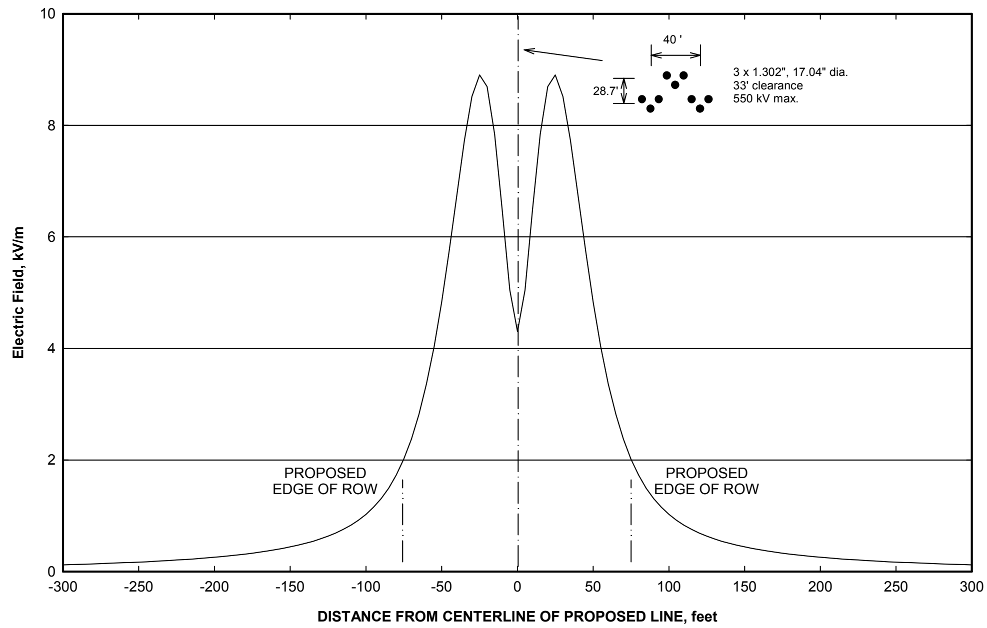
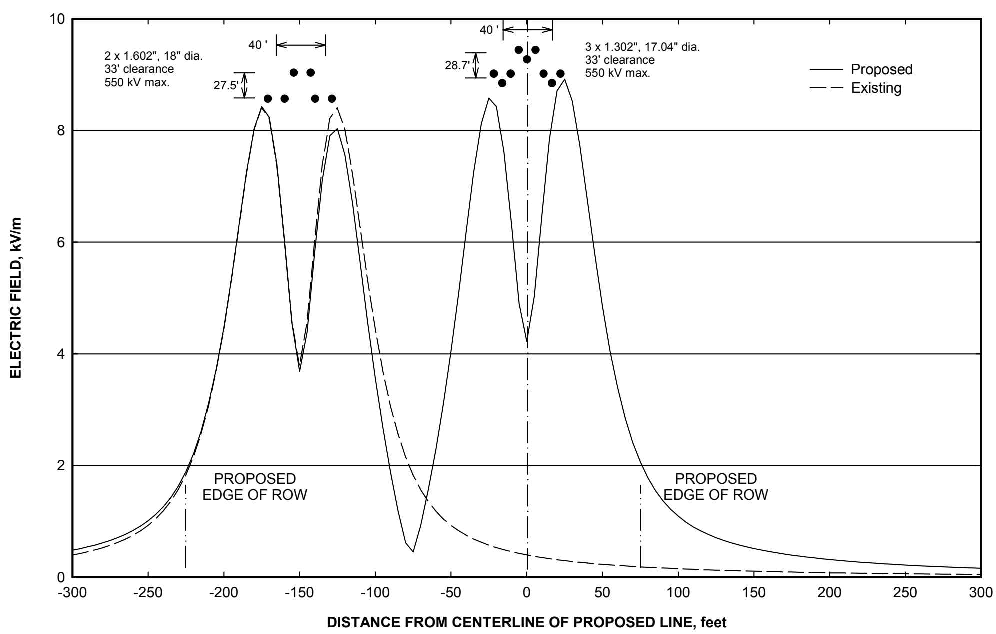


Figure 2: Electric-field profiles for configurations of proposed Kangley - Echo Lake 500-kV line: a) Proposed line with no parallel line (Configuration I); b) proposed line with parallel 500-kV line (Configuration II); and c) proposed line with parallel 115-kV line (Configuration III). Fields for maximum voltage and minimum clearances are shown.

a) Proposed line with no parallel line (Configuration I).



b) Proposed line with parallel 500-kV line (Configuration II)



c) Proposed line with parallel 115-kV line (Configuration III)

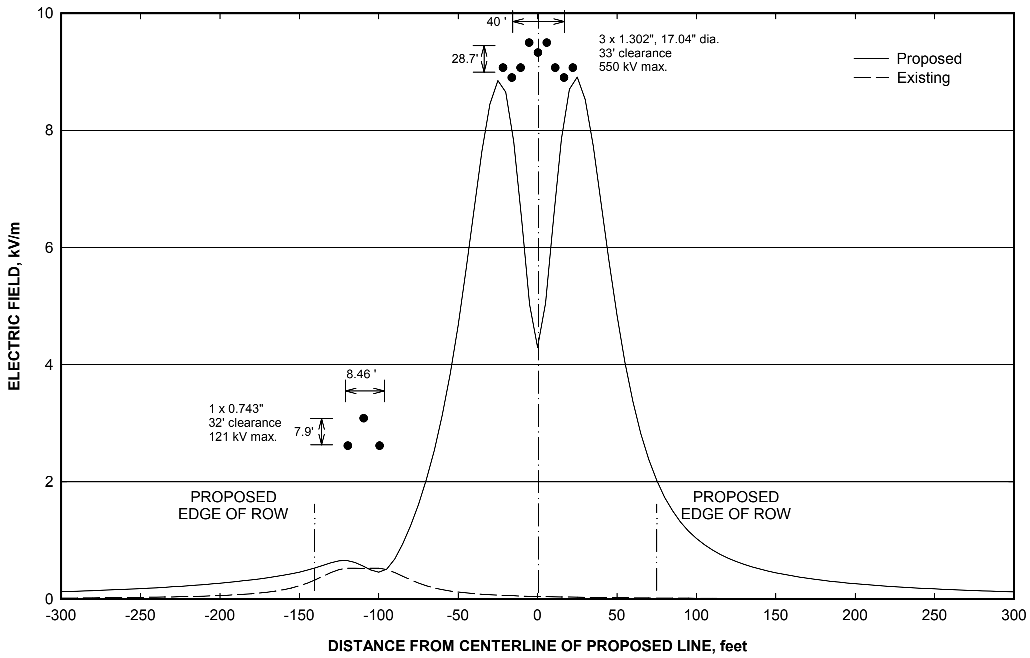
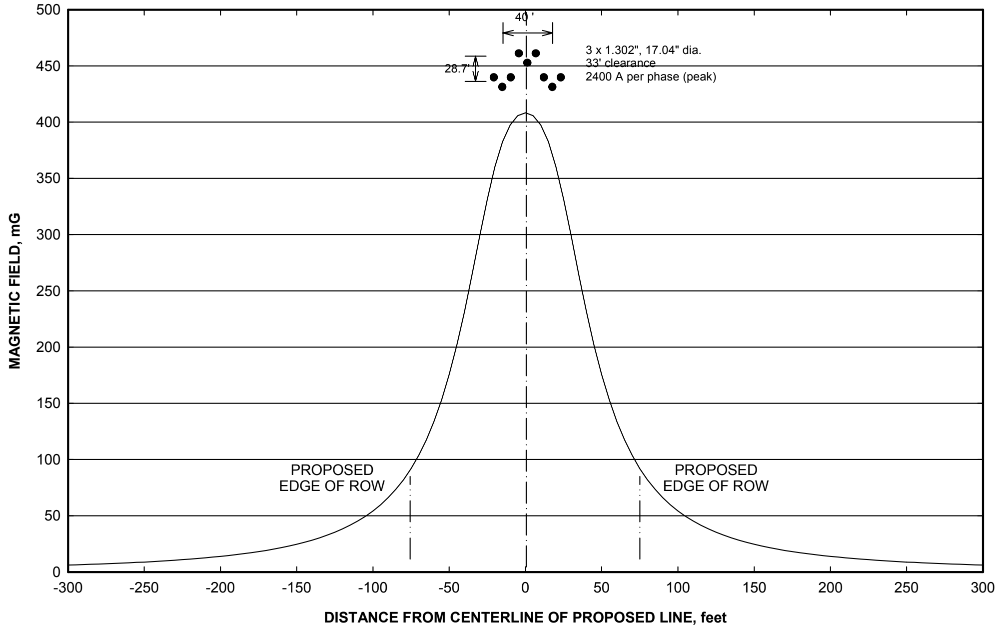
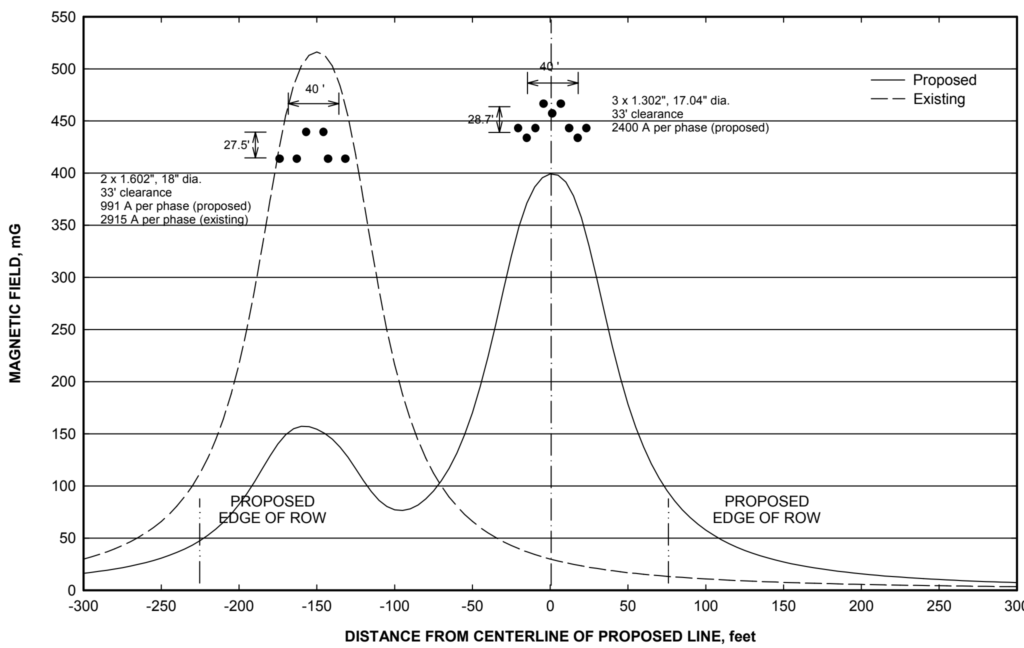


Figure 3: Magnetic-field profiles for configurations of the proposed Kangley - Echo Lake 500-kV line under maximum current conditions: a) proposed line with no parallel line (Configuration I); b) proposed line with parallel 500-kV line (Configuration II); and c) proposed line with parallel 115-kV line (Configuration III).

a) Proposed line with no parallel line (Configuration I)



b) Proposed line with parallel 500-kV line (Configuration II).



c) Proposed line with parallel 115-kV line (Configuration III)

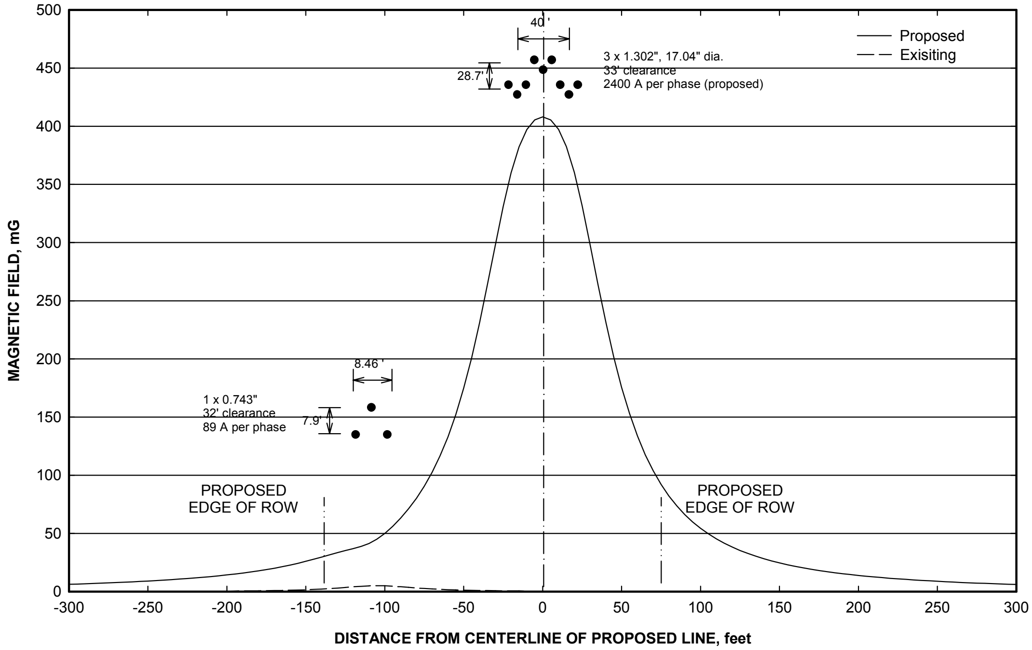
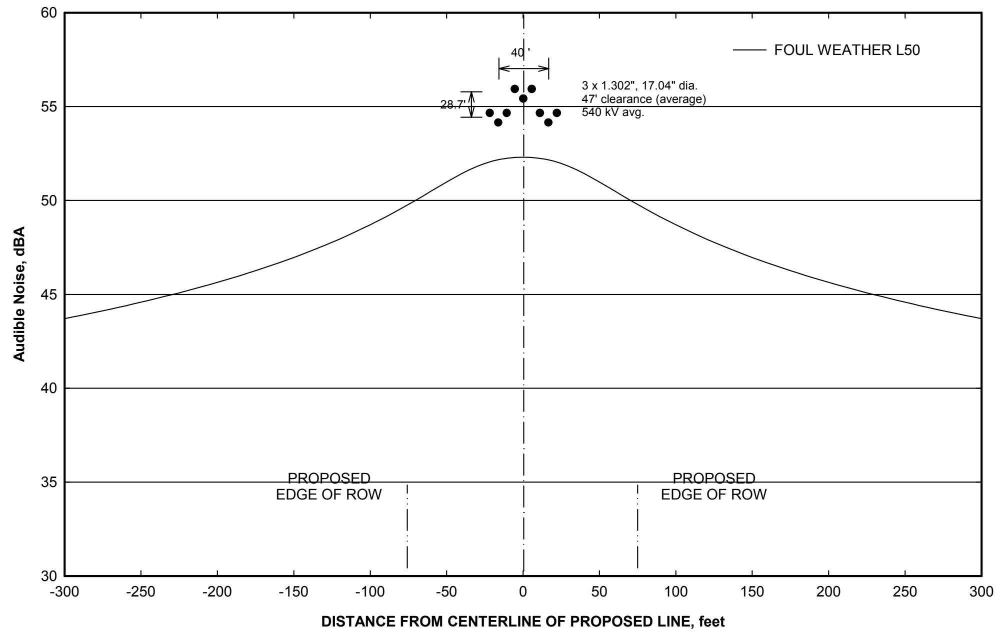
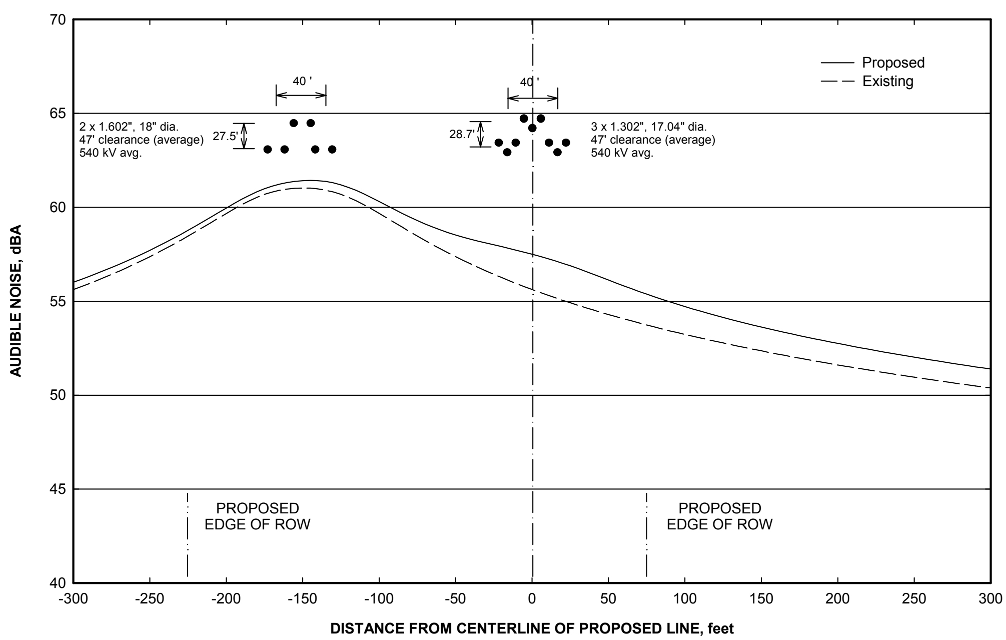


Figure 4: Predicted foul-weather L_{50} audible noise levels from configurations of proposed Kangley - Echo Lake 500-kV line a) proposed line with no parallel line (Configuration I); b) proposed line with parallel 500-kV line (Configuration II); and c) proposed line with parallel 115-kV line (Configuration III).

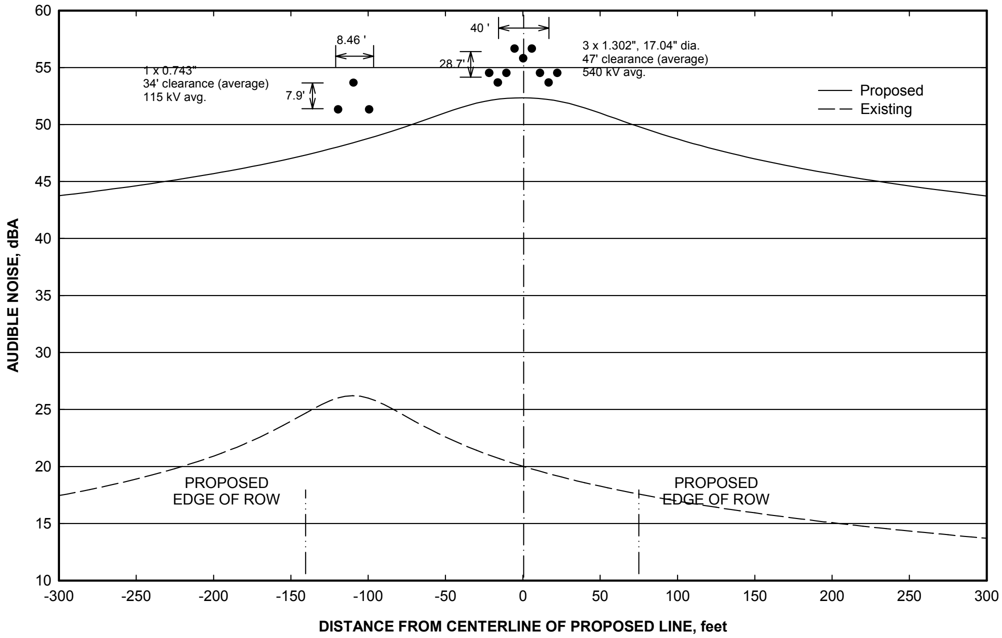
a) Proposed line with no parallel line (Configuration I).



b) Proposed line with parallel 500-kV line (Configuration II).



c) Proposed line with parallel 115-kV line (Configuration III).



KANGLEY – ECHO LAKE
TRANSMISSION LINE PROJECT

ADDENDUM to

APPENDIX E

ELECTRICAL EFFECTS

August 2002

Prepared by
T. Dan Bracken, Inc.

For

Bonneville Power Administration
Portland, Oregon

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ADDENDUM

In considering four alternative routes to the preferred route for the Kangley – Echo Lake Transmission Line Project, eleven additional corridor configurations were identified beyond those analyzed in the original Electrical Effects report prepared for the project. A configuration refers to the physical layouts, voltages, and currents for all transmission lines in a corridor. Two or more configurations are present along each alternative route.

The purpose of this addendum is to report the levels of electric fields, magnetic fields, audible noise, radio interference, and television interference anticipated from these new configurations. The predicted levels for the proposed line in each configuration are compared with the levels that would be present in the same area if the project were not built - the No-action alternative.

Two of the four alternative routes – A and C – entail constructing a new 500-kV line between a BPA corridor in the Kangley area and the Echo Lake Substation in another corridor to the north. Depending on the route the new line would be on new or existing right-of-way (ROW) and on new or existing structures. The other two alternatives - B and D - would involve constructing a 500-kV line from just east of Stampede Pass to the Echo Lake Substation. These alternatives would be on new structures and on new or existing ROW along an existing transmission-line corridor.

The calculation methods and impacts related to electric and magnetic fields and corona-generated audible noise and electromagnetic interference are discussed in the Appendix E: Electrical Effects of the Kangley – Echo Lake Transmission Line Project Draft Environmental Impact Statement (DEIS). An elevation of 1500 ft. (457 m) was assumed in the calculations for the additional configurations.

For additional information about the methods used and discussion about field effects and corona phenomena, please consult the Electrical Effects and Assessment of Research Regarding EMF and Health Effects reports appended to the DEIS (Appendices E and G). Those documents should be consulted when interpreting the levels reported here.

A slightly modified structure design for single-circuit delta-configuration 500-kV lines has been adopted by the Bonneville Power Administration since the initial Electrical Effects appendix was completed. The new design incorporates larger spacing between phases to allow for increased reliability and reduction of audible noise. In the new design the horizontal spacing between phases is 48 ft (14.6 m) and the vertical spacing is 34.5 ft. (10.5 m). The minimum and average clearances are 35 and 45 ft. (10.7 and 13.7 m), respectively. In the analyses presented here the newer design was assumed for the new single-circuit 500-kV lines. (See Table A1 and Figure A1.)

Incorporation of the new structure design into the delta configurations that were analyzed previously would not significantly change the electric-field, magnetic-field, or corona-related effects. Therefore the discussion and conclusions presented in the Electrical Effects appendix are still valid.

A.1 New configurations

The corridor configurations for the new alternative routes for the Kangley – Echo Lake Transmission Project 500-kV line are:

Alternative A

- Configuration A-1 would be an 8.0-mile section of new line on an existing ROW parallel to an existing 230-kV line. This section would extend west from the Kangley area to a point 3 miles east of the Covington Substation.
- Configuration A-2 would be a 3-mile section of new line on an existing ROW parallel to existing 500-kV and 230-kV lines. This section would extend from 3 miles east of Covington Substation to the area of the substation.
- Configuration A-3 would be a 9-mile section with the proposed line located on new double-circuit structures on existing ROW. The new structures would replace existing structures. This section would extend north from the immediate vicinity of Covington Substation to a point on the Echo Lake – Maple Valley corridor approximately 8.1 miles west of the Echo Lake Substation. . .
- Configuration A-4 would be an 8.1-mile section with the proposed line located on existing double-circuit structures on an existing ROW. This section would parallel existing 345-kV and 500-kV lines and extend from 8.1 miles west of the Echo Lake Substation to the substation.

Alternative B

- Configuration B-1 would be a 38-mile section with the proposed 500-kV line located on new double circuit structures on an existing ROW. The new structures would replace an existing 345-kV line. This configuration would extend from just east of Stampede Pass to the Echo Lake Substation. For most of the route, the existing ROW is 150 feet wide (Configuration B-1b). A 3-mile portion of B-1 just west of the pass would have a 300-foot ROW (Configuration B-1b).

Alternative C

- Configuration C-1 would be a 2.3-mile section with the proposed line on new single-circuit structures on new ROW. It would parallel three other existing 500-kV lines and extend 2.3 miles west from a point on the existing corridor near the Raver Substation.
- Configuration C-2 would be a 4.2-mile section with the proposed line on new single-circuit structures on an existing ROW. This section would be an alternative to C-1 in a corridor located north of C-1. It would parallel an existing 230-kV line and extend due west from a point near Kangley.
- Configuration C-3 would be a 7.7-mile section with the proposed line on new single-circuit structures on new ROW. There would be no parallel transmission lines. This section would extend due north from the end of either C-1 or C-2 to a tap point on the existing Echo Lake – Maple Valley corridor.
- Configuration C-4 would be a 4.8-mile section with the proposed line on existing double-circuit structures in the existing Echo Lake – Maple Valley corridor. This section would parallel an existing 345-kV line and extend from a point 4.8 miles west of Echo Lake Substation to the substation.

Alternative D

- Configuration D-1a and D-2a would be a 35-mile section with the proposed 500-kV line located on new single-circuit structures on new ROW. For Configuration D-1a, the new line would be south of and parallel to the existing 345-kV line. For Configuration D-2a the new line would be north of the existing 345-kV line. These configurations would parallel sections of the existing 345-kV line that is on double-circuit structures. This section would extend from just east of Stampede Pass to the Echo Lake Substation with the exception of a 3-mile portion just west of the pass (Configuration D-1b and D-2b). Since the field and corona levels from these configurations are almost identical, only results for D-2a and D-2b, which have slightly higher levels, are presented.
- Configuration D-1b and D-2b would be a 3-mile section of Alternative D with the same new single-circuit structures as Configuration D-1a and D-2a. The new line would be south of the existing line in

Configuration D-1b and north of the existing line in Configuration D-2b. In this section the proposed line would be on existing ROW and would parallel the section of the existing line with single-circuit structures. This section would be just west of Stampede Pass.

Figure A1 shows these configurations; their physical and electrical characteristics are given in Tables A1 and A2.

A.2 Electric-field levels

Calculated electric fields for the new configurations are summarized in Table A3 and plotted in Figure A2. Fields are shown for maximum voltage and minimum clearance (height above ground) for the conductors. Such conditions would occur infrequently during a year. The values shown for average conductor clearance are representative of values that would be found along a span between structures.

The peak field levels for the new configurations would be comparable with each other and with levels for the preferred alternative of the project that were described in the DEIS. Peak values for the new configurations are between 8.3 and 8.9 kV/m for minimum clearance conditions. Peak fields for the No-action alternative would range from 3.0 to 8.7 kV/m on existing ROW. Under the No-action alternative there would be no electric field along the new ROW of Configuration C-3. The peak electric field for all the new and existing configurations would meet the BPA limit of 9 kV/m for peak field on the ROW. The State of Washington has no standards for electric fields from transmission lines.

Electric fields at the edges of the ROW for the proposed line would range from 0.3 to 3.0 kV/m depending on the configuration. The edge-of-ROW electric fields for the existing corridors under the No-action alternative would range from 0.0 to 3.0 kV/m. The lowest edge-of-ROW fields occur for configurations on wide corridors with a vacant ROW.

The actual changes in fields from the No-action alternative will depend on the voltage and location of existing lines on the ROW. For Configuration C-3 the new ROW will introduce electric fields associated with a 500-kV transmission line where existing fields are probably less than a few volts per meter. When a lower voltage line is replaced with the proposed 500-kV line the peak and edge of ROW electric fields would be higher than for the No-action alternative (A-1, A-3, B-1, C-2, D-1, and D-2). When the proposed 500-kV line is added to a corridor with existing 500-kV lines the peak fields do not increase but the addition of new ROW will increase the area over which the higher fields associated with transmission lines extend (A-2, C-1). For configurations where the proposed line is replacing an existing 500-kV line on an existing structure (A-4 and C-4) there would be no change in electric field on or off the ROW with the addition of the proposed line.

A.3 Magnetic-field levels

Calculated magnetic-field levels for the new configurations are summarized in Table A4 and plotted in Figure A3. The levels shown are maximum values that would occur very infrequently (a few times per year). The magnetic fields for average conductor clearance are representative of peak values that would be found at points along a span between structures. Over the course of a year the average magnetic field values would be about one-half these levels.

The calculated peak and edge-of-right-of-way field levels depend on the configuration. For the proposed configurations the peak magnetic fields on the ROW range from 227 to 472 mG. The largest peak magnetic field values on the ROW (> 370 mG) would occur for Configurations C-2, D-1, and D-2 and for Configurations C-3 and C-4 if the C-2 alternative route is selected. These peak fields are due to the large currents associated with alternatives C-2 and D. The selection of alternatives A or B would result in somewhat lower peak values, while the selection of alternative C-1 would produce the lowest magnetic fields on the ROW. The No-action alternative would result in peak fields from 99 to 217 mG on the ROW.

Magnetic fields at the edge of the ROW of the proposed corridors would range from 19 to 191 mG depending on configuration. For the No-action alternative the range of magnetic fields at the edge of the ROW would range from 2 to 59 mG.

More densely populated areas are found adjacent to configurations A-1, A-2, A-3, C-2, and C-3. For the configurations in existing corridors (A-1, A-2, A-3, and C-2), the proposed line would result in peak magnetic fields exceeding 10 mG at distances of from 75 to 245 feet from the edge of the ROW, depending on configuration. For Configuration C-3 in a new corridor, the peak magnetic field would exceed 10 mG at a distance of 125 or 185 beyond the edge of the ROW, depending on whether alternative C-1 or C-2 is selected. For the No-action alternative the magnetic field would exceed 10 mG at distances from 0 to 105 feet from the edge of the ROW, depending on configuration. The distances from the edge of the ROW at which the field exceeds 20 mG are about 60 to 90 feet less than the distances where the field exceeds 10 mG. Ten milligauss is the magnetic field level at which interference can occur to the most sensitive computer monitors.

A.4 Audible noise levels

Corona-generated audible noise (AN) levels from the new configurations are shown in Table A5. If no existing 345-kV or 500-kV lines are present in the corridor, then the proposed line will meet the BPA 50-dBA criterion for L_{50} foul weather AN. This would be the case for configurations A-1, A-3, B-1, B-2, C-2, and C-3. For Configuration C-3 the proposed line would be a new source along the corridor and increase the AN level during foul weather at the edge of the ROW from ambient to 48 dBA. For configurations A-1, A-3, and C-2 the AN level would increase by about 10 dBA which would be perceived as a doubling of the sound level. For the configurations of alternative B the AN levels at the edge of the ROW would be reduced from existing levels by 4 to 10 dBA.

The predicted L_{50} AN level exceeds the BPA 50-dBA limit at the edge of the ROW for corridors with existing 345-kV and 500-kV lines (A-2, A-4, C-1, C-4, D-1, and D-2). (The existing lines were constructed prior to adoption of the 50-dBA limit.) In these cases, AN with the proposed line present would still be dominated by that from the existing lines and there would be no perceivable change in AN levels with the addition of the proposed line.

A.5 Electromagnetic interference

Corona-generated electromagnetic interference levels for the new configurations are shown in Tables A6 and A7 for radio interference (RI) (1 MHz) and television interference (TVI) (75 MHz), respectively. The RI levels would be below the acceptable level of 40 dB(μV/m) at 100 feet from the outside conductors of configurations A-1, A-2, C-2, C-3, and D-2. In some corridors with existing 345-kV or 500-kV lines, RI levels would not change from existing levels even with the addition of the proposed line: these are configurations A-4, B-1, C-1, C-4 and D-1. In Configuration A-3 the RI level at 100 feet from the outside conductors on the east edge of the ROW would be 42 dB(μV/m), slightly above the acceptable level. However, this level is comparable to levels found near existing lines in the project area.

Foul weather TVI levels at 100-feet from the outside conductor of the proposed configurations range from 12 to 33 dB(μV/m) with the highest levels attributed to existing lines on the corridors. TVI levels adjacent to the existing corridors range from 5 to 33 dB(μV/m). The levels predicted for the proposed line are comparable with those found near existing lines in the project area and near other 500-kV lines in Washington.

A.6 Conclusions

The predicted levels for electric fields, magnetic fields, and corona effects from the new configurations of Alternatives A, B, C, and D are similar to those calculated and presented in the DEIS for the configurations in the Preferred alternative. The levels for the proposed configurations are also comparable to levels found on and near existing rights-of-way under the No-action alternative. Therefore, the levels predicted for the new configurations do not change the basic conclusions of either the Electrical Effects or Health Assessment appendices that were prepared previously.

However, in the portions of Alternatives A and C that pass through populated areas (A-1, A-2, A-3, C-2, and C-3), the potential impacts associated with increased ROW use, audible noise, and interference with electronic devices would be greater for these alternatives than for the No-action or Preferred alternative described in the DEIS. In the configurations where land use is similar to that along the Preferred alternative, the potential impacts will be the same as for the Preferred alternative. Similarly, along configurations A-4 and C-4 where field and corona levels are very similar to No-action alternative levels, potential impacts of the Proposed alternative would be minimal. The potential impacts associated with ROW use will be somewhat greater for Alternatives B and D than for the Preferred or No-action alternative.

List of Preparers

T. Dan Bracken was the principal author of this report. He received a B.S. degree in physics from Dartmouth College and M.S. and Ph.D. degrees in physics from Stanford University. Dr. Bracken has been involved with research on and characterization of electric- and magnetic-field effects from transmission lines for over 27 years, first as a physicist with the Bonneville Power Administration (BPA) (1973 - 1980) and since then as a consultant. His firm, T. Dan Bracken, Inc., offers technical expertise in areas of electric- and magnetic-field measurements, instrumentation, environmental effects of transmission lines, exposure assessment, and project management. Joseph Dudman of T. Dan Bracken, Inc., provided data entry, graphics, and clerical support in the preparation of the report.

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Table A1: Possible configurations for proposed Kangley – Echo Lake Project alternatives. (2 pages)

Configur-ation	Location	Description of other lines in corridor with proposed Kangley – Echo Lake 500-kV line	Length, miles
A-1	New line on an existing east/west right-of-way (ROW), parallel to and north of an existing line. This section extends west from a tap on the existing Schultz-Raver No. 2 line near Kangley to a point 3 miles east of the Covington substation.	Proposed line, single-circuit (north) Covington-Columbia #3 230-kV (south)	8.0
A-2	New line on an existing east/west ROW, parallel to and north of two existing lines. This section extends from 3 miles east of Covington substation into the substation.	Proposed line, single-circuit (north) Tacoma-Raver #1 & #2 500-kV double-circuit Covington-Columbia #3 230-kV (south)	3.0
A-3	New line on an existing north/south ROW. The new line would be on the east side of a new double-circuit 230/500-kV line that would replace an existing 230-kV line. This section would extend north from Covington substation to point on the Echo Lake –Maple Valley corridor 8.1 miles west of Echo Lake substation.	Proposed line, *double circuit with* (east) Covington-Maple Valley #2 230-kV (west)	9.0
A-4	New line on existing towers on an existing east/west ROW. The new line would be on the south side of an existing double-circuit 500-kV line. This section would extend east from a point 8.1 miles west of Echo Lake substation to the Echo Lake substation.	Echo Lake-Maple Valley 500-kV (north) *double circuit with*, Proposed line Rocky Reach-Maple Valley 345-kV (south)	8.1
B-1a	New line on existing east/west ROW. The new line would be on the south side of new double-circuit 345/500-kV structures that would replace an existing 345-kV line. This section would extend from just east of Stampede Pass to Echo Lake substation. A 3-mile section (B-1b) just west of Stampede Pass would have the same configuration but a wider ROW.	Rocky Reach-Maple Valley 345-kV (north) *double circuit with*, Proposed line (south)	35
B-1b	Same as B-1a in 3-mile section of existing ROW just west of Stampede Pass with 300-foot ROW.	Rocky Reach-Maple Valley 345-kV (north) *double circuit with*, Proposed line (south)	3

Table A1, continued

Configur-ation	Location	Description of other lines in corridor with proposed Kangley – Echo Lake 500-kV line (north to south)	Length, miles
C-1	New line on new ROW west from near Raver Substation for 2.3 miles. New ROW would be on north side of existing ROW.	Proposed line, single circuit (north) Tacoma-Raver #1 & #2 500-kV double-circuit Raver-Covington #1 500-kV Raver-Covington #2 500-kV (south)	2.3
C-2	New line on existing ROW going west from point 2.3 miles west of Raver substation for 4.2 miles.	Proposed line, single-circuit (north) Covington-Columbia #3 230-kV (south)	4.2
C-3	New line on new ROW going north from point on existing corridor that is 6.5 miles west of Raver substation. The new ROW would terminate on the Echo Lake – Maple Valley corridor at a point 4.8 miles west of Echo Lake substation.	Proposed line, single-circuit only	7.7
C-4	New line on existing towers on existing ROW in the Echo Lake – Maple Valley corridor going east from a point 4.8 miles west of Echo Lake substation to the Echo Lake substation.	Echo Lake-Maple Valley 500-kV, (north) *double circuit with* Proposed line Rocky Reach-Maple Valley 345-kV (south)	4.8
D-1a, D-2a	New line on new ROW from just east of Stampede Pass to Echo Lake substation. New line would be south (D-1a) or north (D-2a)of existing 345-kV line double-circuit structures. A 3-mile section (D-1b or D-2b) just west of Stampede Pass would have single-circuit existing structures and a wider ROW.	Proposed line, single-circuit (north for D-2a) Rocky Reach-Maple Valley 345-kV (south for D-2a)	35
D-1b, D-2b	Three mile section of existing ROW just west of Stampede Pass where new line would be south (D-1b) or north (D-2b) of existing 345-kV line single-circuit structures. No new ROW would be required for D-2b.	Proposed line, single-circuit (north for D-2b) Rocky Reach-Maple Valley 345-kV (south for D-2b))	3

Table A2: Physical and electrical characteristics of lines in corridor for the proposed Kangley – Echo Lake 500-kV transmission-line configurations. See Table A1 for descriptions of corridors and Figure A1 for physical layout of configurations. (3 pages)

	Proposed Line in Corridor								
Line Description	**Single – Circuit**					**Double – Circuit on New Towers with Existing Lines**		**Double – Circuit on Existing Towers with Existing Lines**	
Configurations	**A-1, A-2**	**C-1**	**C-2**	**C-3 (C-1)** **C-3 (C-2)**	**D-1, D-2**	**A-3**	**B-1**	**A-4**	**C-4 (C-1)** **C-4 (C-2)**
Voltage, kV **Maximum/Average[1]**	550/540					550/540		550/540	
Peak current, A[2] **No-action/Proposed**	- /1885	- /1380	- /2373	- /1380 - /2373	- /2753	- /1885	- /2753	- /1885	- /1380 - /2373
Electric phasing: **north — south** **(east – west for A-3)**	B A C					B B A C C A		B B A C A C	
Clearance, ft. **Minimum/Average[1]**	35/45					36/46		33/43	
Tower configuration	Delta					Dbl. Ckt., Vertical		Dbl. Ckt., Delta	
Phase spacing, ft.[3]	48H, 34.5V					32/42H from CL, 36V		17/29.75/42.5H from CL, 36.75V	
Conductor: #/diameter, in.; spacing, in.	3/1.300; 17.04					3/1.300; 17.04		3/1.302; 17.04	

1 Average voltage and average clearance used for corona calculations.
2 Negative current indicates power flow in opposite direction to that on proposed line.
3 H = horizontal feet; V = vertical feet; CL = centerline of structure

Table A2, continued

	Existing Lines in Corridor						
Line Description	**Covington - Columbia #3 230-kV**		**Tacoma – Raver #1 & #2 500-kV Double-circuit**		**Covington – Maple Valley #2 230-kV**	**Echo Lake – Maple Valley #1 & #2 500-kV Double-circuit**	
Configurations	**A-1, A-2**	**C-2**	**A-2**	**C-1**	**A-3**	**A-4**	**C-4 (C-1)** **C-4 (C-2)**
Voltage, kV Maximum/Average[1]	242/237		550/540		242/237	550/540	
Peak current, A[2] **No-action/Proposed**	662/674	662/659	672/638	672/632	685/710	-770/-1624	-770/-1626 -770/-1805
Electric phasing (north – south)	A B C		B B A C A C		A B C (east – west)	B B A C A C	
Clearance, ft. Minimum/Average[1]	27/37		33/43		34/44	33/43	
Tower configuration	Horizontal		Dbl. Ckt., Delta		Horizontal	Dbl. Ckt., Delta	
Phase spacing, ft.[3]	27H		17/29.75/42.5H from CL, 36.75V		34H	17/29.75/42.5H from CL, 36.75V	
Conductor: #/diameter, in.; spacing, in.	1/1.302		3/1.302; 17.04		1/1.602	3/1.302; 17.04	

1 Average voltage and average clearance used for corona calculations.
2 Negative current indicates power flow in opposite direction to that on proposed line.
3 H = horizontal feet; V = vertical feet; CL = centerline of structure

Table A2, continued

	Existing Lines in Corridor					
Line Description	**Rocky Reach – Maple Valley 345-kV**				**Raver – Covington #1 500-kV**	**Raver – Covington #2 500-kV**
Configurations	**A-4**	**B-1a, D-1a, D-2a**	**B-1b, D-1b, D-2b**	**C-4**	**C-1**	**C-1**
Voltage, kV Maximum/Average[1]	362/355				550/540	550/540
Peak current, A[2] **No-action/Proposed**	-822/-819	822/839	822/839	-822/-811	1075/1040	1084/1049
Electric phasing (north – south)	A B C	B A C	C B A	A B C	C B A	C B A
Clearance, ft. Minimum/Average[1]	34/44				33/43	33/43
Tower configuration	Horizontal	One side of vertical DC	Horizontal	Horizontal	Horizontal	Delta
Phase spacing, ft.[3]	34H	18.5/28.5H from CL, 25.5V	34H	34H	33.5H	40H, 27.5V
Conductor: #/diameter, in.; spacing, in.	1/1.602				1/2.5	2/1.602, 18

1 Average voltage and average clearance used for corona calculations.
2 Negative current indicates power flow in opposite direction to that on proposed line.
3 H = horizontal feet; V = vertical feet; CL = centerline of structure

Table A3: Calculated peak and edge-of-ROW electric fields for the proposed Kangley – Echo Lake 500-kV line operated at maximum voltage by configuration. Configurations are described in Tables 1 and 2 and shown in Figure A1. (2 pages)

a) Peak electric field on right-of-way, kV/m

Location	Proposed Corridor		No-action Corridor	
Line Clearance	Minimum	Average	Minimum	Average
A-1	8.7	5.8	3.8	2.3
A-2	8.7	5.9	8.3	5.6
A-3	8.7	6.1	3.0	2.0
A-4	8.3	5.6	8.3	5.6
B-1a	8.7	6.1	4.0	2.7
B-1b	8.7	6.1	4.5	3.0
C-1	8.7	6.1	8.7	6.1
C-2	8.7	5.8	3.8	2.3
C-3	8.6	5.8	-	-
C-4	8.3	5.6	8.3	5.6
D-1a, D-2a	8.6	5.8	4.0	2.7
D-1b, D-2b	8.9	6.1	4.5	3.0

Table A3, continued

b) Edge-of-right-of-way electric field, kV/m

Location	**Proposed Line**[1]		**No-action Corridor**[1]	
Line Clearance	Minimum	Average	Minimum	Average
A-1	0.4, 1.4	0.4, 1.3	0.0, 1.3	0.0, 1.3
A-2	2.5, 1.4	2.5, 1.4	0.6, 1.4	0.6, 1.4
A-3	2.1, 0.8	2.2, 0.9	1.2, 1.2	1.1, 1.1
A-4	3.0, 1.8	2.8, 1.7	3.0, 1.8	2.8, 1.7
B-1a	1.3, 2.1	1.4, 2.1	0.3, 0.5	0.2, 2.7
B-1b	0.3, 2.1	0.3, 2.1	0.1, 1.8	0.1, 1.7
C-1	2.5, 1.0	2.4, 1.1	3.0, 1.0	2.7, 1.1
C-2	0.4, 1.3	0.4, 1.3	0.0, 1.3	0.0, 1.3
C-3	2.5, 2.5	2.4, 2.4	-	-
C-4	3.0, 1.8	2.7, 1.7	3.0, 1.8	2.8, 1.7
D-1a, D-2a	2.5, 0.3	2.4, 0.5	0.3, 0.5	0.1, 0.4
D-1b, D-2b	2.4, 1.7	2.4, 1.6	0.1, 1.8	0.1, 1.7

[1] Electric field at north (east) edge of right-of-way is given first.

Table A4: Calculated peak and edge-of-right-of-way magnetic fields for the proposed Kangley – Echo Lake 500-kV line operated at maximum current by configuration. Configurations are described in Tables 1 and 2. (2 pages)

a) Peak magnetic field on right-of-way, mG

Location		**Proposed Corridor**		**No-action Corridor**	
Line Clearance		Minimum	Average	Minimum	Average
A-1		304	206	167	109
A-2		299	203	159	103
A-3		227	159	133	94
A-4		306	192	151	106
B-1a		332	232	99	66
B-1b		332	232	159	113
C-1		228	156	217	153
C-2		385	262	167	109
C-3	**w/ C-1**	230	158	-	-
	w/ C-2	395	271		
C-4	**w/ C-1**	243	155	151	106
	w/ C-2	374	232		
D-1a, D-2a		461	317	99	66
D-1b, D-2b		472	326	159	113

Table A4, continued

b) Edge-of-right-of-way magnetic field, mG

Location		Proposed Corridor[1]		No-action Corridor[1]	
Line Clearance		Minimum	Average	Minimum	Average
A-1		19, 64	19, 55	2, 53	2, 44
A-2		93, 63	81, 53	10, 57	10, 48
A-3		131, 65	108, 57	47, 47	40, 40
A-4		68, 54	55, 46	53, 59	44, 51
B-1a		86, 191	76, 157	20, 38	18, 32
B-1b		20, 191	20, 157	6, 56	6, 48
C-1		63, 29	55, 27	41, 31	7, 29
C-2		24, 66	23, 56	2, 53	2, 44
C-3	**w/ C-1**	64, 64	55, 55	-	-
	w/ C-2	109, 109	95, 95		
C-4	**w/ C-1**	72, 54	58, 46	53, 59	45, 51
	w/ C-2	73, 52	58, 45		
D-1a, D-2a		126, 53	110, 47	20, 38	4, 32
D-1b, D-2b		122, 45	105, 39	6, 56	6, 48

[1] Magnetic field at north (east) edge of right-of-way is given first.

Table A5: Predicted foul-weather audible noise (AN) levels at edge of right-of-way (ROW) for the proposed Kangley – Echo Lake 500-kV line corridor by configuration. AN levels expressed in decibels on the A-weighted scale (dBA). L_{50} and L_5 denote the levels exceeded 50 and 5 percent of the time, respectively. Configurations are described in Tables 1 and 2 and are shown in Figure A1.

	Foul-weather AN			
	Proposed Corridor[1]		No-action Corridor[1]	
Configuration[1]	L_{50}, dBA	L_5, dBA	L_{50}, dBA	L_5, dBA
A-1	45, 45	48, 49	31, 39	35, 43
A-2	54, 53	58, 57	52, 53	56, 56
A-3	49, 46	53, 50	32, 32	36, 36
A-4	57, 56	60, 59	57, 56	60, 59
B-1a	46, 49	50, 53	53, 55	56, 58
B-1b	43, 49	46, 53	48, 53	52, 57
C-1	60, 63	64, 67	63, 63	66, 67
C-2	45, 45	48, 49	31, 39	35, 43
C-3	48, 48	52, 52	-	-
C-4	57, 56	60, 59	57, 56	60, 59
D-1a, D-2a	52, 55	55, 59	49, 55	53, 58
D-1b, D-2b	51, 53	54, 57	48, 53	52, 57

[1] AN level at north (or east) edge of right-of-way is given first.

Table A6: Predicted fair-weather radio interference (RI) levels at 100 feet (30.5 m) from the outside conductor of the proposed Kangley – Echo Lake 500-kV line corridor by configuration. RI levels given in decibels above 1 microvolt/meter (dBμV/m) at 1.0 MHz. L_{50} denotes level exceeded 50 percent of the time. Configurations are described in Tables 1 and 2 and are shown in Figure A1.

Configuration	**Fair-weather RI**	
	Proposed Corridor [1]	**No-action Corridor**[1]
	L_{50}, dBμV/m	**L_{50}, dBμV/m**
A-1	33[2], 28	13[2], 24
A-2	38, 34	38[2], 34
A-3	42, 36	18, 18
A-4	42, 39	42, 39
B-1a	36, 42	45, 46
B-1b	32[2], 42	31[2], 39
C-1	38, 46	42, 46
C-2	33[2], 28	13[2], 24
C-3	37, 37	-
C-4	42, 39	42, 39
D-1a, D-2a	38, 47	35[2], 46
D-1b, D-2b	38, 39	31[2], 39

[1] RI level at 100 ft. from outside conductor at north (or east) edge of corridor is given first.
[2] RI value at edge of right-of-way because a point 100 ft. from the outside conductor is still on the right-of-way.

Table A7: Predicted maximum foul-weather television interference (TVI) levels at 100 feet (30.5 m) from the outside conductor of the proposed Kangley – Echo Lake 500-kV line corridor by configuration. TVI levels given in decibels above 1 microvolt/meter (dBμV/m) at 75 MHz. Configurations are described in detail in Tables 1 and 2 and are shown in Figure A1.

	Foul-weather TVI	
	Proposed Corridor[1]	**No-action Corridor[1]**
Configuration	**Maximum (foul), dBμV/m**	**Maximum (foul), dBμV/m**
A-1	18[2], 12	-4[2], 13
A-2	25, 18	23[2], 18
A-3	24, 15	5, 5
A-4	28,26	29, 26
B-1a	15, 24	29, 29
B-1b	9[2], 24	15[2], 26
C-1	25, 33	28, 33
C-2	18[2], 12	-4[2], 13
C-3	24, 24	-
C-4	29, 26	29, 26
D-1a, D-2a	24, 30	14[2], 29
D-1b, D-2b	24, 27	15[2], 26

[1] TVI level at 100 ft. from outside conductor at north (or east) edge of corridor is given first.
[2] TVI value at edge of right-of-way because a point 100 ft. from the outside conductor is still on the right-of-way.

Figure A1: New configurations for the proposed Kangley – Echo Lake 500-kV line corridors: a) Configuration A-1; b) Configuration A-2; c) Configuration A-3; d) Configuration A-4; e) Configuration B-1a; f) Configuration B-1b; g) Configuration C-1; h) Configuration C-2; i) Configuration C-3; j) Configuration C-4; k) Configuration D-2a; and l) Configuration D-2b. Configurations D-1a and D-1b are similar to D-2a and D-2b except the proposed line is on the south side of the existing line. Configurations are described in Tables A1 and A2. (13 pages)

a) Configuration A-1: Proposed single-circuit line parallel to existing Covington - Columbia #3 230-kV line (Similar to Configuration C-2.) (not to scale)

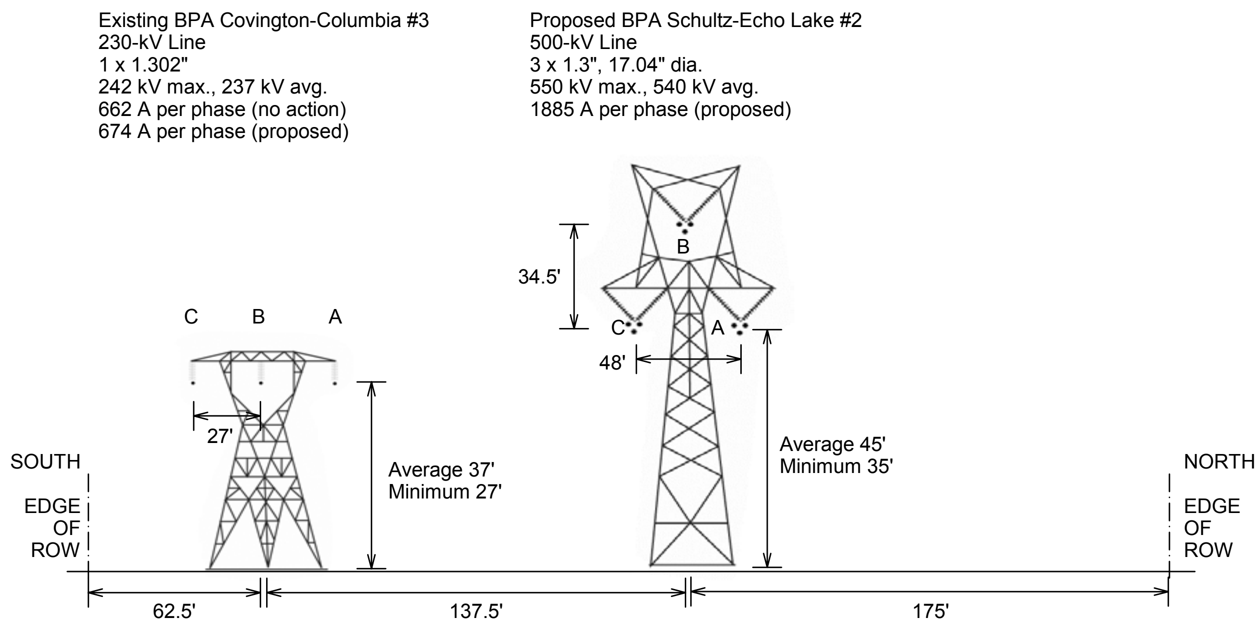


Figure A1, continued

b) Configuration A-2: Proposed single-circuit line parallel to existing Tacoma – Raver #1 and #2 double-circuit 500-kV and Covington – Columbia #3 230-kV lines. (not to scale)

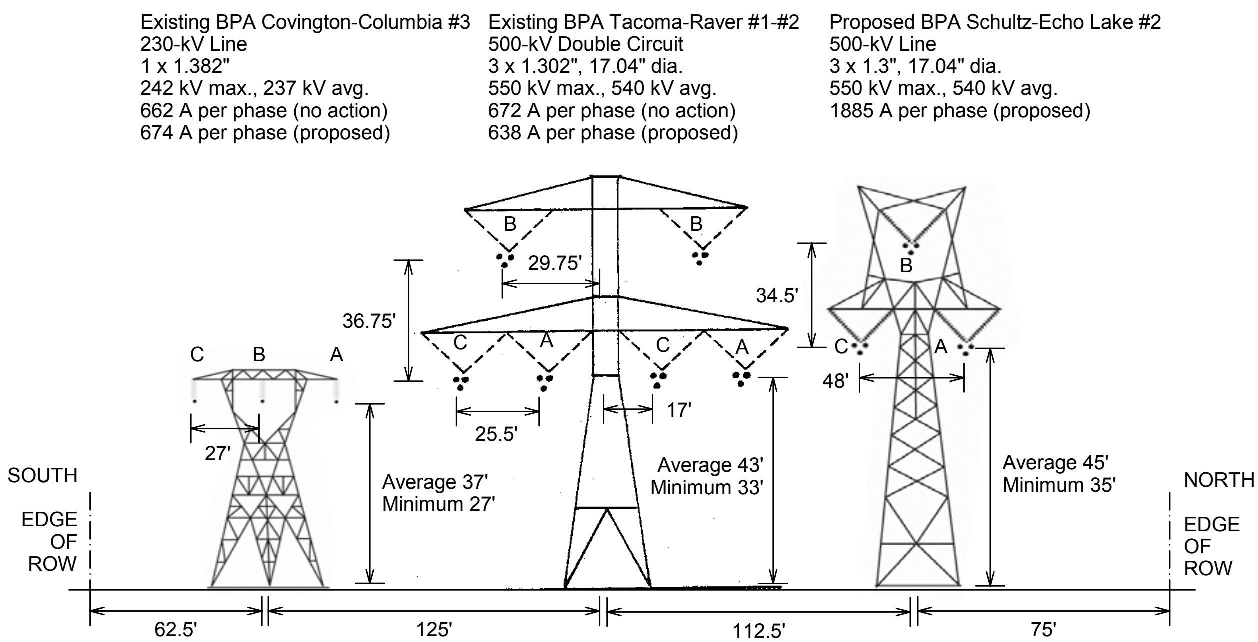
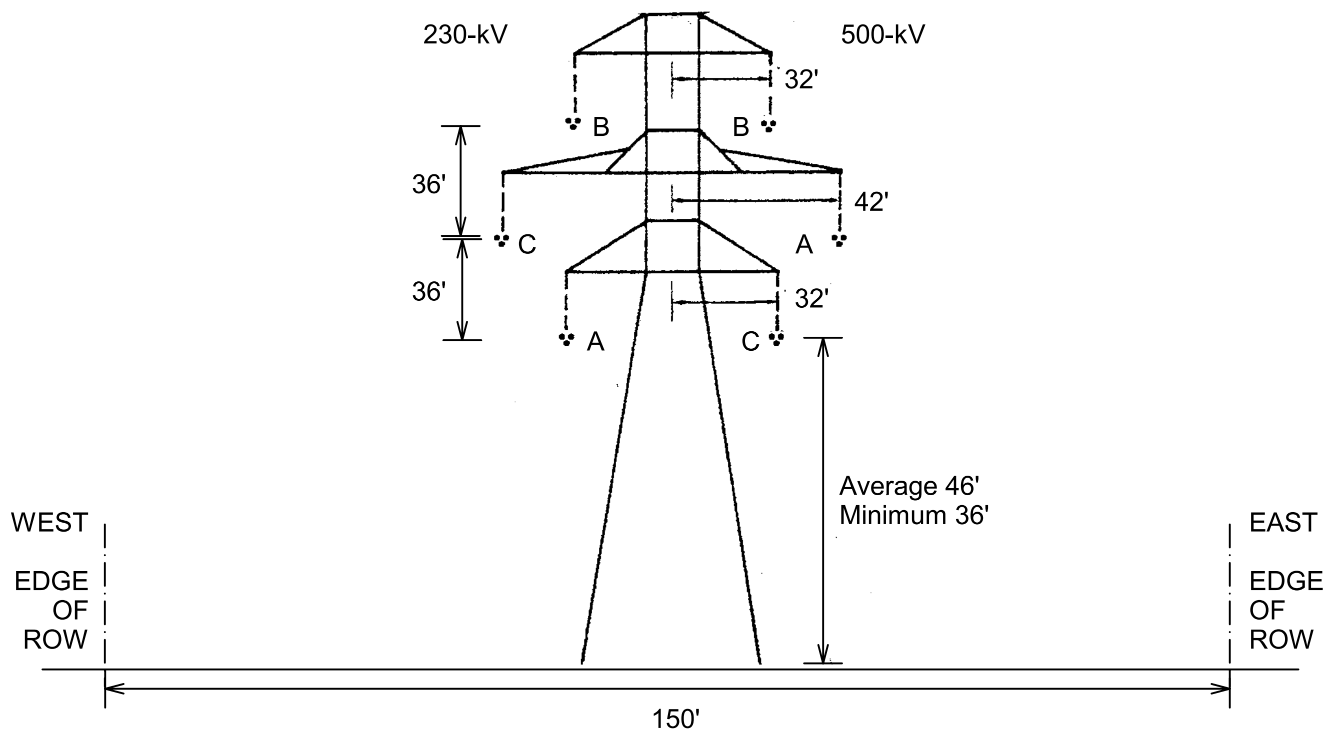


Figure A1, continued

c) Configuration A-3: Proposed line located on new double-circuit structures with existing Covington – Maple Valley #2 230-kV line.

Existing	Proposed
BPA Covington-Maple Valley #2	BPA Schultz-Echo Lake #2
230-kV Line	500-kV Line
3 x 1.3", 17.04" dia.	3 x 1.3", 17.04" dia.
242 kV max., 237 kV avg.	550 kV max., 540 kV avg.
685 A per phase (no action)	1885 A per phase (proposed)
710 A per phase (proposed)	



(not to scale)

Figure A1, continued

d) Configuration A-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to existing Rocky Reach – Maple Valley 345-kV line. (Similar to Configuration C-4). (not to scale)

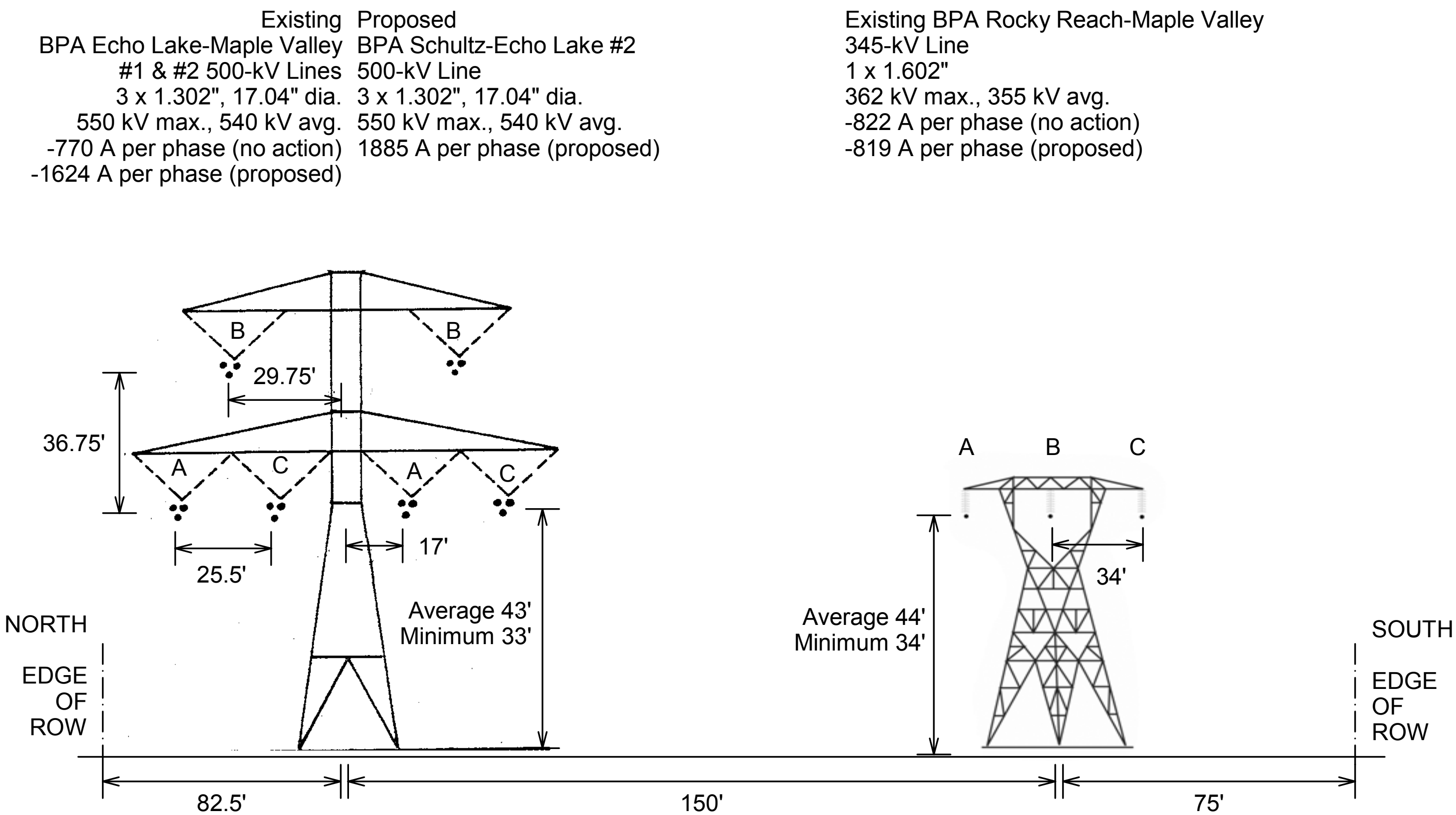


Figure A1, continued

e) Configurations B-1a and B-1b: Proposed line located on new double-circuit structures with existing Rocky Reach – Maple Valley 345-kV line. Configuration B-1a would require new right-of-way; B-1b would not. (not to scale)

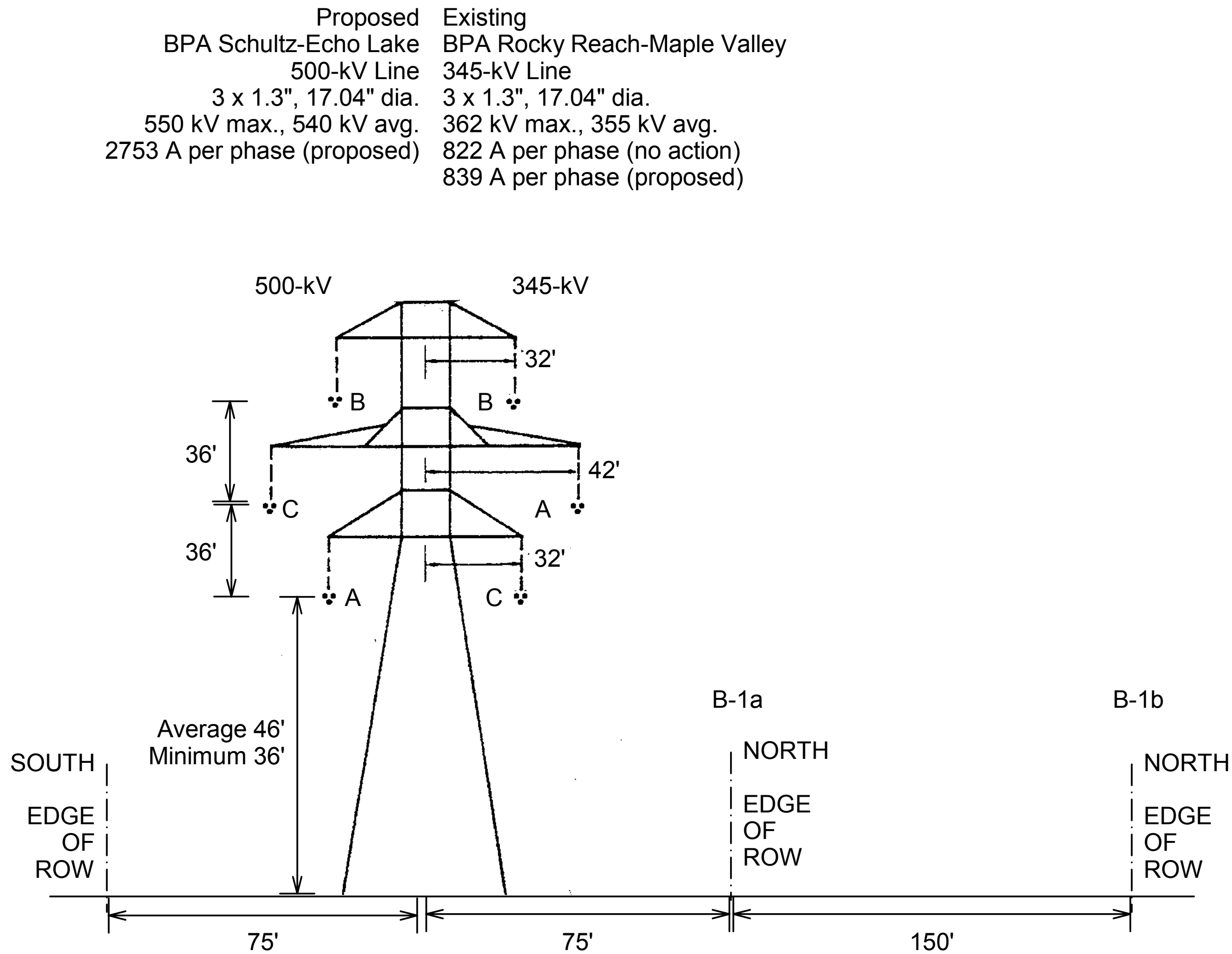


Figure A1, continued

f) Configuration C-1: Proposed single-circuit line parallel to Tacoma – Raver #1 and #2 double-circuit 500-kV, Raver – Covington #1 500-kV, and Raver – Covington #2 500-kV lines. (not to scale)

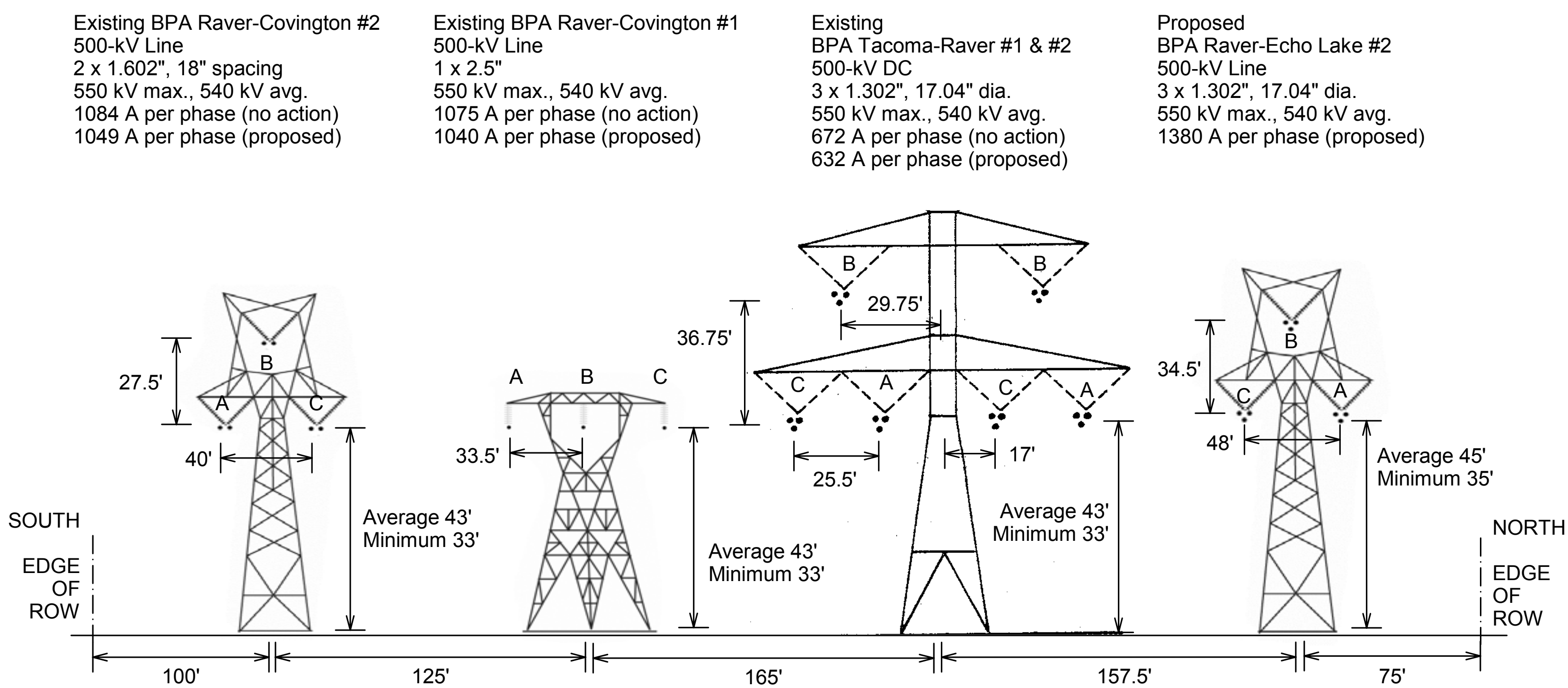


Figure A1, continued

a) Configuration C-2: Proposed single-circuit line parallel to existing Covington – Columbia #3 230-kV line. (Similar to Configuration A-1.) (not to scale)

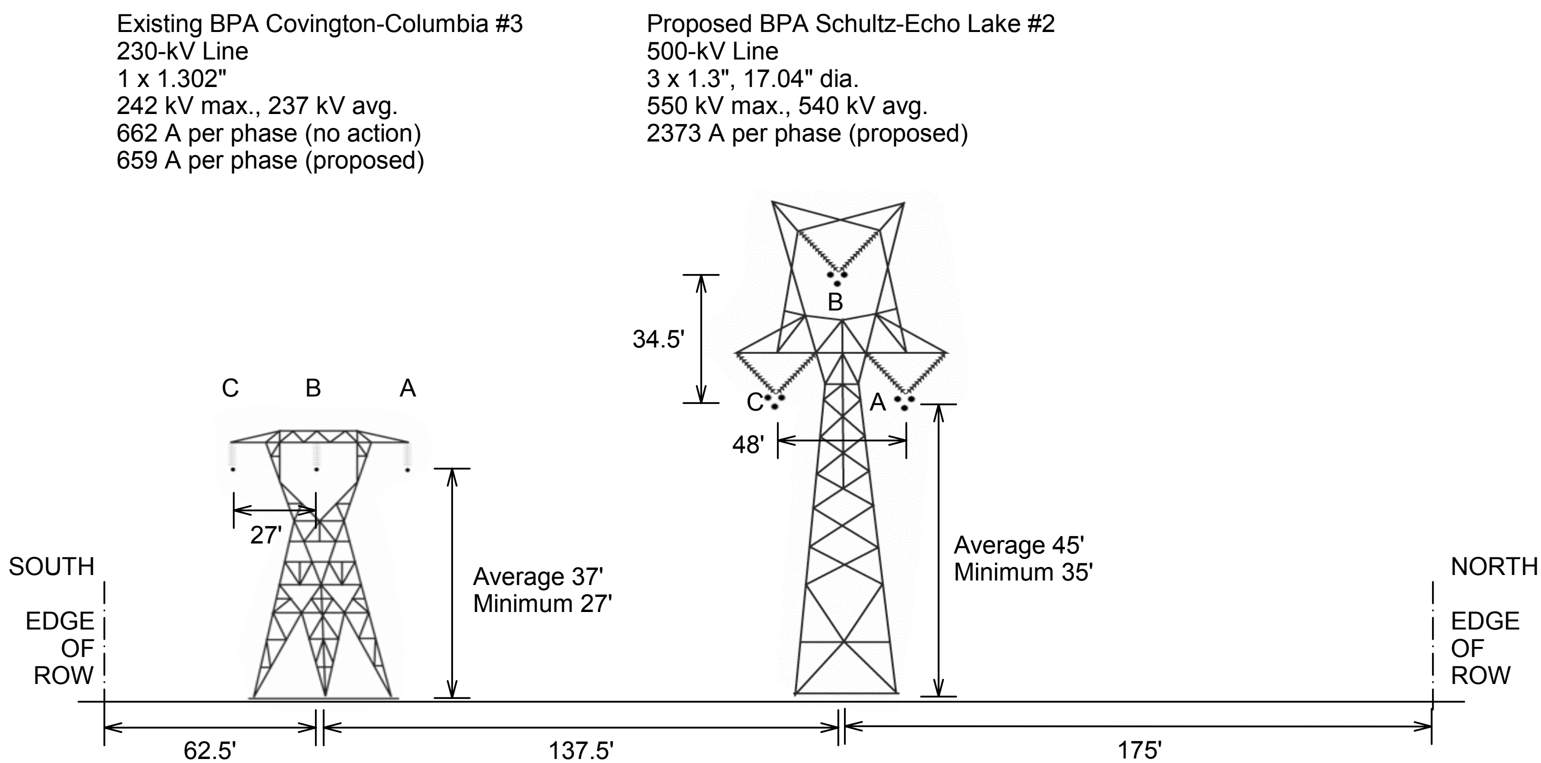


Figure A1, continued

b) Configuration C-3: Proposed single-circuit line on new right-of-way with no parallel lines. (not to scale)

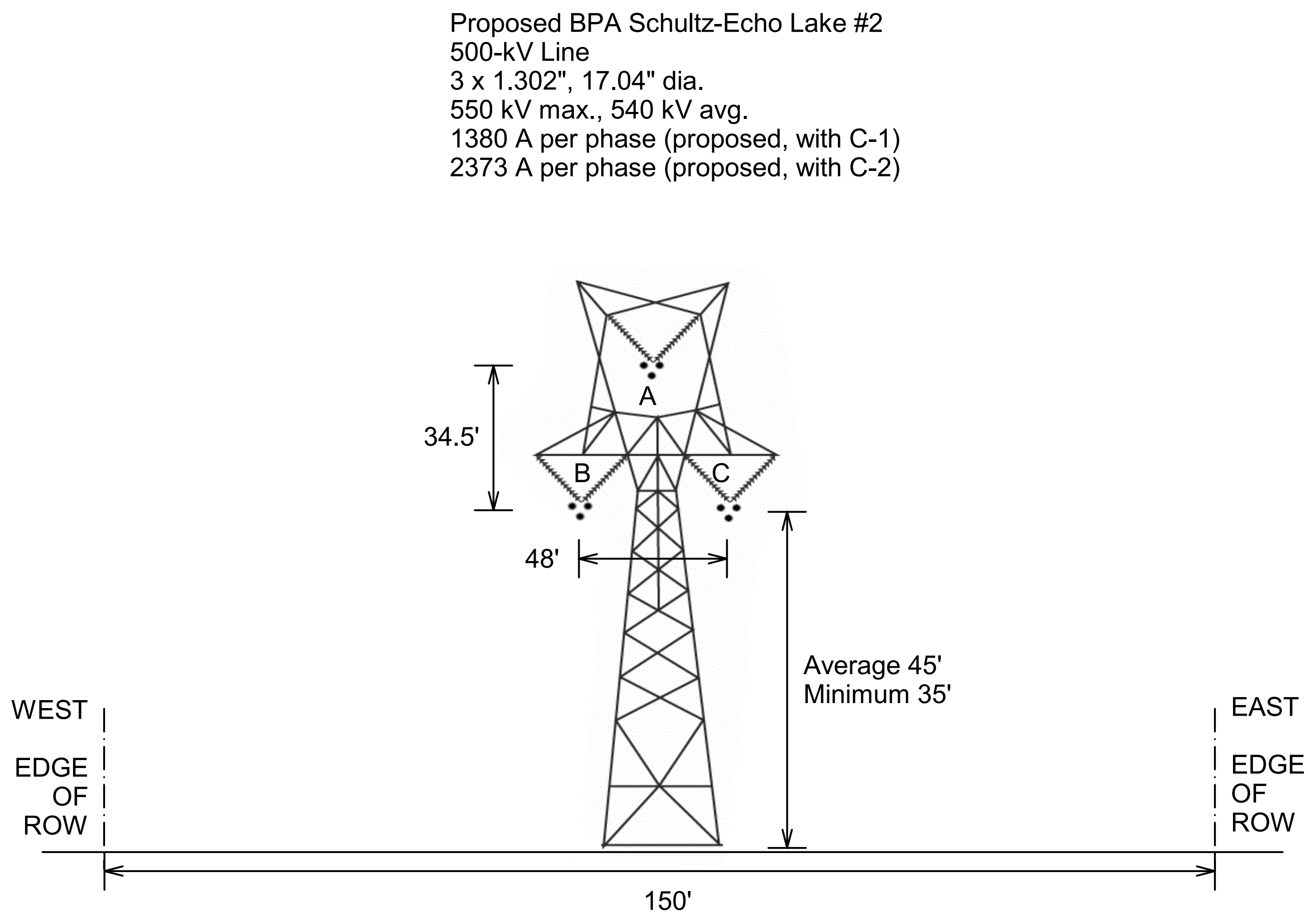


Figure A1, continued

c) Configuration C-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to Rocky Reach – Maple Valley 345-kV line. (Similar to Configuration A-4.) (not to scale)

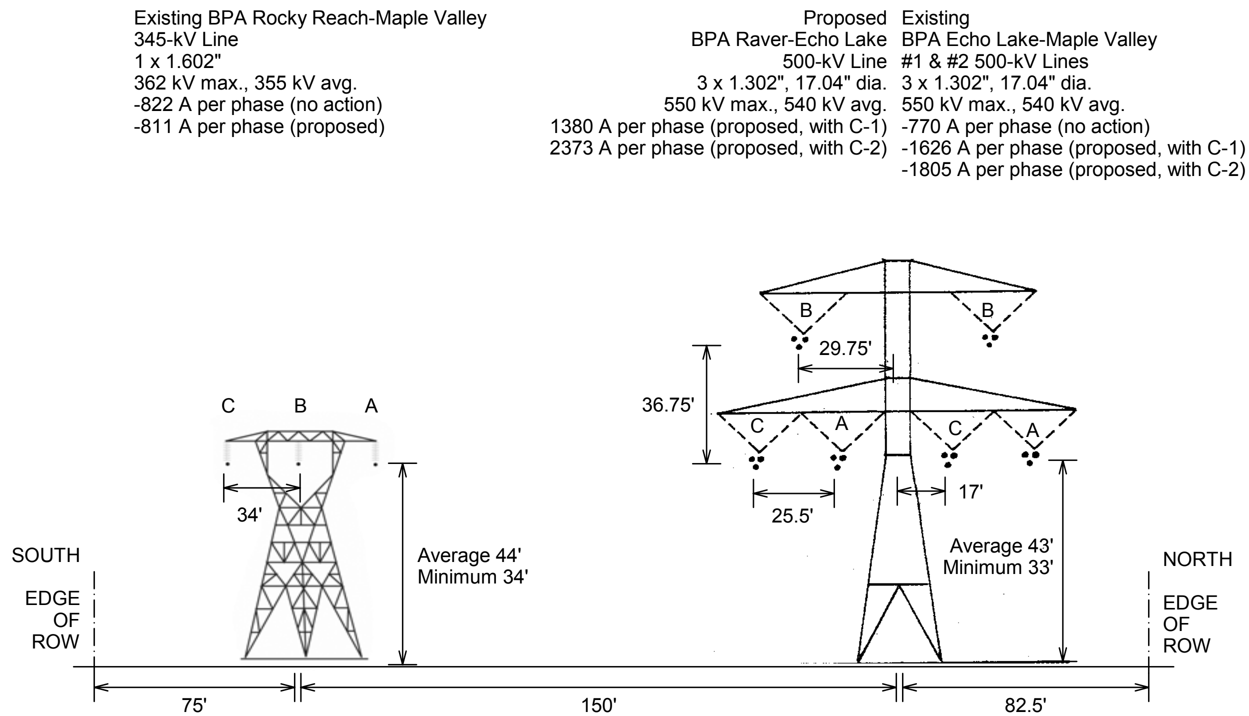


Figure A1, continued

d) Configuration D-2a: Proposed single-circuit line parallel to existing Rocky Reach – Maple Valley 345-kV line. Configuration D-2a would require new right-of-way. Configuration D-1a is similar with the proposed line on the south side of the existing 345-kV line. (not to scale)

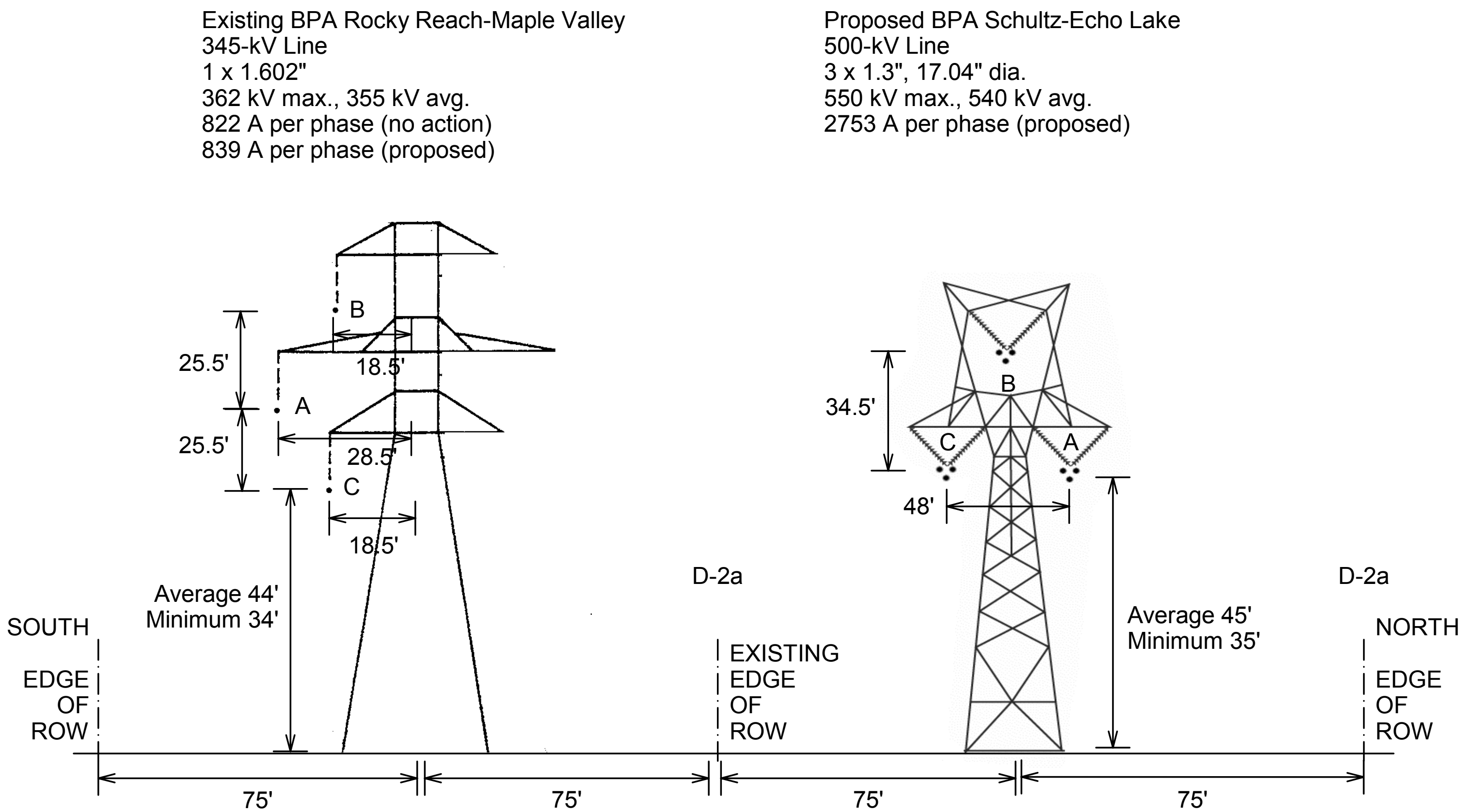


Figure A1, continued

e) Configuration D-2b: Proposed single-circuit line parallel to existing Rocky Reach – Maple Valley 345-kV line. Configuration D-2b would not require new right-of-way. Configuration D-1b is similar with the proposed line on the south side of the existing 345-kV line and would require new ROW. (not to scale)

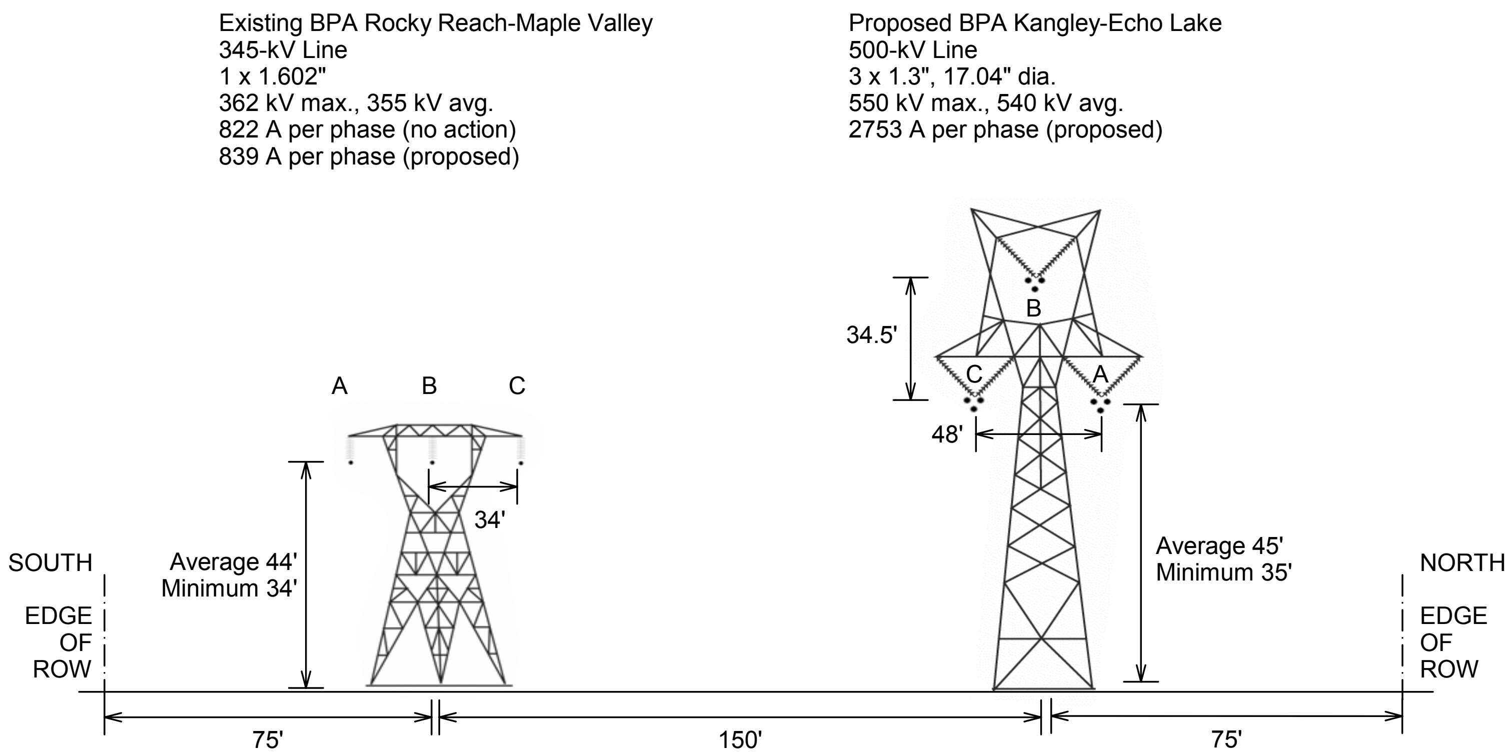
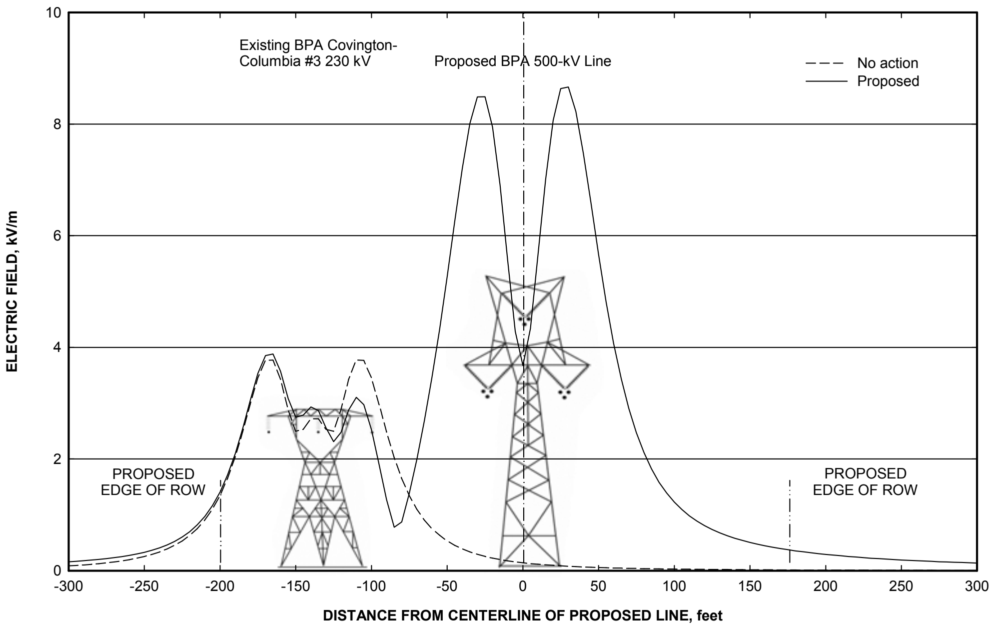


Figure A2: Electric-field profiles for new configurations of the proposed Kangley – Echo Lake 500-kV line under maximum voltage conditions: a) Configuration A-1; b) Configuration A-2; c) Configuration A-3; d) Configuration A-4; e) Configuration B-1a and B-1b; f) Configuration C-1; g) Configuration C-2; h) Configuration C-3; i) Configuration C-4; and j) Configuration D-2a and D-2b. Configurations are described in Tables A1 and A2. (5 pages)

a) Configuration A-1: Proposed single-circuit line parallel to existing Covington - Columbia #3 230-kV line



b) Configuration A-2: Proposed single-circuit line parallel to existing Tacoma – Raver #1 and #2 double-circuit 500-kV and Covington – Columbia #3 230-kV lines

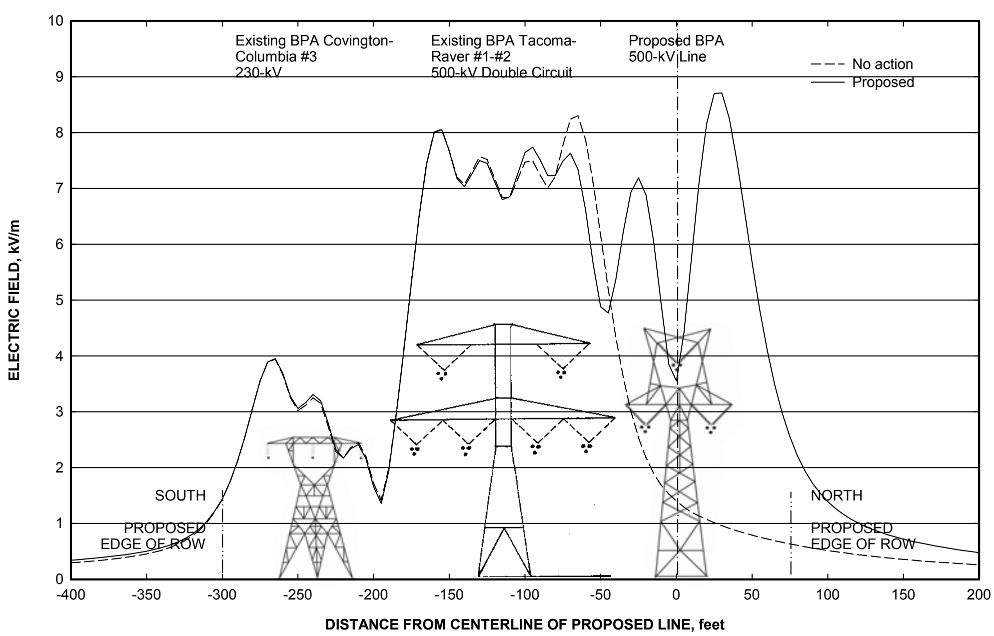
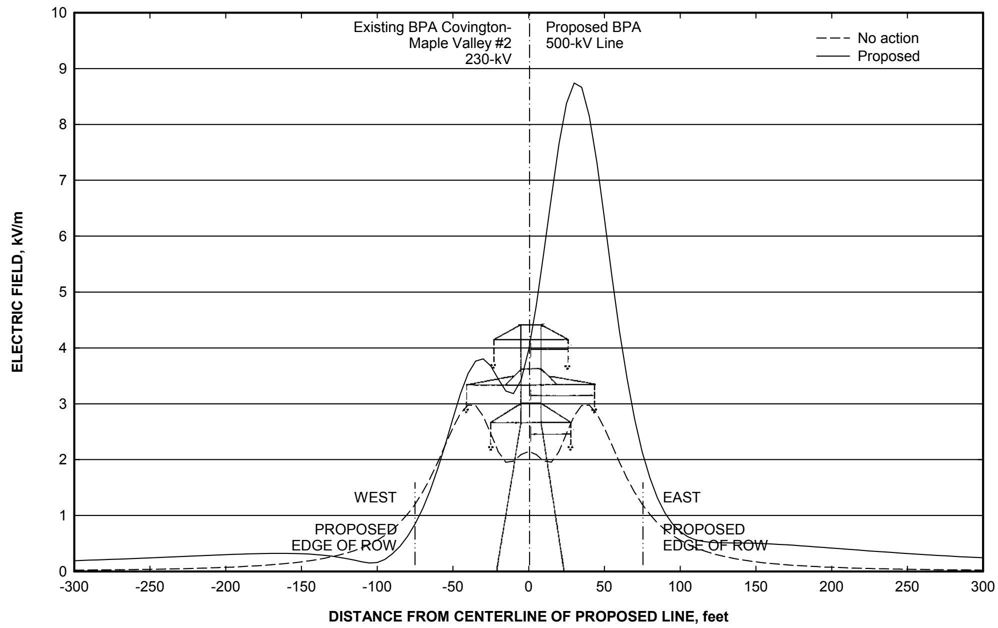


Figure A2, continued

c) Configuration A-3: Proposed line located on new double-circuit structures with existing Covington – Maple Valley #2 230-kV line.



d) Configuration A-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to existing Rocky Reach – Maple Valley 345-kV line

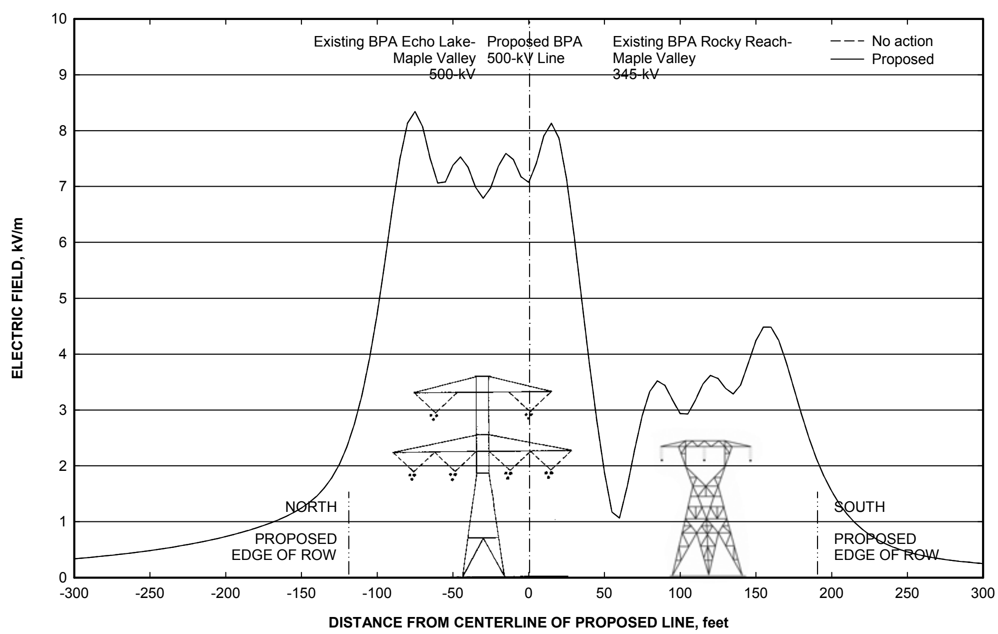
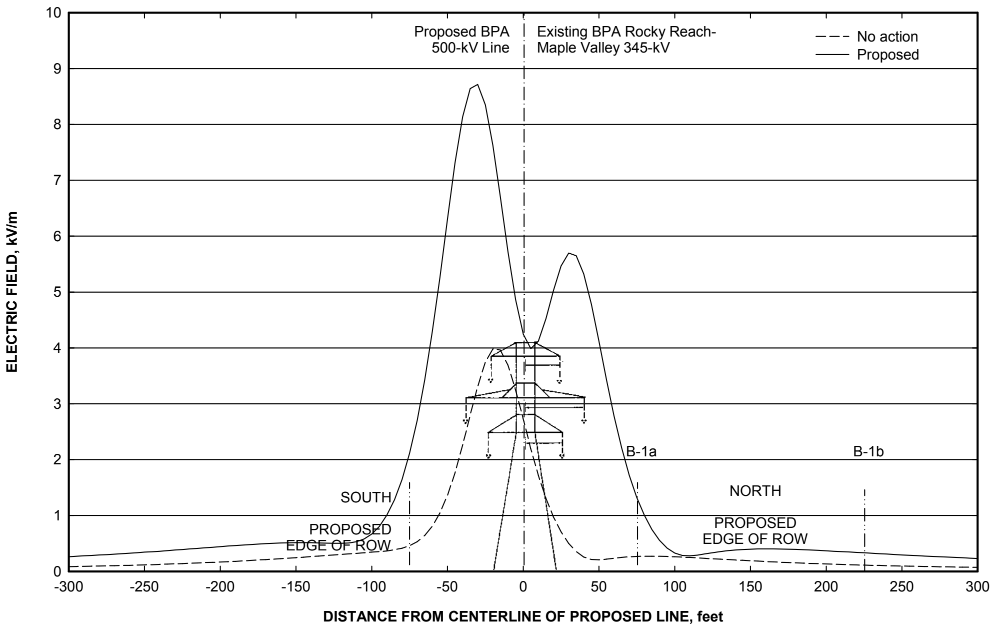


Figure A2, continued

e) Configurations B-1a and B-1b: Proposed line located on new double-circuit structures with existing Rocky Reach – Maple Valley 345-kV line



Configuration C-1: Proposed single-circuit line parallel to Tacoma – Raver #1 and #2 double-circuit 500-kV, Raver – Covington #1 500-kV, and Raver – Covington #2 500-kV lines

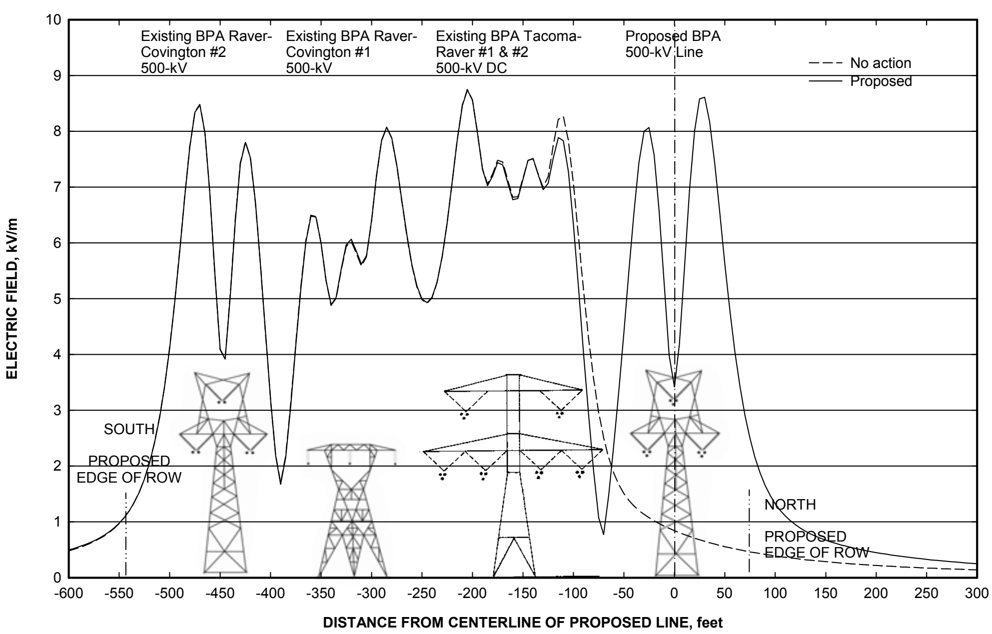
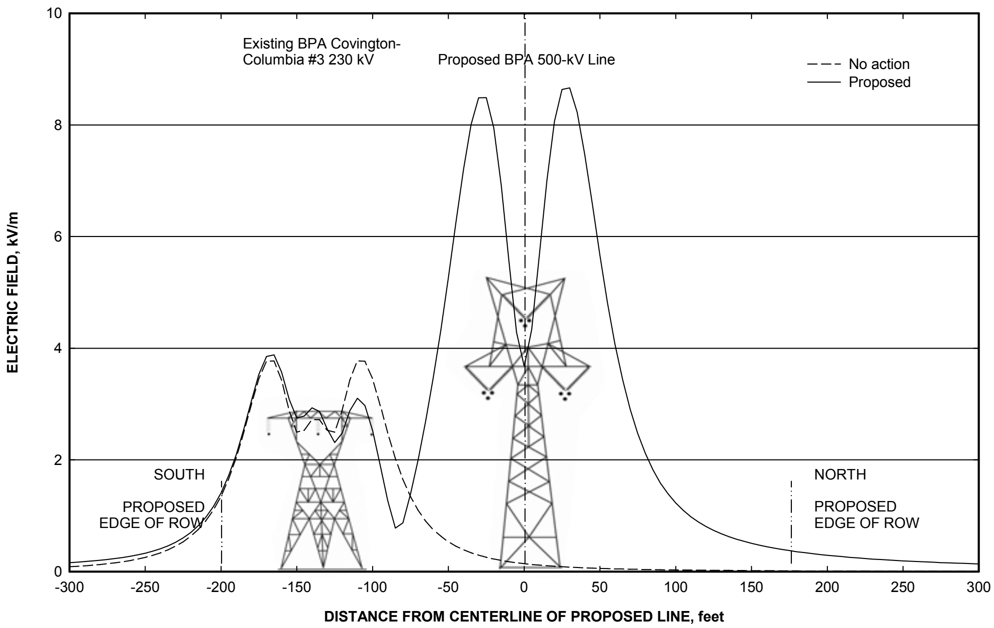


Figure A2, continued

f) Configuration C-2: Proposed single-circuit line parallel to existing Covington – Columbia #3 230-kV line



g) Configuration C-3: Proposed single-circuit line on new right-of-way with no parallel lines

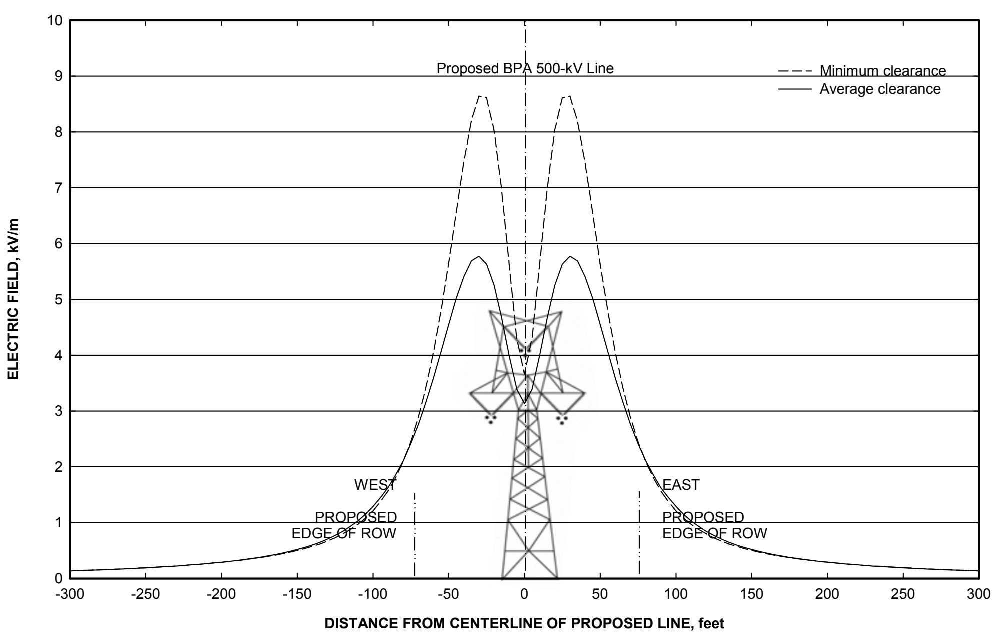
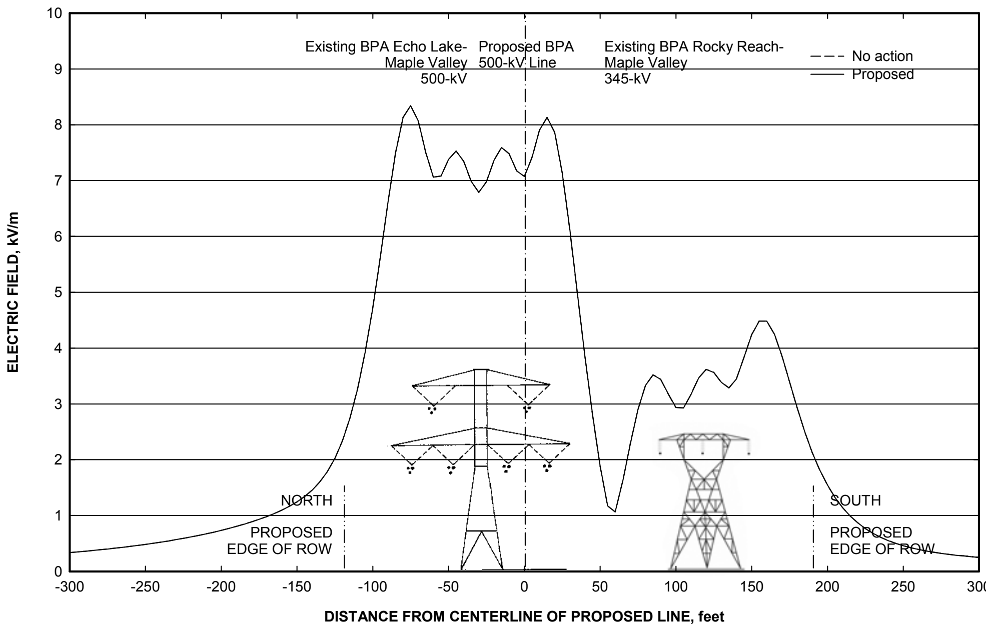


Figure A2, continued

h) Configuration C-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to Rocky Reach – Maple Valley 345-kV line



i) Configuration D-2a: Proposed single-circuit line parallel to existing Rocky Reach – Maple Valley 345-kV line. Configuration D-1a would be have a similar profile going from north to south.

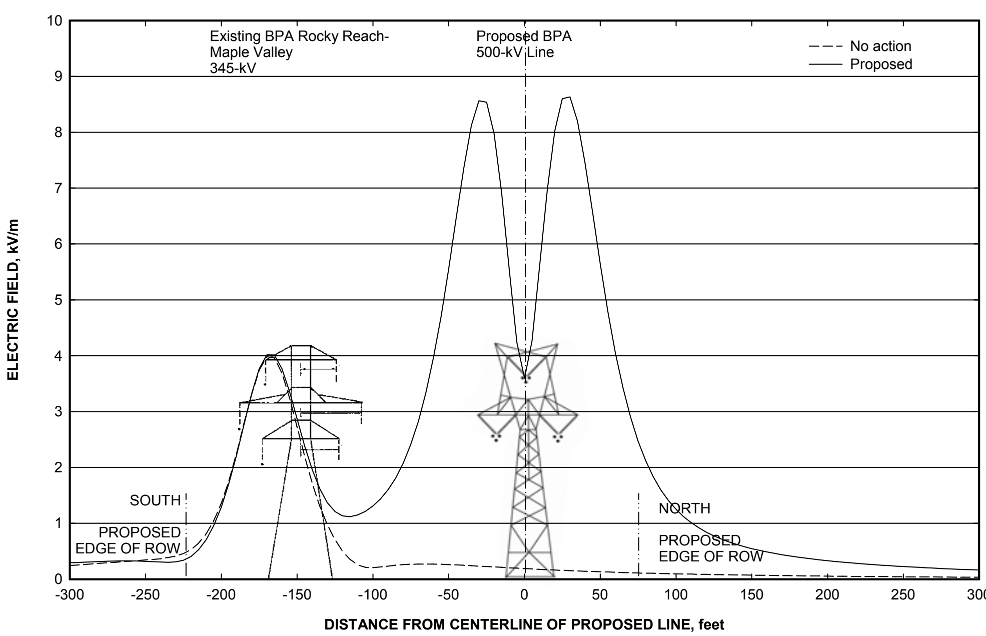


Figure A2, continued

j) Configuration D-2b: Proposed single-circuit line parallel to existing single-circuit Rocky Reach – Maple Valley 345-kV line. Configuration D-1b would have a similar profile going from north to south.

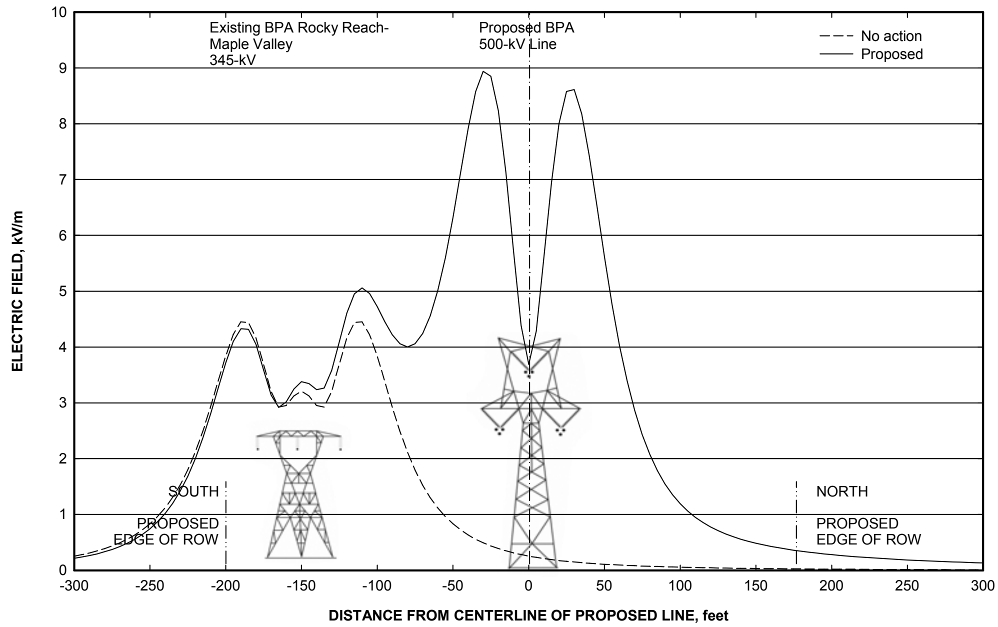
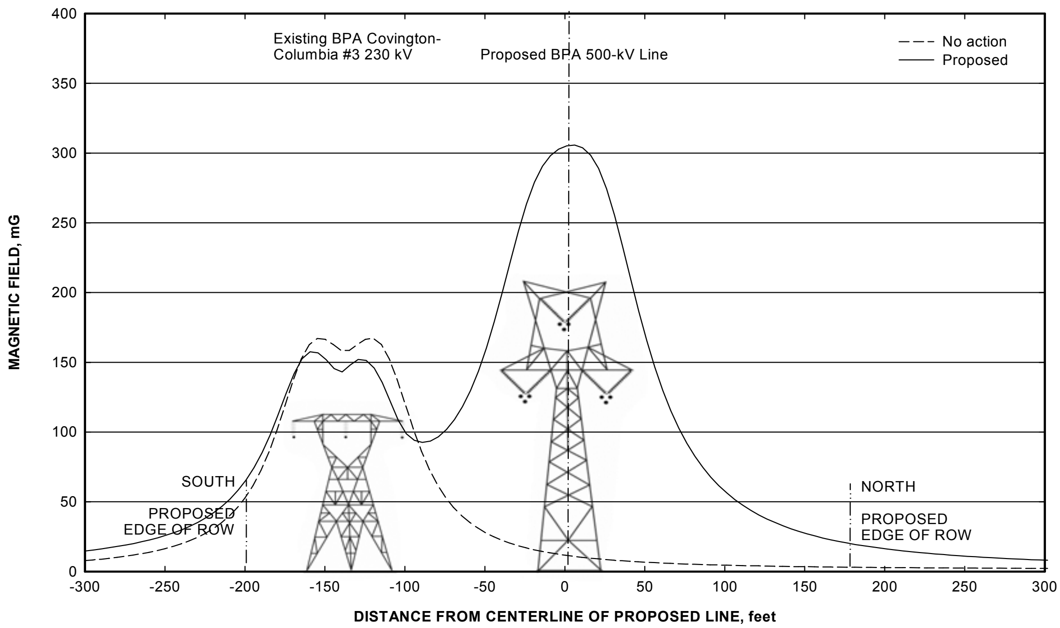


Figure A3: **Magnetic-field profiles for new configurations of the proposed Kangley – Echo Lake 500-kV line under maximum current conditions: a) Configuration A-1; b) Configuration A-2; c) Configuration A-3; d) Configuration A-4; e) Configuration B-1a and B-1b; f) Configuration C-1; g) Configuration C-2; h) Configuration C-3; i) Configuration C-4; and j) Configuration D-2a and D-2b.** Configurations are described in Tables A1 and A2. (7 pages)

a) Configuration A-1: Proposed single-circuit line parallel to existing Covington - Columbia #3 230-kV line



b) Configuration A-2: Proposed single-circuit line parallel to existing Tacoma – Raver #1 and #2 double-circuit 500-kV and Covington – Columbia #3 230-kV lines

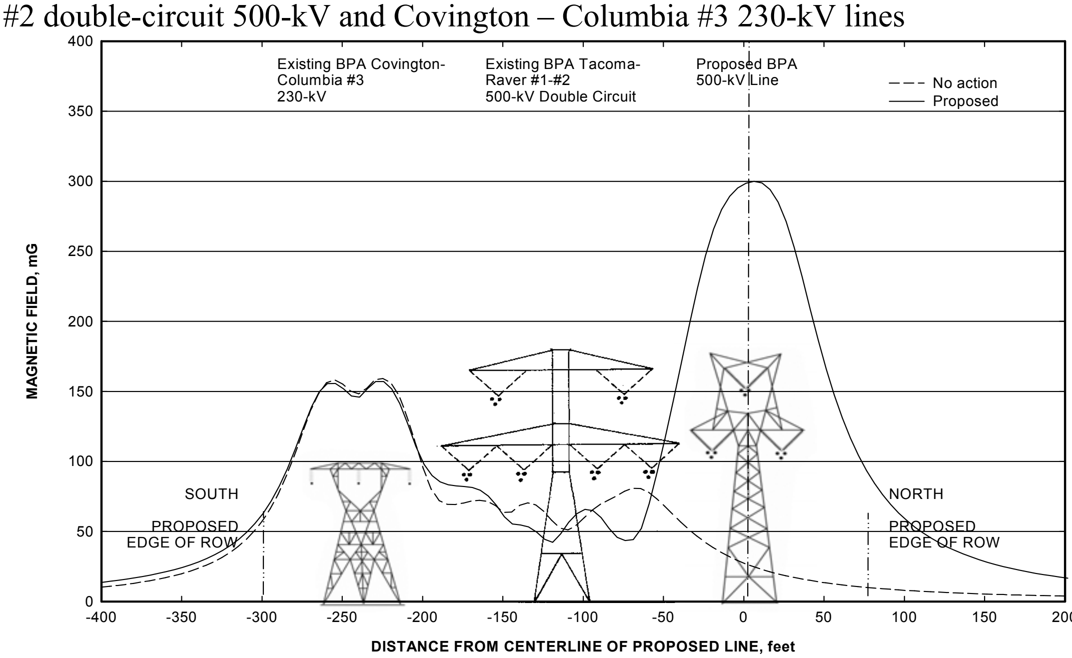
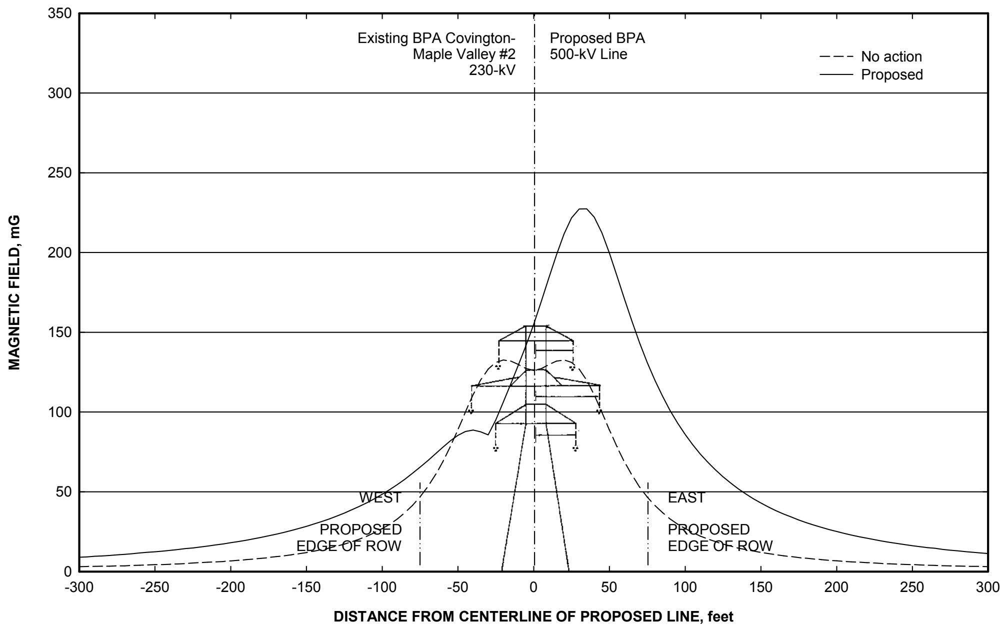


Figure A3, continued

c) Configuration A-3: Proposed line located on new double-circuit structures with existing Covington – Maple Valley #2 230-kV line.



d) Configuration A-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to existing Rocky Reach – Maple Valley 345-kV line

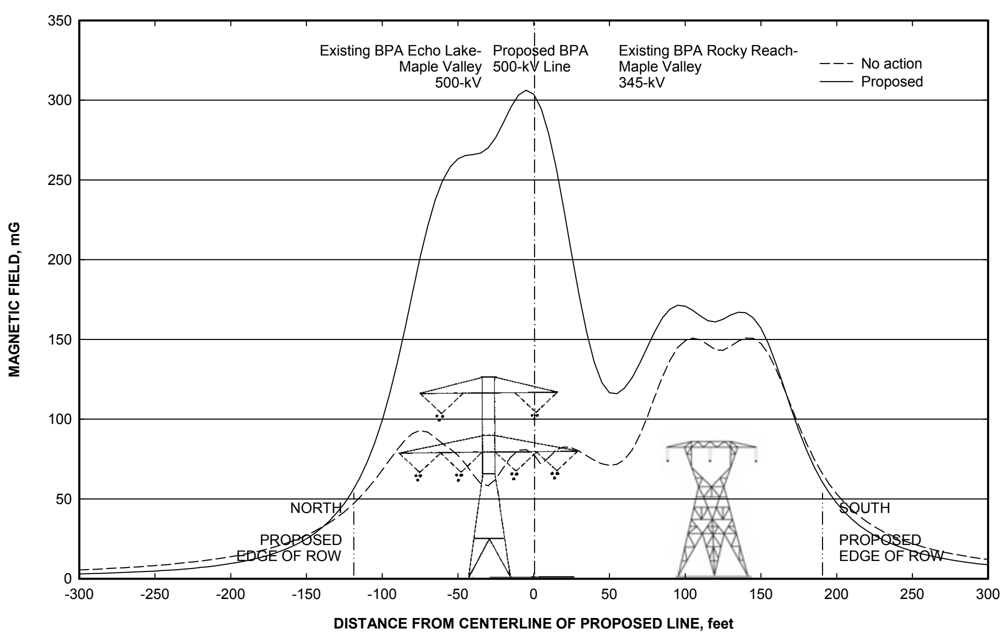
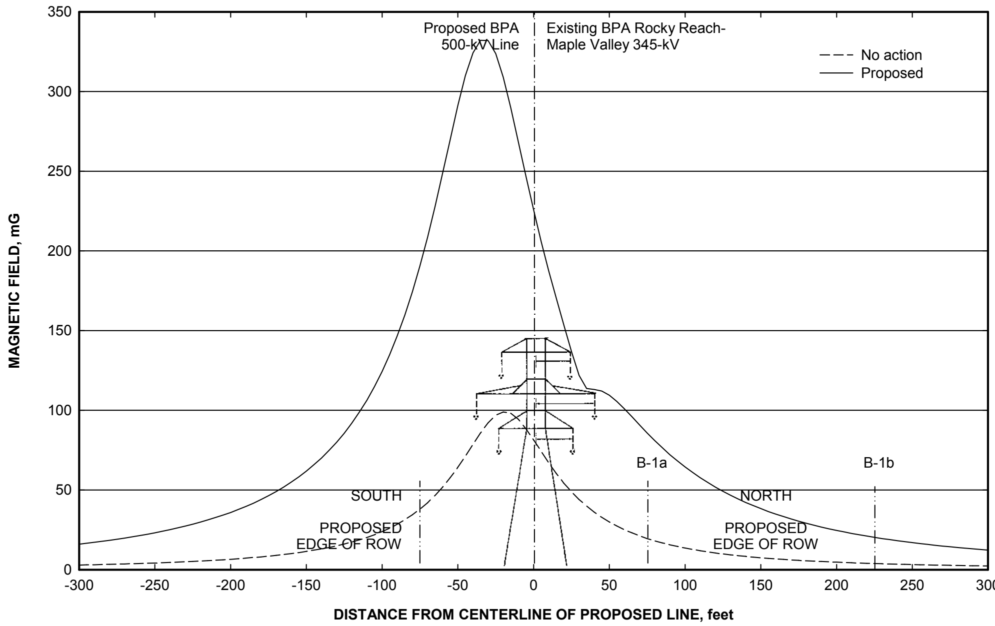


Figure A3, continued

e) Configurations B-1a and B-1b: Proposed line located on new double-circuit structures with existing Rocky Reach – Maple Valley 345-kV line



f) Configuration C-1: Proposed single-circuit line parallel to Tacoma – Raver #1 and #2 double-circuit 500-kV, Raver – Covington #1 500-kV, and Raver – Covington #2 500-kV lines

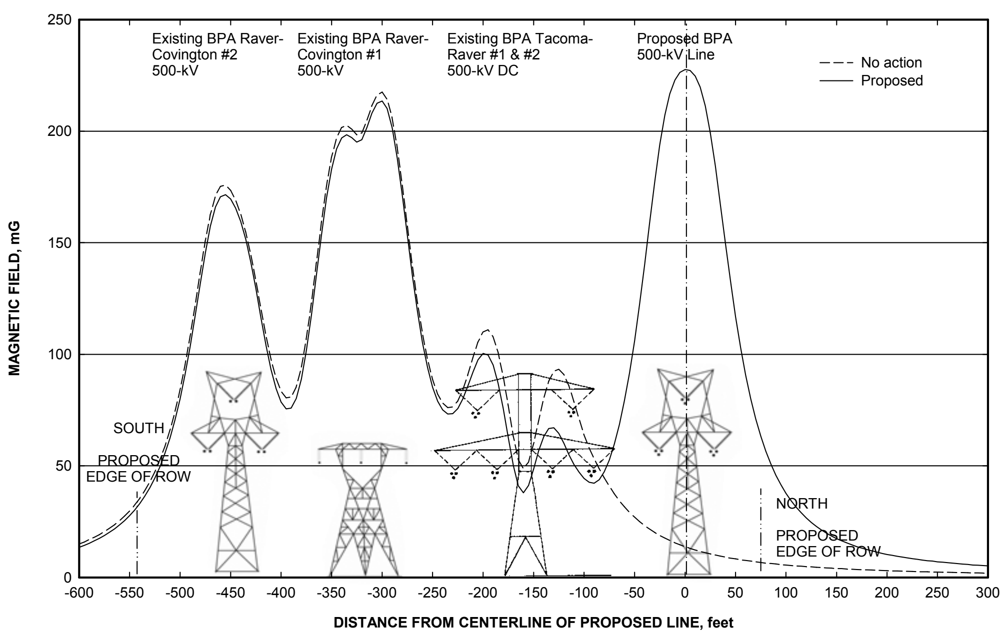
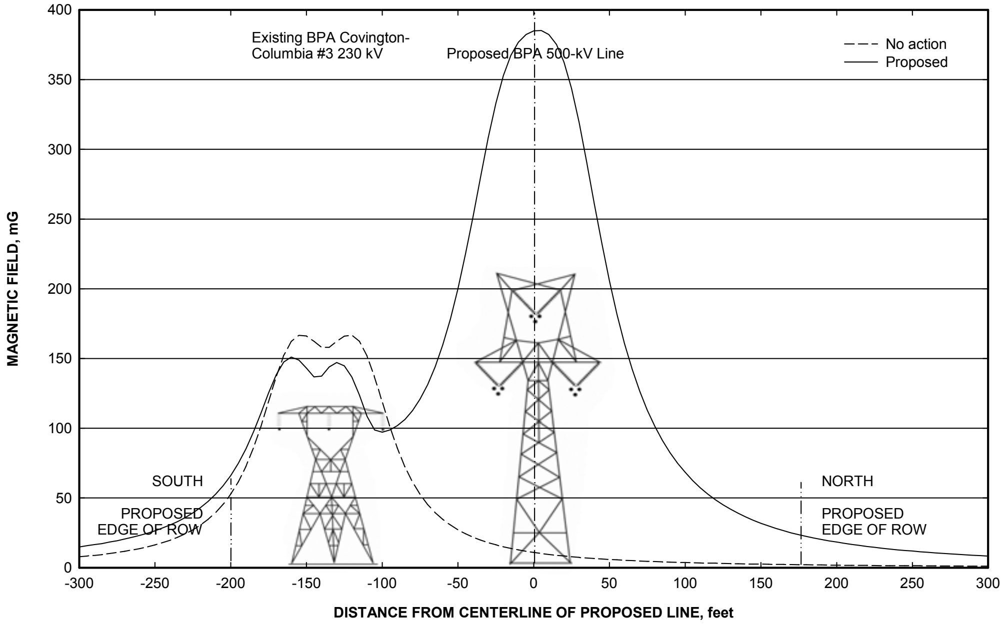


Figure A3, continued

g) Configuration C-2: Proposed single-circuit line parallel to existing Covington – Columbia #3 230-kV line



h) Configuration C-3: Proposed single-circuit line on new right-of-way with no parallel lines

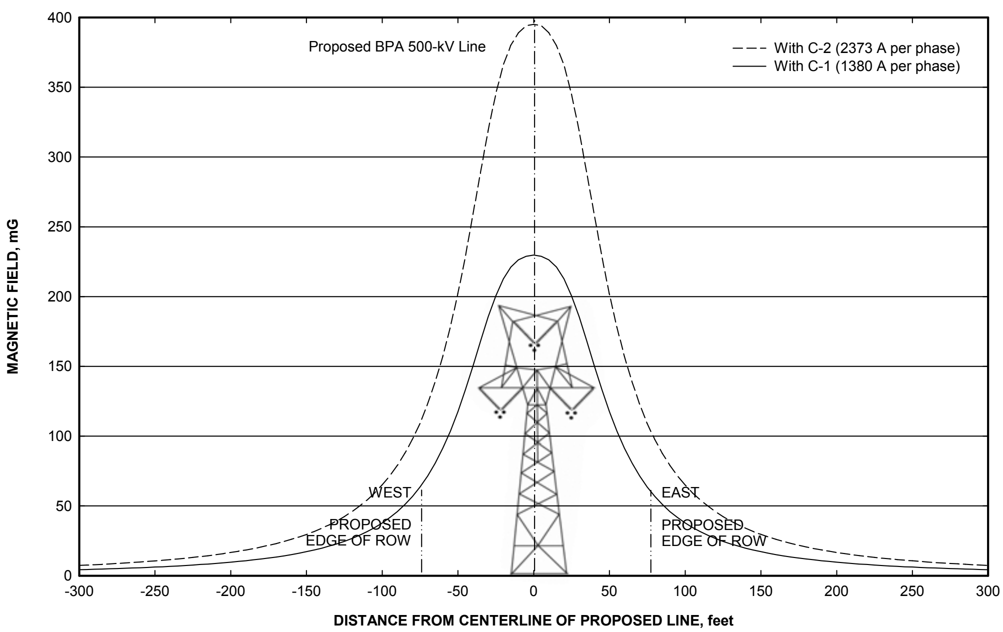
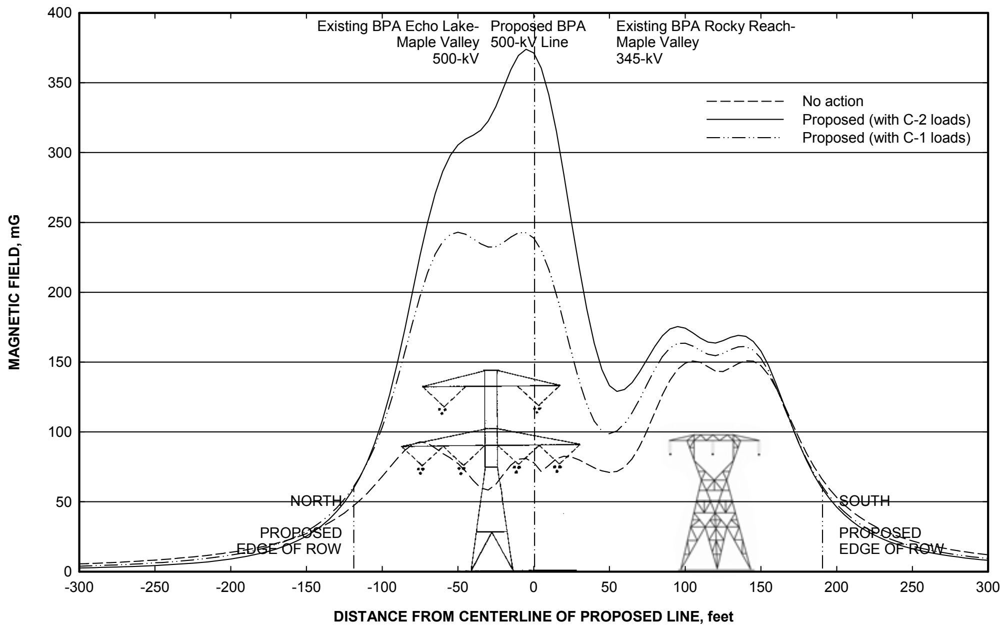


Figure A3, continued

i) Configuration C-4: Proposed line located on existing double-circuit structures with Echo Lake – Maple Valley #1 and #2 500-kV line and parallel to Rocky Reach – Maple Valley 345-kV line



j) Configuration D-2a: Proposed single-circuit line parallel to existing Rocky Reach – Maple Valley double-circuit 345-kV line. Configuration D-1a would have a similar profile from north to south.

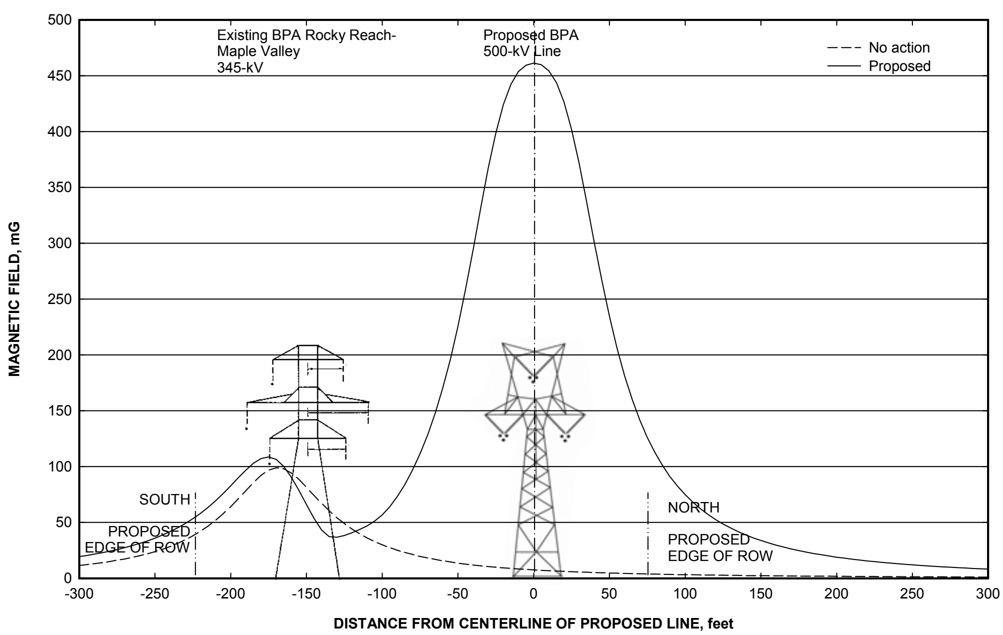
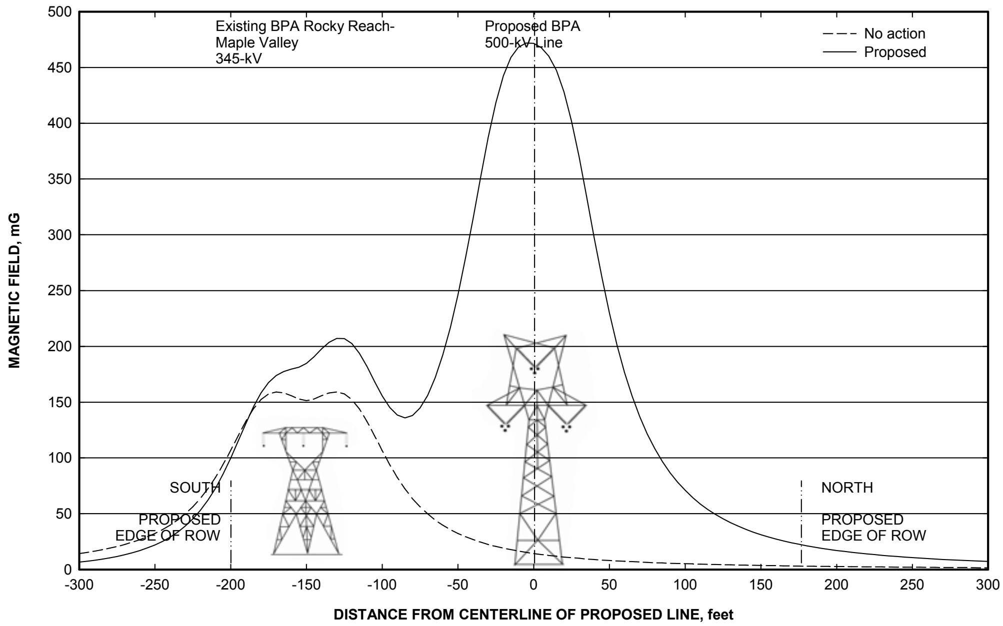


Figure A3, continued

k) Configuration D-2b: Proposed single-circuit line parallel to existing single-circuit Rocky Reach – Maple Valley 345-kV line. Configuration D-1b would have a similar profile from north to south.



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Appendix F Geology, Soil, Climate, and Hydrology Technical Report

Bonneville Power Administration
Kangley – Echo Lake Transmission Project
Geology, Soil, Climate, and Hydrology
Technical Report

January 2001

Submitted To:
Bonneville Power Administration
P.O. Box 3621
Portland, Oregon 97208-3621

By:
Shannon & Wilson, Inc.
400 N 34th Street, Suite 100
Seattle, Washington 98103

21-1-09189-001

EXECUTIVE SUMMARY

This technical report presents information regarding geologic, soil, climatic and hydrologic conditions and natural hazards that could impact or be impacted by construction and operation of a Bonneville Power Administration (BPA) electrical transmission line along one of four proposed route alternatives. These four route alternatives have been proposed in addition to five route alternatives previously proposed that would cross the City of Seattle Cedar River Watershed. A technical report used to support a Draft Environmental Impact Statement (DEIS) was previously completed for the proposed five Cedar River Watershed route alternatives. Information from this current report will be used to prepare a Supplemental Draft Environmental Impact Statement (SDEIS) for the four additional route alternatives.

The additional four transmission line route alternatives are designated A through D. Alternative A proposes constructing a new single-circuit, 500-kilovolt (kV) line for 11 miles and rebuilding the existing 9-mile-long, Covington to Maple Valley 230-kV transmission line to a double-circuit 500-kV line. Alternative B proposes rebuilding 38 miles of the existing Rocky Reach-Maple Valley, 345-kV line from Stampede Pass to the Echo Lake substation, to a double-circuit, 500-kV line. Alternative C proposes constructing a new, single-circuit, 500-kV line from BPA's Raver Substation, 10 miles long (Option C 1), or from near the community of Kangley, 10.5 files long (Option C 2) on mostly new right-of-way (ROW). The new line would connect to an existing vacant (unused) Echo Lake-Maple Valley 500-kV circuit. Alternative D proposes constructing a new, single-circuit, 500-kV line for 38 miles parallel to the existing Rocky Reach-Maple Valley, 345-kV line from Stampede Pass to the Echo Lake substation. The new line could be on the south side (Option D 1) or the north side (Option D 2) of the Rocky Reach-Maple Valley line. New ROW would be required for this alternative.

Chapter 1 of this report presents an overall description of the project, project scope and methods of study. Chapter 2 summarizes the proposed route alternatives.

The affected regional environment is discussed in Chapter 3, which includes sections on topography, geology, soils, seismology, hydrology, and wind. In general, the region has moderately rugged to rugged topography. It is underlain mostly by glacial deposits and by sedimentary and volcanic rock that has been folded and faulted. The affected environment discussion for each of the four route alternatives includes information on major drainages, bedrock and surficial geology, and local topography.

Chapter 4 discusses environmental consequences of the proposed action. It begins with an overview of the resources and natural hazards evaluated, including shallow and deep-seated landslides, soil erosion, settlement, liquefaction, faulting, flooding, and water quality-limited (303[d] listed) water bodies. Each resource was assigned ratings of no impact, low impact, moderate impact, or high impact. Following the overview, Chapter 4 discusses the impacts, mitigation, cumulative impacts, and unavoidable effects, and irreversible or irretrievable commitments of resources along each of the proposed route alternatives.

Chapter 5 provides a description of the review and permit requirements related to the resources discussed in this technical report. Chapter 6 summarizes the individuals and agencies consulted, and Chapter 7 reviews the methods used for this study.

Shannon & Wilson, Inc. has included in the Appendix our "Important Information About Your Geotechnical Report" to assist you and others in understanding the use and limitations of our report.

The affixing of the professional seal below indicates the exercise of professional judgment by participation in developing the engineering and geological matters embodied in our work for this project.

SHANNON & WILSON, INC.

Jeffrey R. Laird, C.E.G.
Senior Principal Engineering Geologist

Christopher A. Robertson, P.E.
Senior Associate

JRL:CAR:WTL/jrl

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BONNEVILLE POWER ADMINISTRATION
KANGLEY-ECHO LAKE TRANSMISSION LINE PROJECT
GEOLOGY, SOIL, CLIMATE AND HYDROLOGY
ADDITIONAL ALTERNATIVES TECHNICAL REPORT

1.0 INTRODUCTION

Bonneville Power Administration (BPA) is proposing to build the Kangley-Echo Lake Transmission Line Project, which will include a new 500-kilovolt (kV) transmission line, in Washington State. BPA's primary reason for building the proposed new transmission line is to improve system reliability in the King County area. Under normal growth demands, system instability could develop as early as the winter of 2002-2003 with an outage of the existing Raver-Echo Lake 500-kV line. Another reason is to enhance the United Sates' delivery of power to Canada as required under the Columbia River Treaty of 1961. The Vicinity Map (Figure 1) shows the project location.

The Project Area Plan (Figure 2) shows the approximate locations of the four additional route alternatives (Alternatives A through D), and five previously proposed route alternatives (Alternatives 1 through 4B). Alternatives C and D each have two options, designated C 1 and C 2, and D 1 and D 2, respectively. Depending on the alternative selected, the new transmission line could be from about 9 miles long (Alternative 1) to 38 miles long (Alternatives B or D).

BPA initially proposed five route alternatives through the City of Seattle Cedar River Watershed. Shannon & Wilson, Inc. prepared a technical report, which describes geologic, soil, climatic and hydrologic conditions, and natural hazards for each of these five alternatives. That report is entitled "Bonneville Power Administration Kangley-Echo Lake Transmission Project Geology, Soil, Climate and Hydrology Technical Report," and dated January 2001.

Once the environmental review is complete, BPA will decide whether and how to proceed with the project. If BPA decides to proceed, construction could begin in 2003.

The proposed project has two major elements:

- A new 500-kV transmission line.
- An expansion to the existing Echo Lake Substation to accommodate the new transmission line. The proposed substation expansion has been addressed in our January 2001 report.

This technical report describes geologic, soil, climatic and hydrologic conditions, and natural hazards that are present along four additional proposed route alternatives that are outside of the Cedar River Watershed. It identifies potential impacts that could result because of construction, operation, and maintenance of the project. The information from this report will be used to prepare portions of a Supplemental Draft Environmental Impact Statement (SDEIS) for the proposed project.

2.0 PROPOSED ACTIONS AND ALTERNATIVES

The four additional route alternatives shown on the Project Area Plan (Figure 2) would be on new and/or existing right-of-way (ROW) and are described below.

Alternative A would begin at a tap on the Schultz-Raver No. 2 transmission line near Kangley, Washington. A new single-circuit, 500-kV line would be constructed on 135-foot-tall towers parallel to and just north of the existing Covington-Columbia Number 3 230-kV transmission line on vacant transmission line ROW. This line would extend west for about 11 miles to near the Covington Substation. New ROW would need to be acquired across from the Covington Substation to the Covington-Maple Valley ROW. That portion of the Covington-Maple Valley 230-kV single circuit transmission line between Covington and the Rocky Reach-Maple Valley, double-circuit 500-kV line, would then be rebuilt with one side operated at 230-kV and the other at 500-kV. This new double circuit line would be supported by 175-foot tall transmission structures, over a distance of approximately nine miles. The 500-kV transmission line would then tie into an existing, unused, 500-kV circuit of the Maple Valley-Echo Lake double circuit 500-kV line, and then into the Echo Lake Substation. Most of the ROW that would be needed is already owned by BPA.

Alternative B would rebuild approximately 38 miles of BPA's existing Rocky Reach-Maple Valley, 345-kV transmission line to a 500-kV, double-circuit line. The new line would be installed on 175-foot-tall towers. The new 500-kV line would be connected to the existing Schultz-Raver No. 2 500-kV transmission line just east of Stampede Pass and to the Echo Lake Substation at the west end. The line would cross Interstate 90 twice. This route would be on existing, mostly cleared BPA ROW. Some clearing would be required because approximately 20 feet of the ROW on the north side of the existing line and towers has not been cleared for many years.

Alternative C would consist of a new, single-circuit, 500-kV line constructed on 135-foot-tall towers. Alternative C could begin at one of two points. Option C 1 would originate at the Raver Substation, then proceed west approximately 2.5 miles in a vacant, cleared ROW along the existing Raver-Tacoma double-circuit 500-kV transmission line. At this point, the segment would turn north for about 7.5 miles to tie into an unused circuit of the Echo Lake-Maple Valley double circuit 500-kV line. This segment would be on new ROW. Option C 2 would begin at a tap point along the Schultz-Raver No. 2 line near Kangley. From the tap point, it would proceed west along vacant transmission line ROW immediately north of the Covington-Columbia No. 3 230-kV transmission line for approximately 4.5 miles. At this point, the C 2 segment would join the same route described for Option C 1 and extend north for about 6 miles. The C 2 Option segment is the same as described previously for the initial section of Alternative A. 1.

Alternative D would involve the construction of a new, single-circuit, 500-kV transmission line from just east of Stampede Pass to the Echo Lake substation. This line would parallel BPA's existing Rocky Reach-Maple Valley, 345-kV transmission line and would generally follow the Interstate 90 corridor. The new line would cross Interstate 90 twice. The new line would require the purchase and clearing of 38 miles of new ROW. Option D 1 would be located on the south side of the existing transmission line, and Option D 2 would be located on the north side of the existing transmission line.

2.1 Right-of-Way Clearing

In general, where new ROW is obtained, a strip of land about 150 feet wide would be cleared to allow for tower construction and conductor clearance. Modern logging methods, including the use of cable logging and low ground pressure equipment, would be used where appropriate to reduce the amount of access road building and ground disturbance. A low ground cover of vegetation consisting of shrubs and grasses would remain following logging, and the cleared area would not be burned. Over the years, the vegetation would grow to a taller and denser condition. Consequently, the benefits of vegetation, including root strength, soil cover, interception of precipitation, and evapotranspiration would remain to some extent during and following construction.

Alternative A would require clearing where new ROW would need to be acquired near the Covington Substation. From the tap, the initial 11 miles would occupy an existing, unused, cleared ROW adjacent to and just north of the existing Covington-Columbia Number 3 230-kV line. The remainder of the line would involve the reconstruction of an existing line in a cleared ROW. Alternative B would require clearing a band of forest vegetation approximately 20 feet wide for 38 miles within the existing ROW. The remainder of the existing ROW has already been cleared. Alternative C1 would require approximately 7.5 miles of clearing within the new 150-foot wide ROW, while Alternative C2 would require about 6 miles of clearing within the new ROW. Alternative D (Options D 1 and D 2) would require the clearing of a 38-mile long, 150-foot wide strip of forest adjacent to the existing cleared ROW.

2.2 Transmission Line

For alternatives A and B, BPA proposes to use double-circuit, steel lattice towers averaging 175 feet in height to support the new transmission line. Alternatives C and D would use single-circuit, steel lattice towers averaging about 135 feet in height. The exact tower locations would be determined after the preferred alternative would be selected.

Stable foundations for the transmission line towers would be necessary to reduce the potential for structure failures. The towers and their foundations would be designed and constructed to withstand the structural dead loads and live loads from construction, ice, wind, and earthquakes. After the preferred alternative is selected, site studies would be conducted to evaluate subsurface conditions so that adequate foundations could be designed and constructed.

In general, foundations would consist of steel plates or grillages buried in excavations averaging 15 feet deep. Soil would be backfilled and compacted over the plates. Where hard or massive rock is encountered, the towers would be anchored to the rock using rock dowels.

2.3 Access Roads

BPA normally acquires ROW easements, and develops and maintains permanent access for travel by wheeled vehicles to each structure. Access roads are designed for use by cranes, excavators, supply trucks, log trucks, boom trucks, and line trucks for construction, ROW clearing, and maintenance of the transmission line. BPA prefers road grades of 6 percent or less in areas of highly erodible soils and 10 percent or less for erosion-resistant soils. For short distances, maximum acceptable road gradients are 15 percent for trunk or main roads and 18 percent for spur roads (roads that go to each structure if the structure is not on a trunk road). The locations and lengths of new trunk and spur access roads that would be required for Alternatives A and C have not yet been determined. These would be determined after a preferred alternative is selected. The total length of new roads for Alternative B would be short because the new route is located along the existing route. Road locations have been proposed for Alternative D. These new roads would generally consist of short spur roads extending from the existing main or spur access roads.

Best Management Practices (BMPs) would be used in constructing and upgrading access roads, as described in Section 4. Where appropriate, new or existing trunk access roads would be surfaced with gravel for construction and maintenance activities. Water bars would usually be installed on spur roads after construction. Cut-and-fill slopes on trunk and spur access roads would be revegetated after construction.

Regardless of the alternative selected, much of the new transmission line could be built using the existing access road system. It is unlikely long distances of new trunk roads would be required. Easements for new trunk roads built outside the ROW would be 50 feet wide. New or existing trunk roads would be graded to provide a 14-foot-wide travel surface, with an additional 4 to 6 feet on curves. About 10 feet on both sides of a trunk road would be graded for ditches, for a total clearing width of 24 to 30 feet. The road surface is usually surfaced with gravel for construction and maintenance activities. New or upgraded spur roads would be required to access most tower locations. Spur roads would be built within the ROW from the on-ROW trunk roads to access structures. The spur roads are usually not surfaced with gravel.

3.0 AFFECTED ENVIRONMENT

Key factors that affect the susceptibility of different areas to erosion and sedimentation are topography, geology, soils, and climate of the project area. Erosion and sedimentation could cause degradation of water quality and affect fisheries and other habitat. Landslides, soil creep, and other mass wasting processes could also contribute to hillslope erosion and stream sedimentation. Logging, ROW clearing and construction, use and maintenance of roads and towers could affect these processes. The following sections describe the topography, geology, soils, seismic conditions, climate, and hydrology present within the project area.

3.1 Topography

Alternatives A and C are located in the Puget Sound Lowland, while Alternatives B and D extend from the east side of the Cascade Mountains to the west side Cascade foothills (Figure 1). The topography of these two areas is distinctly different. Figure 4 shows topographic contours and slope gradients near each route alternative.

Beginning at the east end of Alternative A near Kangley, the proposed route would extend due west across generally flat glacial outwash plains (Sheet A-1, Figure 4B). Just north of Georgetown, the route would traverse the south side of a 250-foot-high hill and then cross the west-flowing Rock Creek drainage. From this point, the route would extend west-southwest across generally flat to gently-sloping ground, crossing the Cranmar Creek drainage, to near the Covington Substation (Sheet A-2, Figure 4B). From just west of the Covington Substation, the route would traverse north to northeast across northwest-oriented, generally low-lying ridge and swale topography. Several creeks, including Little Soos Creek and the headwater drainage of Big Soos Creek, would be crossed in this section. In addition, numerous lakes, ponds, and wetlands exist in this area (Sheet A-3, Figure 4B). Near the north end of the route, the proposed line would cross the Cedar River Valley, and then extend northeast along an unnamed valley

(Sheet A-4, Figure 4B). The route would turn north and ascend the north side of this valley and tap into the Maple Valley-Echo Lake double-circuit 500-kV line just south of the Cedar Hills landfill.

The east end of Alternative C, Option C 1, would begin at the Raver Substation and extend along a vacant ROW just north of the Covington-Columbia No. 3 transmission line (Sheet C-1, Figure 4B). Option C1 would initially cross an unnamed, low-gradient drainage; and then ascend a 350-foot-high, 30 percent slope. From the slope top, the route would extend west-northwest approximately 1½ miles before turning due north. The route would cross the Cedar River Valley, and then traverse generally level to gently sloping ground along an as yet undefined ROW route in the vicinity of 276th Avenue (Sheet C-2, Figure 4B). Near the north end, the route would cross Carey and Holder Creeks (headwaters to Issaquah Creek) and then traverse a 500-foot-high, 40 to 50 percent, forested slope on the south side of South Tiger Mountain (Sheet C-3, Figure 4B). The proposed transmission line would tap into the Echo Lake-Maple Valley on the south side of South Tiger Mountain. Option C2 would follow the Alternative A route for about 4.5 miles across generally flat glacial outwash plains from Kangley to the west side of the 250-foot-high hill, at which point it would turn north and follow the Option C1 route for approximately 6 miles to the Echo Lake-Maple Valley transmission line.

Alternatives B and D would begin just east of Stampede Pass on the east side of the Yakima River Valley near Interstate 90 (Sheet B/D-1, Figure 4C). The routes would extend northwest along the valley, cross the Yakima River, and then traverse up onto the west side of the valley. The routes would continue north-northwest across steep to moderate slopes along the west side of Keechelus Lake (Sheet B/D-2, Figure 4C). The lake is a reservoir on the Yakima River maintained by the U.S. Bureau of Reclamation. Near the north end of the reservoir, the routes would turn northwest up moderately steep slopes into the Mill Creek drainage and cross the Snoqualmie West ski area (formerly Mount Hyak ski area) (Sheet B/D-3, Figure 4C). The routes would then traverse gentle slopes before descending steep slopes into the South Fork Snoqualmie River Valley. The routes would generally follow along the toe of moderate to steep slopes on the south side of this valley. Along these south valley slopes, the routes would cross 11 stream channels, as shown on the U.S. Geological Survey (USGS) topographic quadrangle maps, and numerous smaller channels that are not shown (Sheets B/D-3 and B/D-4, Figure 4C). The routes would traverse the south valley slopes for approximately 9 miles before turning north and crossing Interstate 90 and the South Fork Snoqualmie River (Sheet B/D-5, Figure 4C). Along the north valley side, the routes would traverse northwest for about 4 miles across gentle to moderate slopes and then across a nearly flat plateau. The routes would then cross Interstate 90 and the South Fork Snoqualmie River (Sheet B/D-6, Figure 4C). For about four miles west from the South Fork Snoqualmie River, the routes would traverse moderate slopes and cross several streams below Rattlesnake Mountain (Sheet B/D-7, Figure 4). West of these moderate slopes, the routes would traverse up and across steep slopes on the east side of Rattlesnake Mountain, crossing numerous stream channels. The routes would then extend around the north end of Rattlesnake Mountain before turning south to the Echo Lake Substation.

3.2 Geology

Alternatives A through D are located across and west of the South Cascade Range (Galster and others, 1989). The geology of Alternatives A and C is dominated by glacial deposits in the Puget Lowlands, while the geology of Alternatives B and D is dominated by volcanic rocks in the South Cascades. The South Cascades are composed primarily of Tertiary-age volcanic, volcaniclastic, and associated sedimentary rocks. These rock units have been folded and faulted since they were deposited. Pre-Tertiary Western Melange Belt rocks occur in scattered outcrops along the South Fork Snoqualmie River Valley. Repeated advances of continental glacial ice sheets into the Puget Lowlands during the Quaternary Period eroded the Cascade foothills and deposited thick sequences of glacial sediments. The geology along the alternative routes is shown on the Geologic Map (Figures 5A, 5B, and 5C). Table 1 presents descriptions of the geologic units present along the alternative alignments. The map and descriptions of the geologic units are based on published geologic maps.

3.2.1 Pre-Tertiary Geology

Pre-Tertiary rocks occur along Alternatives B and D in the South Fork Snoqualmie River Valley at and just east of North Bend, as mapped by Frizzell and others (1984) and as shown on Figure 5C. These rocks may be as old as middle Jurassic (165 million years before present [mybp]), and include well-bedded sandstone and argillite (pTwa), serpentized pyroxenite (pTwu), and metagabbro (pTwg). These rocks originated as ocean crust and ocean sedimentary deposits that were later thrust onto the overriding North American Plate. This emplacement has caused substantial deformation, as reflected in large-scale structures such as faults, folds and shear zones, as well as small-scale deformation, including mineral metamorphism, foliation and crushing.

3.2.2 Tertiary Geology

Tertiary rocks are exposed along all of the alternative alignments. The following paragraphs describe each rock unit from oldest to youngest.

The oldest Tertiary rocks exposed in the project area are the late Eocene (36 to 43 mybp) rocks of the Naches Formation (Frizzell and others, 1984). The Naches Formation is mapped along Alternatives B and D between the east end of the route and Humpback Creek. These rocks consist of rhyolite, andesite, and basalt flows, tuff and breccia, with interbedded sandstone and siltstone. The flow rocks are generally well bedded and may have columnar jointing. Rhyolite occurs as flow-banded flows and ash-flow tuffs. Interbedded sedimentary rocks include micaceous sandstone with crossbedding and graded bedding, as well as siltstone. The Naches Formation (Tn, Figure 5C) has been divided locally into the following units:

< Feldspathic sandstone and volcanic rocks (Tns, Figure 5C) consisting of tan to gray, well-bedded, medium to coarse-grained, micaceous sandstone and interbedded siltstone and shale. It also includes interbedded rhyolite, andesite, and basalt flows, tuff and breccia.

< White to gray, flow-banded, platy jointed rhyolite with ash flow tuff and pumice fragments (Tnr, Figure 5C).

< Mt. Catherine Rhyolite, a black, welded, ash flow tuff with pumice lapilli and breccia (Tnmc, Figure 5C). This unit includes thin interbeds of sandstone and shale.

< Guye Sedimentary Member (Tng, Figure 5C) consisting of light to dark gray, feldspathic sandstone, black slatey shale and hard, chert pebble conglomerate.

Nonmarine volcanic and sedimentary rocks of the 11,000-foot-thick, middle to late Eocene Puget Group are mapped along Alternatives A and C (Frizzell and others, 1984). These rocks were deposited primarily in fluvial environments and to a lesser extent in near-shore marine environments. The rocks include sandstone, siltstone, claystone, and coal. The sandstone is generally massive to cross bedded, with occasional channel cut-and-fill structures. The Puget Group has locally been divided into several formations, which include (from oldest to youngest) the Tiger Mountain, Tukwila (Tpt), and Renton (Tpr) Formations. Only rocks of the Tukwila and Renton Formations occur along Alternatives A and C. The following paragraphs describe these formations. Numerous outcrops of the Puget Group that have not been differentiated into one of the formations are mapped at the east ends of Alternatives A and C (Tpg, Figures 5A and 5B).

The middle to late Eocene (36 to 50 mybp) Tukwila Formation conformably overlies the Tiger Mountain Formation (Vine, 1962). These rocks are composed of volcanic lava flows, sills and dikes, breccia, conglomerate and sandstone. Volcanic tuff and breccia probably make up most of the Tukwila Formation, but the volcanic flow rocks are more resistant to erosion, thereby forming much of the visible outcrop. Tukwila Formation rocks are exposed at the north end of the Alternative C route and at the west end of Alternatives B and D (Tpt, Figures 5B and 5C).

The youngest rocks in the Puget Group, the late Eocene Renton Formation, conformably overlie the Tukwila Formation. The Renton Formation is as thick as 2,250 feet and consists of sandstone, siltstone, claystone, and coal. This formation was deposited in fluvial and near-shore marine environments. Clay commonly binds the sandstone. Fine-grained, interbedded siltstone and claystone commonly form valleys between more resistant sandstone ridges. The Renton Formation outcrops just to the north of the north end of the Alternative C route (Tpr, Figure 5B). Renton Formation coal has been mined from underground workings in the project area.

Eocene (36 to 57 mybp) dikes and plugs composed of diabase, gabbro, and basalt are mapped at the east end of Alternative A and at the north end of Alternative C, where they intrude rocks of the Puget Group (Tpg, Figures 5A and 5B). These rocks are characterized as black, fine to medium-grained diabase and gabbro (Frizzell and others, 1984).

The Oligocene (24 to 36 mybp) Mt. Persis volcanics are mapped along Alternatives B and D on the east flank of Rattlesnake Mountain (Tpa, Figure 5C). These rocks are gray to black, porphyritic andesite and andesite breccia flow rocks (Frizzell and others, 1984). The rocks are characterized as massive to blocky jointed.

Late Oligocene (25 to 30 mybp) Huckleberry Mountain Formation volcanic rocks (Thm, Figure 5C) are mapped along Alternatives B and D along the south side of the South Fork Snoqualmie River. These volcanic rocks begin at Twin Falls State Park and extend to the east end of the routes (Frizzell and others, 1984). These rocks consist of generally well-bedded andesite and basalt breccia, tuff, and lava flows with minor amounts of volcanic sandstone, siltstone, and conglomerate.

Other volcanic rocks that are probably correlative with the Huckleberry Mountain Volcanics are mapped on the north side of the South Fork Snoqualmie River (Tv, Figure 5C). These rocks include andesite breccia, tuff, and ash flow tuff.

A unit of the Huckleberry Mountain Volcanics, the Tuff of Lake Keechelus (Thmk, Figure 5C) is mapped across Alternatives B and D near the approximate center of Keechelus Lake (Frizzell and others, 1984). These rocks consist of dacite tuff and breccia.

The youngest rocks exposed in the project area are associated with the Snoqualmie Batholith (Frizzell and others, 1984). These rocks are mapped along Alternatives B and D in the South Fork Snoqualmie River Valley from Twin Falls State Park, where the rocks first crop out on the north valley side, east to Rockdale Creek. Snoqualmie Batholith rocks include granodiorite and tonalite (Tsgs, Figure 5C), characterized by equigranular medium grains and coarse jointing; fine-grained monzonite (Tsgf, Figure 5C); and mafic diorite and gabbro (Tsm, Figure 5C).

3.2.3 Quaternary Geology

Geologic processes profoundly influenced the surficial deposits and landforms in the project area during the Quaternary Period (present to 2 mybp). The areas crossed by Alternative A and C routes were repeatedly overridden by continental glacial ice during the Pleistocene Era. The continental glaciers deposited variable thicknesses of till and extensive glaciofluvial and ice-contact deposits, and reshaped the surface with a series of meltwater channels that formed beneath and in front of the ice sheets as the continental glacial ice advanced and retreated. The continental ice sheets also blocked the South Fork Snoqualmie River drainage, creating lakes and causing sediment to deposit. Extensive alpine glaciers in the Cascades modified the landscape along the routes of Alternatives B and D. Following glacial retreat, the landforms were locally modified by fluvial erosion and deposition, and mass wasting.

3.2.3.1 Pleistocene Glacial Geology

At least six periods of continental glaciation have been documented in the Puget Lowland and adjacent margins of the Cascade and Olympic Mountain Ranges. The most recent period is termed the Fraser Glaciation. Each advance and retreat of an ice sheet may be characterized by a complex sequence of glaciolacustrine sediment, glaciomarine drift, advance outwash, till, and recessional outwash. Erosion and subsequent deposition of the glacial sediments between each glacial interval have altered these deposits. The total thickness of these Pleistocene deposits can range between 0 and 3,700 feet in the Puget Lowlands.

Pre-Fraser glacial deposits, consisting of hard, lacustrine clay and dense, stratified sand and gravel, are mapped in the Cedar River Valley along Alternatives A and C (Qpf, Figures 5A and 5B).

During the Vashon Stade of the Fraser Glaciation that occurred between 15,000 and 13,500 years ago in the central part of the Puget Lowlands, the Puget Lobe of the continental glacier flowed southeast across the Puget Lowlands, covering and reshaping the ground in the vicinity of Alternatives A and C, and the far west portions of Alternatives B and D. The upper limits of ice can be determined from the highest presence of till and erratic boulders. As glaciers advanced over the area, they eroded the underlying bedrock. A mantle of lodgment till, which consists of subangular to rounded gravel-, cobble- and boulder-sized clasts supported in a dense matrix of silt and sand, was deposited at the base of the glacier. Till is prevalent along Alternatives A and C, and along Alternatives B and D west of Twin Falls State Park (Qvt, Figures 5A, 5B, and 5C).

The Vashon Stade glacier blocked the Snoqualmie and Cedar Rivers, diverting these drainages south along the eastern ice margin. Meltwater from these drainages flowed into the valley currently occupied by Taylor Creek, and then flowed southeast to Eagle Gorge and down the Green River to Kankaskat. From Kankaskat, meltwater continued south along the ice margin against the western Cascade foothills. Ultimately, the meltwater reached the Chehalis Valley, which was the principal outflow channel beyond the glacier terminus. At the maximum stand, ice-contact deposits, consisting of stratified sand and gravel, silt, clay and till, were deposited along the glacial margin. Stagnant ice that was covered with sediment subsequently melted, creating collapse features such as kettles. Ice-contact deposits are mapped at the east end of Alternative A, at both ends of Alternative C, and near the west end of Alternatives B and D (Qvic, Figures 5A, 5B, and 5C).

As the glacier receded, a series of meltwater channels developed as the ice front successively moved to the northwest. Meltwater streams deposited recessional outwash consisting of stratified sand and gravel. Recessional outwash is prevalent along Alternatives A and C, and in the west half of Alternatives B and D (Qvr, Figures 5A, 5B, and 5C).

Glaciolacustrine deposits consisting of well-stratified sand and silt, with a few thin lenses of gravel, were deposited in blocked drainages. These glaciolacustrine deposits typically have a limited aerial extent. As such, they are generally not included in the geologic mapping by Frizzell and others (1984), and are not shown on Figure 5 or listed in Table 1.

Alpine glacial deposits occur along Alternatives B and D between the east end and Snoqualmie Pass (Qag, Figure 5C). These deposits typically include boulder tills in the uplands and gravel and sand outwash on valley floors.

3.2.3.2 Holocene Geology

Holocene deposits include landslides, talus, colluvium, bogs, alluvium, volcanic ash, and human-modified land. Landslide deposits result from the relatively rapid downslope movement of rock and soil, and are generally found on and at the base of hill slopes. They usually consist of a remolded, heterogeneous mixture of several soil types and commonly include organic debris. Three large, ancient, deep-seated landslides are mapped across or in the vicinity of Alternatives B and D (Qls, Figure 5C). Scattered, recent, shallow landslide and debris flow features were observed on steep slopes along Alternatives B and D. Recent deep-seated and shallow landslide features were observed on the valley walls above the Cedar River along Alternative A (Figure 5A). Section 3.2.3.3, Landslides, provides additional discussion about the occurrence of landslides along the proposed Alternatives.

Colluvium is soil that has been transported downslope, generally by mass wasting processes, including shallow landsliding, rain splash erosion, frost heave, and soil creep. It generally develops on slopes. The thickness can range from a few inches to 10 feet or more, with the thickness usually increasing downslope. Colluvium is relatively widespread in the project area, as described in Section 3.3; however, the unit is generally not shown on geologic maps because it is relatively thin.

Talus deposits, consisting of nonsorted, angular boulders to gravel derived from rock slopes, are mapped at the east end of Alternatives B and D (Qt, Figure 5C). Smaller talus deposits that were not mapped on the published geologic maps likely are present along the slopes above Keechelus Lake and the South Fork Snoqualmie River Valley.

Bog deposits include peat and organics with lacustrine deposits. They occur in poorly drained, low-lying areas. Bog deposits are most prevalent along Alternatives A and C, which are characterized by till and enclosed drainages resulting from glacial deposition (Qb, Figures 5A and 5B). No mapped bog deposits occur along Alternatives B and D. Bog deposits typically are located in areas currently designated as wetlands and generally provide poor foundation conditions.

Rivers and streams deposited alluvial sediment in and adjacent to their current and historical channels after the continental glaciers had fully retreated. Alluvium includes fine-grained, overbank deposits and coarse-grained channel deposits. Extensive alluvial deposits are present along the Yakima, South Fork Snoqualmie, and Cedar Rivers (Qa, Figures 5A, 5B, and 5C). Terraces formed as the rivers eroded and incised a deeper channel, leaving remnants of the alluvial deposits along the valley sides. Recent alluvial deposits occur in and adjacent to all streams and rivers in the project area in the form of sand, gravel and cobble bars, and alluvial fans.

Volcanic ash was widely deposited over most of western Washington as a result of the catastrophic eruption of Mount Mazama in southern Oregon approximately 6,600 years ago, as well as from other, less extensive, volcanic eruptions. The ash deposits are well preserved in bog deposits. Elsewhere, they typically are mixed with other soil types.

More recently, humans have modified the land, including excavations for surface and subsurface mines and fills for highway embankments, mine spoils and landfills. Two large areas of modified land include the Cedar Hills Landfill and a gravel pit adjacent to the north end of Alternative A (Sheet A-4, Figure 5A). The abandoned Hobart Landfill is located on the north side of the Cedar River just to the east of the proposed Alternative C route (Sheet C-2, Figure 5B). The abandoned Hobart Landfill is within the Cedar River Watershed boundary.

3.2.3.3 Landslides

Three large, ancient landslides were identified in the published geologic maps of the project area. We identified several more recent landslides during our photogeologic studies and aerial overflight. The general paucity of landslides is probably due to the relatively gentle to moderate slopes along Alternatives A and C, and relatively stable bedrock conditions along Alternatives B and D.

Deep-seated landslides can range in depth from 10 feet to more than 100 feet and may involve movement of bedrock and soil. Deep-seated landslides generally initiate as a single mass movement that may then separate into discrete blocks. Typically, deep-seated landslides have a zone of weakness, such as a layer of clay or weak rock, where a landslide slip surface forms. Landslide movement is usually initiated by:

< Excessive pore water pressure in the landslide mass that typically occurs during and/or closely following wet storm periods.

< Removal of support from the toe of the landslide by stream erosion or excavation for a road or other feature.

< An increase of driving forces at the top of the landslide. Typically, this occurs when a fill is placed on the slope for construction of a road or other structure.

< Strong ground motions during an earthquake. The large, ancient, deep-seated landslides on the Alternative B and D routes may have been initiated during large-magnitude earthquakes.

Shallow landslides are normally less than 10 feet deep and occur in soil and highly weathered bedrock. Shallow landslides typically occur on slopes steeper than 65 percent (33 degrees), although they can occur on flatter slopes under certain conditions. Shallow landslides usually occur during periods of intense and/or prolonged precipitation. Other factors that contribute to shallow landslides include changes that tend to increase the steepness of a slope, such as erosion or excavation of soil at the toe of the slope or placing fill on a slope. Poorly constructed road fills are particularly susceptible to shallow landsliding. Stormwater runoff that discharges as concentrated flow on a slope can contribute to instability both by causing erosion that oversteepens a slope and by increasing the pore water pressure in the slope soils. Shallow landslides that enter confined drainages can transform into debris flows that can travel for miles.

3.2.4 Geologic Structure

The geologic structure of the project vicinity is dominated by a broad zone of northwest-southeast-trending faults and folds that comprise the Olympic-Wallowa Lineament (Frizzell and others, 1984). The once near-horizontally bedded sedimentary and volcanic flow rocks have been uplifted and folded, tilting the rock in various directions and at various angles.

Previous workers have mapped several faults in and adjacent to the project area (Frizzell and others, 1984; Phillips, 1984; and Walsh, 1984). These faults generally trend northwest to north-northwest (Figure 1). The fault planes are apparently high angle, and most displacement is vertical.

The only fault structure mapped within the Alternative A project area is a northwest-trending trace inferred along the Cedar River Valley at the north end of the route (Sheet A-4, Figure 5A). The north side is shown to have moved up relative to the south side (Vine, 1962). A southwest-plunging anticline is mapped north of the Cedar River and northwest of Alternative A.

Within the Alternative C project area, the northwest-trending Hobart Fault extends across the proposed route on the south flank of South Tiger Mountain at the north end of the route (Sheet C-3, Figure 5B). The north side of the fault is shown to have moved down relative to the south side, while a branch of this fault just to the south is indicated to have moved in the opposite direction.

Along the Alternative B and D routes, a west-trending fault trace is mapped across the routes near the center of Keechelus Lake (Sheet B/D-2, Figure 5C). This fault extends west into Lost Lake and east across the reservoir. The north side of the fault has moved down relative to the south side. Just to the north of this fault, faulted contacts between Huckleberry Mountain Volcanics and Tuff of Lake Keechelus are shown. The axis of an anticline is mapped across the route west of the Mount Hyak ski area (Sheet B/D-3, Figure 5C). The axis of an east-southeast-plunging syncline is mapped about one mile south of the route at McClellan Butte (Sheet B/D-4, Figure 5C). A north-trending fault trace is mapped just south of the proposed route across the South Fork Snoqualmie River near Twin Falls State Park. The northwest-trending Rattlesnake Mountain syncline and an adjacent fault lie just to the east of the substation (Sheet B/D-7, Figure 5C). This fault crosses the proposed route and parallels it to the west. The northwest-trending Raging River fault trace extends just west of the Echo Lake Substation along the Raging River Valley.

The age of faulting in the project area is uncertain; however, Gower and others (1985) found that movement on the Rattlesnake Mountain fault is not older than the Miocene-Oligocene boundary (24 mybp). There is no published evidence that these mapped faults have recently moved, or that these faults offset Pleistocene or Holocene sediments.

3.3 Soils

The soils in the project area have characteristics typical of the western Cascades of Washington. The soil characteristic most relevant to this study is erodability. The Soil Maps (Figures 6A, 6B, and 6C) are based on soil maps published by the Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service (SCS). Table 2 lists the soil types that have been mapped in the project area. These soils formed by a variety of processes, resulting in complex soils with varying thicknesses. The general soil types based on the processes that formed them include:

- Alluvial soil (alluvium) that was deposited directly by streams and rivers. Alluvial soils are restricted to the valley bottoms in the project area.

- Glacial soil that was deposited directly by glaciers (till) and by glacial outwash streams (glaciofluvial deposits).

- Residual soils (residuum) that formed by weathering in place of the underlying bedrock, alluvium, or glacial deposits. The composition of residual soil depends on the type of underlying parent material and its weathering characteristics, i.e., whether the soil is predominantly fine-grained (silt and clay) or coarse-grained (sand and gravel). Because of active slope processes, residual soil is relatively thin in the project area.

- Colluvial soil (colluvium) has been transported downslope, generally by mass wasting (e.g., landsliding and soil creep). Colluvial soil may cover a layer of residual soil derived from the underlying parent material.

- Volcanic ash from nearby Cascade volcanoes periodically fell over the area and mixed with the other soil types.

Most of the soils in the Alternative A and C project areas are 5 feet or more in depth, reflecting the depth of underlying glacial and alluvial deposits. Thinner soils are present in Alternative B and D project areas because of resistant bedrock, steep slopes, and lack of glacial deposits. The depth of soil in areas underlain by bedrock ranges from zero to more than 5 feet, but typically is between 2 and 4 feet. The soil depth can influence surface water runoff and mass wasting potential.

3.4 Regional Seismological Setting

The project site is located in a moderately active tectonic region that has been subjected to numerous earthquakes of low to moderate strength and occasional strong shocks during the brief

170-year historical record in the Pacific Northwest. The tectonics and seismicity of the region are the result of ongoing, oblique, relative northeastward subduction of the Juan de Fuca Plate beneath the North American Plate along the Cascadia Subduction Zone. The convergence of these two plates not only results in east-west compressive strain (Lisowski, 1993), but also results in dextral shear, clockwise rotation, and north-south compression of accreted crustal blocks that form the leading edge of the North American Plate (Wells and others, 1998). The subduction zone extends from Northern California to central Vancouver Island in British Columbia. Western Washington is located in the continental forearc of the Cascadia Subduction Zone. The forearc consists of accreted sedimentary and volcanic rocks (i.e., Olympic Mountains and Puget Lowlands) in front of a landward mountainous, active volcanic arc (Cascade Mountains). The project site is located at the juncture between the accreted rocks and the landward mountainous, volcanic arc.

Within the present understanding of the regional tectonic framework and historical seismicity, three seismogenic sources have been identified (Yelin and others, 1994; Rogers and others, 1997):

< A shallow crustal zone within the North American Plate.

< A deep subcrustal zone (intraslab) in the subducted Juan de Fuca Plate and Gorda Plates.

< An interplate source in the Cascadia Subduction Zone, which is the interface between the North American and Juan de Fuca Plates beneath the coast.

3.4.1 Shallow Crustal Earthquakes

Shallow crustal earthquakes within the North American Plate beneath the Puget Lowlands have historically occurred in a diffuse pattern, typically within 12 miles of the earth's surface. The largest historic event is the 1872 North Cascades earthquake, which occurred in the vicinity of Lake Chelan and had an estimated magnitude 7.0+. However, surface rupture from this large event or other historic shallow crustal earthquakes in the Puget Lowlands or Cascade Mountains have not been observed. Two fault sources with known or suspected Holocene movement (i.e., movement within the last 10,000 years) are the Seattle and Southern Whidbey Island Faults. The locations of these faults relative to the project area are shown on Figure 1. The Seattle Fault Zone is an approximately 1½- to 4-mile-wide (north-south) zone consisting of multiple east-west-trending strands that extend from near Hood Canal on the west to the Sammamish Plateau on the east (Johnson and others, 1999). The east end of the Seattle Fault Zone (as mapped by Gower and others, 1985) is approximately 6 to 8 miles north-northwest of the Echo Lake substation. As mapped by Rogers and others (1996), the Southern Whidbey Island Fault extends southeast from near Vancouver Island beneath the south end of Whidbey

Island and terminates at the foot of the Cascades Mountains on the north side of Mount Si (Figure 1). The southeast end of the northwest-southeast-trending Southern Whidbey Island Fault is located approximately 5 miles north-northeast of the project area.

The locations of other mapped faults are shown on Figures 1 and 5A, 5B, and 5C, some of which cross the proposed alternative alignments. These faults are inferred based on offsets in Tertiary rock. However, no offset or displacement of overlying Vashon glacial deposits is known. This lack of offset indicates that no movement large enough to cause ground rupture has occurred on these faults since deposition of the Vashon deposits (i.e., no ground surface rupture within the last 13,500 to 15,000 years).

3.4.2 Intraslab Earthquakes

Deep, subcrustal, intraslab earthquakes can occur in the subducted portions of the Juan de Fuca Plate beneath the North American Plate, typically at depths of 25 to 38 miles. Earthquakes within this zone are associated with tensional forces that develop in the subducted plate because of mineralogical and density changes in the plates at depth. The largest historic earthquakes to affect the project area include the magnitude (M_s) 7.1 Olympia earthquake of April 13, 1949, the magnitude (m_b) 6.5 Seattle-Tacoma earthquake of April 29, 1965, and the recent February 28, 2001, magnitude (M_W) 6.8 Nisqually earthquake. All three of these events were located in the subducted Juan de Fuca slab beneath the Puget Lowlands at depths of 32 miles and greater. Ludwin and others (1991) estimate that the maximum magnitude from this source zone would be about 7.5.

3.4.3 Interplate Cascadia Subduction Zone Earthquakes

The third seismogenic source is within the Cascadia Subduction Zone, near the line of subduction between the Juan de Fuca Plate and the North American Plate west of the Pacific Northwest coastline. The Cascadia Subduction Zone is presently generally quiet, with only scattered and diffuse seismicity. Geologic evidence suggests that coastal estuaries have experienced rapid subsidence at various times within the last 2,000 years (Atwater, 1987 and 1997) as a result of movement along the Cascadia Subduction Zone. It appears that ruptures of this zone have occurred at irregular intervals that span from about 100 to more than 1,200 years with an average recurrence interval of about 600 years. Weaver and Shedlock (1997) estimate that rupture of this zone could result in earthquakes with magnitudes on the order of 8.5 to 9. The last large earthquake is estimated to have been a magnitude 9 event about 300 years ago, based on the geologic evidence and historical Japanese tsunami records.

3.4.4 Ground Motions

The USGS has conducted regional, probabilistic, ground motion studies to estimate potential earthquake ground motions considering the proximity and activity of the various earthquake source zones (Frankel and others, 1996). This study indicates that for ground motions with a 10 percent chance of being exceeded in 50 years (about a 500-year recurrence interval), random crustal earthquakes (i.e., earthquakes occurring on unknown or unidentified faults in the crust) are the greatest contributor to the ground motion hazard. While not as great, intraslab earthquakes also comprise a significant portion of the ground motion hazard. Peak ground accelerations (PGA) on bedrock consistent with a 10 percent chance of exceedance in 50 years range from about 0.18g at the east end of the project area (near the southeast end of Keechelus Lake) to 0.24g in the center (near North Bend), to 0.29g near the west end of the project area (Kent area).

3.5 Hydrology

3.5.1 Precipitation

Precipitation patterns in the project area are under the prevailing marine influence of the Pacific Ocean, which except in the high Cascades, produces mild, wet falls and winters; relatively dry summers; and mild temperatures year-round. There is a distinct wet season between October and April, when over 75 percent of the total annual precipitation falls. Most of the precipitation in the lowlands of the project area falls as rain. At higher elevations, snowfall dominates during the winter months. Annual precipitation in the project area averages between 40 and 60 inches in the Kent area along the western extension of Alternative A, to more than 180 inches at Stampede Pass along Alternatives B and D. In general, the annual precipitation amounts increase from west to east as elevation increases.

3.5.2 Flooding

The Federal Emergency Management Agency (FEMA) National Flood Insurance Program mapping program identifies areas that have a one-percent chance of being flooded in any given year (FEMA, 1989). These areas typically are referred to as the 100-year floodplain. This mapping is usually conducted in populated areas. As a result, floodplain mapping has not been accomplished for the entire project area. FEMA has mapped the 100-year floodplain along the Cedar River from the City of Seattle's Cedar River Watershed northwest to Puget Sound. Based on this mapping, it appears that the 100-year floodplain just west of the watershed is initially limited to a narrow area along the active Cedar River channel. Therefore, the Alternative C route would not be impacted by Cedar River flooding. However, farther downstream the Cedar River flows into a broad valley. From here north-northwest, the floodplain averages 1,000 to 1,500 feet in width. Only the north end of Alternative A, where it crosses the Cedar River valley, might be affected by flooding.

The floodplain of the South Fork of the Snoqualmie River in the vicinity of North Bend has also been mapped by FEMA. Here the floodplain is also generally confined to a narrow area along the active channel. Geomorphic conditions and their effect on flooding in the mapped area appear similar to the river upstream of North Bend where Alternatives B and D cross the South Fork Snoqualmie River twice, so that flooding is unlikely to impact these crossings. The east ends of Alternatives B and D cross the Yakima River. No FEMA mapping has been conducted in this reach of the Yakima River Valley. However, the valley is generally broad and flat in this area, and several bog areas occur. These features would tend to indicate periodic flooding does occur where the B and D routes cross the Yakima River, resulting in potential impacts. Flooding in the Yakima River is controlled to a certain degree by operation of the Keechelus Lake Reservoir, which is about 4 miles upstream of the proposed river crossing.

Tributaries to the Cedar, South Fork Snoqualmie, and Yakima Rivers are in moderately incised channels. Therefore, these streams do not have significant floodplains, and flooding generally would not overtop the incised channels. Towers and roads constructed in the vicinity of these stream channels should not affect or be affected by flooding.

3.5.3 Federal Clean Water Act

The Federal Clean Water Act requires that states protect the water quality of their rivers, streams, lakes, and estuaries. To accomplish this, Section 303(d) of the Clean Water Act requires that each state develop a list of water bodies that do not meet the standards. The 303(d) list is a means of identifying water quality problems. Once a stream is placed on the list, the Clean Water Act requires that the state develop a plan to reduce pollution. The states must submit the "water quality limited" list to the U.S. Environmental Protection Agency (EPA) every two years. In Washington State, the Department of Ecology (Ecology) is responsible for developing the standards that protect beneficial uses of water, such as drinking water, cold water for fish, industrial water supply, and recreational and agricultural uses. Ecology is also responsible for compiling the 303(d) list and submitting it to EPA for approval. The most recent EPA-approved list for Washington is for 1998. Parameters that Ecology typically monitors include bacteria, pH, dissolved oxygen, temperature, total dissolved gas, certain toxic and carcinogenic compounds, habitat and flow modification, fecal coliform, turbidity, and aquatic weeds or algae that affect aquatic life.

Water bodies that the proposed alternative transmission line routes cross that are on the Washington State 303(d) water quality-limited list are presented in Table 3. The Cedar River is listed for fecal coliform, as measured at points 2 miles and 10 miles downstream from Alternative A and Alternative C river crossings, respectively. In our opinion, the proposed action should not increase fecal coliform, which primarily comes from livestock and failing septic systems. For Alternatives B and D, the upper Yakima River is listed as temperature-impaired at a point 7 miles downstream from where the Alternatives B and D would cross the river. In our opinion, the proposed action would not cause a measurable increase in the Yakima River water temperatures. Two segments of the South Fork Snoqualmie River are listed as pH-impaired at a point 1,000 feet upstream from the western crossing and at a point 2,000 feet downstream from the eastern crossing. Reduced pH levels are usually a result of acid rain (not considered significant in the Puget Lowlands) and industrial discharges or drainage from acidic rock, such as mine tailings. Levels of pH could be raised because of increased temperatures and/or high nutrient levels that could cause increased productivity (University of Washington and The Nature Mapping Program in Washington, 1996). In our opinion, Alternatives B and D would not impact the existing pH levels in the South Fork Snoqualmie River.

3.5.4 Groundwater

Groundwater resources vary with the alternative route locations. No sole-source aquifers designated or proposed by the EPA exist in the project area; however, numerous domestic wells and a wellhead protection program are located within the project area. The principal groundwater aquifers are in glacial outwash deposits and the underlying bedrock. These aquifers are locally developed for domestic and some farm consumption. Because Alternatives A and C traverse areas underlain by extensive deposits of glacial sediments, these areas are important local and regional aquifers. Alternatives B and D predominantly traverse moderate to steep slopes underlain with slowly permeable bedrock. However, potential aquifers in alluvium, outwash, and ice contact drift deposits exist between North Bend and Twin Falls State Park along the Snoqualmie River valley.

Alternative A traverses the Covington Plain, where several aquifers have been mapped (Woodward and others, 1995). These aquifers include 1) near-surface Holocene alluvium present along rivers and streams, 2) advance outwash deposits of the Vashon Stade, and 3) deeper, glacial drift outwash sediments deposited during glacial periods prior to the Vashon Stade. These aquifers are recharged by precipitation and stream infiltration. Numerous public supply wells in advance outwash and alluvial deposits occur along most of Alternative A, and several wells in the older outwash sediments are located near Covington (Woodward and others, 1995). Numerous domestic wells probably obtain groundwater from the shallow aquifers in the project vicinity. The southeastern boundary of the Cedar River Valley sole-source aquifer is located about 2 miles northwest across Lake Youngs from Alternative A. Alternative A extends through an area designated for the City of Kent's wellhead protection program (City of Kent, 1996). This program is intended to protect the groundwater quality for the Clark Springs, Kent Springs and Armstrong Springs source areas (Sheets A-1 and A-2, Figure 5A). These source areas represent approximately 95 percent of the City of Kent's water supply.

Alternative C Options C1 and C2 also cross glacial outwash deposits and shallow aquifers similar to Alternative A; however, fewer alluvial aquifers exist. There are also numerous domestic wells in the project vicinity of Alternative C. Options C1 and C2 also extend across the Kent wellhead protection program area (Sheet C-1, Figure 5B).

The eastern end of Alternatives B and D extends across the upper Yakima River Basin. Groundwater in this portion of the project area occurs in shallow aquifers in Holocene alluvium and Pleistocene glacial outwash deposits (Pearson, 1985). Recharge is from precipitation, a substantial portion of which is snow, and stream flow. No known wells exist in the area, although scattered vacation homes in the area probably derive their domestic water from shallow wells. Between the Yakima River and the eastern crossing of the South Fork Snoqualmie River, the route traverses bedrock slopes. Porosity and permeability of the rocks is low, and groundwater is generally confined to joints and fractures. Although locally the rock is capable of yielding water to wells, it is not considered an important aquifer. From the eastern crossing of the South Fork Snoqualmie River west to Rattlesnake Mountain, the route crosses alluvium and glacial outwash deposits. Numerous domestic supply wells, as well as some public and institutional wells, occur in this area. In addition, springs also supply groundwater for human use (Turney and others, 1995). West along Rattlesnake Mountain to the Echo Lake substation, no known water supply wells exist.

3.6 Wind

Wind could affect the stability of transmission lines and towers. Wind could also affect forests adjacent to the cleared ROW. High winds could cause windthrow, which would affect timber resources and pose a potential hazard to transmission lines. A study of the distribution of extreme wind speeds in the BPA service area was conducted in 1980 (Bonneville Power Administration, 1980). Extreme wind speeds in the project area vary from 45 to 50 miles per hour (mph) for a 10-year recurrence interval event to 60 to 70 mph for a 100-year recurrence interval event.

In addition to high winds, windthrow is affected by the soil characteristics. Trees growing on soils that preclude development of a deep and strong root system, such as saturated soil or shallow soils over massive bedrock, would have greater potential for windthrow.

4.0 ENVIRONMENTAL CONSEQUENCES

This chapter discusses the environmental consequences of the additional alternatives on the resources described in the previous chapter. This chapter is divided into three general sections: Geology and Soils, Seismology, and Hydrology and Climate. Each of these sections first defines impact levels for each resource, generally using a scale of high impact, moderate impact, low impact, and no impact. Next is a discussion of general impacts that are common to all of the proposed alternatives and a general background regarding impacts to each resource. Following the general discussion of impacts, the impacts that could occur along each alternative are described in greater detail, with a description of mitigation measures that likely would be required. Finally, cumulative impacts and unavoidable effects, and irreversible or irretrievable commitments of resources are discussed.

4.1 Geology and Soils

4.1.1 Geology and Soil Impact Levels

Direct impacts from the project would be caused by new access road construction, improvements to existing access roads, ROW clearing, and site preparation for construction of structures. During construction, these activities would disturb the soil surface, which could lead to an increase in soil erosion, runoff, and sedimentation of nearby water bodies. Long-term maintenance, and especially ROW maintenance, could impair soil productivity and remove land from timber and farm production or other uses.

The following sections describe potential environmental consequences from construction, operation, and maintenance of the proposed BPA Kangley-Echo Lake Transmission Line Project in hazard areas identified along each of the proposed route alternatives. Of the identified hazards, landslides and soil erosion resulting from construction or operation and maintenance of the project would be most likely to impact environmental resources (fish and water). The extent and level of the various hazards for each alternative are summarized in Table 4.

4.1.1.1 Landslide Impact Levels

Landslide impacts could occur if construction or maintenance of the proposed project triggers a landslide, or if a landslide is triggered by natural factors, such as a large storm, combined with factors related to the transmission line.

Deep-seated landsliding has the greatest potential to impact a transmission alignment; however, the potential for a deep-seated landslide is relatively small. Three mapped, deep-seated landslides were identified along Alternative B and D routes (Figure 5C). These landslide features are apparently ancient and do not appear to be active. More recent, deep-seated landsliding was observed along Alternative A on the north valley slope of the Cedar River. Portions of the route alternatives were assigned a high, moderate, low, or no deep-seated landslide hazard category as follows:

< **High, deep-seated landslide hazard** was assigned to areas with active deep-seated landsliding, or where numerous ancient deep-seated landslides were identified adjacent to the alignment. No high, deep-seated landslide hazard areas were identified in the project area.

< **Moderate, deep-seated landslide hazard** was assigned to areas where isolated ancient or more recent deep-seated landslides were identified near the alignment. The ancient landslides on Alternatives B and D (Sheets B/D-4 and B/D-5, Figure 6C) and the north valley slope on Alternative A (Sheet A-4, Figure 6A) are the only moderate deep-seated landslide hazards in the project area.

< **Low, deep-seated landslide hazard** was assigned to areas that had similar characteristics as the moderate hazard landslide areas (i.e., slope, dip of bedded rocks, geologic contacts, etc.), but no landslides were identified nearby. Several areas of low deep-seated landslide hazard were identified along Alternatives B and D (Sheets B/D-2 and B/D-4, Figure 6C), and one area along Alternative C (Sheet C-3, Figure 6B).

< **No deep-seated landslide hazard** was assigned to areas where deep-seated landslides were not identified and the geologic conditions do not appear conducive to deep-seated landsliding. Most of the project area falls within this category.

Shallow landslides were observed along Alternatives B and D, and along Alternative A on the south side of the Cedar River Valley. Shallow landslide hazards were assigned to a high, moderate, low, or no shallow landslide hazard category as follows:

< **High, shallow landslide hazard** was assigned to those sections of the route alternatives on slopes that exceed 65 percent and that are in the vicinity of mapped or observed areas of concentrated, past shallow landslide movement. No high shallow landslide hazard areas were identified in the project area.

< **Moderate, shallow landslide hazard** was assigned to those sections of the route alternatives on slopes that exceed 65 percent and that are in the vicinity of isolated shallow landslides. Moderate shallow landslide hazard areas were identified along Alternatives A (Sheets A-4, Figure 6A); B; and D (Sheets B/D-2, -3, -5, and -7, Figure 6C) in the project area.

< **Low, shallow landslide hazard** was assigned to those sections of the route alternatives where no existing shallow landslides were identified, but where converging slopes exceed 65 percent or where slopes steeper than 40 percent are present in confined drainages. Low shallow landslide hazard areas were identified along Alternatives B and D (Sheets B/D-2, -3, and -5, Figure 6C) in the project area.

- **No shallow landslide hazard** was assigned to all remaining sections of the route alternatives not identified as high, moderate, or low.

4.1.1.2 Soil Erosion Impact Levels

Potential soil-related impacts in the project area were evaluated and mapped using the following soil survey reports: Soil Survey of King County Area, Washington (U.S. Department of Agriculture [USDA] SCS, 1973), Soil Survey of Snoqualmie Pass Area, Parts of King and Pierce Counties, Washington (USDA NRCS, 1992), and a draft soils map of Kittitas County provided in electronic digital form by the USDA NRCS (2002). The soil surveys include soil maps and descriptions of soil composition and structure. They also describe the soil engineering characteristics, such as Unified Soil Classification (USC), grain size, plasticity, erosion potential and organic content.

Surface erosion of soil could occur as a result of wind and downslope movement, such as creep or ravel; however, soil erosion is most often associated with flowing water. Soils that are most susceptible to surface erosion by water have no or minor cohesion (as a result of a low percentage of clay minerals) or have a low percentage of gravel-size particles (which would otherwise armor the soil surface). Other factors that could lead to high rates of soil erosion are disturbance, absence of vegetative cover, concentrated water, and steep slopes.

The referenced soil reports define soil erosion hazards of slight, moderate, severe, and very severe, which indicate the risk of loss of soil in *well-managed woodland* (italics added for emphasis). These ratings are summarized below. The soil hazard ratings for soils that occur in the project area are listed in Table 2. Those soils for which a range of hazards was provided (i.e., slight to severe), were assigned the greatest hazard level. Erosion hazard ratings have not yet been developed for the Kittitas County soil units. For those Kittitas County soil units that were not the same soil type as the adjacent King County soils (for which erosion hazards have been developed, erosion hazards were developed by Shannon & Wilson based on the soil description, the erosion factor "k," and the slope.

- **High erosion impact** was assigned to those sections of the alternatives that cross soil units identified as very severe or severe erosion hazards. These soils could require intensive management or special equipment and methods to prevent excessive loss of soil.

- **Moderate erosion impact** was assigned to those sections of the route alternatives that cross soil units identified as moderate erosion hazards. These soils could require erosion-control measures during logging and road construction to prevent excessive loss of soil.

- **Low erosion impact** was assigned to those sections of the route alternatives that cross soils identified as slight erosion hazards. Loss from these soils during construction is expected to be small.

- **No erosion impact** would occur only in soils that are not disturbed during the construction and maintenance of the proposed project.

4.1.1.3 Excavation Difficulty Impact Levels

The degree of excavation difficulty for road and transmission line tower construction is based on expected depths of soil and bedrock, and the expected strengths of bedrock. An average excavation depth of 15 feet was assumed for tower footings. Similar excavation depths could be assumed for road construction (i.e., cut slopes). For assigning excavation difficulty, rock is defined as material that requires blasting or use of hydraulic breakers for excavation. Material that could be excavated entirely with conventional earth-moving equipment, including rippers, is considered to be soil.

Although excavation difficulty would not represent a hazard to the environment, the type of excavation required would affect the construction methods used, which in turn could affect the environment. Excavation difficulty ratings of high, moderate, and low were assigned based on the expected geologic unit and the following criteria:

- **High excavation difficulty** was assigned to areas that are underlain by bedrock. Much of the near-surface rock could probably be ripped and/or excavated by machine. However, deeper excavations or excavations in harder or more massive bedrock could require blasting and/or hydraulic breaking.

- **Moderate excavation difficulty** was assigned to areas that are underlain by till and other glacially overridden soils (advance outwash and some ice-contact deposits). In general, these soil types could be excavated with conventional excavation equipment. However, excavation could require large earthwork equipment and rates may be slow. Local boulder deposits and unanticipated bedrock outcrops could require hydraulic breaking and/or blasting to complete excavations.

- **Low excavation difficulty** was assigned to the remaining sections of the route alternatives that were not assigned a moderate or high hazard rate. While the potential for rock excavation is small, large boulders, rockslide blocks, or other unidentified, hard or massive rock could be encountered.

4.1.1.4 Settlement Impact Levels

Settlement occurs when soft or loose soil consolidates or densifies under loads. Loads could include fill placed for a road, or foundations of a transmission line tower or other structure. Wet, fine-grained soil or soil that contains abundant organic material usually would have the greatest potential for settlement. These types of soil typically occur in alluvial environments, such as river valleys, bays, and estuaries. Poorly compacted fills and fills with organic material are also susceptible to settlement. Collapse of underground coal mine workings could cause surface subsidence.

Settlement impact levels were assigned as follows:

< **High settlement impact** was assigned to areas where structures might be built on swampy areas, recent alluvium, and old underground mine workings.

< **No settlement impact** was assigned to all other areas.

4.1.2 Geology and Soil General Impacts

4.1.2.1 Landslides

Poor practices in design and construction of access roads and clearing of wide swaths of forest on slopes that are susceptible to landsliding could cause an increase in the rate and/or size of landslides. The factors that affect landsliding, other than natural factors, include poor road construction practices, improperly placed fills, poorly designed cut slopes, poor drainage and, to a lesser degree, logging. Fills placed for roads on slopes steeper than about 60 percent, poorly compacted fills, poor-quality fill material, and poorly prepared subgrades create conditions that are particularly susceptible to landsliding. A steep cut made in poorly drained soil or in loose, granular soil could initiate a landslide. Landslides are commonly triggered by poor road drainage resulting from undersized culverts, culverts spaced too far apart, blocked culverts, or from poorly maintained roads and ditches. Logging dense, coniferous forests on steep slopes could increase the potential for landslides to occur as a result of reduced soil strength. Reduced soil strengths could occur from increased soil water that results from the loss of interception and evapotranspiration of precipitation and the loss of root strength.

Most shallow landslides would probably not significantly impact the transmission line towers. However, they could increase the rate at which sediment and debris is delivered to streams, reduce the amount of land for timber production, and cause temporary access road closures. Shallow landslides could liquefy after moving a short distance and become debris flows. Debris flows typically move rapidly down the slope, eroding and accumulating additional material until they reach a low-gradient slope or the valley bottom.

Deep-seated landslides could deposit large quantities of debris into streams, which could degrade fish habitat and water quality. Because of their potential size, deep-seated landslides could have a significant impact on existing public and private roads and properties that are downslope of the landslide. Movement of a deep-seated landslide across the transmission line ROW could displace or topple the towers and potentially snap or short the conductors. Small, chronic movements of the landslide mass would require frequent maintenance. Deep-seated landslides could be initiated by poorly designed road cuts, excessive fills, or discharge of concentrated drainage.

4.1.2.2 Soil Erosion

Construction of roads, ROW clearing, and site preparation for transmission line tower footings would expose and disturb soil, increasing the potential for surface erosion of soil from its pre-disturbed condition. The eroded soil could enter streams and impact fish habitat and water quality. Sources for increased sediment include unprotected cut-and-fill slopes, road surfaces, and spoil piles. Most impacts would likely be short-term. Once the cuts and fills adjacent to roads and the areas cleared for tower construction revegetate and the road surfaces are graveled or naturally become armored, erosion rates should reduce substantially and not significantly affect nearby streams and other water bodies. Long-term impacts should be small, unless efforts to revegetate and control erosion and runoff are unsuccessful and/or not maintained.

4.1.2.3 Excavation Difficulty

Based on expected soil depths and rock strengths, excavation for most of the roads and footings could be accomplished with conventional earthwork equipment. However, some sections of the access roads could require blasting to remove massive and/or hard bedrock. At locations where bedrock is close to the surface and is hard and sound, tower foundations could require drilled rock anchors. Blasting of the bedrock could temporarily disturb wildlife and residents living nearby. Excavations in soil could generate spoils and create slopes that typically are more susceptible to erosion than bedrock spoils and slopes.

4.1.2.4 Settlement Hazard

Transmission line towers founded improperly on settlement-prone soil could settle differentially to the point that they would not function as designed. Settlement induced by constructing the transmission line towers could have indirect environmental impacts because of additional maintenance work and possible construction of new foundations. Abandoned underground coal mine workings exist in portions of the project area. Mine collapse could cause surface subsidence, which could impact the transmission line towers.

4.1.3 Alternative A Geology and Soils

4.1.3.1 Impacts

Alternative A would parallel the existing Covington-Columbia No. 3 230-kV transmission line to the Covington substation in a vacant ROW that is already cleared. From the substation, the existing Covington-Maple Valley line would be rebuilt to a double-circuit, 500-kV line. As a result of this proposed alternative following the existing cleared ROW, clearing of undisturbed ground would not be required with the exception of the area around the Covington Substation. In addition, most of the road system is already in place. Only short spur roads to the actual tower sites along the Covington-Columbia line from the existing roads would be needed. Small intermittent streams might be crossed by these spur roads, and culverts could be required for passage of stormwater.

Landslides

One area of moderate deep-seated landslide hazard was identified along an approximately 500-foot-long portion of Alternative A (Table 4 and Sheet A-4, Figure 6A). This area includes and is adjacent to a relatively recent landslide on the valley slope north of the Cedar River. No high or low, deep-seated landslide hazard areas were identified along Alternative A.

High or low, shallow landslide hazard areas were not identified along Alternative A. A moderate shallow landslide hazard area (Table 4 and Sheet A-4, Figure 6A), extending for about 1,300 feet in length, was identified on the valley slope south of the Cedar River.

Road construction across the deep-seated landslide hazard area could activate a landslide. Poor design and road construction practices, excessive road drainage, or poor maintenance of roads in the areas of shallow landslide hazard could initiate a landslide that could deliver sediment to fish-bearing waters. A road system already exists along most of Alternative A so that only short spur roads should be required, and towers would not be placed on the valley slopes above the Cedar River. Therefore, the potential for project-related, road or tower construction related landslides would be small. Upgrading of the existing roads (grading, drainage measures) could reduce the overall project potential for landslide initiation.

Because Alternative A traverses existing cleared ROWs, no substantial clearing would be required, except near the Covington Substation. Minor clearing might be required for construction of short access roads. Landslides could be triggered in the areas identified as shallow landslide hazard because of hydrologic changes caused by clearing. However, only one area of moderate shallow landslide hazard was identified along Alternative A. Because this area would not require additional clearing, we conclude the possibility of triggering shallow landslides is remote.

Soil Erosion

The total length of the Alternative A route is approximately 20 miles. Of this, about 2.2 miles (11 percent) crosses soil designated as a severe erosion hazard, 13.5 miles (68 percent) crosses soil designated as a moderate erosion hazard, and the remaining 4.3 miles (21 percent of the route crosses soil designated as a slight erosion hazard (Table 4 and Figure 6A).

Poor design and construction and/or poor maintenance activities on severe and moderate hazard soil erosion areas could increase soil erosion and delivery of sediment to fish-bearing waters. In most cases, no roads or only short, new spur roads from the existing roads to the actual tower sites, would be needed. In addition, the need for construction of additional culverts and bridges, and the resulting potential impacts to water bodies, would be significantly reduced compared with the number of similar drainage structures required for a new road system. Culverts could be required where the short spur roads cross small, intermittent streams.

The increased amount of surface water runoff resulting from the lengthened road prism could cause an increase in peak flows. Increased surface runoff and peak flows could cause additional erosion at road cuts and fills, along drainage ditches, below culvert outfalls, and in stream channels. Because little road construction will occur, the anticipated increase is expected to be small relative to existing conditions.

Excavation Difficulty

We did not observe rock outcrops along the Alternative A route, and soil units that are indicative of shallow bedrock were not mapped along this alternative (Figure 6A). Puget Group Formation bedrock is mapped in several locations at the east end of the alternative; however, these rocks are generally soft and weathered near the surface (Figure 5A). Therefore, we do not anticipate that shallow, hard bedrock would be present that could cause difficult excavation conditions.

Extensive boulder and gravel recessional outwash deposits are mapped along this route. In addition, isolated glacial erratic boulders could be present in glacial till deposits, i.e., at almost all locations along the proposed alignment. Large boulders might require blasting to excavate for tower foundations because rock anchors placed in large boulders generally would not form a suitable foundation.

Typically, tower foundations are placed to the same depth, whether in soft rock or soil, to provide sufficient resistance to uplift. Therefore, the amount of spoils generated should be similar for soft rock or soil excavation. However, the amount of material produced that is erodible by surface processes should be less for rock excavation than for soil excavation. Unless adequate mitigation measures are implemented, erosion of the spoils could deliver sediment to nearby water bodies.

Hard rock excavation could require the use of blasting and/or hydraulic breakers. These methods would generate more noise and dust than excavation equipment only.

Settlement Hazard

Alternative A crosses two mapped bog deposits for a total distance of 1,300 feet (Table 4 and Qb, Figure 5A). Other bog deposits are mapped in the vicinity. Towers located in the bog deposits could settle unless properly supported. Also, abandoned underground coal mine workings exist near the proposed route. Portions of these workings have collapsed in the past and have caused surface subsidence. Collapse of coal mine workings beneath a transmission tower could cause tower displacement.

4.1.3.2 Mitigation

Where practical, hazard avoidance is the most effective method of mitigating impacts from or to the project facilities. During preliminary and final route selection (including tower and road locations), avoidance would be the primary means of mitigation. For those areas where potential natural hazards are present and unavoidable, measures to mitigate impacts that could result from the construction, operation and maintenance of the project could be implemented. Site-specific mitigation measures would be developed following selection of a specific route.

Roads

Most landslide and soil erosion impacts probably would be the result of road construction and use. Therefore, the most direct way to reduce these impacts would be to reduce the amount of new road construction. Access roads would be required to construct and maintain each transmission line tower.

Once a specific route is selected, the proposed access road routes should be evaluated in the field to identify site-specific hazards. Engineering analyses should be conducted and road stabilization measures designed and constructed where required. An Erosion and Sediment Control Plan (ESCP) that incorporates Best Management Practices would be developed and implemented for specific areas, such as road crossings at streams, to reduce delivery of sediment to sensitive resources. To reduce the potential for road failures, roads could be located along ridge tops wherever feasible. Seasonal restrictions could be placed on road construction operations to reduce the potential for erosive events and impacts to wildlife.

Erosion of fine sediment from road surfaces could contribute sediment to a drainage system. To reduce surface erosion, those roads that would be actively used could be surfaced with sound, crushed rock and maintained on a regular basis. Maintenance could include grading, ditch and culvert cleaning, cut-slope revegetation, and repair of failure sites. Roads that would not be used following construction could be restored to approximately preexisting conditions or stabilized with vegetation and drainage measures (e.g., water bars, culvert removal, and sidecast fill removal). Roads could also be gated to prevent unauthorized use.

Right-of-Way Clearing

ROW clearing on Alternative A would be limited to a relatively small area near the Covington Substation and possibly for some access roads. Currently, low ground cover consisting of shrubs and grasses grows along the route. Over the years, this vegetation would grow to a taller, denser condition. Consequently, the benefits of vegetation, including root strength, soil cover, interception, and evapotranspiration of precipitation, would remain. Under local regulations, wetlands and streams are required to have protective buffers. Wetlands, streams, and associated buffers would be left undisturbed where practical.

Other Mitigation Measures

- Properly space and size the culverts to reduce the chance of road failure. Use cross-drains, water bars, rolling dips, and armoring of ditches, drain inlets and outlets to drain water from the road surface.

- Improve all existing culverts and stream crossings that pose a risk to riparian, wetland, or aquatic habitat and fisheries to accommodate a 100-year flood and associated bedload and debris.

- Coordinate all culvert installations with the appropriate federal, state, and local agencies.

- Preserve vegetation where possible and stabilize disturbed portions of the site. Implement stabilization measures as soon as practicable where construction activities have temporarily or permanently ceased.

- Promptly seed disturbed sites with an approved herbaceous seed mixture suited to the site.

- Use vegetative buffers and sediment barriers to prevent sediment from moving off site and into water bodies.

- Design and construct fords and bridges to reduce bank erosion. Identify specific locations and measures when road and line designs are finalized.

- Schedule construction and maintenance operations during periods of low precipitation and runoff potential to reduce the risk of erosion, sedimentation, and soil compaction.

- Design facilities to meet regional seismic criteria.

- Use full-bench road construction and end hauling of excess material on slopes exceeding 60 percent, if needed to stabilize road prisms. Prior to construction, locate suitable waste areas for depositing and stabilizing excess material.

- Construct access roads consistent with the standards and guidelines of the Washington State Department of Natural Resources and other applicable guidelines.

- Avoid riparian areas, drainage ways, and other water bodies. Where these areas cannot be avoided, apply sediment reduction practices to prevent degradation of riparian or stream quality. Consider using riparian plantings where needed to restore streamside vegetation and increase streambank stability.

- Restrict road construction to the minimum needed. Restore nonessential existing roads and temporary construction access roads to approximately pre-existing conditions.

- Avoid discharge of solid materials, including building materials, into waters of the United States unless authorized by a Section 404 permit of the Clean Water Act. Reduce off-site tracking of sediment and dust generation. Leave vegetative buffers along stream courses to minimize erosion and bank instability.

- Prepare a Stormwater Pollution Prevention Plan (SWPPP), as required under the National Pollutant Discharge Elimination System General Permit.

- Design the project to comply with local regulations and state and federal water quality programs to prevent degradation of aquifer quality and to avoid jeopardizing their usability as a drinking water source.

4.1.3.3 Cumulative Impacts

Most of the long-term land use impacts of the new transmission line would be in addition to similar impacts from existing transmission and distribution lines in the project vicinity, and from other types of development and land use. Alternative A extends across substantial areas of suburban residential and commercial development, primarily in the Kent and

Maple Valley areas. Existing and new residential and commercial development in the project vicinity would cause additional impacts. Additional impacts could also occur from improvement or construction of new streets and highways, such as the ongoing Highway 18 expansion. Impacts could also result from improvements to the Burlington Northern and Santa Fe Railroad that extends from Kent to Georgetown across the southern portion of the route.

The most likely impacts would be increased soil erosion from construction sites or as a result of increased surface water runoff from less pervious surfaces, such as rooftops and parking lots. Poorly planned additional development could trigger landslides by excavating and undermining slope toes, placing additional loads at slope tops, or by discharging excessive water onto steep slopes.

4.1.3.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Some road construction, with its attendant short- and long-term impacts discussed above, would be unavoidable to complete the proposed project. However, as discussed in Section 4.1.3.3, improvements to the existing road system could result in reduced sediment delivery levels below current levels. If the project is abandoned, the disturbed ground could be restored and, over a period of years, revegetated to preexisting conditions. Resources, such as fuel oil, lubricants, and metals, would be consumed during construction and maintenance of the project. Aggregate materials would be used in road and tower foundation construction, and for road surfacing maintenance. These materials would require mining and transportation.

4.1.4 Alternative B Geology and Soils

4.1.4.1 Impacts

Alternative B would rebuild approximately 38 miles of BPA's existing Rocky Reach-Maple Valley, 345-kV transmission line to a 500-kV, double-circuit line. The new line would be installed on 175-foot-tall towers. The line would begin just east of Stampede Pass and extend west along the Interstate 90 corridor to the Echo Lake Substation, crossing Interstate 90 twice. This route would be on existing ROW with access roads already in place. A majority of the ROW is already cleared, however, approximately 20 feet on the north side of the existing ROW would require clearing.

Landslides

Sections of moderate (8,000 feet or 5 percent of total length) and low (12,000 feet or 6.4 percent of total length) deep-seated landslide hazard areas were identified along the Alternative B route (Figure 6C and Table 4). Shallow landslide hazard areas were identified, with about 9,500 feet (5 percent of total length) identified as moderate hazard and about 12,200 feet (6.5 percent of total length) identified as low hazard (Figure 6C and Table 4). No high hazard landslide areas were identified along this Alternative.

Impacts to slope stability from Alternative B construction, such as reactivating portions of deep-seated landslides and hydrologic change, would be similar to those discussed for Alternative A (Section 4.1.3.1). Because this alternative occurs on existing, mostly cleared ROW, access roads to the tower sites currently exist in most locations. Access roads have been washed out by debris flows in at least four locations between Ollalie Creek near Ski Acres west to Alice Creek near Tinkham Campground (Sheets B/D-3 and -4, Figure 5C). These washouts required development of alternative access routes or suitable repairs. Existing condition of the access roads in this section of the line is generally poor. Most of the access roads along this line would require relatively minor clearing and road building. However, access roads on the portion of the line between Ollalie and Alice Creeks would require some reconstruction and upgrading. This alternative occurs along steeper ground and where more precipitation occurs than Alternatives A and C.

Soil Erosion

About 1 mile (2 percent) of Alternative B crosses soil designated as a severe erosion hazard and 10.5 miles (28 percent crosses soil designated as a moderate erosion hazard. The remaining 26.5 miles (70 percent) crosses soil designated as a slight erosion hazard (Table 4 and Figure 6C).

Because numerous streams cross the route, which is on steeply- to moderately-sloped ground, delivery of construction-derived sediment could be significant if appropriate BMPs are not implemented. Impacts from clearing the approximately 92 acres of ROW over a 38-mile distance are considered to be low to moderate. Most of the access roads in the ROW would require only slight modification. However, the segment requiring more extensive work is in steep terrain with significant rainfall; therefore, the amount of sediment generated could be moderate.

During construction, temporary amounts of sediment delivery to streams could rise above current background levels. These levels could be moderate because of reconstruction of existing roads across many stream crossings. The tower sites would be generally away from streams and BMPs would be employed, which would lessen the overall impacts. Following construction and stabilization of the disturbed ground, sediment delivery levels would reduce to pre-construction background levels. Improvements made to the existing road system in association with the new line construction could reduce levels of sediment delivery below the current levels.

Excavation Difficulty

Almost half of the Alternative B route (45 percent of the total length [Table 4]) traverses bedrock mantled with generally shallow soils. This ground is rated as high excavation difficulty. Another approximately one-quarter of the route (23 percent of total length [Table 4]) crosses glacially overridden soils, which are rated as moderate excavation difficulty. Therefore, excavation difficulty and its attendant impacts (blasting, noise, dust) would be generally high.

Settlement Hazard

No settlement hazards were identified along Alternate B.

4.1.4.2 Mitigation

Refer to measures described for Alternative A, Section 4.1.3.2.

4.1.4.3 Cumulative Impacts

Other activities that could cause cumulative impacts include use and maintenance of existing roads, construction and use of new roads, sand and gravel mining, rock quarries, and timber harvesting. Increased erosion because of exposed soil and/or increased surface water runoff would be the predominant cumulative impact from these activities. Landslides could occur from existing and new roads, and on slopes from which timber was harvested. Improvement and proposed expansion of Interstate 90 would also cause cumulative impacts.

4.1.4.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Refer to the effects and commitments under Alternative A, Section 4.1.3.4.

4.1.5 Alternative C Geology and Soils

4.1.5.1 Impacts

Option C 1 would originate at the Raver Substation, then proceed west approximately 2.5 miles in a vacant, cleared ROW along the existing Raver-Tacoma double-circuit 500-kV transmission. At this point, the segment would turn north for about 7.5 miles to tie into an unused circuit of the Echo Lake-Maple Valley double circuit 500-kV line. This segment would be on new ROW. Option C 2 would begin at the tap point along the Schultz-Raver No. 2 line near Kangley. From the tap point, it would proceed west along vacant transmission line ROW immediately north of the Covington-Columbia No. 3 230-kV transmission line for approximately 4.5 miles. At this point, the C 2 segment would turn north for approximately 6 miles along the same route described for Option C 1.

Some clearing and construction of short spur roads from existing BPA roads would be required along the first 2.5 miles of the Option C1 alignment or along the first 4.5 miles of the Option C2 route. The actual route along the remaining north-south oriented 7.5 miles (Option C1) or 6 miles (Option C2), much of which would pass through rural residential areas, has not been determined. This portion could require substantial clearing of vegetation and structures and construction of access roads along the proposed ROW.

Landslides

Most of the Alternative C route is along gently sloping ground. No high or moderate hazard, deep-seated landslide areas were identified along Alternative C, Option C1 or C2. About 1,700 feet at the north end of this route (approximately 3 percent of the total length) on the southern ridge of South Tiger Mountain has been identified as an area of low, deep-seated landslide hazard, with no deep-seated landslide hazard along the remainder of the route (Table 4 and Figure 6B).

No high or moderate shallow landslide hazard areas were identified along Alternative C, Option C1 or C2. The same route portion identified as low, deep-seated landslide hazard was also identified as a low, shallow landslide hazard (Table 4 and Figure 6B).

Assuming a 150-foot-wide transmission line corridor along the northern 6-mile section (Option 2) or 7.5-mile section (Option 7) that would require clearing, approximately 140 acres (Option C1) or 110 acres (Option C2) would be impacted. The type of impacts to slope stability from Alternative C land clearing and road construction would be similar to those of Alternative A (Section 4.1.3.1). The greatest potential landslide impacts would occur on the steep slopes listed as low-hazard, deep-seated, and shallow landslide hazards on the west-facing slope of the south ridge of South Tiger Mountain. No significant streams are present in these steep slopes area. Nearby Issaquah Creek and its tributaries, Holder and Carey Creeks, are more than 1,000 feet from the toe of these steep slopes. Therefore, it is unlikely that sediment from a landslide could enter Issaquah Creek. However, residences are located at the slope toe on the west side of the ridge.

Soil Erosion

About 1 mile (8 percent) of Alternative C, Option C1 crosses soil designated as a severe erosion hazard, and 3 miles (32 percent) crosses soil designated as a moderate erosion hazard. The remaining 6.2 miles (60 percent) of the route crosses soil designated as a slight erosion hazard (Table 4 and Figure 6B). The Option C2 route crosses about 0.5 miles (5 percent) of soil designated as a severe erosion hazard, about 3.5 miles (33 percent) of soil designated as a moderate erosion hazard, with the remaining 6.5 miles (62 percent) of the route designated as a slight erosion hazard.

Impacts from project construction and operation on soil erosion and sediment delivery would be similar to those impacts described for Alternative A (Section 4.1.3.1).

Excavation Difficulty

Bedrock, considered to have a high excavation difficulty, is mapped at the north and south ends of Alternative C, Options C1 and C2. Bedrock along Option C1 accounts for about 17 percent of the total length (Table 4). Bedrock along Option C2 accounts for about 16 percent of the total length. Because the bedrock probably consists of generally soft, weathered, sedimentary rock, it is anticipated that most excavations could be conducted with conventional equipment without the need for blasting. Glacially overridden soils, considered to have a moderate excavation difficulty, occur for about 37 and 31 percent of the total alternative Option C1 and C2 lengths, respectively.

Settlement Hazard

No soft soil settlement hazards were identified along the Alternative C alignment. Abandoned underground coal mine workings are present near the route, including the Landsburg Mine site (Sheet C-2, Figure 5B). Portions of these workings have collapsed in the past and caused surface subsidence. Collapse of coal mine workings beneath a transmission tower could cause tower displacement.

4.1.5.2 Mitigation

In general, erosion and sedimentation mitigation required for this alternative would be similar to Alternative A (Section 4.1.3.2). The north end of the route crosses into the Issaquah Creek drainage and the Tiger Mountain State Forest. The Issaquah Creek Basin and No point Action Plan (King County, 1994) discusses several measures regarding timber harvesting, including education and monitoring, to reduce pollution and improve water quality.

4.1.5.3 Cumulative Impacts

Most of the long-term land use impacts of the new transmission line would be in addition to similar impacts from existing transmission and distribution lines in the project vicinity, as well as from other types of development and land use. Both options of Alternative C extend across substantial areas of suburban residential and commercial development, primarily in the Maple Valley area. Existing and new residential and commercial development would cause cumulative impacts. Cumulative impacts could occur from improvement or construction of new streets and highways. Impacts could also result from improvements to the Burlington Northern and Santa Fe Railroad that extends through Georgetown across the southern portion of the route. Mining operations, predominantly for aggregate, occur south of the Cedar River.

The most likely impacts would be increased soil erosion from construction sites or because of increased surface water runoff from reductions in pervious surfaces, such as rooftops and parking lots. Additional development could trigger landslides by excavating and undermining slope toes, by placing additional loads at slope tops, or by discharging excessive water onto steep slopes.

4.1.5.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Refer to the effects and commitments under Alternative A, Section 4.1.3.4.

4.1.6 Alternative D Geology and Soils

4.1.6.1 Impacts

Alternative D would involve the construction of a new, single-circuit, 500-kV transmission line from just east of Stampede Pass to the Echo Lake Substation. This line would parallel BPA's existing Rocky Reach-Maple Valley 345-kV transmission line and would generally follow the Interstate 90 corridor, which it would cross twice. The new line could be either on the north side of the existing Rocky Reach-Maple Valley transmission line (D1) or on the south side (D2).

Landslides

Landslide hazards for Alternative D are the same as for Alternative B (Section 4.1.4.1 and Table 4). However, this alternative would require clearing of approximately 650 acres of forested ground on steep to moderate slopes, and construction of additional spur roads to access the tower sites. Therefore, the potential impacts to slope instability from this alternative would be greater than for Alternative B.

Soil Erosion

Soil erosion hazard ratings along this alternative are the same as for Alternative B (Section 4.1.4.1 and Table 4), however, the large increase in the amount of clearing and road construction would result in larger soil erosion impacts. Because of the numerous streams and moderate to steep slopes along the route and evidence of past failure of roads due to debris flows, the potential for sediment delivery from the disturbed ground is considered high.

Excavation Difficulty

Excavation difficulty would be similar to Alternative B (Section 4.1.4.1 and Table 4). The additional road construction required for this alternative would make the impacts expected for this alternative greater than Alternative B.

Settlement Hazard

No settlement hazards were identified along Alternative D.

4.1.6.2 Mitigation

Refer to measures under Alternative A, Section 4.1.3.2.

4.1.6.3 Cumulative Impacts

Refer to the discussion of Alternative B, Section 4.1.3.3.

4.1.6.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Refer to the effects and commitments under Alternative A, Section 4.1.3.4.

4.2 Seismology

4.2.1 Seismic Impact Levels

4.2.1.1 Liquefaction Impact Levels

Liquefaction is a phenomenon in which saturated, cohesionless soils are temporarily transformed into a near liquid or "quicksand" state. During an earthquake, ground shaking could result in a buildup of pore-water pressure in the saturated soil to a point where the pore-water pressure approaches the grain-to-grain contact pressure. As this occurs, the soil particles would begin to lose contact with each other and the soil would liquefy. The effects of liquefaction could include lateral spreading (permanent lateral ground displacements for a distance to about 10 feet on near-level ground), differential settlement, loss of vertical and lateral foundation support, and buoyant rise of buried structures. Historically, soils that have high liquefaction susceptibility include artificial fill (particularly along or in bodies of water) and granular Holocene geologic deposits (e.g., alluvium) in valley bottoms and along rivers and creeks.

Regional liquefaction studies (Grant and others, 1992; Palmer, 1992; and Palmer and others, 1994 and 1995) indicate that late Pleistocene, nonglacially overridden deposits have a moderate to low liquefaction susceptibility, while Pleistocene and older, glacially overridden sediment and bedrock have a low liquefaction susceptibility. The Geologic Maps (Figures 5A, 5B, and 5C) show the locations of these deposits along the alternative routes. Liquefaction impact levels were assigned to these units as follows:

< **High liquefaction impact** was assigned to Holocene alluvium along the Yakima, South Fork Snoqualmie, and Cedar Rivers.

< **Moderate to low liquefaction impact** was assigned to Pleistocene, recessional glacial outwash near the Yakima, South Fork Snoqualmie and Cedar Rivers.

< **No liquefaction hazard** was assigned to all other deposits.

4.2.1.2 Soft Ground Amplification Impact Levels

Earthquake ground motion or waves could resonate in relatively soft, cohesive soil resulting in local ground motion amplification. The amount of ground motion amplification would depend on the characteristics of the earthquake and the thickness and properties of the soil. Soft, cohesive soil (e.g., clay, peat, and organic soils) is typically geologically recent alluvial deposits that are commonly located in valley bottoms, depressions in bedrock or glaciated uplands, and along rivers and lakes.

< **High soft ground amplification impact** was assigned to areas indicated to be underlain by Holocene (nonglacially-overridden) peat and bogs.

< **No soft ground amplification impact** was assigned to all other areas.

4.2.1.3 Tsunami and Seiche Impact Levels

Earthquake-induced flooding could result from tsunami or seiche waves generated in open (i.e., oceans) or closed (e.g., lake, reservoir) water bodies, respectively. The project area is not near an ocean and would not be impacted by a tsunami. Seiches could occur in nearby lakes and reservoirs.

4.2.1.4 Fault Ground Rupture Impact Levels

Fault ground surface rupture occurs where movement on a fault propagates to the ground surface, resulting in permanent ground displacement across the fault. It is unlikely that ground surface rupture on either the Seattle or Southern Whidbey Island Faults would affect the project routes because of the distance between the routes and the faults (5 to 45 miles). Furthermore, while movement apparently has occurred on these faults in the last 10,000 years, preliminary recurrence interval estimates for earthquakes on these faults that could cause ground rupture are on the order of 1,000 to 7,000 years. Other faults mapped within the project area do not show evidence of ground rupture for at least the last 13,500 to 15,000 years, as evidenced by no known displacement of Pleistocene glacial deposits.

- **High fault rupture hazard** was assigned to areas along and adjacent to potentially active faults.

- **Low fault rupture hazard** was assigned to all other areas because unidentified faults could be present.

4.2.2 Seismic General Impacts

4.2.2.1 Liquefaction

Construction of the project generally would not affect the liquefaction susceptibility of the soil. Transmission line tower foundations built on soil that is susceptible to liquefaction could settle differentially and/or displace laterally during strong ground motion. Depending on the magnitude of movement and/or lateral spreading that occurs, the tower could be rendered unusable or, in extreme conditions, the tower could fail. Under these circumstances, additional maintenance and/or repairs would be required, which could cause indirect environmental impacts.

Liquefiable soils could be present in the project area in alluvium on the valley floors adjacent to the Yakima, South Fork Snoqualmie, and Cedar Rivers (Qa, Figures 5A, 5B, and 5C and Table 4).

4.2.2.2 Soft Ground Amplification

Towers founded on soft ground could be subjected to amplified ground motions during an earthquake, causing damage to or failure of the structures. Soft ground amplification-related damage could have indirect environmental impacts caused by additional maintenance work and/or construction of new towers damaged during an earthquake.

Soft ground is present along less than 2 percent of Alternative A, as shown on the published geologic maps (Table 4 and Figure 5A). Therefore, most of the planned structures would be in no soft ground amplification hazard areas.

4.2.2.3 Tsunami and Seiche

A seiche in either the Chester Morse reservoir (Cedar River Watershed, Alternatives A and C) or Keechelus Lake reservoir (Yakima River watershed, Alternatives B and D) could overtop the respective dams and cause downstream flooding. Such flooding could impact Alternative A in the Cedar River floodplain or Alternatives B or D in the Yakima River floodplain. Alternative C would span the Cedar River and would not be located in the floodplain.

4.2.2.4 Fault Ground Rupture

If an unidentified active fault is present at a tower location and the fault ruptures, the tower could be damaged or fail, which could cause indirect environmental consequences during maintenance or repairs.

No potentially active faults have been identified in the project area; therefore, no high fault rupture hazard areas are known. Because unidentified faults could be present, the entire project area has a low fault rupture hazard designation.

4.2.3 Alternative A Seismic

4.2.3.1 Impacts

A high liquefaction hazard could be present in some recent alluvial deposits along the Cedar River. The hazard would be greatest in saturated sand deposits.

Moderate to low liquefaction hazards could be present in the recessional outwash sediment between the tap into the Schultz-Raver No. 2 line and to just north of the Covington Substation. Recessional outwash deposits and moderate to low liquefaction hazards also occur along the route north of the Cedar River. Liquefaction occurs only in saturated, cohesionless soil. Lakes, bogs and streams occur along and adjacent to the route and are indicative of general groundwater elevations. The liquefaction potential in these low-lying areas would be higher than in the recessional outwash at higher elevations.

4.2.3.2 Mitigation

Liquefaction-susceptible soil could be improved and/or foundations could be designed to resist liquefaction-related damage. We recommend conducting a site-specific subsurface study prior to final design and construction to evaluate the liquefaction susceptibility of structures that would be built in liquefaction hazard areas.

4.2.3.3 Cumulative Impacts

No cumulative impacts would be associated with seismic hazards.

4.2.3.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

No unavoidable effects would be associated with seismic hazards. Improvement of liquefiable ground or construction of suitable foundations would require materials, such as concrete and steel, as well as fuel oil and lubricants used by construction equipment.

4.2.4 Alternative B Seismic

4.2.4.1 Impacts

A high liquefaction hazard could be present in some recent alluvial deposits along the Yakima and South Fork Snoqualmie Rivers. The hazard would be greatest in saturated sand deposits; however, most alluvial deposits in the upper reaches of these rivers (where the route crosses) are primarily composed of gravel and cobbles.

Moderate to low liquefaction hazards could be present in the recessional outwash sediments in the western portion of the route along the South Fork Snoqualmie River. Liquefaction occurs only in saturated cohesionless soil. The section of Alternative B that crosses the recessional outwash deposits is generally between 100 to 500 feet above the South Fork Snoqualmie River, so groundwater is probably relatively deep. These conditions tend to reduce the potential for liquefaction and reduce the likely damage that would occur if the soil liquefies. In our opinion, the potential for liquefaction in the recessional outwash deposits is low.

4.2.4.2 Mitigation, Cumulative Impacts, Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Mitigation, cumulative impacts and unavoidable effects, and irreversible or irretrievable commitments of resources for Alternative B would be essentially the same as for Alternative A (Section 4.2.3).

4.2.5 Alternative C Seismic

4.2.5.1 Impacts

Because no substantial Holocene alluvial deposits are present along this route, no high liquefaction hazards exist. Much of the route crosses recessional outwash deposits. Areas of recessional outwash along the route near Ravensdale and at the north end near Highway 18 are characterized by streams, lakes, and bogs. As a result, the groundwater elevation could be relatively close to the surface in these areas, resulting in a potential for liquefaction of susceptible soils. Areas of recessional outwash at higher elevations along the route generally would have deeper groundwater levels and consequently lower liquefaction potential.

4.2.5.2 Mitigation, Cumulative Impacts, Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Mitigation, cumulative impacts and unavoidable effects, and irreversible or irretrievable commitments of resources for Alternative C would be essentially the same as for Alternative A (Section 4.2.3).

4.2.6 Alternative D Seismic

Impacts, mitigation, cumulative impacts and unavoidable effects, and irreversible or irretrievable commitments of resources for Alternative D would be the same as along Alternative B (Section 4.2.4).

4.3 Hydrology and Climate

4.3.1 Hydrology, Water Quality and Climate Impact Levels

4.3.1.1 Floodplain Impact Levels

Construction and development could directly impact floodplains by obstructing or changing floodwater channels, which could increase downstream flows and/or upstream flooding. Indirect impacts could occur when resources are degraded (e.g., vegetation is removed and soil is compacted) to lessen the ability of the floodplain to store excess water, which would increase the chance of flooding.

< **A floodplain impact** would occur when structures or permanent access roads encroach on designated floodplains and increase the potential for flooding, or could cause loss of human life, personal property, or natural resources within the floodplain.

< **No impacts** would occur where floodplains are avoided or spanned, or where standard mitigation would effectively eliminate impacts.

4.3.1.2 Water Quality Limited Water Bodies Impact Levels

The water quality limited water bodies impact is assigned as follows:

- **High 303(d) water quality impact** is assigned to any water body segment that is on the 1998 Washington State 303(d) list and is crossed by the proposed route alternatives.
- **No 303(d) water quality impact** was assigned to the remaining areas.
- No 303(d)-listed water body segments are crossed by the alternatives.

4.3.1.3 Groundwater Impact Levels

The City of Kent has established a wellhead protection program. Alternatives A and C cross the wellhead protection area. Numerous residential wells exist in areas of all the alternative routes. Groundwater impact is assigned as follows:

- **High groundwater impact** is assigned to areas within a 100-foot radius of groundwater wells or within a wellhead protection area.
- **Moderate groundwater impact** is assigned to private land where groundwater wells likely exist within ½ mile.
- **Low groundwater impact** was assigned to the remaining areas.

4.3.1.4 Wind Impact Levels

Table 2 shows the windthrow hazard for each soil unit, as reported in the referenced soils reports. Ratings of windthrow impacts were assigned based on these hazard ratings, which range from slight to severe. The ratings are based on soil characteristics that affect root development and the ability of the soil to hold trees firmly:

- **Severe windthrow impact** was assigned to soil units where many trees could be blown over by moderate or strong winds.
- **Moderate windthrow impact** was assigned to soil units where some trees could be blown over by moderate or strong winds when the soil is wet.
- **Slight windthrow impact** was assigned to soil units where, under normal conditions, no trees would be blown over. Strong winds could damage some trees but no trees would be uprooted.
- **No windthrow impact** would be assigned only to areas that would not be affected by the construction and maintenance of the proposed project.

4.3.2 Hydrology, Water Quality, and Climate General Impacts

4.3.2.1 Floodplains and Flooding

Portions of the proposed transmission line Alternatives A, B, and D would be sited in the floodplains of the Yakima, South Fork Snoqualmie, or Cedar Rivers. These floodplains could be impacted by new roads and tower structures. Currently, tower structures along the existing transmission lines are located in the floodplains adjacent to these channels. With regard to floodplains along smaller streams, the transmission lines would span these features so that the floodplains would not be impacted. Alternative C would also span the Cedar River (i.e.; no towers in the floodplain) so that this floodplain would not be impacted along this alternative route.

Surface water runoff is typically more rapid from areas that have been cleared of vegetation and/or have disturbed soil than it is from areas with a mature forest canopy and/or with undisturbed soil. The forest canopy intercepts and temporarily stores some of the rainfall, much of which could evaporate. The remaining rainfall eventually reaches surface water or groundwater, but over a longer time than rain falling on unforested ground. Forested areas typically return moisture to the atmosphere by evapotranspiration, which could reduce the total amount of runoff; thus, more runoff would occur more rapidly after an area is cleared.

Disturbed soil is generally less permeable than undisturbed soil. Therefore, rainfall would be more likely to run off directly to streams from areas of disturbed soil than from undisturbed soil where rainfall typically infiltrates. While these impacts would occur along ROW clearings and access roads, the total area affected would be small compared with the watersheds they cross.

4.3.2.2 Water Quality

The proposed alternative transmission line routes would cross several major rivers and numerous smaller streams (Table 4). Segments of the Yakima, South Fork Snoqualmie, and Cedar Rivers are listed as 303(d) waters, but these segments do not occur where the alternative routes would cross the rivers. Therefore, no water quality limited water bodies would be affected by construction of a new transmission line and associated roads.

While 303(d) limited water bodies are not present along the alternative routes, the construction, operation and maintenance of the project, and especially ROW clearing and access road construction, could impact streams and rivers. As discussed in the following paragraphs, most impacts would occur for a short time. Overall, construction, operation, and maintenance impacts are expected to be low and localized. The impacts to water quality related to the landslide and soil erosion impacts are discussed in Section 4.1.

Short-term impacts to water quality would be associated with ground disturbance from ROW clearing, the building of access roads, excavating, and/or blasting for foundations and towers, and cable stringing. Clearing vegetation and exposing and disturbing soil would increase erosion, runoff, and the risk of sediment reaching surface waters. Access road construction would require complete vegetation removal and grading, which would typically disturb more soil than ROW clearing. The impacts would be most intense during and immediately after construction. Impact intensity would diminish as disturbed sites are stabilized and revegetated, which would reduce runoff and erosion.

In the long term, increased clearing could create foraging habitat that could attract deer, elk, and other warm-blooded animals that are potential sources of pathogens and viruses such as giardia and cryptosporidium. Erosion of unsurfaced roads could be a significant source of turbidity and could contribute to the turbidity levels. The amount of road surface erosion would increase with increasing traffic volumes, such as during the construction phase of this project. The temperature of surface water could be affected by reductions in shade where the ROW clearing crosses streams.

4.3.2.3 Groundwater

Construction and maintenance activities generally would not directly or indirectly introduce contaminates into groundwater aquifers. The project should not affect the chemical or biological characteristics of groundwater in the area. However, uncontrolled accidental spills from construction fuels and lubricants could infiltrate into and contaminate the aquifers that provide groundwater for residences. BPA commonly uses, with concurrence of landowners, herbicides during maintenance activities to prevent the return of tall growing vegetation on its rights-of-way.

4.3.2.4 Wind

Trees typically develop firmness against prevailing winds. However, ROW clearing could alter the speed and direction of wind against which the trees have developed firmness. In addition, trees typically buffer each other from winds. This sheltering effect would be lost for trees exposed along the edges of the cleared ROW and new roads. Therefore, windthrow might be more likely along areas logged and maintained for the transmission line tower route. High winds could also affect the transmission line towers and conductors.

The main impacts from windthrow are loss of timber resources, possible damage to structures, and exposure of soil to erosion. Section 4.1.2 describes soil erosion impacts. Impacts related to ROW clearing likely would decrease in the first years after construction. New trees growing adjacent to the ROW clearing, and to some extent trees that survive windstorms following construction, would develop firmness against wind and resist windthrow in the long term.

4.3.3 Alternative A

4.3.3.1 Impacts

Floodplains and Flooding

As discussed in Section 4.3.2, the proposed project could affect the Cedar River floodplain. Roads and towers in the floodplain could alter the floodways. Debris could be trapped against the tower structures during floods and divert flows or cause the structure to fail. If additional ROW clearing and access road construction is needed, the peak runoff and total annual runoff could increase. These impacts would be most intense during and following construction. As vegetation becomes well-established in the ROW clearing, the impacts would decrease. However, because no significant, additional cleared ROW area or roads are proposed, significant project-related changes in the peak and total amount of runoff would be unlikely.

Water Quality

Two major drainage basins could be affected by Alternative A. Approximately 5.6 miles of the route would be within the Cedar River watershed, and the remaining 14.1 miles of the route would be in the Big Soos Creek drainage basin. Surface water runoff containing fuel spills, herbicide runoff, and other contaminants could reach these main streams. Construction-related landslides, soil erosion, and clearing activities along the ROW could affect water quality, as discussed in Section 4.3.2. Because Alternative A would follow existing transmission line ROWs, new access road construction would be limited to improving the existing trunk access and spur roads, and construction of some new, short spur roads to the new tower locations. Because the ROW would cross gently to moderately sloping ground, the potential for erosion and landslides would be generally low. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources. Most potential landslide and soil erosion impacts would be short term.

Groundwater

From the tap point of the Schultz-Raver No. 2 line west to Covington, Alternative A would cross private land with numerous residences. Many of the residences likely have groundwater wells for domestic use. This portion of the route also extends through an area designated for the City of Kent's wellhead protection program (City of Kent, 1996). This program is intended to protect the groundwater quality for the Clark Springs, Kent Springs, and Armstrong Springs source areas (Figure 5A). These source areas represent approximately 95 percent of the City of Kent's water supply (City of Kent, 1996). Alternative A would cross directly through the Clark Springs area. Much of the wellhead protection area that Alternative A traverses has been rated as highly susceptible to groundwater contamination. Construction- and maintenance-related accidental fuel spills or use of herbicides could affect groundwater quality. This portion of the route has been designated as a high groundwater impact area (Table 4).

The remainder of Alternative A north of Covington would also cross private land with numerous residences. Many of these residences likely have groundwater wells for domestic use. This portion of the route is designated as a moderate groundwater impact area (Table 4).

Wind

Because the route is mostly in an existing cleared ROW, large areas of timber would not be removed, although danger trees may need to be removed. As a result, the potential for windthrow that would impact the lines would be low.

4.3.3.2 Mitigation

Floodplains and Flooding

Impacts to floodplains and impacts from flooding could be avoided by locating the towers and associated roads outside of the floodplain. If construction must occur within a floodplain, the towers should be located, to the extent feasible, as far as practical from active channels and out of the channel migration zone. The towers should be designed to withstand floodwater forces. If towers are located near active channels or if the active channel could migrate to a tower location, foundations should be reinforced to withstand scour. Access road lengths should be kept to a minimum to reduce hydrologic and erosion impacts.

Water Quality

Most impacts to water quality would be from construction of roads and ROW clearing, followed by operation and maintenance of roads. Most of the impacts and mitigation measures would be related to soil erosion, as discussed in Section 4.1.3.2. In addition to those mitigation measures, the following measures could be used to reduce impacts on water quality:

- Preserve existing vegetation where practical, especially adjacent to intermittent and perennial creeks and streams. Plant riparian vegetation that provides shade for streams but that also meets clearance requirements for the proposed transmission line.

- Avoid construction in wetland areas.

- Gate roads to restrict access.

- Avoid refueling and/or mixing hazardous materials where accidental spills could enter surface or groundwater.

- Use BMPs to prevent fuel spills and herbicide runoff from reaching streams.

- Have a Spill Prevention Plan in place prior to construction activities.

- Avoid or mitigate water quality and fish habitat degradation. Design and maintain roads so that drainage from the road surface does not directly enter streams, ponds, lakes, or impoundments. Direct water off the roads into vegetation buffer strips or control through other sediment-reduction practices. Restrict road construction to areas physically suitable based on watershed resource characteristics. Design stream crossings to avoid adverse impacts to stream hydraulics and deterioration of stream bank and bed characteristics.

Groundwater

The BPA would design, construct, and maintain the project to comply with local ordinances and laws, and state and federal water quality programs to prevent degradation of the quality of aquifers so as not to jeopardize their usability as a drinking water source. An on-site refueling plan and spill notification plan would be designed and implemented to protect groundwater quality. During construction and maintenance, refueling and/or mixing of hazardous materials would be done in a manner and location that would reduce the potential for accidental spills to impact groundwater.

Prior to using herbicides for ROW maintenance, BPA would contact affected landowners to find out if they have concerns with the use of herbicides on or near their properties. BPA's policy on herbicide use in the vicinity of domestic and public drinking water wells is to maintain a 165-foot buffer for any herbicide having a ground or surface water advisory and a 50-foot buffer for any other herbicide. Any herbicide used in construction, operation or maintenance of the proposed project would be EPA-approved and would be applied by licensed applicators in accordance with the label instructions.

Wind

Structures and conductors would be designed to resist toppling and excessive sway, respectively. Because no ROW clearing of timber would be required, the potential for windthrow damage that could affect the transmission line, and potentially affect service or cause a fire, would be low. The transmission line would be inspected following severe windstorms to evaluate possible windthrow damage, so that appropriate remedial measures could be implemented as needed for safety and to prevent excessive soil erosion.

4.3.3.3 Cumulative Impacts

Although no waters are 303(d) listed within the Alternative A alignment, potential increases in sedimentation, temperature, or other 303(d) parameters from this and other construction projects in the cities and county could affect future listings. The potential cumulative impacts on water quality and fish and other habitat would occur mostly from soil-disturbing activities such as construction of buildings and roadways or development of new tracts of housing. In addition, many of the streams could contain populations of fish with special status that could be impacted by the cumulative effects of many soil-disturbing projects happening at once within a watershed. Several impacts discussed in the previous section could affect fish habitat. These include changes in water temperature from clearing vegetation adjacent to stream channels, increased sedimentation, increased peak runoff resulting from reduced evapotranspiration and interception in cleared areas, and from reduced permeability of road surfaces.

Increased development in the watersheds through which Alternative A passes could lead to increased flood flows as a result of reduced evapotranspiration and interception in cleared areas, and reduced permeability of road surfaces. Cumulative impacts to groundwater could occur from existing and future development. Residential and commercial development will require additional water supplies. Development and increased human population would increase risks of groundwater contamination from spills or misapplication of chemicals.

4.3.3.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Impacts from the additional roads, if any, would diminish with time, but not completely. Therefore, during the project life, the long-term impacts described in the previous sections would continue. If the transmission line is abandoned, a mature forest canopy could develop, and unused road surfaces would slowly revegetate. Related geology and soils effects and commitments of resources are discussed in Section 4.1.

4.3.4 Alternative B

4.3.4.1 Impacts

Floodplains and Flooding

Construction of Alternative B would consist of tearing down the existing transmission structures, extending existing short spur roads to new tower locations, excavating new foundations in different locations from the existing towers, and erecting new towers along the existing route. Construction activity would include removing danger trees outside the ROW and reconstructing and upgrading existing roads. Alternative B crosses the Yakima River and South Fork Snoqualmie River floodplains. These floodplains are wide and may require tower structures within the floodplain to cross them. Therefore, the impacts would be similar to those described for Alternative A in Section 4.3.3.1. Because some additional ROW clearing and reconstruction of roads would be required, some impacts to peak flows from the project are likely.

Water Quality

Two major drainage basins could be affected by Alternative B. Approximately 11 miles of the route would be within the Yakima River watershed, and the remaining 27 miles of the route would be in the South Fork Snoqualmie River drainage basin. Surface water runoff containing fuel spills, herbicide runoff and other contaminants could reach these main streams. Construction-related landslides, soil erosion, and clearing activities along the ROW could affect water quality, as discussed in Section 4.3.2. Alternative B would follow an existing transmission line ROW; therefore, new access road construction would be limited to improving the existing trunk access and spur roads, reconstructing some spur roads to improve drainage, and construction of some new, short spur roads to any new tower locations. Because of the amount of earth-disturbing activities, the numerous streams crossed, and the moderate to steep topography, the potential for erosion and landslides is considered to be moderate. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources. Most potential landslide and soil erosion impacts would be short-term.

Alternative B would cross numerous streams in the existing ROW. Towers for the transmission line could be placed far from the channel so that streamside vegetation would not be impacted. However, streamside vegetation would be removed in some locations within the ROW for transmission line reliability and where access roads require reconstruction or improvement. This route would cross the Yakima and South Fork Snoqualmie Rivers in an existing predominantly cleared ROW. Some existing bank vegetation at these crossings may be disturbed if clearing of the additional 20 feet within the ROW is needed for transmission line reliability.

Groundwater

Alternative B would cross the Yakima River Valley floor where substantial groundwater probably occurs. However, few residences that may be dependent on water supply wells are located in this area. The route would continue west across the lower portion of steep to moderate slopes, where there is also minor development. Between the most western crossing of the South Fork Snoqualmie River and Rattlesnake Mountain, southeast of the City of North Bend, residential development increases. Many of these residences may be dependent upon wells for water supply. No groundwater supply users exist along Rattlesnake Mountain to the Echo Lake Substation. All of the route is considered to be a low groundwater impact area except the area of denser residential development southeast of North Bend, which is considered a moderate impact area (Table 4).

Wind

Structures and conductors would be designed to resist toppling and excessive sway, respectively. Because the ROW clearing of trees that is required is predominantly trees less than 40 years old, the potential for windthrow damage that could affect the transmission line, and potentially affect service or cause a fire, would be low. The transmission line would be inspected following severe windstorms to evaluate possible windthrow damage, so that appropriate remedial measures could be implemented as needed for safety and excessive soil erosion prevention.

4.3.4.2 Mitigation

Refer to the measures under Alternative A, Section 4.3.3.2.

4.3.4.3 Cumulative Impacts

Refer to the discussion of Alternative A, Section 4.3.3.3.

4.3.4.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative A, Section 4.3.3.4.

4.3.5 Alternative C

4.3.5.1 Impacts

Floodplains and Flooding

This route would be located in a new ROW north of Ravensdale. The Cedar River floodplain is narrow in the vicinity of the proposed crossing so that the floodplain would be spanned and therefore would not be impacted. Smaller streams along the route would also be spanned so that their floodplains would not be impacted. The required ROW clearing and access road construction could increase the peak and total annual runoff volumes. These impacts would be most intense during and following construction. As vegetation becomes more established in the ROW clearing, the runoff impacts would decrease.

Water Quality

Three major drainage basins could be affected by Alternative C. From south to north, approximately 3.6 miles of the Option C1 route or 4.0 miles of the Option C2 route, would be within the Cedar River watershed. About 4 miles of the Alternative C route would be in the Big Soos Creek watershed. The remaining 2.6 miles of the route would be in the Issaquah Creek drainage basin. Surface water runoff containing fuel spills, herbicide runoff, and other contaminants could reach these main streams. Construction-related landslides, soil erosion, and clearing activities along the ROW could affect water quality, as discussed in Section 4.3.2. Because much of Alternative C would be in a new ROW, erosion and sedimentation from additional cleared ground and new roads could impact surface water sources. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect these resources. Most potential landslide and soil erosion impacts would be short-term.

Alternative C would cross several streams, including the Cedar River. These streams would be spanned so that as little streamside vegetation as practical would be impacted; therefore, substantial impacts to water quality, such as temperature increase, should not occur.

Groundwater

Alternative C would cross the east end of the City of Kent's wellhead protection area. This section of the route is rated as a high groundwater impact area (Table 4). To the north, the route crosses traverses -rural residential development. Some of these residences may be dependent upon groundwater supplies for domestic use. This area is designated a moderate groundwater impact (Table 4).

Wind

This alternative would require clearing of timber within newly acquired ROW. Soils along the route are generally evenly divided between low and moderate windthrow hazard, with only 3 percent of the route soils rated as high windthrow hazard for both Options C1 and C2. These high hazard windthrow soils are characterized by generally constant, saturated conditions and occur in wetlands, ponds, and other closed depressions where water could collect.

4.3.5.2 Mitigation

Refer to measures under Alternative A, Section 4.3.3.2. Because ROW clearing would be required, the initial clearing would be wider than that required for safe operation of the line. This would allow the trees to grow back along the new ROW edge under the changed conditions and develop wind firmness.

4.3.5.3 Cumulative Impacts

Refer to discussions of Alternative A, Section 4.3.3.3.

4.3.5.4 Unavoidable Effects and Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative A, Section 4.3.3.4).

4.3.6 Alternative D

4.3.6.1 Impacts

Floodplains and Flooding

Alternative D would require new ROW clearing and access roads. The new ROW would be adjacent to the existing ROW so that new road construction would be limited to short spur-road extensions to the new tower sites from existing roads. Alternative D would cross the Yakima River and South Fork Snoqualmie River floodplains. These floodplains are wide and may require tower structures and roads within the floodplain to cross them. Therefore, the impacts would be similar to those described for Alternative A, Section 4.3.3.1. Because additional ROW clearing and roads are required, peak and total flow volumes would likely increase. However, because the total area of increased cleared and roaded ground would be small relative to the subbasin and total watershed areas, such impacts would not be significant. Floodplains of smaller streams would be spanned by the new route so that they would not be impacted.

Water Quality

Two major drainage basins could be affected by Alternative D. Approximately 11 miles of the route would be within the Yakima River watershed, and the remaining 27 miles of the route would be in the South Fork Snoqualmie River drainage basin. Surface water runoff containing fuel spills, herbicide runoff, and other contaminants could reach these main streams. Construction-related landslides, soil erosion, and clearing activities along the ROW could affect water quality, as discussed in Section 4.3.2. Because of the increased earth-disturbing activities relative to Alternative B, the potential for erosion and landslides would be greater. This potential would be greatest during and following construction, but would diminish with time as the areas revegetate and stabilize. Section 4.1.3.1 describes landslide and soil erosion impacts that could affect water resources.

Alternative D would cross numerous streams. These streams would be spanned as much as practical to limit impacts to streamside vegetation. However, it is likely that some streamside vegetation would be removed in many locations. This route would cross the South Fork Snoqualmie River twice in a new ROW. Depending on tower location and clearing requirements, vegetation could be removed from the riverbanks. This vegetation removal could result in impacts to water quality, such as increased temperature resulting from reduced shade.

Groundwater

Impacts to groundwater resources from Alternative D would be similar to those for Alternative B (Section 4.3.4.1). However, because this alternative would require new ROW clearing, the impacts would be greater.

Wind

This alternative would require clearing new ROW along one side of the existing cleared ROW, so that one edge of the new, wider ROW would be forested with trees that had not developed wind firmness. However, less than one percent of the route length would cross soils rated with a high windthrow potential, with the remainder of the route generally divided evenly between low and moderate windthrow potential. The high hazard windthrow soils are characterized by generally constant, saturated conditions and occur in wetlands, ponds, and other closed depressions where water could collect.

4.3.6.2 Mitigation

Refer to measures under Alternative A, Section 4.3.3.2. Because ROW clearing would be required, the initial clearing would be wider than that required for safe operation of the line. This would allow the trees to grow back along the new ROW edge under the changed conditions and to develop wind firmness.

4.3.6.3 Cumulative Impacts

Refer to discussion of Alternative A, Section 4.3.3.3.

4.3.6.4 Unavoidable Effects, and Irreversible or Irretrievable Commitments of Resources

Refer to effects and commitments under Alternative A, Section 4.3.3.4.

5.0 ENVIRONMENTAL CONSULTATION, REVIEW AND PERMIT REQUIREMENTS

The specific permits/reviews that would likely be involved in this project follow:

< **Army Corps of Engineers (Corps) – Section 404.** The Corps Section 404 review process is required for projects involving discharges of dredged or fill materials into the waters of the U.S., including wetlands and streams. Any proposed work located within a jurisdictional wetland and/or below the ordinary high water mark of a stream would require a permit from the Corps, either a nationwide permit (NWP) or an individual permit.. Nationwide permits that could apply to this project include: (1) NWP 7 for outfall structures and maintenance, (2) NWP 12 for utility line activities, and (3) NWP 39 for wetland fills that would not be covered in NWP 12, such as maintenance buildings or structures.

< **National Marine Fisheries Service (NMFS) and United States Fish and Wildlife Service (USFWS) – Endangered Species Act compliance**. The project has a federal nexus (actions authorized, funded, or carried out by federal agencies). Therefore, a biological evaluation/assessment of the project area would be required to determine whether this project would affect Endangered Species Act (ESA) species or their habitat. Based on the findings of the biological evaluation/assessment, either informal or formal consultation would be required with NMFS and/or USFWS.

< **Ecology – Section 401 Water Quality Certification and Coastal Zone Management Consistency.** Section 401 Water Quality Certification and a Coastal Zone Management Consistency determination, issued by Ecology, could be required as a condition of the Section 404 Nationwide permits for the proposed project. Some general requirements for Section 401, if required, include pollution spill prevention and response measures, disposal of excavated or dredged material in upland areas, use of fill material that does not compromise water quality, equipment fueling and wash water discharge restrictions, clear identification of construction boundaries, and site access to permitting agency for inspection.

If Coastal Zone Management Consistency is required, a brief project description, assessment of project impacts, and a statement of whether the project complies with the

Coastal Zone Management Program would be required for Ecology's review. If the project is consistent with the Coastal Zone Management Program, Ecology would concur in writing.

< **Ecology – Section 303(d).** The proposed transmission line alternatives cross the water bodies listed in Table 4. At this time, no segments in these water bodies are listed on the approved 1998 Washington State 303(d) water quality limited water bodies list for the alternative alignments. Therefore, a 303(d) review most likely would not be required.

< **Ecology – Section 402 NPDES Permit to Discharge Stormwater During Construction Activity.** The clearing, grading, and/or excavating activities involved with this project are expected to disturb more than 1 acre and would discharge stormwater from the project area into surface water. Land-disturbing activities of one or more acres would require an NPDES General Permit to Discharge Stormwater associated with construction activity from Ecology. The purpose of this permit is to reduce stormwater pollution from construction activities.

The application for this permitting process is referred to as a Notice of Intent (NOI) and must be submitted to Ecology at least 38 days prior to the start of construction activities. At the time of application, the permittee must also publish a notice in the newspaper that has general circulation within the county in which the project is to take place.

Prior to granting the permit, the applicant must prepare a Stormwater Pollution Prevention Plan (SWPPP) for the project. The SWPPP must include Temporary Erosion and Sedimentation Control (TESC) and Spill Control Containment and Countermeasures (SPCC) plans. The SWPPP is not submitted to Ecology, but is required to be kept on site during construction activities and made available to Ecology and local government agencies upon request.

< **Washington State Department of Fish and Wildlife (WDFW) – Hydraulic Permit Approval (HPA).** An HPA issued by the WDFW is required for any project that uses, diverts, obstructs, or changes the natural flow or bed of any fresh water in the state. General plans for the overall project and complete plans and specifications of the proposed construction are required for the permit submittal. The plans and specifications must include provisions for the proper protection of fish life.

The BPA is not subject to local government's land use permit requirements. However, the BPA does intend to meet local governments substantive regulations. Local government permits that would be required for a similar non-federal government project include the following:

< **Washington State Department of Natural Resources (DNR) – Forest Practice Application (FPA).** An FPA is required when harvesting timber, constructing forest roads or applying forest chemicals. The FPA must address road design and layout, and drainage features. The FPA must also address property ownership, harvest plans, and

sensitive areas needing protection.

- **King County Department of Development and Environmental Services (DDES) – Grading Permit and Environmentally Sensitive Areas Review.** A clearing and grading permit is generally required for any earth disturbing project in which:
  - Cumulative filling and excavating of 100 cubic yards or more.
  - Filling to a depth of 3 feet or more.
  - Excavating to a depth of 5 feet or more.
  - Clearing, filling or grading in a shoreline area, on steep slopes, in wetlands, or into or next to any body of water or sensitive area.

- One of many exceptions to this requirement is if the clearing and grading occurs in Class II, III, or IV Special Forest Practice in an F (Forestry) zone and conducted in accordance with RCW 76.09 and WAC 22. The proposed project appears to lie partially within a Forestry Production Zone.

  If requested, King County would review the proposed project for compliance with the Environmentally Sensitive Areas Ordinance in conjunction with their grading permit review. Environmentally sensitive areas in the project area could include wetlands, streams, flood hazards, erosion hazards, landslide hazards, seismic hazards, coalmine hazards, steep slope hazards, and/or volcanic hazards.

- **Wellhead Protection Program.** Alternatives A and C would extend across the City of Kent's wellhead protection program area. In addition, residential wells exist in the project area. Regulatory agencies could require an on-site refueling plan and spill notification plan for this project to protect groundwater quality. Manual brush removal instead of pesticide application could also be required in some areas.

6.0 INDIVIDUALS AND AGENCIES CONSULTED

During the course of this study, the following agencies were consulted, by direct telephone conversations, web sites, or policy publications:

- Seattle Public Utilities
- King County Department of Development and Environmental Services
- City of Kent Wellhead Protection Program, Kelly Peterson, Environmental Engineer
- USDA Natural Resources and Conservation Service, Kittitas County, WA

7.0 PROJECT STUDY METHODS

The objective of this study was to evaluate the geologic, soil, hydrologic and climatic conditions that could be affected by or could affect the siting, design, construction, and maintenance of the proposed project. This objective was met by accomplishing the following items of work:

Data Gathering. Existing available information was collected from government agencies, private companies, and public libraries:

U.S. Geologic Survey (USGS) 1:24,000 scale Washington topographic maps

1989 Bandera, Washington

1989 Chester Morse Lake

1989 Lost Lake

1989 Snoqualmie Pass

1989 Stampede Pass

1993 Cumberland

1993 North Bend

1993 Hobart

1994 Black Diamond

1995 Maple Valley

USGS geologic maps and reports
USGS seismologic studies
Aerial photographs (Bonneville Power Administration [BPA] and private)
U.S. Department of Agriculture soil maps
Washington State Department of Natural Resources Division of Geology and Earth Resources maps and charts
BPA and Seattle Public Utilities (SPU) geographic information system (GIS) files and maps for the project area
Digital orthophoto maps for the project area

Data Compilation. The geologic, soil, hydrologic and wind data were compiled and plotted on GIS base maps provided by BPA.

Aerial Photograph Analyses. We interpreted and mapped geologic features along the route alternatives using stereo pairs of aerial photographs. This mapping focused on identifying features such as landslides, chronic erosion areas, floodplains, and organic soils, using the following aerial photographs:

Date Flown	Color	Approximate Scale	Flight	Source

Date Flown	Color	Approximate Scale	Flight	Source
May 2001	Color	1:12,000	BPA-SHEL	BPA
July 2000	Color	1:24,000	BPA-GCR	BPA
October 1999	Color	1:24,000	BPA-RMV	BPA
July 1999	Color	1:12,900	BPA-RMV	BPA
July 1999	Color	1:12,400	BPA-CMV	BPA
July 1999	Color	1:12,800	BPA-TGC	BPA
July 1990	Black and White	1:13,700	BPA-CJSQ	BPA

Helicopter Overflight. Following the aerial photographic interpretation and mapping, we flew over each alternative route at low altitude to observe the landforms and ground conditions.

Technical Report. The findings of this study are documented in this technical report.

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GLOSSARY

100-year Floodplain – Areas that have a 1 percent chance of being flooded in a given year. (See **Floodplain**.)

Alluvial – Formed by flowing water.

Access road – Roads constructed to each structure site, first to build the tower and line, and later to maintain and repair it. Access roads are built where no roads exist. Where county roads or other access is already established, access roads are built as short spurs to the structure. Access roads are maintained even after construction.

Advance outwash – Glacial outwash that is deposited by, and in front of, an advancing glacier and is subsequently overridden by the glacier. Advance outwash deposits are overconsolidated and typically are very dense.

Alluvium – Clay, silt, sand, gravel, or similar material deposited by running water.

Alternatives – Refers to different choices of means to meet the need for action.

Andesite – A moderate-colored volcanic rock containing iron and magnesium minerals and quartz. Andesite is usually derived from Cascade volcanoes.

Anticline – A convex-up fold, the core of which contains stratigraphically older rocks.

Aquifer – Water-bearing rock or sediment below the ground surface.

Argillite – A compact metamorphic rock derived from mudstone or shale.

Basalt – A dark-colored volcanic rock containing iron and magnesium minerals, usually covering an extensive area.

Batholith – An intrusive rock body with a surface area of at least 40 square miles.

Bedding (geologic) – The arrangement of a sedimentary deposit or rock in beds or layers of varying thickness and character.

Bedrock – The solid rock that underlies the soil and other unconsolidated material that is exposed at the surface.

Best Management Practices (BMP) – A practice or combination of practices that are the most effective and practical means of preventing or reducing the amount of pollution generated by non-point sources to a level compatible with water quality goals.

BPA – Bonneville Power Administration

Breccia – A coarse-grained clastic rock composed of large (greater than sand-sized), angular, and broken rock fragments that are cemented together in a finer-grained matrix. Breccia is similar to conglomerate except that most of the fragments have sharp edges and unworn corners.

Chert – A hard, extremely dense rock composed of microcrystalline quartz.

Clast - An individual constituent, grain, or fragment of a sediment or rock produced by the disintegration of a larger rock mass.

Clastic – Pertaining to or being a rock or sediment composed principally of clasts that have been transported individually for some distance from their places of origin.

Claystone – An indurated clay having the texture and composition, but lacking the fine lamination, of shale.

Coal – A readily combustible rock containing more than 50 percent by weight and more than 70 percent by volume carbonaceous material that was formed from compaction and induration of plant remains similar to those in peat.

Cohesive – Said of a soil that has relatively high shear strength when wet, e.g., a clayey soil.

Cohesionless – Said of a soil that has relatively low shear strength when air dried, e.g., a sandy soil.

Colluvial soil, Colluvium – Rock and soil accumulated on or at the foot of a slope.

Columnar Jointing – rock jointing that forms columns, usually in a hexagonal pattern.

Conductor – The wire cable strung between transmission towers through which electric current flows.

Conformable (geologic) – Said of sedimentary strata characterized by an unbroken sequence in which the layers are formed one above the other in parallel order.

Conglomerate – A coarse-grained, clastic sedimentary rock composed of rounded fragments larger than 2 millimeters in diameter (granules, pebbles, cobbles, and boulders) set in a fine-grained matrix of sand, silt or cementing materials. The rock equivalent of gravelly soil deposits.

Creep – The slow, continuous downslope movements of soil and rock under the influence of gravity.

Crossbedding – The arrangement of laminations of strata transverse or oblique to the main bedding layers.

Culvert – A corrugated metal or concrete pipe used to carry or divert runoff water from a drainage, usually installed under roads to prevent washouts and erosion.

Cumulative impact – Created by the incremental effect of an action when added to other past, present, and reasonably foreseeable future actions.

Current – The amount of electrical charge flowing through a conductor (compared with voltage, which is the force that drives the electrical charge).

Cut and Fill – The process whereby a road is cut or filled on a side slope. The term refers to the amount of soil that is removed (cut) or added (fill).

Dacite – A fine-grained volcanic rock with the same general composition as granite.

Danger Trees – Trees or high-growing brush outside of the ROW that could be hazardous to the transmission line. These trees are identified by special crews and must be removed to prevent tree-fall into the line or other interference with the wires. The owners of danger trees are compensated if they would be found to be merchantable timber. BPA's Construction Clearing Policy requires that trees be removed that meet either one of two technical categories. Category A is any tree that within 15 years would grow to within about 18 feet of conductors with the conductor at maximum sag (212 degrees F) and swung by 6 lb. per sq. ft. of wind (58 mph). Category B is any tree or high-growing brush that after 8 years of growth would fall within about 8 feet of the conductor at maximum sag (176^{o} F) and in a static position.

DDES – King County Department of Development and Environmental Services

Debris Flows – Rapid movement of water-charged mixtures of soil, rock, and organic debris.

DEIS – Draft Environmental Impact Statement

Dextral shear – Shear movement, as occurs along a fault, where the movement of the side opposite an observer appears to have moved to the right.

Diabase – A dark colored, intrusive igneous rock comprised essentially of the minerals labradorite and pyroxene.

Dike (geologic) – A long, narrow, crosscutting mass of igneous or eruptive rock intruded into a fissure in older rock.

DNR – Washington State Department of Natural Resources

Easement – The granting of certain rights to use a piece of land (which then becomes a "ROW"). BPA acquires easement for many of its transmission facilities. This includes the right to enter the ROW to build, maintain, and repair facilities. Permission for these activities is included in the negation process for acquiring easements of private land.

Ecology – Washington State Department of Ecology

Environmental Impact Statement (EIS) – A detailed statement of environmental impacts caused by an action, written as required by the National Environmental Policy Act.

Eocene – An epoch of the lower Tertiary period, lasting 21 million years, after the Paleocene (57.8 mybp) and before the Oligocene (36.6 mybp).

Erosion – The process by which the surface of the earth is worn away by water, wind, glaciers, waves, and other forces of nature.

ESA – Endangered Species Act

ESCP – Erosion and Sediment Control Plan

EPA – U.S. Environmental Protection Agency

Evapotranspiration – The combined processes of evaporation and transpiration. Transpiration is the process by which plants take water from the subsurface, convey it through their woody parts, and give off water vapor through their leaves.

Fault (geologic) – A surface or zone of rock fracture along which there has been movement. The amount of movement can range from a few inches to miles.

Fault trace – The line formed where a fault intersects the ground surface.

FEMA – Federal Emergency Management Agency

Feldspathic – Said of sedimentary rocks containing a certain percentage of feldspar minerals.

Floodplain – The surface or strip of relatively smooth land adjacent to a river channel, constructed (or in the process of being constructed) by the present river in its existing regimen and covered with water when the river overflows its banks.

Fluvial – Of or pertaining to a river or rivers.

Foliation – The planar arrangement of textural or structural features in any type of rock.

Footings – The supporting base for the transmission towers, usually steel assemblies buried in the ground for lattice-steel towers.

Forearc – The zone in front (toward the ocean) of an island arc complex.

Formation – The basic stratigraphic unit used in the local classification of rocks that have some character (age, origin, composition) in common.

FPA – Forest Practice Application

g – Acceleration due to gravity, equal to 9.8 meters/second/second (32.2 feet/second/second).

Gabbro – A dark colored, intrusive igneous rock composed chiefly of the minerals labradorite and augite.

GIS – Geographic Information Systems, a computer system that analyzes graphical map data.

Geotechnical – Pertaining to the properties of soil and rock, such as compaction, stabilization, and compressibility.

Glacial drift – A general term for sediment transported and deposited directly by glaciers.

Glacial erratic – A rock fragment carried by glacier ice and deposited when the ice melted some distance from the outcrop from which the fragment was derived. Generally of boulder size, although fragments range from pebbles to house-sized blocks.

Glacial outwash – Stratified sediment, consisting chiefly of sand and gravel, removed or “washed out” from a glacier by meltwater streams and deposited in front of or beyond the terminal moraine or the margin of an active glacier.

Glaciofluvial – Pertaining to the meltwater streams flowing from wasting glacier ice, and especially to the deposits and landforms produced by such streams.

Glaciolacustrine – Pertaining to, derived from, or deposited in glacial lakes. Also said of the deposits and landforms composed of suspended material brought by meltwater streams flowing into lakes bordering a glacier.

Glaciomarine – Said of marine sediments that contain glacial material. Similar to glaciolacustrine, except related to marine water that borders a glacier, and containing clastic debris.

Granodiorite – An igneous intrusive rock of intermediate chemistry similar in composition to granite.

Groundwater – The water beneath the surface of the ground. Typically, groundwater occurs in the small pores between grains of soil or in rock.

Group – A major rock stratigraphic unit next higher in rank than formation, consisting of two or more associated formations.

Headwater – The source (or sources) and upper part of a stream, including the upper drainage basin.

Holocene – The upper epoch of the Quaternary period, from the end of the Pleistocene to present time. Formerly referred to as "Recent."

HPA – Hydraulic Permit Approval

Hydrogeology – The science that deals with subsurface waters and related geologic aspects of surface waters.

Hydrology – The science dealing with the properties, distribution, and circulation of water.

Ice-contact deposits – Stratified glacial drift deposited in contact with melting glacier ice, normally marked by numerous kettles and hummocky ground.

Intermittent – Referring to periodic water flow in creeks or streams.

Intraslab earthquakes – Earthquakes that originate within a subducting slab, or plate, as opposed to originating on the slab or plate boundaries (interslab).

Intrusive igneous rock – Rock formed when molten rock (magma) is injected into existing rock. The intrusive body can range from a narrow dike or sill to a body that is miles across.

Island arc complex – A generally curved linear belt of volcanoes above a subduction zone, and the volcanic (extrusive) and plutonic (intrusive) rocks formed there.

Joint (geologic) – A fracture or parting surface in a rock without displacement.

Jurassic – The second period of the Mesozoic era covering the span of time between 190 and 135 million years ago.

Kettle (geologic) – A steep-sided, usually basin- or bowl-shaped hole or depression without surface drainage in glacial drift deposits. Commonly contains a lake, pond or swamp. Formed by the melting of a large block of stagnant ice (left behind after a retreating glacier) that had been wholly or partly buried in the glacial drift.

kV – kilovolt (thousand volts)

Landform – Any physical, recognizable form or feature of the Earth's surface, having a characteristic shape, and produced by natural causes. It includes major forms such as a plain, plateau, mountain, slope or dune, among others.

Landslide – Any mass movement process characterized by downslope movement of soil and rock by means of gravity, or the resulting landform. Can also include other forms of mass wasting not involving sliding, e.g., rockfall. The terminology designating particular landslide types generally refers to the landform as well as the process responsible for the landform, e.g., deep-seated landslide, or earth flow.

Lapilli – Grains of pyroclastic material with a size range between 2 and 64 mm.

Lattice steel – Refers to a transmission tower constructed of multiple steel members connected to make up the frame.

Liquefaction – The phenomenon in which saturated, cohesionless soils are temporarily transformed into a near liquid or "quicksand" state. During an earthquake, ground shaking may result in a buildup of pore-water pressure in the saturated soil to a point where the pore-water pressure approaches the grain-to-grain contact pressure. As this occurs, the soil particles begin to lose contact with each other and the soil liquefies.

Lodgment till – A very dense glacial till containing a distribution of all soil particles, from clay to boulders, formed beneath a moving glacier and deposited upon bedrock or other glacial deposits. Commonly characterized by fissile structure (capable of being split easily along closely spaced planes) and stones oriented with their long axes generally parallel to the direction of ice movement.

Low-gradient – With gentle slopes.

Mafic Diorite – An intrusive igneous rock of intermediate chemistry with a composition between granite and gabbro.

Magnitude (earthquake) – A measure of the strength of an earthquake or the strain energy released by it, as determined by seismographic observations.

Mass movement – The dislodgment and downhill transport of soil and rock materials under the direct influence of gravity. Includes movements such as creep, debris torrents, rock slides, and avalanches.

Mass wasting – A general term for the dislodgement and downslope transport of soil and rock material under gravitational forces. It includes slow displacements such as soil creep and rapid movements such as earthflows, rock falls and avalanches.

M_b – An earthquake magnitude determined by using the logarithm of the ratio of amplitude to period for body waves.

Metagabbro – A metamorphosed gabbro.

Metamorphism – The mineralogical, chemical and structural adjustment of solid rocks to changed physical and chemical conditions at depth below the Earth's surface.

Micaceous – Rock containing a significant percentage of mica, a mineral that typically forms as sheets.

Miocene – An epoch of the upper Tertiary period, lasting 18.4 million years, after the Oligocene (23.7 mybp) and before the Pliocene (5.3 mybp).

Mitigation – Steps taken to lessen the effects predicted for each resource, as potentially caused by the transmission project. They may include reducing the impact, avoiding it completely, or compensating for the impact. Some mitigation, such as adjusting the location of a tower to avoid a special resource, is taken during the design and location process. Other mitigation, such as reseeding access roads to desirable grasses and avoiding weed proliferation, is taken after construction.

Monzonite – An intrusive igneous rock of intermediate chemistry similar in composition to granite.

mph – miles per hour

M_s - An earthquake magnitude determined by using the logarithm of the amplitude of the 20-second period earthquake surface waves.

M_w - An earthquake magnitude determined, in part, by multiplying the area of the fault's rupture surface by the distance the earth moves along the fault. This measurement provides a direct value of earthquake energy and is the preferred method.

mybp – million years before present

NMFS – National Marine Fisheries Service

NOI – Notice of Intent

Normally consolidated – Soil and sedimentary deposits that are consolidated in equilibrium with the overburden pressure.

NPDES – National Pollutant Discharge Elimination System

NRCS – National Resource Conservation Service (formerly Soil Conservation Service)

NWP – Nationwide Permit

Oligocene – An epoch of the lower Tertiary period, lasting 12.9 million years, after the Eocene (36.6 mybp) and before the Miocene (23.7 mybp).

Outcrop – An area where rock is exposed at the Earth's surface.

Overconsolidated – Said of soil and sedimentary deposits that are consolidated greater than normal for the existing overburden pressure. Commonly caused by large overburden pressures that have subsequently been removed. Soil and sedimentary deposits that were overridden by glacier ice are typically overconsolidated.

Peak ground acceleration – The maximum instantaneous ground acceleration caused by an earthquake.

Perennial – Streams or creeks with year-round water flow.

Permeability – The ease with which a fluid will move through a porous medium, such as rock or soil.

PGA – peak ground acceleration

Pleistocene – An epoch of the Quaternary, lasting 2 million years, after the Pliocene (2 mybp) and before the Holocene (0.01 mybp).

Plug (geologic) – A vertical, pipe-shaped body of magma that represents the conduit of a former volcano.

Plunging (geologic) – The inclination of a fold axis inclined to the horizontal.

Porphyritic – Said of the texture of an igneous rock in which larger crystals are present in a generally fine-grained rock.

Pumice – A light-colored, vesicular, glassy, volcanic rock with the composition of rhyolite.

Pyroxenite – An iron and magnesium rich igneous intrusive rock chiefly composed of the mineral pyroxene.

Quaternary – The second period of the Cenozoic era (following the Tertiary) thought to cover the last 2 or 3 million years. It includes the Pleistocene and Holocene epochs.

Rainsplash erosion – Erosion that occurs when raindrops impact bare soil and incorporate soil particles in the water that splashes. On a slope, more of the rainsplash moves downslope, resulting in a net downslope soil movement.

Ravel – The downslope movement of single, granular particles, usually as a result of gravity.

Recessional outwash - Glacial outwash deposited by a receding glacier. Recessional outwash deposits are normally consolidated and typically are loose to medium dense.

Residual soil, residuum – An accumulation of rock debris and soil formed by weathering and remaining essentially in place as a thin surface layer over the underlying parent material.

Rhyolite – An extrusive igneous rock with large crystals in a fine grained mass, typically showing flow texture.

ROW (ROW) – An easement for a certain purpose over the land of another, such as a strip of land used for a road, electric transmission line, or pipeline.

Sandstone – Sedimentary rock consisting usually of quartz sand, but also feldspar or basalt, united by some cementing agent.

SCS – Soil Conservation Service

SDEIS – Supplemental Draft Environmental Impact Statement

Sediment – Solid fragmental material or a mass of such material, either inorganic or organic, that originates from weathering rocks and is transported by, suspended in, or deposited by air, water, or ice, and that forms in layers on the Earth's surface.

Sedimentary – Pertaining to or containing sediment.

Sedimentation – The process of forming or accumulating sediment in layers.

Seiche – A seismically induced wave that forms on a lake or other closed body of water. It is similar to a tsunami but restricted to a closed body of water.

Seismic – Earthquake activity

Seismogenic – Said of a fault or zone that is capable of generating earthquakes.

Serpentinized – Hydrothermally-altered rock by which magnesium-rich silicate minerals are replaced by the mineral serpentine.

Shale – A fissile rock that is formed by the consolidation of clay, mud, or silt, has a finely stratified or laminated structure, and is composed of minerals essentially unaltered since deposition.

Sill (geologic) – A tabular body of igneous intrusion that parallels the planar structure of the surrounding rock. Similar to a dike, except that the orientation of a dike cuts across the planar structure of the surrounding older rock.

Siltstone – A rock composed chiefly of indurated silt.

Single circuit – A line with one electrical circuit on the same tower.

Slump – Deep, rotational landslide, generally producing coherent movement (back rotation) of blocks over a concave failure surface. Typically, slumps are triggered by the buildup of pore-water pressure in mechanically weak materials (deep soil or clay-rock rock).

Soil – All earthy material overlying bedrock.

SPCC – Spill Control Containment and Countermeasures

SPU – Seattle Public Utilities

Stratified – Formed, arranged, or laid down in layers or strata, especially said of any layered sedimentary rock or deposit.

Structure – Refers to a type of support used to hold up transmission or substation equipment.

Subduction zone – An elongate region along which a crustal block of the Earth's surface descends relative to another crustal block.

Subcrustal intraslab earthquake – An earthquake that occurs within a subducting plate beneath the crustal plate.

Substation – The fenced site that contains the terminal switching and transformation equipment needed at the end of a transmission line.

Swale – A low-lying or depressed and sometimes wet stretch of land.

SWPPP – Stormwater Pollution Prevention Plan

Syncline – A concave-up fold, the core of which contains stratigraphically younger rocks.

Talus – Rock debris that has accumulated at the base of a cliff or steep slope.

Tap – The point at which a transmission line is connected to a substation or other electrical device to provide service to a local load.

Tectonics – A branch of geology concerned with the structure of the crust of a planet (as Earth) with the formation of folds and faults in it.

Terrace – An old plain of various origins, ordinarily flat or undulating, that borders a river, lake or the sea.

Tertiary - The first period of the Cenozoic era covering the span of time between 65 and 2 million years ago.

TESC – Temporary Erosion and Sedimentation Control

Till – Unsorted and unstratified glacial drift deposited directly by and underneath a glacier without subsequent reworking by water from the glacier. Glacial till typically consists of a heterogeneous mixture of clay, silt, sand, gravel, cobbles and boulders that vary widely in size and shape.

Tonalite – A light-colored, intrusive igneous rock similar to granite.

Tower – See **Structure**.

Transmission line – The structures, insulators, conductors, and other equipment used to transmit electrical power from one point to another.

Tsunami – A gravitational sea wave formed by any large-scale, short-duration disturbance of the ocean floor, which commonly is an earthquake.

Tuff – A general term for lithified consolidated pyroclastic rocks.

Turbidity – The state or condition or quality of opaqueness or reduced clarity of a fluid, due to the presence of suspended matter.

USC – Unified Soil Classification

USDA – U.S. Department of Agriculture

USFWS – United States Fish and Wildlife Service

USGS – United States Geological Survey

USLE – Universal Soil Loss Equation

Vashon Stade – The middle of three stades of the last glaciation of the Puget Lowland, the most recent stade that reached the central Puget Lowland.

Volcanic – Pertaining to the activities, structures or rock types of a volcano.

Volcanic ash – Fine material formed by a volcanic explosion or aerial expulsion from a volcanic vent.

Volcaniclastic – Pertaining to clastic rocks, containing volcanic material in various proportions and without regard to its origin or environment.

Volcanic tuff – A compact deposit of volcanic ash and dust formed by a volcanic explosion or aerial expulsion from a volcanic vent. It may contain up to 50 percent of non-volcanic sediment.

Volt – The international system unit of electric potential and electromotive force.

Voltage – The driving force that causes a current to flow in an electrical circuit.

Water bars – Smooth, shallow ditches excavated at an angle across a road to decrease water velocity and divert water off and away from the road surface.

WDFW – Washington State Department of Fish and Wildlife

WRIA – Water Resource Inventory Area

Wetlands – An area where the soil experiences anaerobic conditions because of inundation of water during the growing season. Indicators of a wetland include types of plants, soil characteristics, and hydrology of the area.

Windthrow – The uprooting and tipping over of trees by wind.

LIST OF PREPARERS

Principal Investigators

William T. Laprade, C.E.G. — Engineering Geologist, Vice President

Responsible for geology and engineering geology review.

Education: B.A. and M.A. Geography, B.S. Geological Sciences, Post-Graduate Studies.

Experience: Engineering geology including landslides, tunnels, foundations, dams, and pipeline and roadway alignments; with Shannon & Wilson since 1973.

Christopher A. Robertson, P.E., C.E.G. — Geotechnical Engineer, Project Manager

Responsible for geotechnical engineering and project management.

Education: B.S. and M.S. Geology, M.S. Civil Engineering

Experience: 20 years of professional experience in geotechnical engineering, hydrogeology, slope stability, and seismic geotechnical engineering; with Shannon & Wilson since 1995.

Jeffrey R. Laird, C.E.G. — Senior Principal Engineering Geologist

Responsible for geologic analysis and report preparation.

Education: B.S. Geology, M.S. Geomorphology

Experience: 15 years of professional experience in geologic field mapping, erosion and sedimentation, and fluvial geomorphology and slope stability; with Shannon & Wilson since 1987.

Technical and Clerical Assistance

A.G. Black	Reproduction Technician
Andrew J. Caneday	Geologist, GIS Technician
Conrad S. Kartanas	Information Resources Specialist
Lori K. Doherty	Word Processing Supervisor
William J. Perkins, R.P.G	Geologist, Seismic Hazards Specialist
Becki S. Kniveton	Ecologist
Katie L. Walter, P.W.S.	Senior Principal, Wetland Biologist

**TABLE 1: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT GEOLOGIC DESCRIPTIONS OF
UNITS LIKELY TO BE ENCOUNTERED ON PROPOSED ALTERNATIVE ALIGNMENTS**

Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
QUATERNARY DEPOSITS					
Qf	Fill	Holocene	Unit primarily includes Cedar River Landfill; other fill material could include highway embankments, and quarry and borrow pits.	Fill commonly placed in lifts and compacted, but does not create internal structure with potential planes of weakness.	Generally low and variable density levels, leachate and methane gas from landfill material, variable materials over short distances.
Qa	Alluvium	Holocene	Cedar and Snoqualmie Rivers: Well-sorted pebble to cobble gravel and sand, bars and terraces. Smaller streams: thin deposits of sand and gravel.	Very loose to medium dense. Stratified with crossbedding. May contain organic material.	Streambank erosion, ponding, high groundwater, flooding, siltation and potentially liquefiable; locally compressible.
Qb	Bog	Holocene	Organic sediment deposited mostly in closed depressions. The thickness is highly variable.	Very soft to medium stiff. Horizontally laminated, rooted and bioturbated.	Poor foundation material that could cause large, differential foundation and/or road settlements. Fills potentially unstable. High groundwater and ponded water.
Qt	Talus Deposits	Holocene	Nonsorted, angular boulder gravel to boulder diamicton.	No sorting or structure.	Variable foundation strength. Excavations or drainage modifications could reactivate movement. Boulders would impede excavations.
Qls	Landslide	Holocene to Pleistocene	Landslide debris composed of colluvium and/or weak bedrock.	No sorting or structure, hummocky topography, and weak slip planes.	Renewed ground movement, variable foundation strength, poor drainage. Excavations, erosion, fills, drainage modifications or removal of vegetation could reactivate movement.
Qag	Alpine Glacial Deposits	Pleistocene	Ranges from boulder till in mountains to gravel and sand outwash in valleys.	Loose to dense. Well-sorted and stratified to poorly sorted and massive deposits.	Variable strength and drainage characteristics, low liquefaction potential. Scattered boulders could impede excavation.

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Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
Qvic	Vashon Stade Ice Contact Deposits	Pleistocene	Pebbly sand and pebble-cobble gravel, with occasional boulders. Forms kames, kame terraces and eskers.	Loose to dense. Well-sorted and stratified to poorly sorted and massive deposits.	Variable strength and drainage characteristics, low liquefaction potential. Scattered boulders could impede excavation.
Qvr	Vashon Stade Glacial Recessional Outwash	Pleistocene	Sand, pebble-cobble gravel, and silty sand.	Stratified, moderately to well-sorted sand and gravel to well-bedded silt and clay. Loose to dense, variable permeability.	Variable strength and drainage characteristics, cut slopes could ravel from lack of cohesion, low liquefaction potential. Scattered boulders could impede excavation.
Qvt	Vashon Stade Till	Pleistocene	Gravel and occasional boulders in a silty sand matrix. Glacial till deposits are typically 10 feet thick, but could be as thick as 50 feet.	Dense to very dense. Typically massive and unsorted to poorly sorted, may contain lenses of sand.	Typically high load-bearing characteristics, but high pore-water pressure could exist in perched ground water or in confined sand lenses. Scattered boulders could impede excavation.
Qpf	Pre-Fraser glaciation sedimentary deposits	Pleistocene	Sand and gravel, lacustrine deposits and diamict composed of silt-rounded gravel in silt matrix.	Moderately dense to very dense. Sand and gravel could show bedding, diamict typically massive and unsorted.	Typically high load-bearing characteristics, but high pore-water pressure could exist in perched ground water or in confined sand lenses. Scattered boulders could impede excavation.
TERTIARY BEDROCK UNITS					
Tsgs	Snoqualmie Batholith Granodiorite and Tonalite	Early Miocene	Hornblende-biotite granodiorite and tonalite, medium-grained, equigranular.	Generally massive with widely spaced jointing.	Adversely oriented joints could form failure planes if daylighted. Rockfall.
Tsgf	Snoqualmie Batholith Fine-Grained Monzonite	Early Miocene	Highly altered, light-colored, fine-grained monzonite.	Generally massive with widely spaced jointing.	Adversely oriented joints could form failure planes if daylighted. Rockfall.

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Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
Tsm	Snoqualmie Batholith Mafic Diorite and Gabbro	Early Miocene	Biotite-hornblende diorite and gabbro.	Fractures and joints.	Adversely oriented joints could form failure planes if daylighted. Rockfall.
Thm	Huckleberry Mountain Volcanics	Oligocene	Andesite and basalt breccia, tuff and flows, minor dacite and rhyoloite tuff and breccia.	Bedding, joints and fractures.	Adversely oriented joints and bedding could form failure planes if daylighted. Failures could develop on weak interbedded layers. Rockfall.
Thmk	Tuff of Lake Keechelus	Oligocene	Dacite crystal-vitric tuff and breccia.	Massive to relict bedding defined by flattened pumice grains, and breccia blocks to 3.5 feet in diameter.	Adversely oriented joints and bedding could form failure planes if daylighted. Failures could develop on weak interbedded layers. Rockfall. Massive, fresh flow rocks could require blasting/hydraulic breaking.
Tv	Volcanic Rocks	Oligocene	Andesite with minor dacite and rhyolite breccia, tuff, ash flow tuff and rare flows, most recrystallized by thermal metamorphism to biotite hornfels.	Massive to blocky jointing. Obscure flow layering.	Adversely oriented joints could form failure planes if daylighted. Rockfall. Massive, metamorphically-altered rocks could require blasting/hydraulic breaking.
Tdg	Diabase, gabbro and basalt	Oligocene	Fine- to medium-grained, black diabase and gabbro dikes and plugs.	Jointing and dike contacts.	Adversely oriented joints could form failure planes if daylighted. Rockfall. Massive, fresh flow rocks could require blasting/hydraulic breaking.
Tpa	Volcanic Rocks of Mt. Persis	Oligocene	Gray to black, porphyritic andesite and andesite breccia.	Massive to blocky jointing. Obscure flow layering.	Adversely oriented joints could form failure planes if daylighted. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.

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Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
Tpg	Puget Group, undifferentiated	Middle to Late Eocene	Sandstone, siltstone, claystone and coal, deposited primarily in a fluvial environment.	Sandstone is generally massive to crossbedded. Occasional channel cut-and-fill structures. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, interbedded weak rocks (coal, claystone), bedding planes and joints could form failure planes. Rockfall. High pore-water pressures in perched groundwater. Massive rock could require blasting/hydraulic breakers.
Tpr	Renton Formation	Late Eocene	Sandstone, siltstone, claystone and coal deposited in fluvial and nearshore marine environments.	Fine-grained siltstone and claystone interbeds commonly form valleys between more resistant sandstone- capped ridges. Fractures, joints, bedding planes and facies contacts.	Adversely oriented, interbedded weak rocks (coal, claystone), bedding planes and joints could form failure planes. Rockfall. High pore-water pressures in perched groundwater. Massive rock could require blasting/hydraulic breakers.
Tpt	Tukwila Formation	Middle to Late Eocene	Volcanic lava flows, sills and dikes, tuff, and breccia, with sandstone and conglomerate interbeds.	Flow rocks are more resistant to erosion and make up most Tukwila Formation outcrops. Fractures, joints, bedding planes and facies contacts.	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
Tn	Naches Formation	Late Eocene	Rhyolite, andesite and basalt flows, tuff and breccia with interbedded sandstone and siltstone.	Flow bedding, columnar jointing, joint sets. Sedimentary beds with crossbedding and graded bedding.	Interbedded and fractured/jointed weak and strong rocks and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
Tnr	Naches Formation Rhyolite	Late Eocene	White to gray flows or ash-flow tuffs with pumice. Minor interbeds of basaltic flows and tuff.	Flow banding and platy jointing. Beds tens to hundreds of feet thick.	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.

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Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
Tns	Feldspathic Sandstone and Volcanic Rocks	Late Eocene	Tan to gray, well-bedded, medium to coarse-grained, micaceous sandstone and interbedded siltstone and shale, with rhyolite, andesite and basalt flows, tuff and breccia.	Bedding, interbeds, joint sets	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
Tnmc	Mt. Catherine Rhyolite	Late Eocene	Black, welded, crystal-lithic ash-flow tuff with pumice lapilli and breccia. Interbedded thin sandstone and shale.	Flow-banded, platy jointing.	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
Tng	Guye Sedimentary Member	Late Eocene	Light to dark-gray feldspathic sandstone, black slaty shale, and hard chert pebble conglomerates. Rare volcanic interbeds.	Bedding and joint sets.	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
pTwa	Western Melange Belt Argillite and Graywacke	Pre-Tertiary	Well-bedded marine sandstone and argillite.	Bedding, graded bedding, load casts. Folds and shears.	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.
pTwg	Western Melange Belt Metagabbro	Pre-Tertiary	Massive to foliated, fine to medium grained metagabbro.	Foliation, shears	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock-form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.

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Map Unit	Description	Age	Soil/Rock Type	Structure and Bedding	Associated Hazards
pTwu	Western Melange Belt Ultramafite	Pre-Tertiary	Serpentinized pyroxenite	Shears	Interbedded and fractured/jointed weak and strong rocks, and zones of highly weathered rock-form failure planes. Rockfall. Massive, fresh-flow rocks could require blasting/hydraulic breaking.

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
1	Alderwood gravelly loam	20-60	0.32	6-15	Weathered glacial till.	Slight	Moderate
2	Alderwood gravelly loam	40-60	0.32	15-30	Weathered glacial till.	Slight	Moderate
5	Altapeak gravelly sandy loam	40-60 Soft	0.15	30-65	Mixture of volcanic ash and colluvium over granitic and metamorphic rocks.	Moderate	Slight
7	Altapeak - Rock outcrop complex	0 Hard	0.15	45-90	Hard and mostly unweathered granitic or metamorphic rocks.	Severe	Slight
10	Barneston gravelly coarse sandy loam	>60	0.15	0-6	Glacial outwash terraces and volcanic ash.	Slight	Slight
11	Barneston gravelly coarse sandy loam	>60	0.15	6-30	Glacial outwash terraces and volcanic ash.	Slight	Slight
12	Barneston gravelly coarse sandy loam	>60	0.15	30-65	Glacial outwash terraces and volcanic ash.	Moderate	Slight
13	Barneston gravelly sandy loam	>60	0.15	0-8	Glacial outwash terraces and volcanic ash.	Slight	Slight
14	Barneston gravelly sandy loam	>60	0.15	8-30	Glacial outwash terraces, terrace escarpments and volcanic ash.	Slight	Slight
15	Barneston gravelly sandy loam	>60	0.15	30-65	Glacial outwash terraces, terrace escarpments and volcanic ash.	Moderate	Slight
16	Barneston gravelly sandy loam, windswept	>60	0.15	6-30	Glacial outwash terraces and volcanic ash.	Slight	Slight
17	Beausite gravelly loam	24-60	0.20	6-30	Colluvium derived from glacial till and sandstone.	Slight	Moderate
18	Beausite gravelly loam	24-60	0.20	30-65	Colluvium derived from glacial till and sandstone.	Moderate	Moderate
24	Blenthen gravelly loam	>60	0.24	30-65	Colluvium and slope alluvium formed from glacial drift. Some admixture of volcanic ash.	Moderate	Slight
35	Chinkmin sandy loam	>60	0.20	15-30	Mixture of volcanic ash and colluvium derived from glacial till.	Slight	Moderate
36	Chinkmin sandy loam	>60	0.20	30-65	Mixture of volcanic ash and colluvium derived from glacial till.	Moderate	Moderate
41	Chuckanut loam	>60	0.32	6-15	Colluvium and slope alluvium formed from glacial drift. Some admixture of volcanic ash.	Slight	Slight

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Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
42	Chuckanut loam	40-60	0.32	15-30	Mixture of volcanic ash and colluvium derived from sandstone and glacial till.	Slight	Slight
43	Chuckanut loam	40-60	0.32	30-65	Mixture of volcanic ash and colluvium derived from sandstone and glacial till.	Moderate	Slight
51	Cryohemists	>60	0.00	0-2	Mixture of peat, muck, pumice, volcanic ash, and glacial till.	Not evaluated	Not evaluated
53	Edgewick silt loam	>60	0.37	0-3	River terrace alluvium.	Slight	Slight
54	Elwell silt loam	>60	0.28	6-30	Weathered glacial till and volcanic ash.	Slight	Moderate
55	Elwell silt loam	20-40	0.28	30-65	Weathered glacial till with an admixture of volcanic ash and loess.	Moderate	Moderate
65	Gallup loam, breccia substratum	>60	0.32	30-65	Volcanic ash and colluvium derived from volcanic breccia.	Moderate	Slight
70	Grotto gravelly loamy sand	>60	0.10	0-8	Alluvial terraces.	Slight	Slight
71	Hartnit silt loam	20-40	0.24	8-30	Mixture of glacial till, volcanic ash, and colluvium derived from andesite.	Slight	Moderate
73	Haywire sandy loam	20-40 Hard	0.20	30-65	Mixture of volcanic ash and colluvium derived from volcanic rock.	Moderate	Moderate
80	Index loamy sand	40-70 Soft	0.15	8-30	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Slight	Slight
81	Index loamy sand	40-70 Soft	0.15	30-65	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Moderate	Slight
82	Index loamy sand	40-70 Soft	0.15	65-90	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Moderate	Slight
83	Index - Rock outcrop complex	0	0.15	45-90	Granitic or metamorphic rocks.	Severe	Slight
90	Kaleetan sandy loam	>60	0.20	30-65	Mixture of volcanic ash and colluvium derived from andesite and glacial till.	Moderate	Slight
91	Kaleetan sandy loam, windswept	>60	0.20	30-65	Mixture of volcanic ash and colluvium derived from andesite and glacial till.	Moderate	Slight

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Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
92	Kaleetan sandy loam, till substratum	>60	0.20	8-30	Mixture of volcanic ash and colluvium derived from andesite and glacial till.	Slight	Slight
93	Kaleetan sandy loam, till substratum	>60	0.20	30-65	Mixture of volcanic ash and colluvium derived from andesite and glacial till.	Moderate	Slight
106	Klaber silt loam	30-40	0.32	0-8	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Slight	Severe
109	Klapatche loamy sand	30-40 Hard	0.20	30-65	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Moderate	Moderate
110	Klapatche - Rock outcrop complex	30-40 Hard	0.20	45-90	Hard and mostly unweathered granitic or metamorphic rocks.	Severe	Moderate
111	Klaus sandy loam	>60	0.20	0-8	Mixture of volcanic ash and alluvium overlying glacial outwash.	Slight	Moderate
114	Klaus sandy loam, windswept	>60	0.20	0-8	Glacial outwash terraces and volcanic ash.	Slight	Moderate
115	Klaus sandy loam, windswept	>60	0.20	30-65	Glacial outwash terraces and volcanic ash.	Moderate	Moderate
121	Littlejohn gravelly sandy loam	25-40	0.15	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from extrusive igneous rocks.	Moderate	Moderate
128	Marblemount gravelly loamy sand	20-40 Soft	0.10	8-30	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Slight	Moderate
129	Marblemount gravelly loamy sand	20-40 Soft	0.10	30-65	Mixture of volcanic ash, glacial till, and colluvium derived from granitic and metamorphic rocks.	Moderate	Moderate
131	Marblemount - Rock outcrop complex	20-40 Soft	0.10	45-90	Hard and mostly unweathered granitic or low-grade metamorphic rocks.	Severe	Moderate
135	Melakwa sandy loam	20-40 Hard	0.28	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from andesite.	Moderate	Moderate
136	Melakwa sandy loam, windswept	20-40 Hard	0.28	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from andesite.	Moderate	Moderate

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
138	Melakwa - Rock outcrop complex	20-40 Hard	0.28	45-90	Hard and mostly unweathered andesite.	Severe	Moderate
142	Nagrom sandy loam	20-40 Hard	0.17	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from volcanic rock.	Moderate	Moderate
145	Nagrom - Rock outcrop complex	20-40 Hard	0.17	30-90	Hard and mostly unweathered andesite.	Moderate	Moderate
146	Nargar fine sandy loam	>60	0.32	0-15	Mixture of volcanic ash and sandy alluvium over glacial outwash.	Slight	Slight
147	Nargar fine sandy loam	>60	0.32	15-30	Mixture of volcanic ash and sandy alluvium and glacial outwash terraces.	Slight	Slight
148	Nargar-Pastik complex	>60	0.32	35-70	Terrace escarpments of sandy alluvium and glacial outwash, and lake sediments mixed with volcanic ash.	Moderate	Slight
152	Nimue loamy sand	>60	0.17	30-65	Mixture of volcanic ash and pumice overlying residuum and colluvium derived from volcanic rock.	Moderate	Slight
156	Nimue - Rock outcrop complex	0 Hard	0.17	30-90	Hard and mostly unweathered andesite.	Moderate	Slight
157	Nooksack silt loam	>60	0.37	0-2	Flood plains and alluvial terraces.	Slight	Slight
158	Norma loam	>60	0.37	0-3	Alluvium in depressions in glacial till.	Slight	Severe
162	Ogarty gravelly loam	20-40 Hard	0.20	8-30	Volcanic ash and colluvium, and residuum developed from andesite and breccia.	Slight	Moderate
163	Ogarty gravelly loam	20-40	0.20	30-65	Volcanic ash and colluvium, and residuum developed from andesite and breccia.	Moderate	Moderate
171	Orthents, avalanche chutes - Humods complex	20-60 Hard	0.10	30-100	Colluvium derived from granite.	Not evaluated	Not evaluated
172	Ovall gravelly loam	20-40	0.17	15-30	Mixture of glacial drift and colluvium derived from andesite.	Slight	Moderate
173	Ovall gravelly loam	20-40	0.17	30-65	Mixture of glacial drift and colluvium derived from andesite.	Moderate	Moderate
174	Pastik silt loam	>60	0.32	0-30	Terrace escarpments of lake sediments and volcanic ash.	Slight	Moderate

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
176	Persis sandy loam	>60	0.28	0-8	Stream terraces of a mixture of volcanic ash and alluvium over deltaic deposits.	Slight	Slight
181	Pheeney - Rock outcrop complex	0	0.17	30-90	Andesite.	Moderate	Moderate
182	Phillipa sandy loam	>60	0.32	0-30	Mixture of volcanic ash, colluvium, and ablation till over dense glacial till.	Slight	Moderate
183	Phillipa sandy loam	>60	0.32	30-65	Mixture of volcanic ash, colluvium, and ablation till over dense glacial till.	Moderate	Moderate
187	Pilchuck loamy fine sand	>60	0.10	0-3	Sandy alluviual flood plains.	Slight	Slight
189	Pitcher sandy loam	>60	0.28	30-65	Volcanic ash and colluvium and residuum derived from andesite.	Moderate	Slight
195	Pits	>60	Not evaluated	na	Areas excavated for gravel, sand, and hard rock.	Not evaluated	Not evaluated
197	Playco loamy sand	>60	0.17	30-65	Mixture of volcanic ash and pumice and colluvium derived dominantly from volcanic rock.	Moderate	Slight
201	Playco - Rock outcrop complex	0 Hard	0.17	30-90	Volcanic rocks.	Moderate	Slight
203	Ragnar loam	>60	0.32	6-15	Glacial outwash terraces.	Slight	Slight
204	Ragnar loam	>60	0.32	15-30	Glacial outwash terraces.	Slight	Slight
205	Ragnar-Lynnwood complex	>60	0.32	2-15	Glacial outwash terraces.	Slight	Slight
206	Ragnar-Lynnwood complex	>60	0.32	30-45	Glacial outwash terraces.	Moderate	Slight
207	Reggad very cobbly muck	>60	0.02	30-90	Mixture of organic material, volcanic ash, and pumice over rock rubble.	Not evaluated	Not evaluated
210	Reggad-Serene complex	20-40	0.02	45-90	Mixture of volcanic ash and colluvium and residuum derived from granitic and low-grade metamorphic rocks.	Moderate	Moderate
211	Reichel silt loam	40-60 Hard	0.32	6-30	Mixture of volcanic ash and colluvium and residuum derived dominantly from volcanic rock.	Slight	Slight
216	Rober loam	>60	0.32	0-30	Volcanic ash and glaciolacustrine sediments.	Slight	Moderate
218	Rock outcrop	0 Hard	Not evaluated	na	Granite, andesite, breccia, or metasedimentary rocks.	Not evaluated	Not evaluated

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
223	Rock outcrop - Rubble land - Serene complex	0 Hard	0.15	45-90	Mixture of volcanic ash and colluvium, and residuum derived from granitic and low-grade metamorphic rocks.	Moderate	Moderate
224	Rubble land	>40 Hard	Not evaluated	na	Talus slopes at the base of rock outcrops.	Not evaluated	Not evaluated
227	Sauk silt loam	>60	0.28	0-8	River terraces of alluvium and volcanic ash.	Slight	Slight
233	Serene gravelly sandy loam	20-40 Soft	0.15	30-65	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Moderate	Moderate
235	Shalcar muck	>60	0.49	0-1	Herbaceous and woody organic deposits over glaciofluvial deposits.	Slight	Severe
236	Si silt loam	>60	0.37	0-2	Alluvial terraces.	Slight	Moderate
239	Skykomish gravelly sandy loam, windswept	>60	0.10	0-30	Glacial outwash terraces and volcanic ash.	Slight	Slight
240	Skykomish very stony loam	>60	0.17	0-30	Glacial outwash terraces, terrace escarpments and volcanic ash.	Slight	Slight
249	Teneriffe loamy sand	>60	0.17	8-30	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Slight	Slight
250	Teneriffe loamy sand	>60	0.17	30-65	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Moderate	Slight
251	Teneriffe loamy sand, windswept	40-60 Soft	0.17	30-65	Mixture of volcanic ash and colluvium derived from granitic and metamorphic rocks.	Slight	Slight
255	Tokul gravelly loam	20-40	0.20	6-15	Mixture of volcanic ash and glacial till.	Slight	Moderate
256	Tokul gravelly loam	20-40	0.20	15-30	Mixture of volcanic ash and glacial till.	Slight	Moderate
257	Tokul gravelly loam	20-40	0.20	30-65	Mixture of volcanic ash and glacial till.	Moderate	Moderate
258	Tokul - Pastik complex	20-40	0.20	45-90	Mixture of volcanic ash and glacial till.	Severe	Moderate
259	Tokul - Pastik complex, windswept	>60	0.32	45-90	Lake sediments and volcanic ash.	Slight	Moderate
267	Udifluvents	>60	0.15	0-8	Alluvium in low stream terraces and drainageways.	Slight	Slight

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
280	Winston loam, windswept	>60	0.24	0-30	Glacial outwash terraces, terrace escarpments and volcanic ash.	Slight	Slight
158 / No	Norma loam	>60	0.37	0-3	Alluvium formed in depressions of glacial till.	Slight	Severe
187 / Pc	Pilchuck loamy fine sand	>60	0.10	0-3	Floodplains of sandy alluvium.	Slight to severe	Slight
215 / Rh	Riverwash	>60	Not evaluated	na	Bottom land along rivers - typically stratified cobbles, pebbles, and sand.	Severe to very severe	Not evaluated
231 / Sk	Seattle muck	>60	0.00	0-1	Herbaceous and woody organic deposits.	Slight	Severe
235 / Sm	Shalcar muck	>60	0.49	0-1	Herbaceous and woody organic deposits over alluvium and glaciofluvial deposits.	Slight	Severe
261 / Tu	Tukwila muck	>60	0.00	0-1	Herbaceous and woody organic deposits stratified with mineral layers.	Slight	Severe
AgB	Alderwood gravelly sand loam	20-40	Not evaluated	0-6	Soils formed from glacial deposits overlying glacial till.	Slight to severe	Slight
AgC	Alderwood gravelly sand loam	20-40	Not evaluated	6-15	Soils formed from glacial deposits overlying glacial till.	Moderate to very severe	Slight
AgD	Alderwood gravelly sand loam	20-40	Not evaluated	15-30	Soils formed from glacial deposits overlying glacial till.	Moderate to very severe	Slight
AkF	Alderwood and Kitsap Soils	20-40	Not evaluated	25-70	Soils formed from glacial deposits overlying glacial till.	Severe to very severe	Moderate
BeC	Beausite gravelly sandy loam	20-40	Not evaluated	6-15	Soils formed from glacial deposits overlying sandstone.	Slight to severe	Slight
BeD	Beausite gravelly sandy loam	20-40	Not evaluated	15-30	Soils formed from glacial deposits overlying sandstone.	Moderate to very severe	Slight
Bh	Bellingham silt loam	> 60	Not evaluated	0-2	Alluvial soils in depressions on glacial till.	Slight	Severe
EvB	Everett gravelly sandy loam	> 60	Not evaluated	0-5	Glacial outwash deposits.	Slight to moderate	Slight
EvC	Everett gravelly sandy loam	> 60	Not evaluated	5-15	Glacial outwash deposits.	Slight to moderate	Slight
EvD	Everett gravelly sandy loam	> 60	Not evaluated	15-30	Glacial outwash deposits.	Moderate to severe	Slight
KpB	Kitsap silt loam	> 60	Not evaluated	2-8	Terraces of glacial lake deposits.	Slight to severe	Moderate

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
KpD	Kitsap silt loam	> 60	Not evaluated	15-30	Terraces of glacial lake deposits.	Severe to very severe	Moderate
Ma	Mixed alluvial land	> 60	Not evaluated	0-2	Alluvial soils.	Slight	Slight
NeC	Neilton very gravelly loamy sand	> 60	Not evaluated	2-15	Glacial outwash terraces.	Slight to moderate	Slight
Or	Orcas peat	> 60	Not evaluated	0-1	Herbaceous and woody organic deposits in basins.	None	Severe
Os	Oridia silt loam	> 60	Not evaluated	0-2	Alluvial soils in river valleys.	Slight	Moderate
Py	Puyallup fine sandy loam	> 60	Not evaluated	0-2	Alluvial soils on levees and adjacent to streams in river valleys.	Slight	Slight
RdC	Ragnar - Indianola association, sloping	> 60	Not evaluated	2-15	Glacial outwash terraces.	Slight to moderate	Slight
Su	Sultan silt loam	> 60	Not evaluated	0-2	Alluvial soils in the river valleys.	Slight	Moderate
Ur	Urban land	> 60	Not evaluated	na	Soils that have been modified by disturbance and addition of fill material.	Slight to moderate	Not evaluated
95k	Andic dystrudepts	> 60	0.20	0-3		Slight*	
138k	Pits, mine	0	Not evaluated	na		Not evaluated	
139k	Nard ashy loam	> 60	0.43	0-3		Moderate *	
180k	Nimue ashy sandy loam	> 60	0.17	5-30		Slight*	
214k	Borosaprists	> 60	Not evaluated	0-2		Not evaluated	
217k	Roxer gravelly ashy sandy loam	> 60	0.15	5-25		Slight*	
230k	Rock outcrop - Roxer complex	0	Not evaluated	40-70		Not evaluated	
237k	Kladnick ashy sandy loam	> 60	0.20	0-3		Slight*	
241k	Thetis ashy sandy loam	> 60	0.15	25-45		Slight*	
242k	Roxer gravelly ashy sandy loam	> 60	0.15	25-45		Slight*	
254k	Kachess gravelly ashy sandy loam		0.10	5-25		Slight*	
255k	Thetis ashy sandy loam	> 60	.15	45-65		Slight*	
259k	Fluvaquents	> 60	.37	0-2		Moderate *	

TABLE 2: BONNEVILLE POWER ADMINISTRATION
KANGLEY-TO-ECHO LAKE TRANSMISSION PROJECT SOIL UNIT DESCRIPTIONS

Map Unit	Name	Bedrock Depth (inches)	Erosion Factor, K	Slope %	Description	Erosion Hazard	Windthrow Hazard
301k	Vabus ashy sandy loam	20-40	.24	0-25		Slight*	
306k	Vabus stony ashy sandy loam	20-40	.24	5-25		Slight*	
308k	Vabus stony ashy sandy loam	20-40	.24	45-65		Slight*	
309k	Vabus ashy sandy loam	20-40	.24	45-65		Slight*	
313k	Vabus stony ashy sandy loam	20-40	.24	25-45		Slight*	
332k	Stirrup ashy sandy loam	> 60	.24	5-30		Slight*	
333k	Stirrup ashy sandy loam	> 60	.24	30-65		Slight*	
335k	Vabus-rock outcrop complex	20-40		45-70		Slight*	
342k	Gilpar-rock outcrop complex	0	.2	45-65		Slight*	
346k	Gilpar ashy sandy loam	> 60	.2	25-45		Slight*	
347k	Gilpar ashy sandy loam	>60	.2	45-65		Slight*	

* Erosion hazard estimated based on erosion factor and slope.

TABLE 3
COMPARISON OF IMPACTS ON ALTERNATIVES

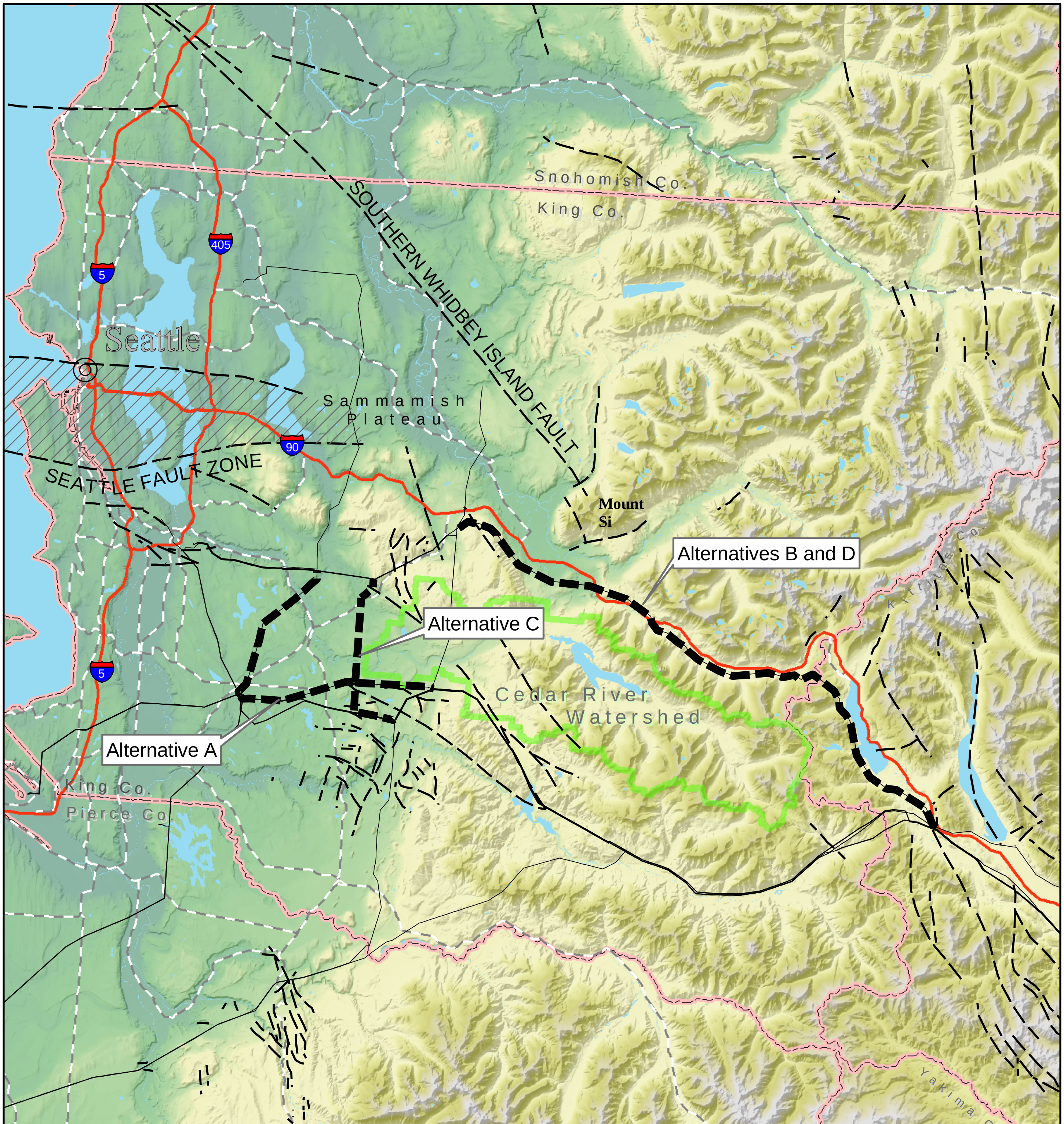
					Soil Erosion (% of Length)				Windthrow (% of Length)	
Alternative	Length (miles)	Clearing[1] (acres)	Deep-[2] Seated Landslide (% of length)	Shallow[3] Landslide (% of length)	Severe	Moderate	Slight	Stream Crossings[4]	High	Moderate
1	9.1	165	6	5	3	15	82	9	0	55
2	9.1	165	6	3	3	15	82	10	1	71
3	10.6	190	4	5	2	20	78	13	1	60
4A	9.6	175	6	5	3	15	82	10	1	60
4B	10.2	185	6	5	3	15	82	10	1	57

(1) Based on 150-foot wide corridor
(2) Moderate and low deep-seated landslide hazard areas
(3) Low shallow landslide hazard areas
(4) Based on intersection of alignment with streams mapped on 1973 Hobart, 1968 North Bend, and 1968 Eagle Gorge USGS 7.5 minute quadrangle maps

TABLE 4: SUMMARY OF ALTERNATIVE ALIGNMENT HAZARD RATINGS

HAZARD	A	B	C1	C2	D
Length (miles)	20	38	10	10.5	38
Clearing[(1)] (acres)	0	0	140	119	650
Stream Crossings[(2)]	11	38	7		38
Deep-Seated Landslide (% of Length)					
High	0	0	0	0	0
Moderate	1	5	0	0	5
Low	0	6	3	3	6
None	99	89	97	97	89
Shallow Landslide (% of Length)					
High	0	0	0	0	0
Moderate	1	4	0	0	5
Low	0	7	3	3	6
None	99	89	97	97	88
Soil Erosion (% of Length)					
High	11	2	8	5	2
Moderate	68	28	32	33	28
Low	21	70	60	62	70
Excavation Difficulty (% of Length)					
High	4	45	17	16	45
Moderate	36	23	37	31	23
Low	60	32	46	53	32
Settlement Impact (% of Length)					
High	2	0	0	1	0
None	98	100	100	100	100
Seismic Liquefaction Impacts (% of Length)					
High	2	6	0	0	6
Moderate to Low	0	0	1	1	0
None	98	94	99	99	94
Soft Ground Amplification (% of Length)					
High	2	0	0	0	0
None	98	100	100	100	100
Fault Ground Rupture (% of Length)					
High	0	0	0	0	0
Low	100	100	100	100	100
Floodplain Impacts					
Impacts	X	X	-	-	X
No Impacts	-	-	X	X	-
Water-Quality Limited Water Body Segments					
High	-	-	-	-	-
None	X	X	X	X	X
Groundwater Impacts (% of Length)					
High	56	0	37	370	0
Moderate	44	11	63	63	11
Low	0	89	0	0	89
Windthrow (% of Length)					
High	4	1	3	3	1
Moderate	4	45	43	43	45
Low	92	54	54	54	54

1 – Assumes a 150-foot-wide ROW clearing.
2 –Based on perrenial and intermittent streams shown on USGS topographic maps (see references). Includes multiple crossings of same stream.



Fault
Major Road

N

0 5 10
Miles

Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

VICINITY AND
REGIONAL FAULT MAP

July 2002 21-1-09189-002

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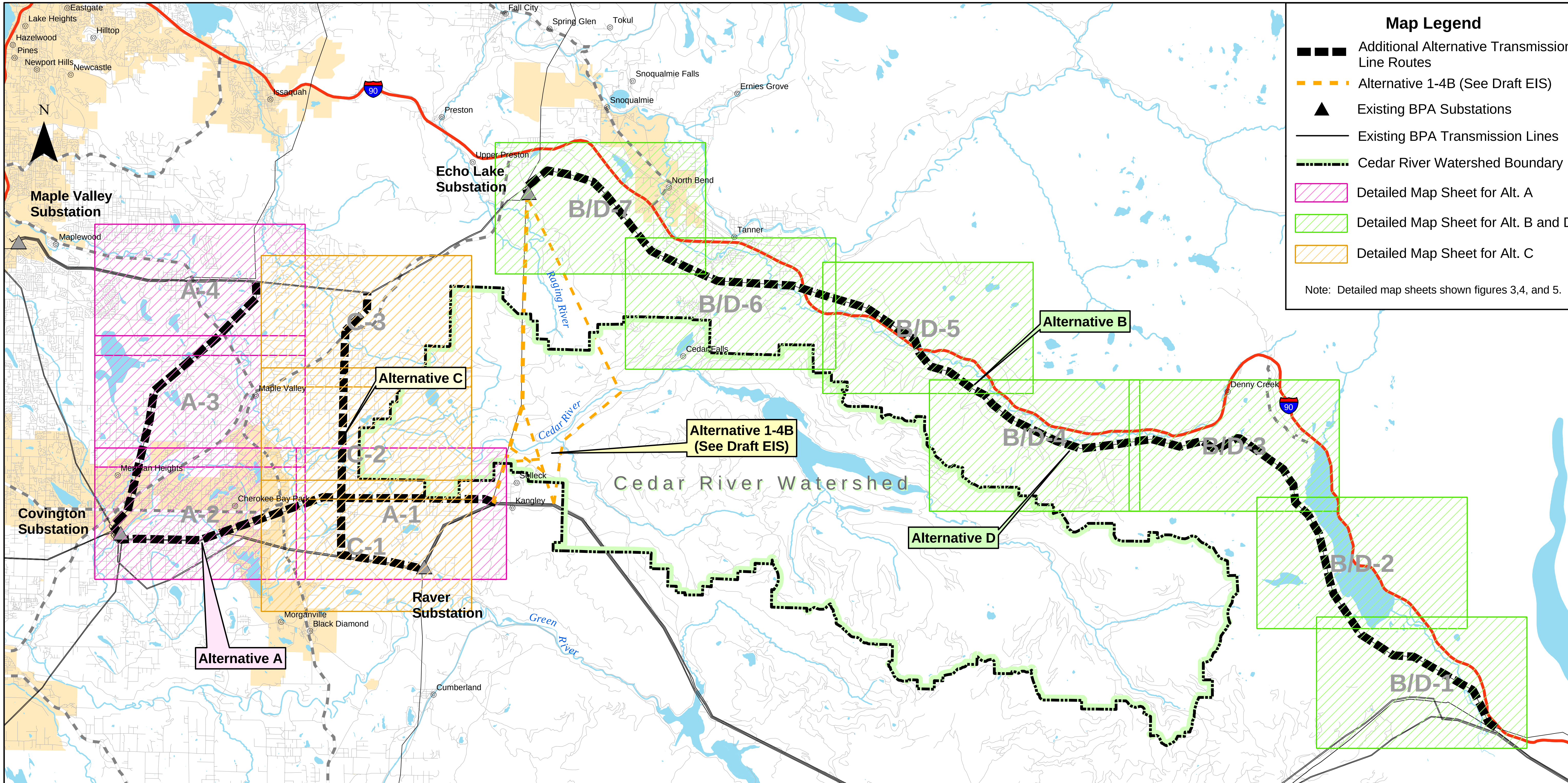
FIG. 1

perkins.mxd



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

PROJECT AREA PLAN

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FIG. 2

project_area.mxd

Faulted and Folded Geologic Structures

Observed Location | Approximate Location | Concealed

Syncline

Anticline

Fault (Ball on downthrown side)

Landslides

Deep-Seated Landslides observed by S & W (not to scale)

Shallow Landslides/Debris Torrents observed by S & W

Arrow shows direction of landslide movement

Geologic Units; See Table 1 for Unit Descriptions

Quaternary Deposits

- Qf - Fill
- Qa - Alluvium
- Qb - Bog
- Qt - Talus Deposits
- Qls - Landslide
- Qag - Alpine Glacial Deposits
- Qvic - Vashon Stade Ice Contact Deposits
- Qvr - Vashon Stade Glacial Recessional Outwash
- Qvt - Vashon Stade Till
- Qpf - Pre-Fraser Glaciation Sedimentary Deposits

Tertiary Bedrock

- Tsgs - Snoqualmie Batholith Granodiorite and Tonalite
- Tsgf - Snoqualmie Batholith Fine Grained Monzonite
- Tsm - Snoqualmie Batholith Mafic Diorite and Gabbro
- Thm - Huckleberry Mountain Volcanics
- Thmk - Tuff of Lake Keechelus
- Tv - Volcanic Rocks
- Tdg - Diabase, Gabbro and Basalt
- Tpa - Volcanic Rocks of Mt. Persis
- Tpg - Puget Group, Undifferentiated
- Tpr - Renton Formation
- Tpt - Tukwila Formation
- Tn - Naches Formation
- Tnr - Naches Formation Rhyolite
- Tns - Naches Formation Feldspathic Sandstone and Volcanic Rocks
- Tnmc - Naches Formation Mt. Catherine Rhyolite
- Tng - Naches Formation Guye Sedimentary Member

Pre-Tertiary Bedrock

- pTwa - Western Melange Belt Argilite and Graywacke
- pTwg - Western Melange Belt Metagabbro
- pTwu - Western Melange Belt Ultramafite

Note:

1. Geologic mapping adapted from Vine (1962), Frizzel et al (1984), Walsh (1984) and Booth (1995). Additional mapping by Shannon and Wilson, Inc. (2002).

36 188 — Soil Units; See Table 2 for Unit Descriptions

Additional Alternative Transmission Line Routes

Existing BPA Substations

Existing BPA Transmission Lines

River / Stream

Waterbody

Freeway

Major Road

Minor Road

2400 — Contour with elevation; 40 ft intervals

22 — Section Number

Cedar River Watershed Boundary

Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

LEGEND

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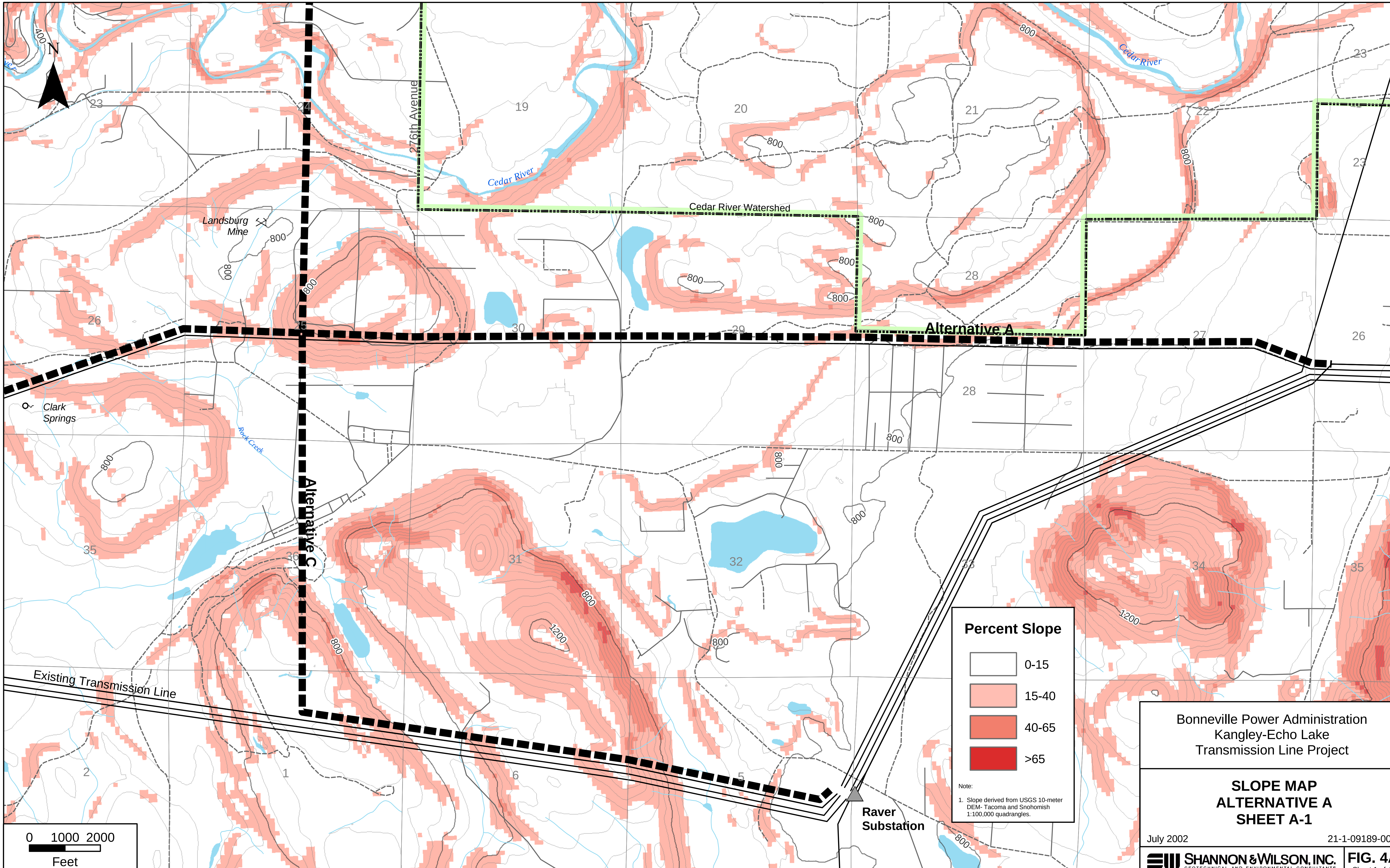
FIG. 3

legend.mxd



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

SLOPE MAP
ALTERNATIVE A
SHEET A-1

July 2002 21-1-09189-002

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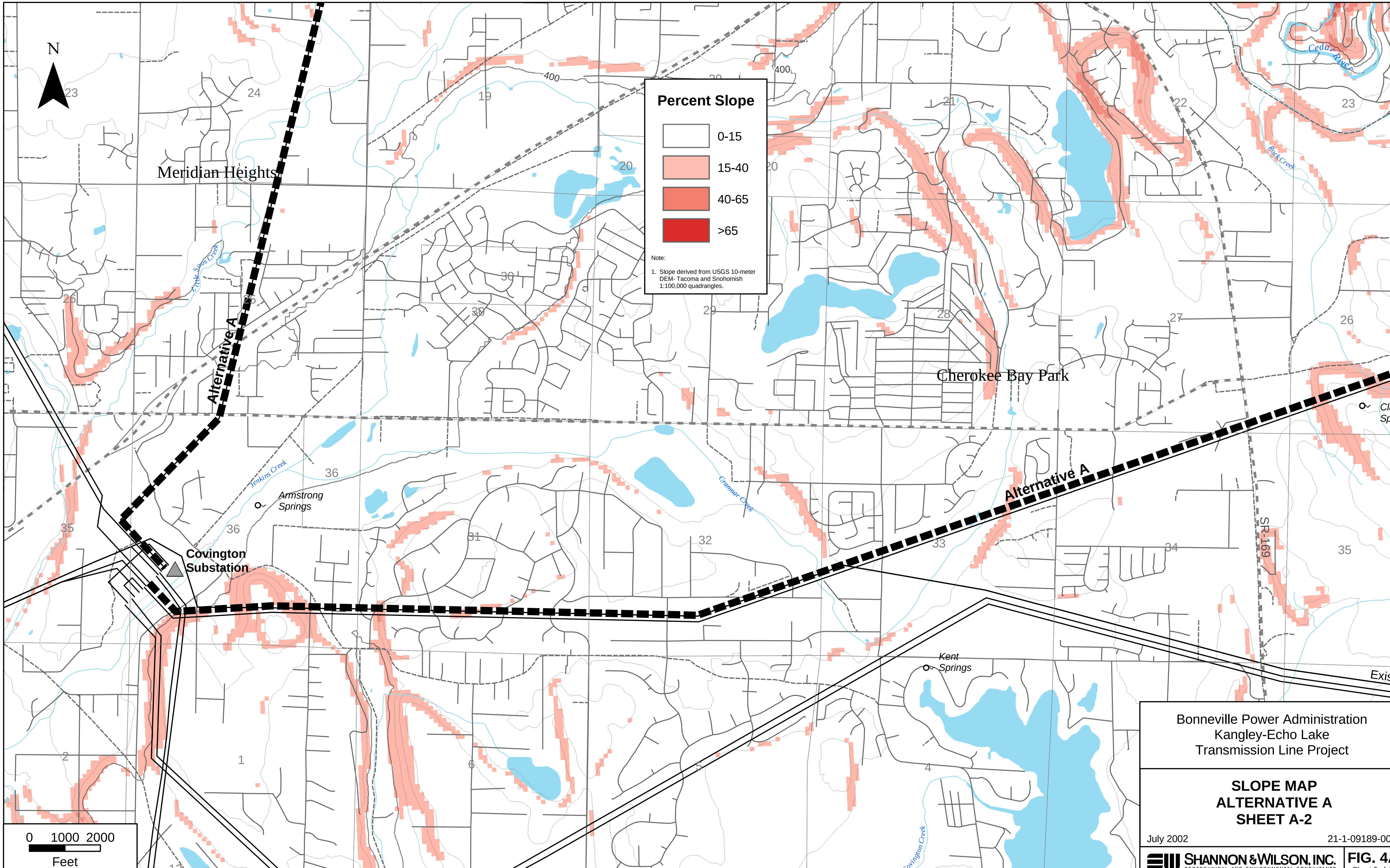
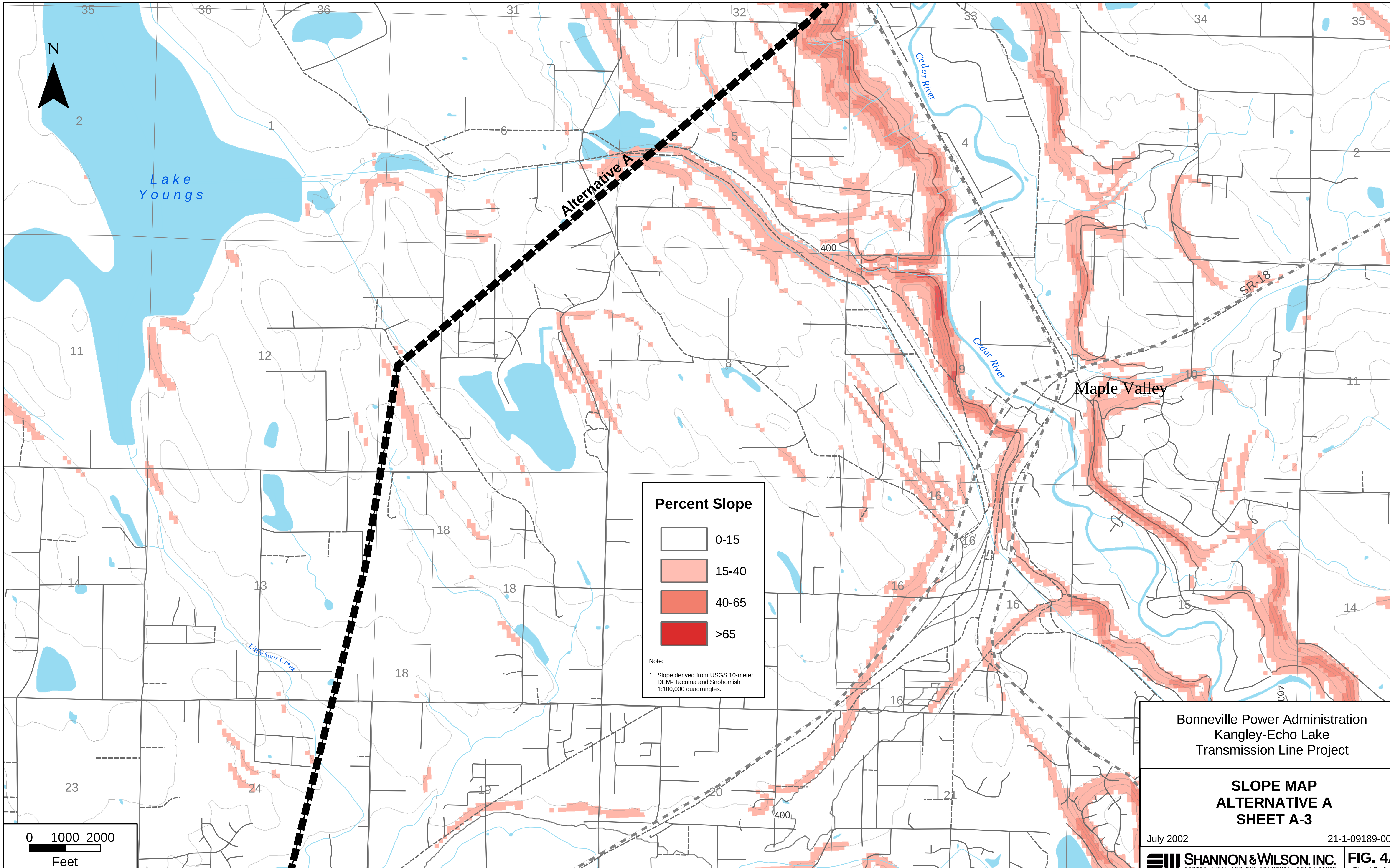
FIG. 4A
Sheet 1 of 4


N
Meridian Heights
Alternative A
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
Cherokee Bay Park
Alternative A
Armstrong Springs
Jenkins Creek
Covington Substation
Kent Springs
Cedar River
Rock Creek
Jenkins Creek
Covington Creek
SR-169
Existi
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE A
SHEET A-2
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4A
Sheet 2 of 4


N
Lake Youngs
Alternative A
Cedar River
Cedar River
Maple Valley
SR-18
Little Soos Creek
400
35
36
36
31
32
33
34
35
2
1
6
5
4
3
2
11
12
7
8
9
10
11
14
13
18
18
18
16
16
16
16
16
15
14
23
24
19
20
21
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE A
SHEET A-3
July 2002
21-1-09189-002
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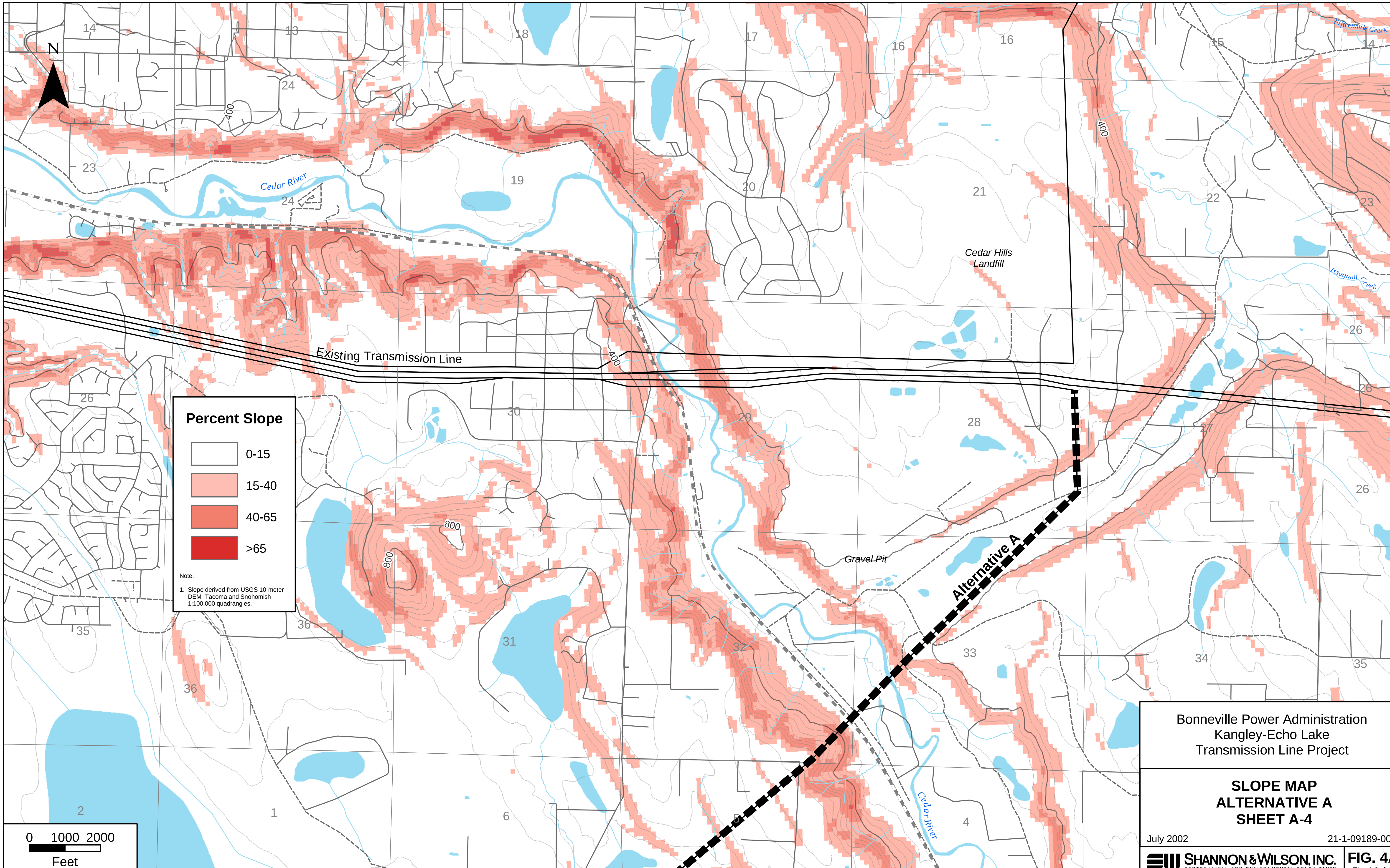
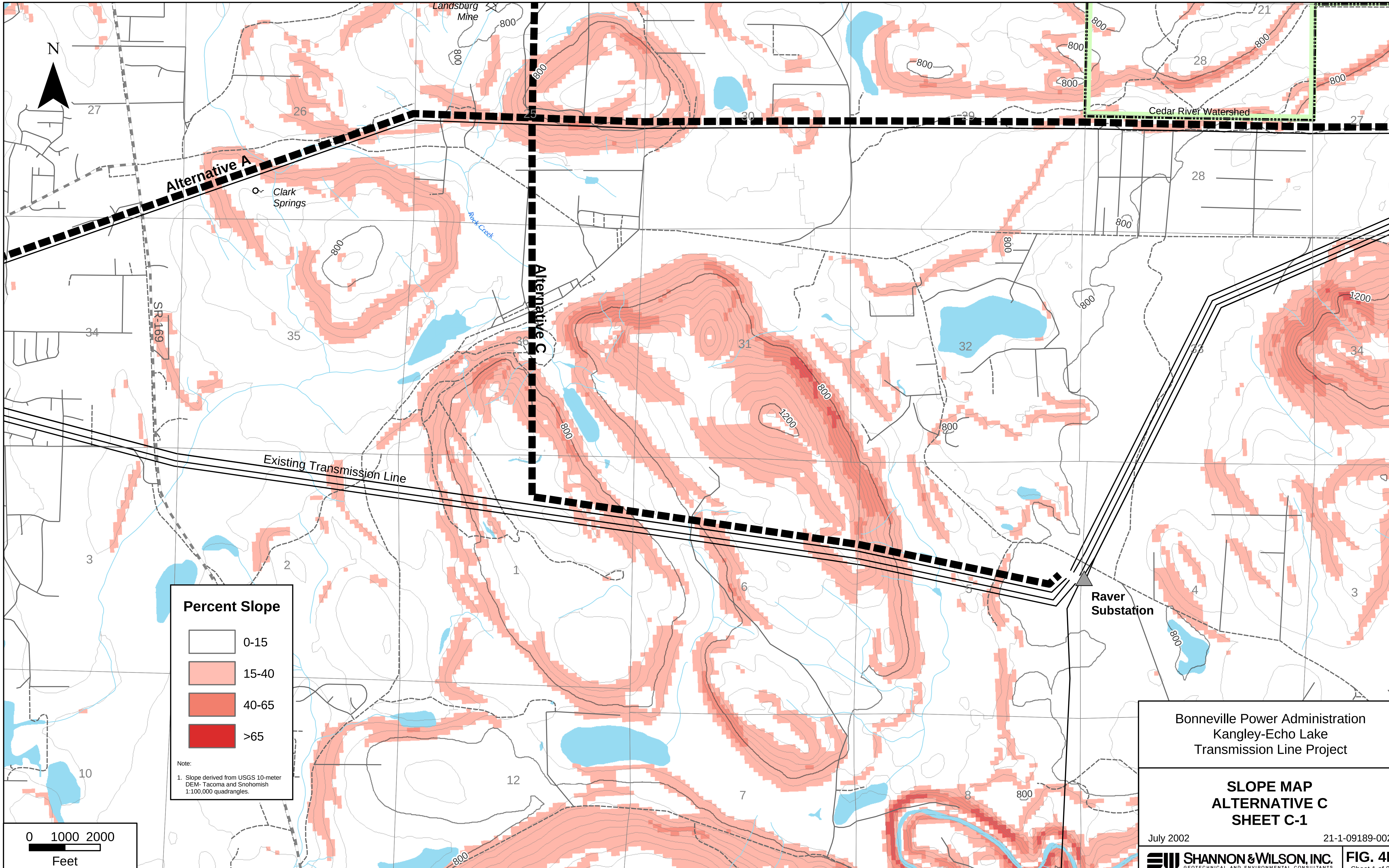
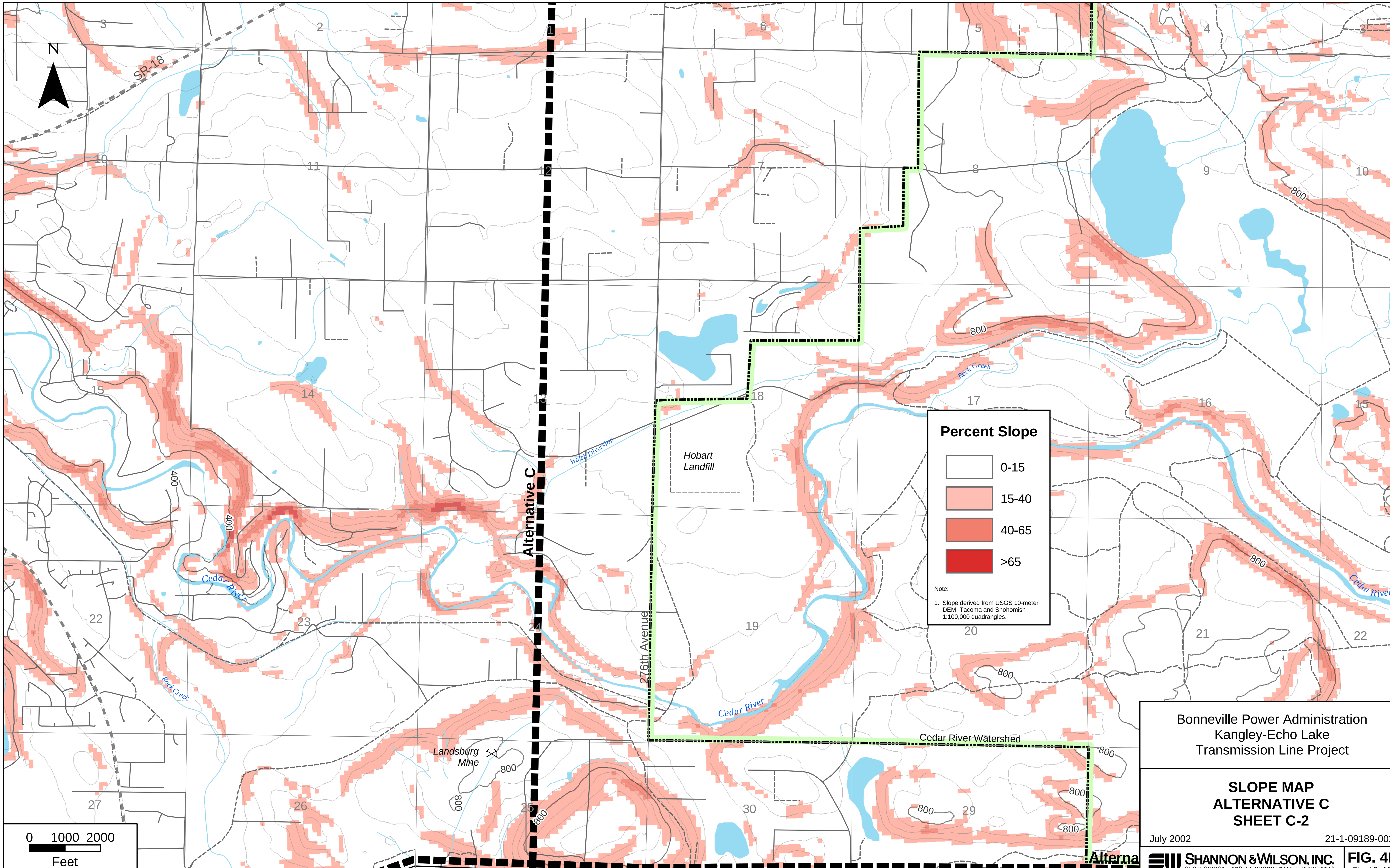
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4A
Sheet 3 of 4


N
Cedar River
Existing Transmission Line
Cedar Hills Landfill
Gravel Pit
Alternative A
Fifteenmile Creek
Issaquah Creek
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE A
SHEET A-4
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4A
Sheet 4 of 4


N
Landsburg Mine
Clark Springs
Rock Creek
Alternative A
Alternative C
Existing Transmission Line
Cedar River Watershed
SR-169
Raver Substation
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE C
SHEET C-1
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4B
Sheet 1 of 3



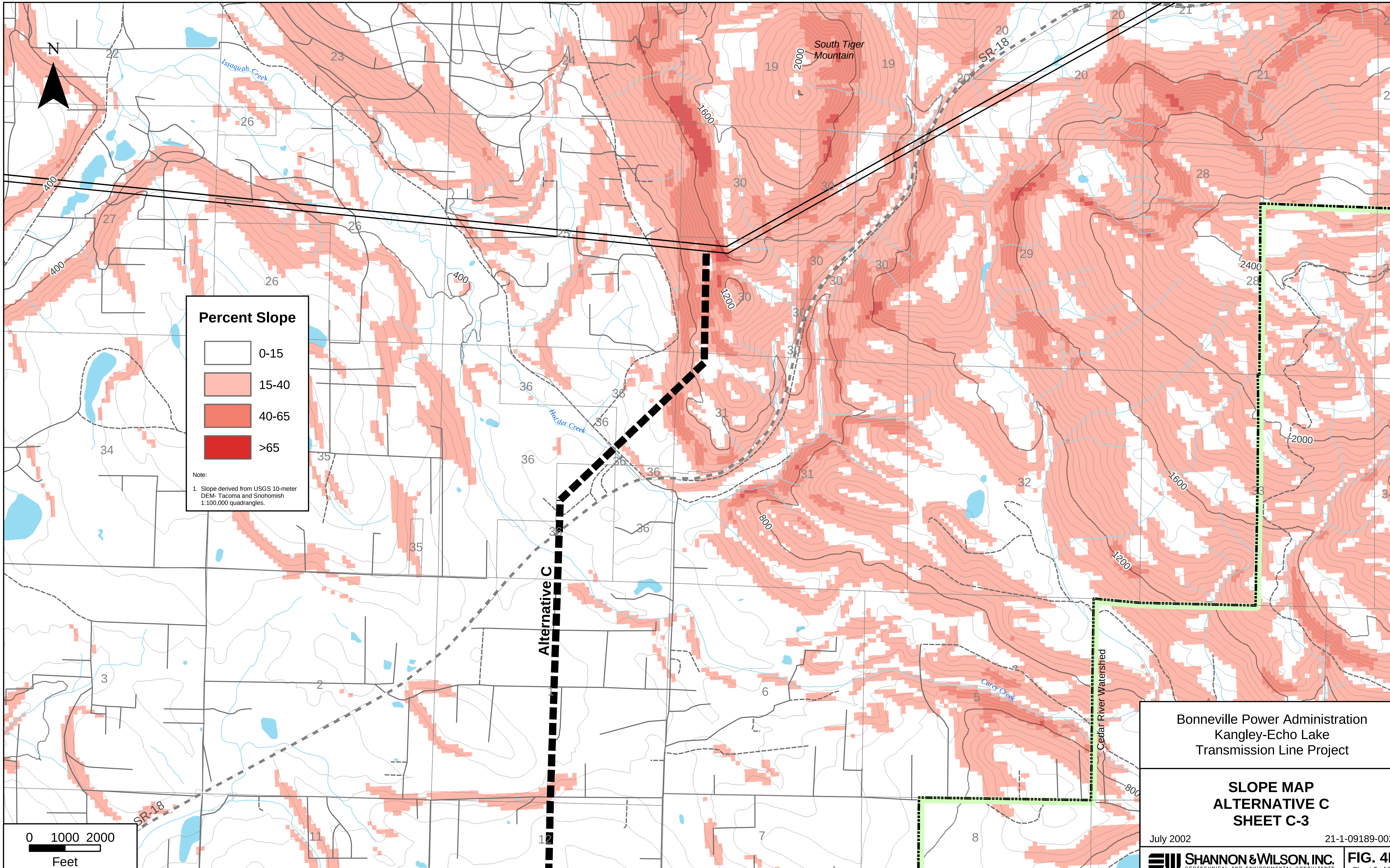
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

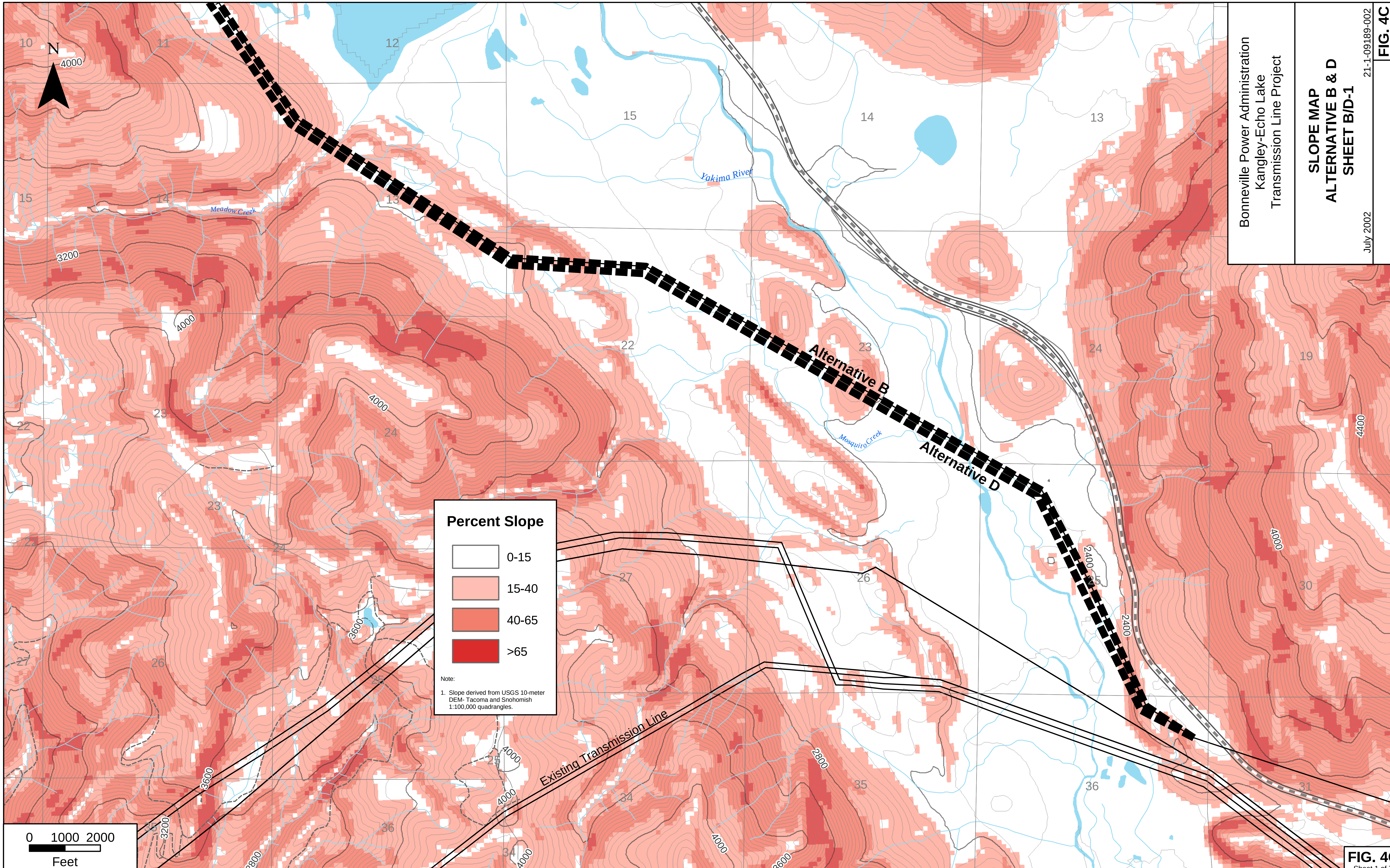
SLOPE MAP
ALTERNATIVE C
SHEET C-2

July 2002 21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 4B
Sheet 2 of 3


N
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
South Tiger Mountain
SR-18
Issaquah Creek
Holder Creek
Carey Creek
Cedar River Watershed
Alternative C
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE C
SHEET C-3
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4B
Sheet 3 of 3



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-1

July 2002

21-1-09189-002

FIG. 4C
Sheet 1 of 7

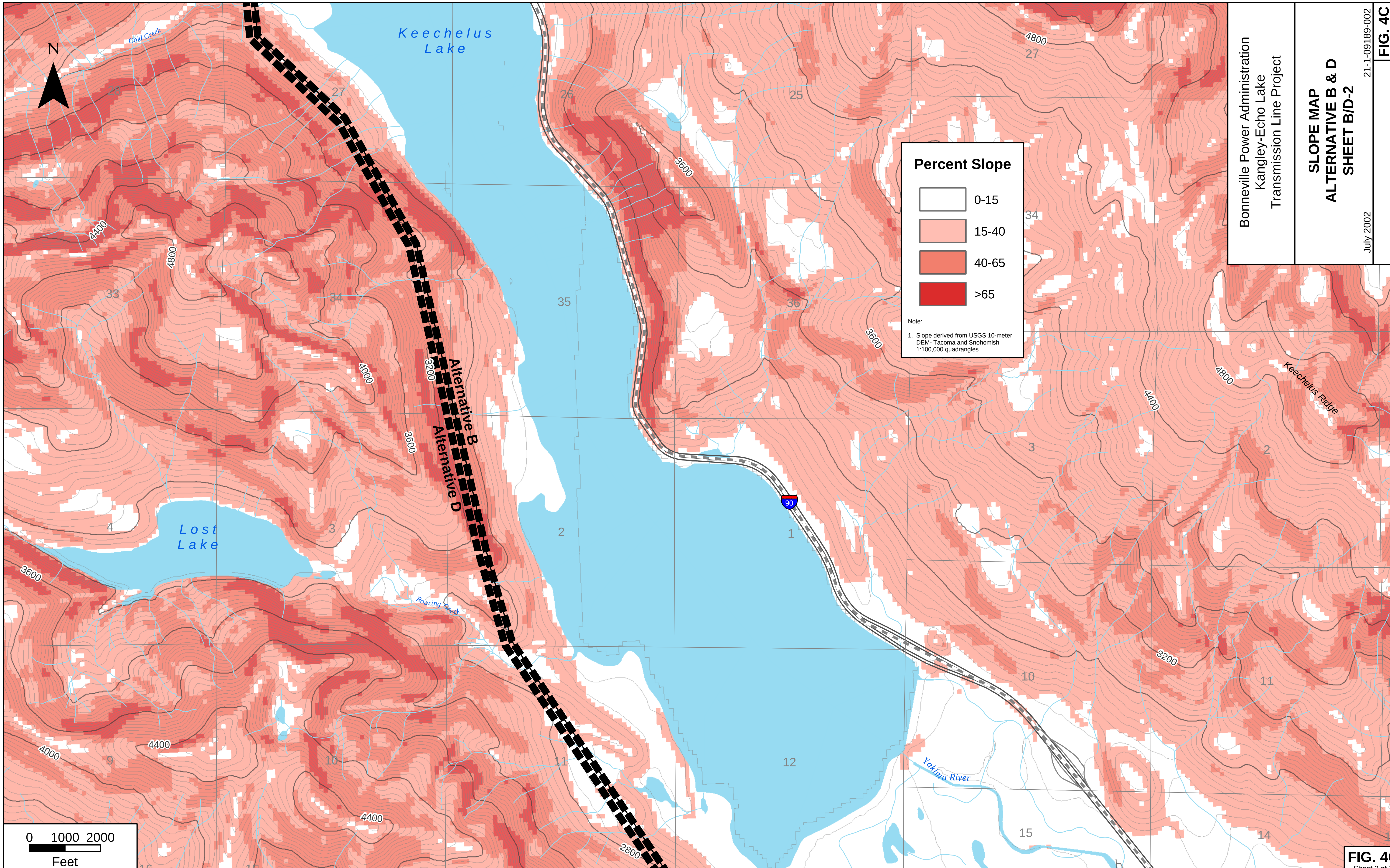
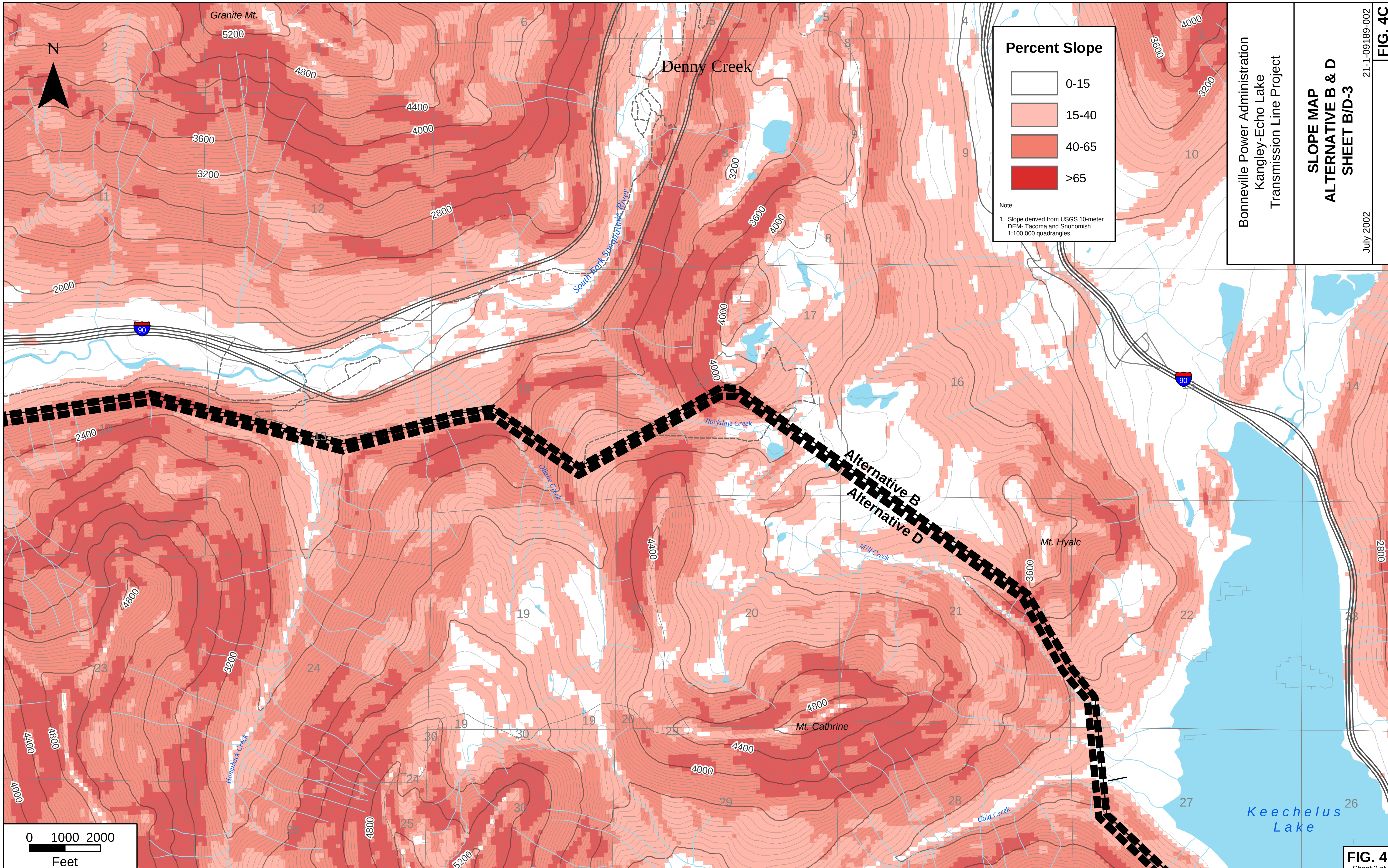


FIG. 4C
Sheet 2 of 7



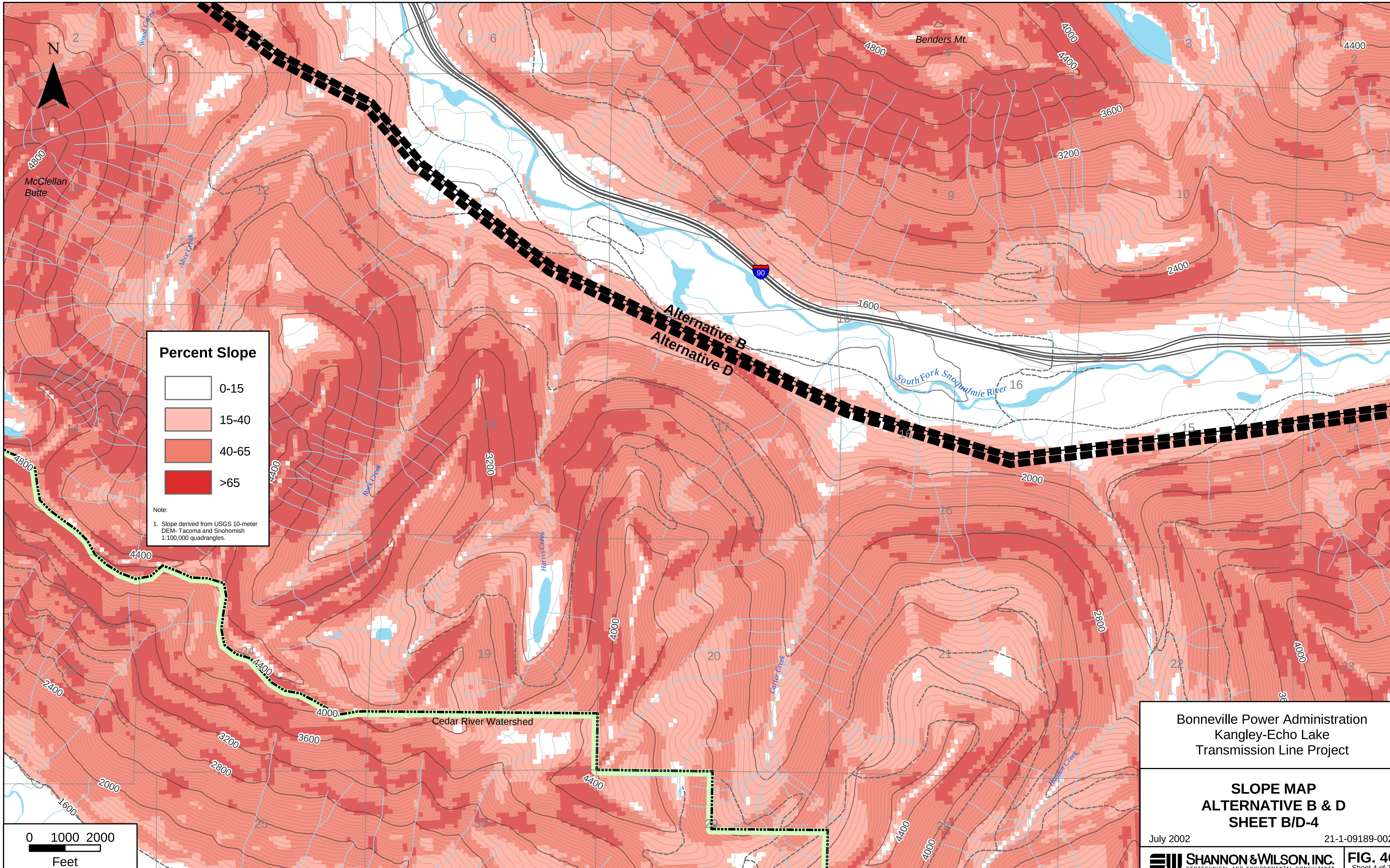
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

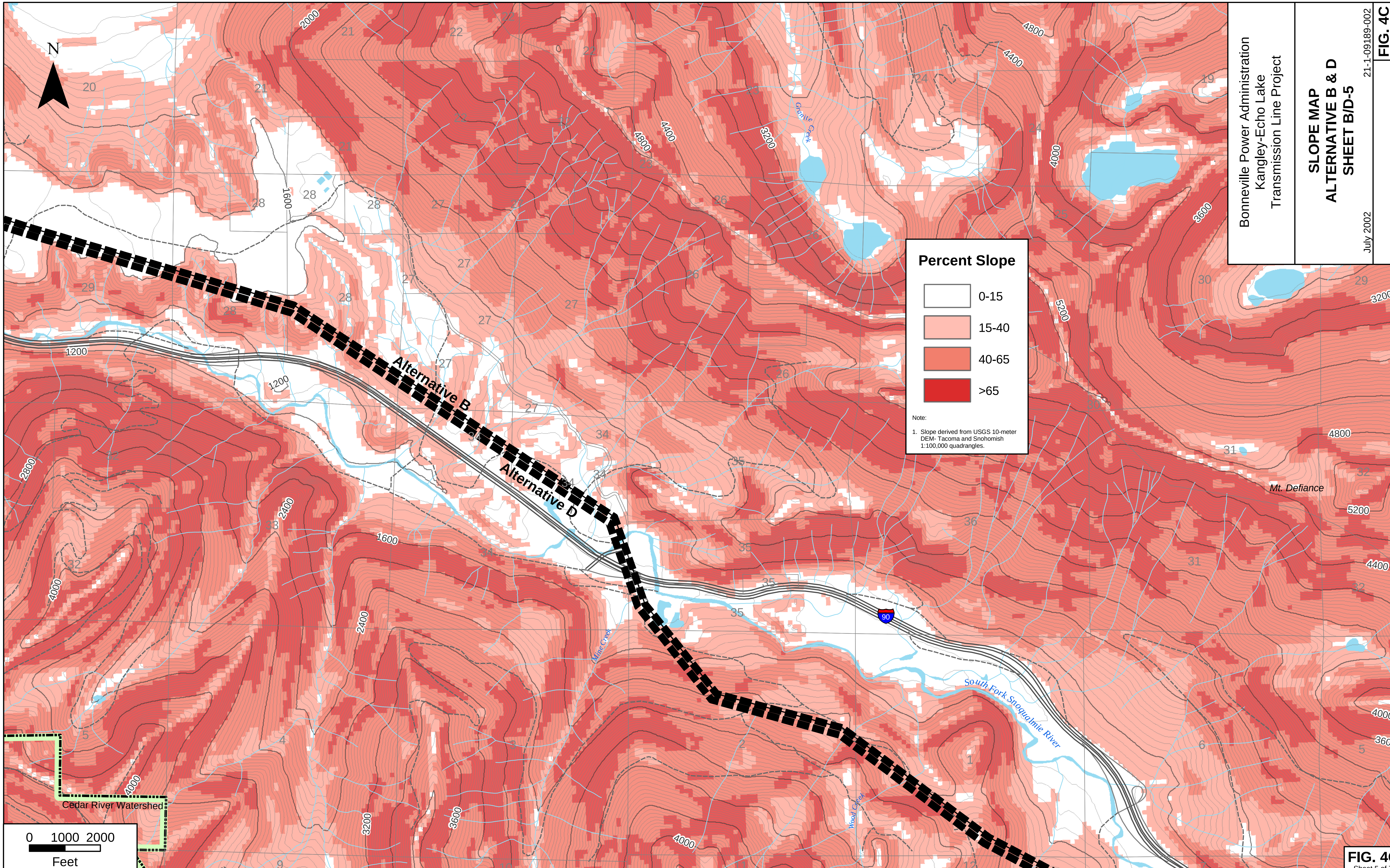
SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-3

July 2002

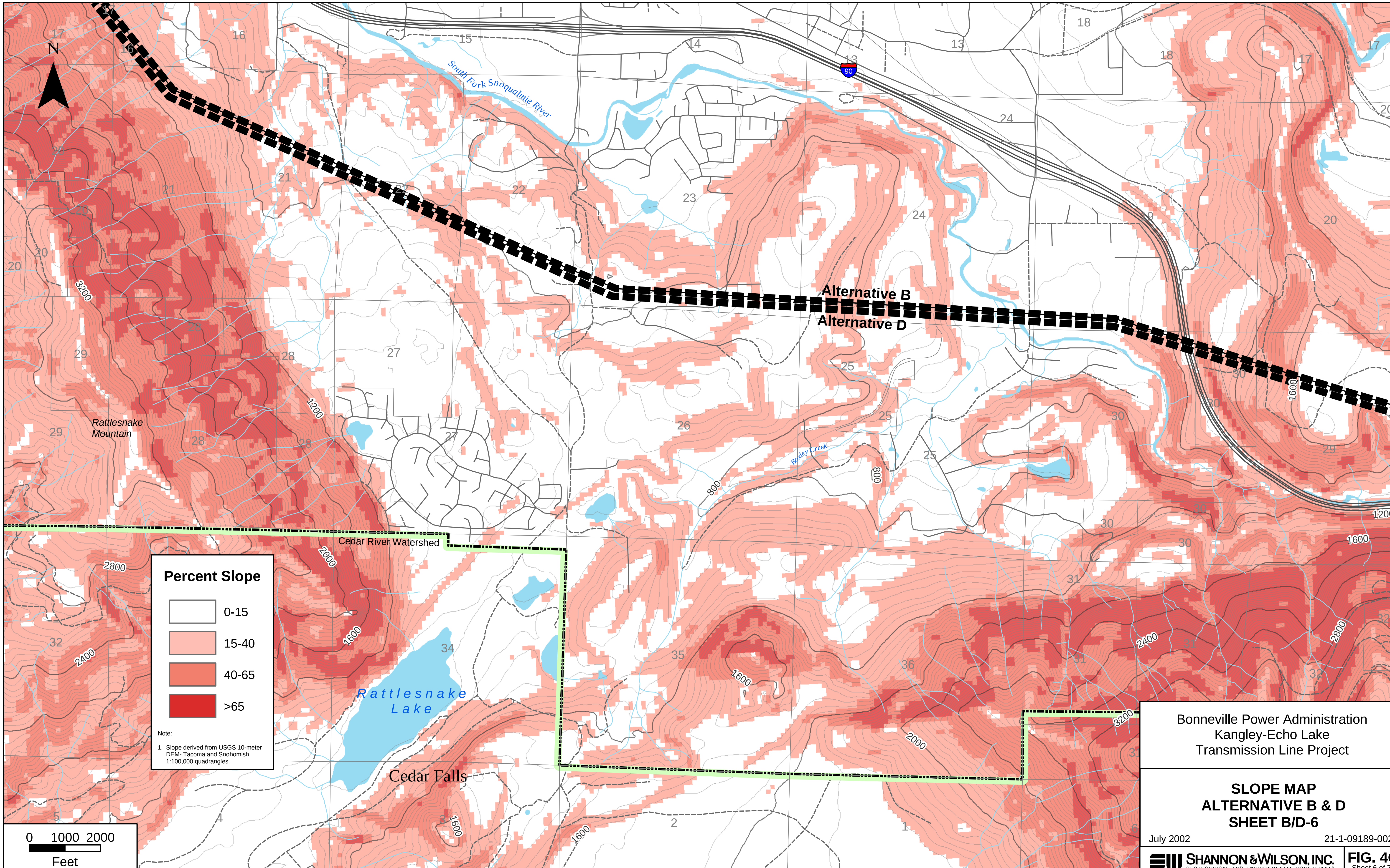
21-1-09189-002

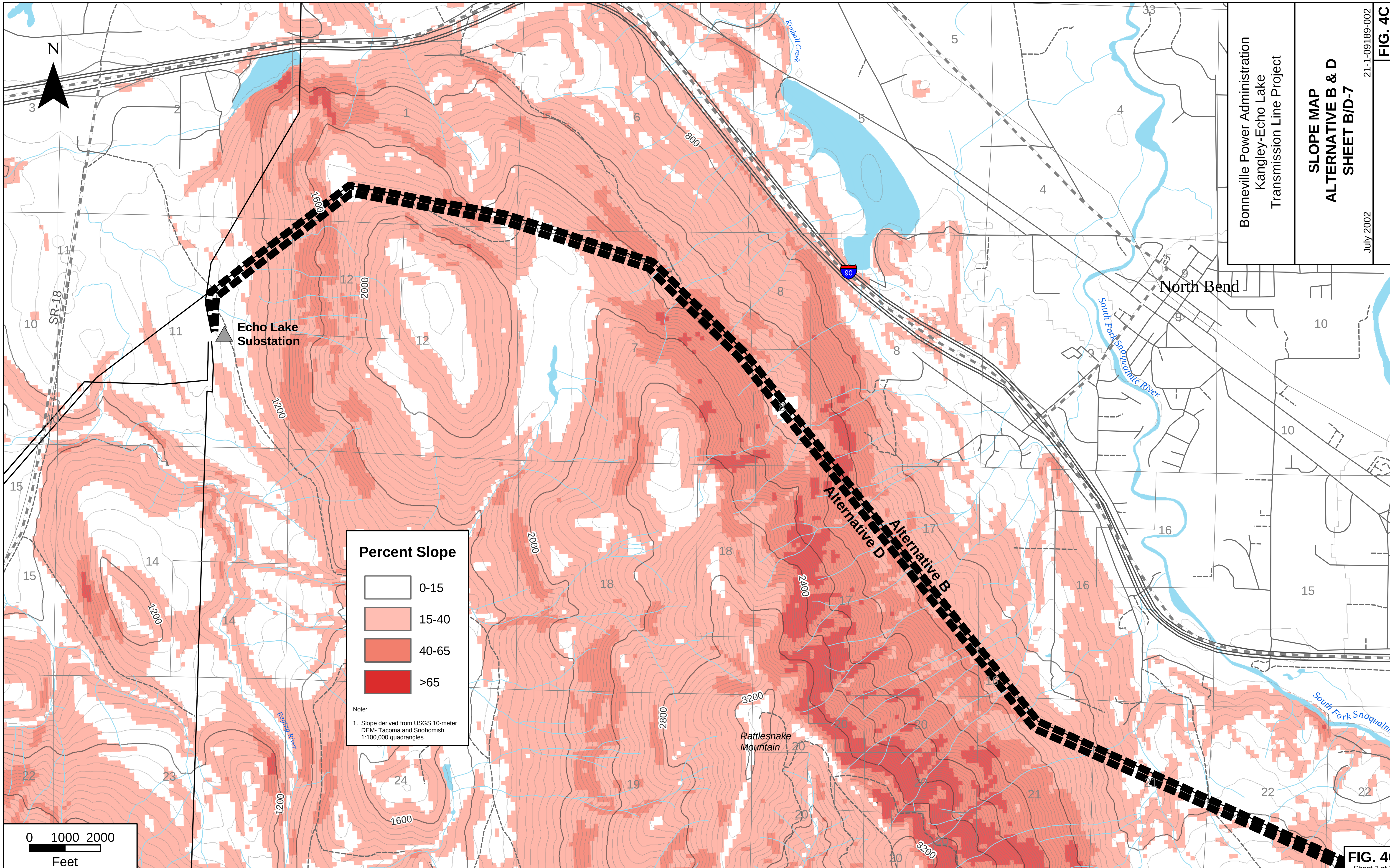
FIG. 4C
Sheet 3 of 7


Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
N
McClellan Butte
Benders Mt.
Alternative B
Alternative D
South Fork Snoqualmie River
Cedar River Watershed
Wood Creek
Alice Creek
Rock Creek
Harris Creek
Carter Creek
Hansen Creek
90
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-4
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4C
Sheet 4 of 7



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-5
July 2002
21-1-09189-002
FIG. 4C
Sheet 5 of 7
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
N
Alternative B
Alternative D
Mt. Defiance
South Fork Snoqualmie River
Granite Creek
Mine Creek
Wood Creek
Cedar River Watershed
90
0 1000 2000
Feet
FIG. 4C
Sheet 5 of 7


N
South Fork Snoqualmie River
90
Alternative B
Alternative D
Rattlesnake Mountain
Boxley Creek
Cedar River Watershed
Rattlesnake Lake
Cedar Falls
Percent Slope
0-15
15-40
40-65
>65
Note:
1. Slope derived from USGS 10-meter DEM- Tacoma and Snohomish 1:100,000 quadrangles.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-6
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 4C
Sheet 6 of 7



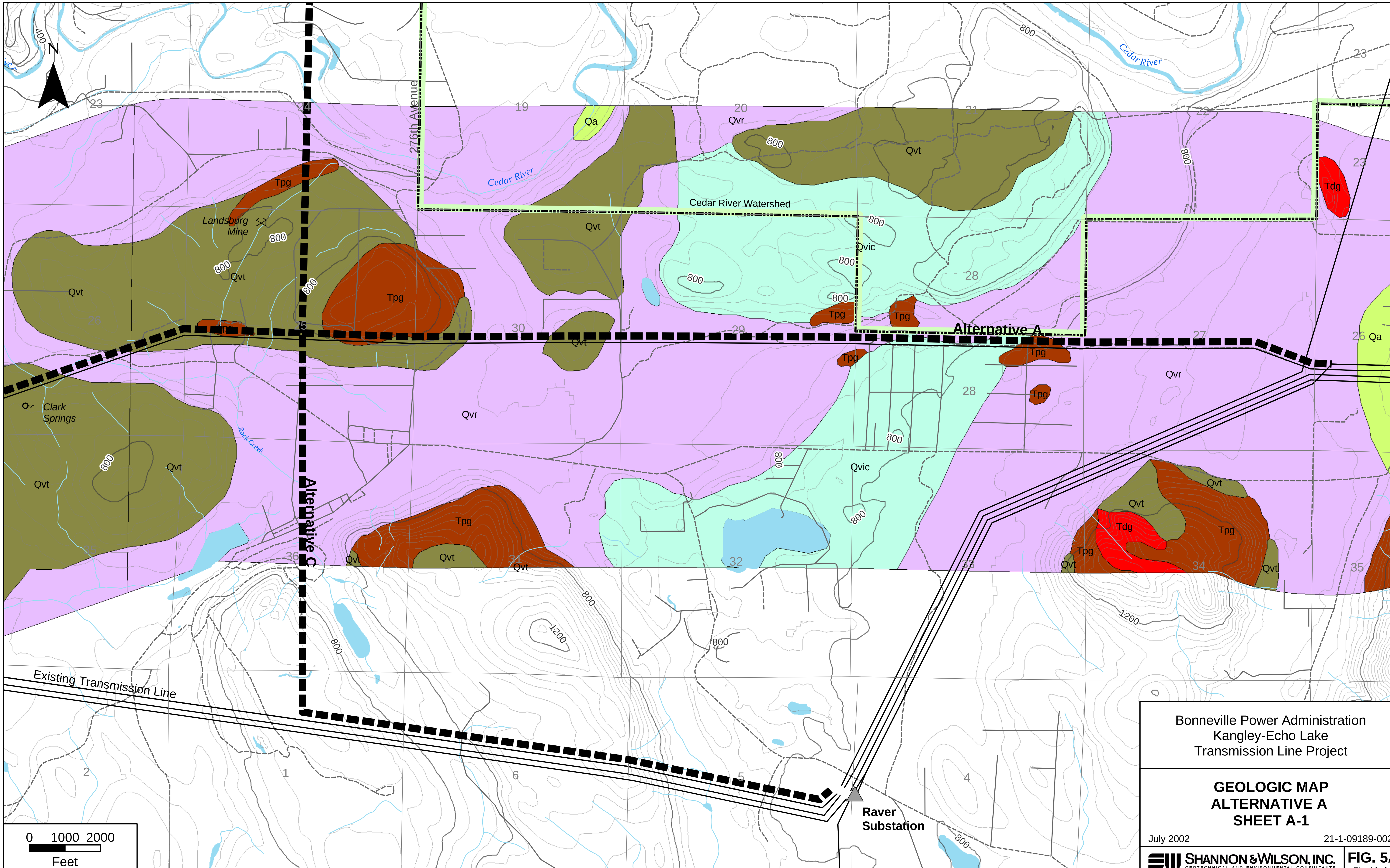
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

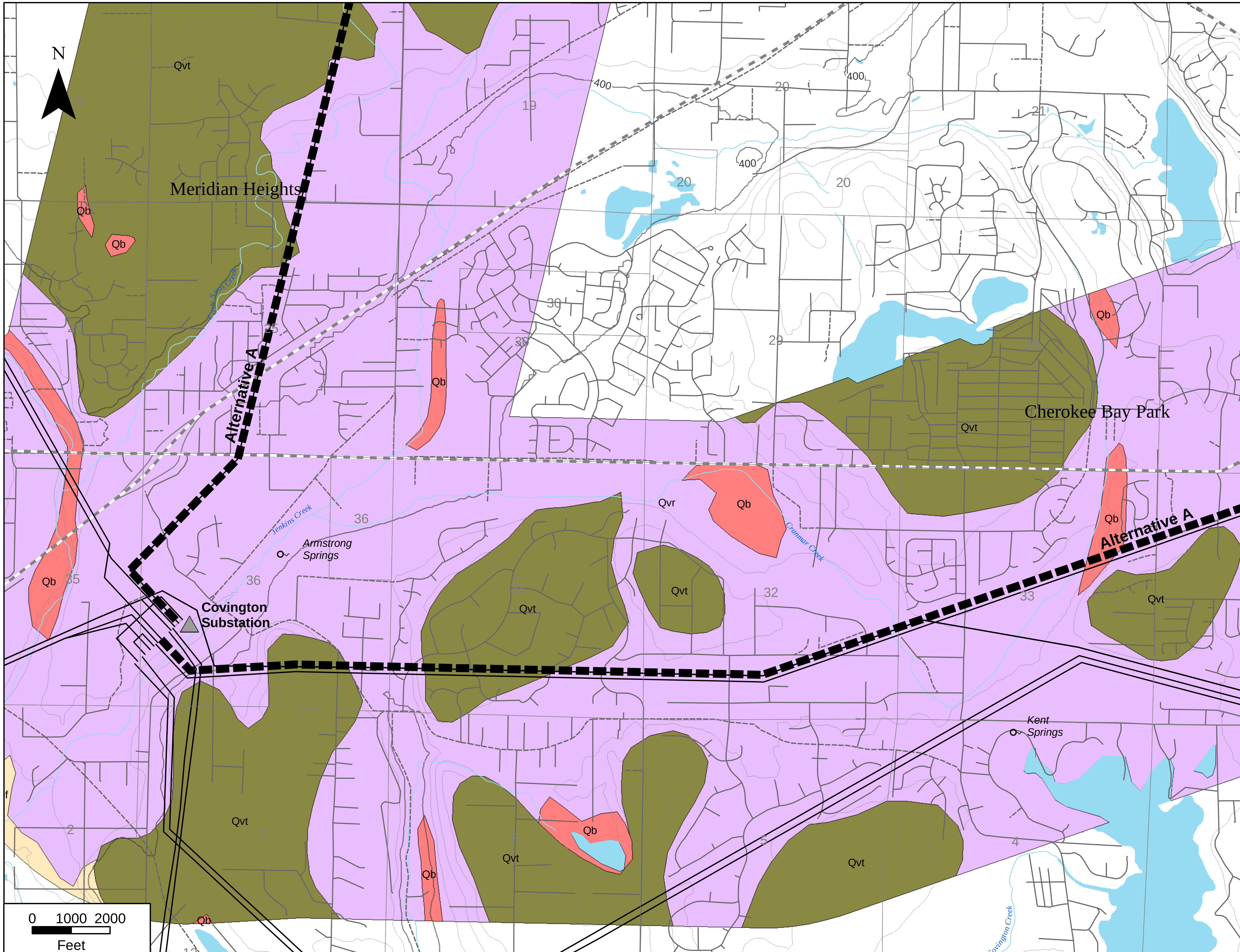
SLOPE MAP
ALTERNATIVE B & D
SHEET B/D-7

July 2002

21-1-09189-002

FIG. 4C
Sheet 7 of 7


N
Qvr
Qvt
Qa
Tpg
Tdg
Qvic
Cedar River
Cedar River Watershed
276th Avenue
Landsburg Mine
Clark Springs
Rock Creek
Alternative A
Alternative C
Existing Transmission Line
Raver Substation
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
GEOLOGIC MAP
ALTERNATIVE A
SHEET A-1
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 5A
Sheet 1 of 4



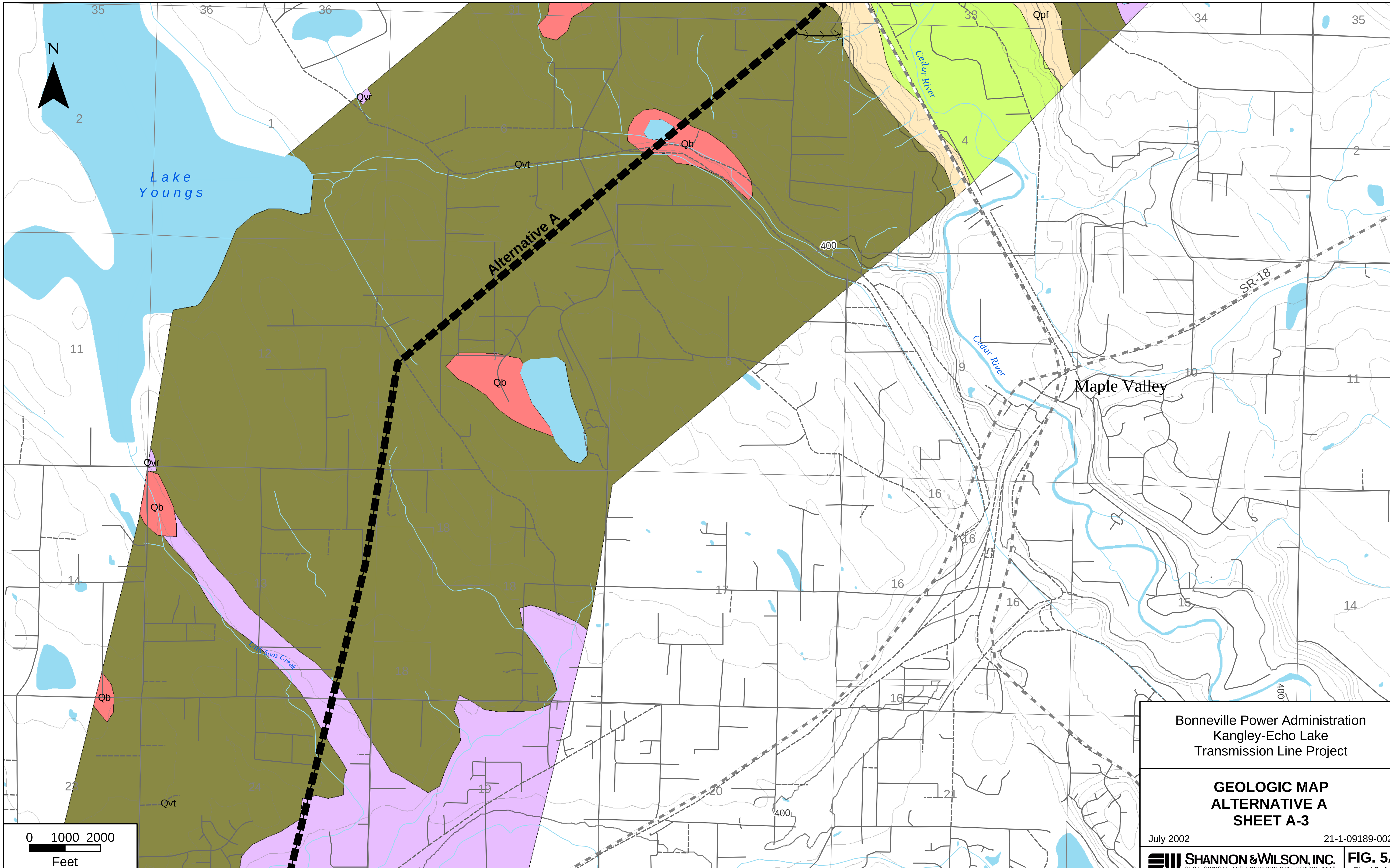
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE A
SHEET A-2

July 2002 21-1-09189-002

SHANNON & WILSON, INC. GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5A
Sheet 2 of 4



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

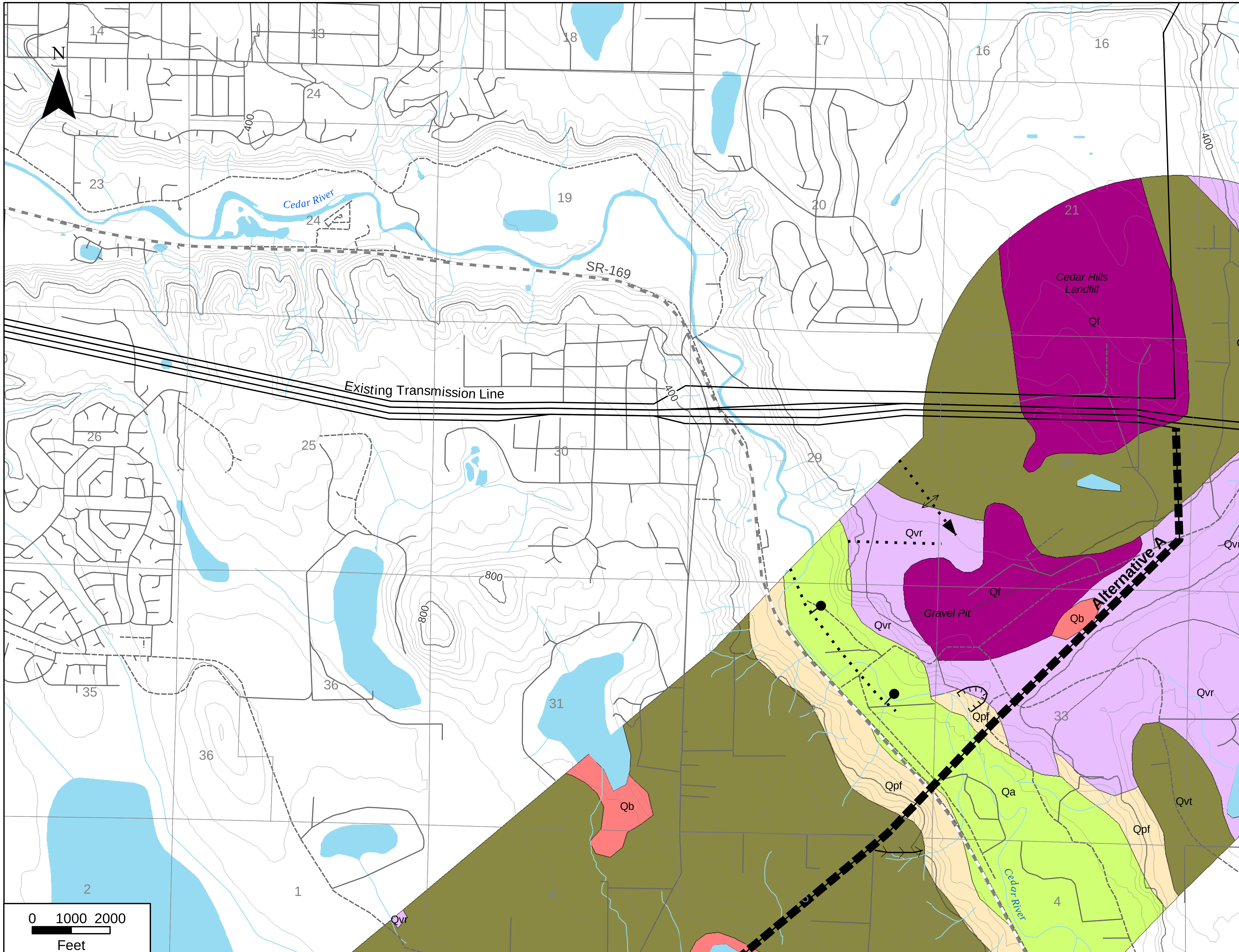
GEOLOGIC MAP
ALTERNATIVE A
SHEET A-3

July 2002

21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5A
Sheet 3 of 4



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

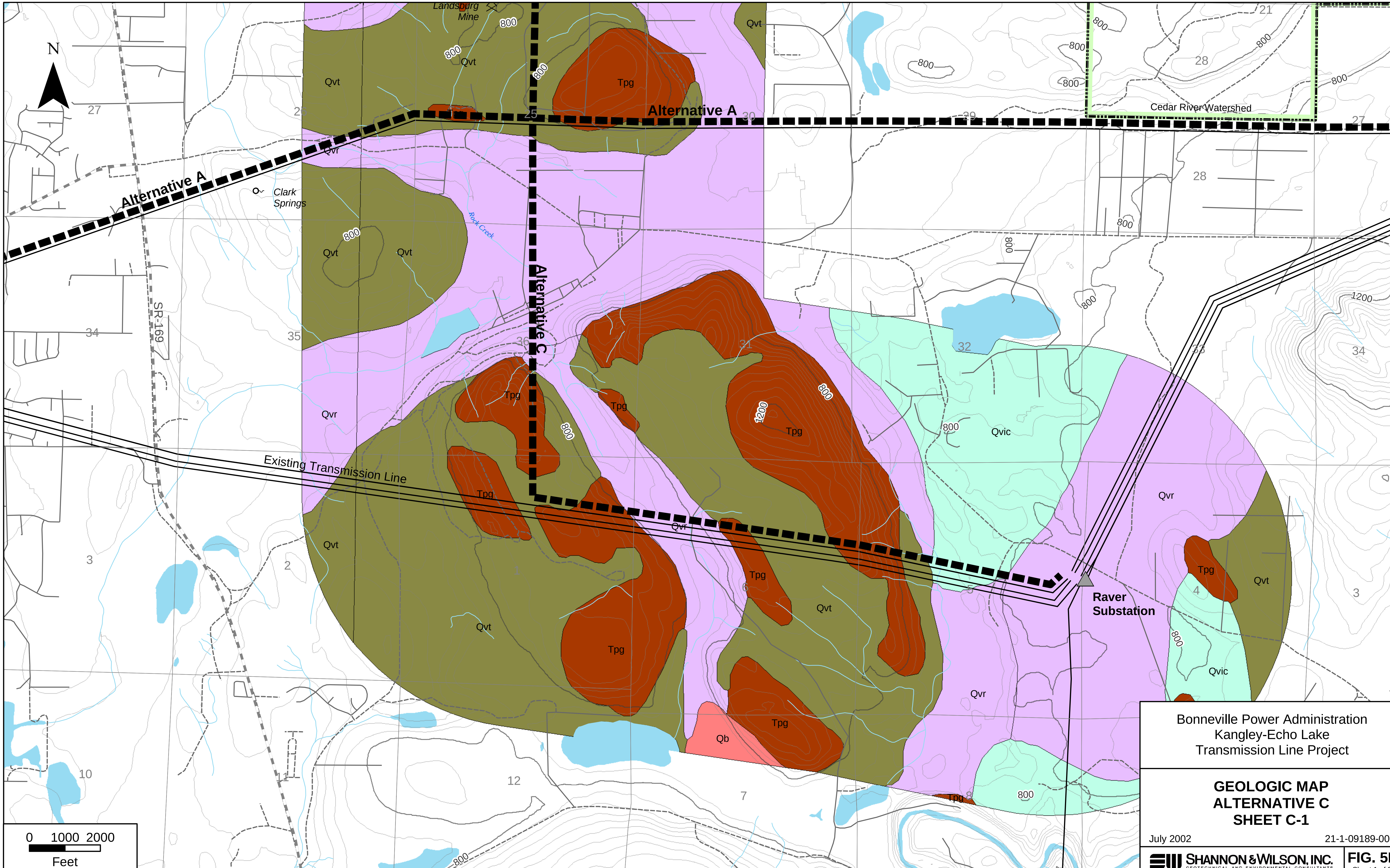
GEOLOGIC MAP
ALTERNATIVE A
SHEET A-4

July 2002

21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5A
Sheet 4 of 4



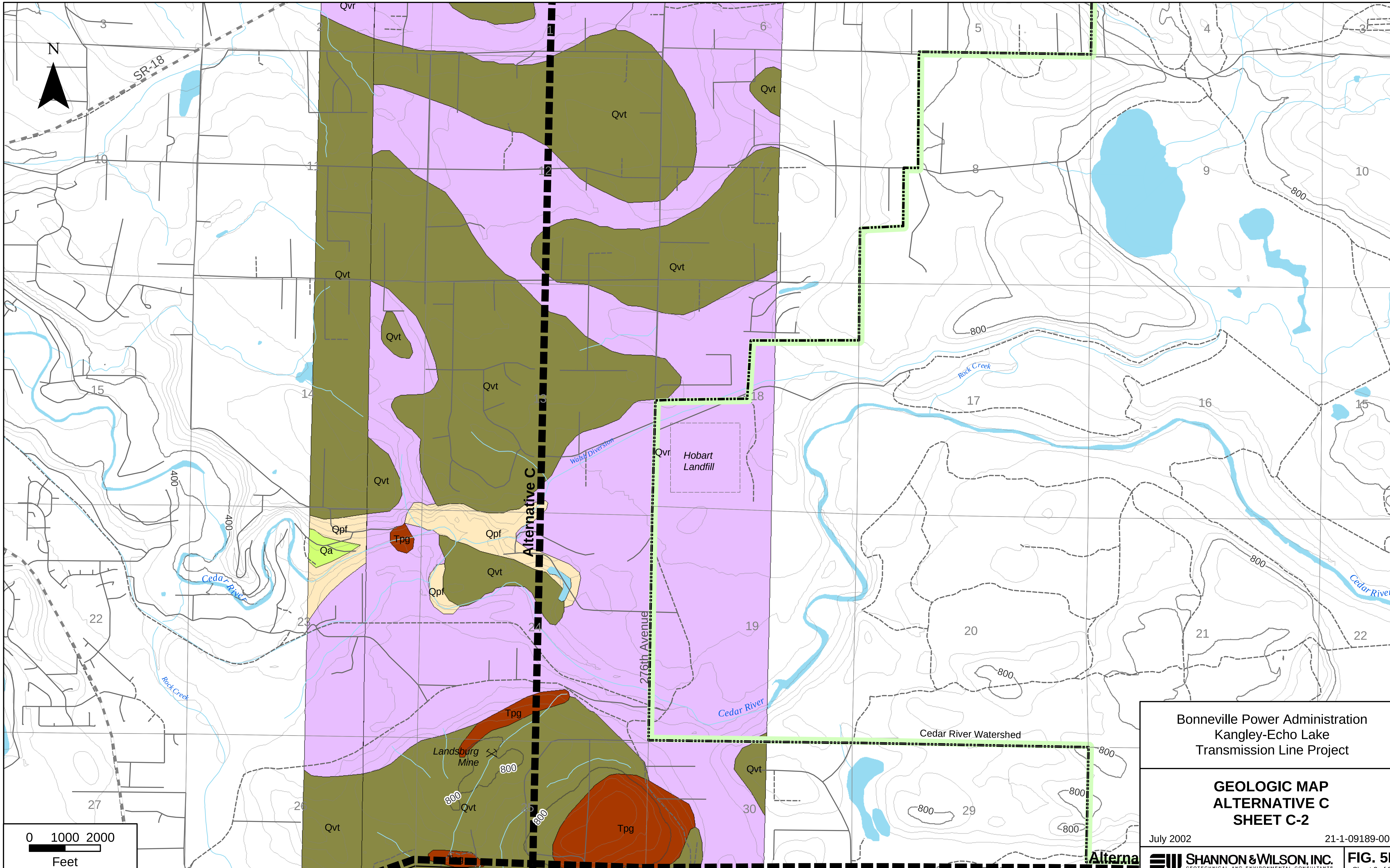
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

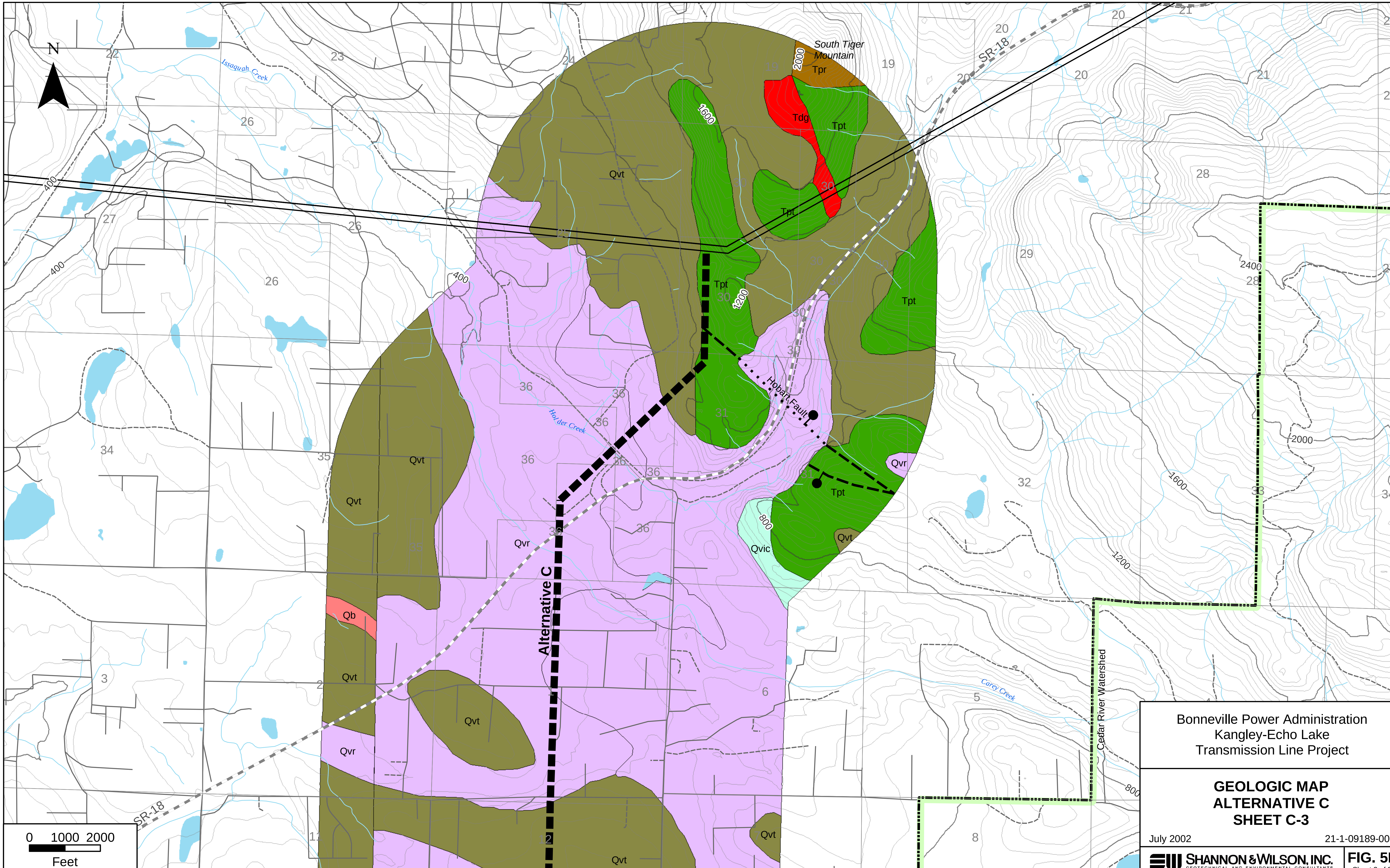
GEOLOGIC MAP
ALTERNATIVE C
SHEET C-1

July 2002 21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5B
Sheet 1 of 3


N
SR-18
Alternative C
276th Avenue
Qvr
Qvt
Qpf
Qa
Tpg
Hobart
Landfill
Landsburg
Mine
Walsh Diversion
Rock Creek
Cedar River
Cedar River Watershed
400
800
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
GEOLOGIC MAP
ALTERNATIVE C
SHEET C-2
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 5B
Sheet 2 of 3



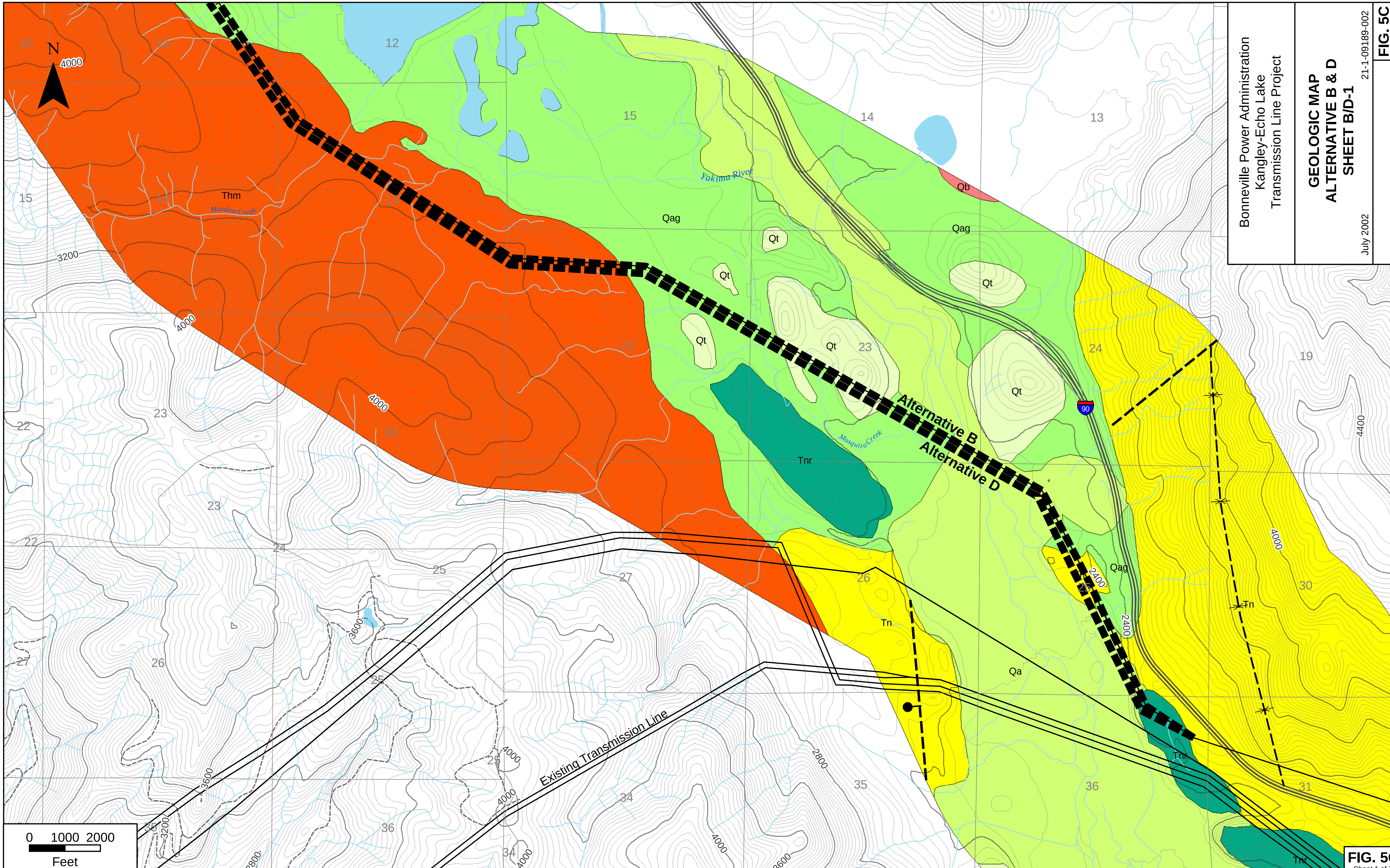
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE C
SHEET C-3

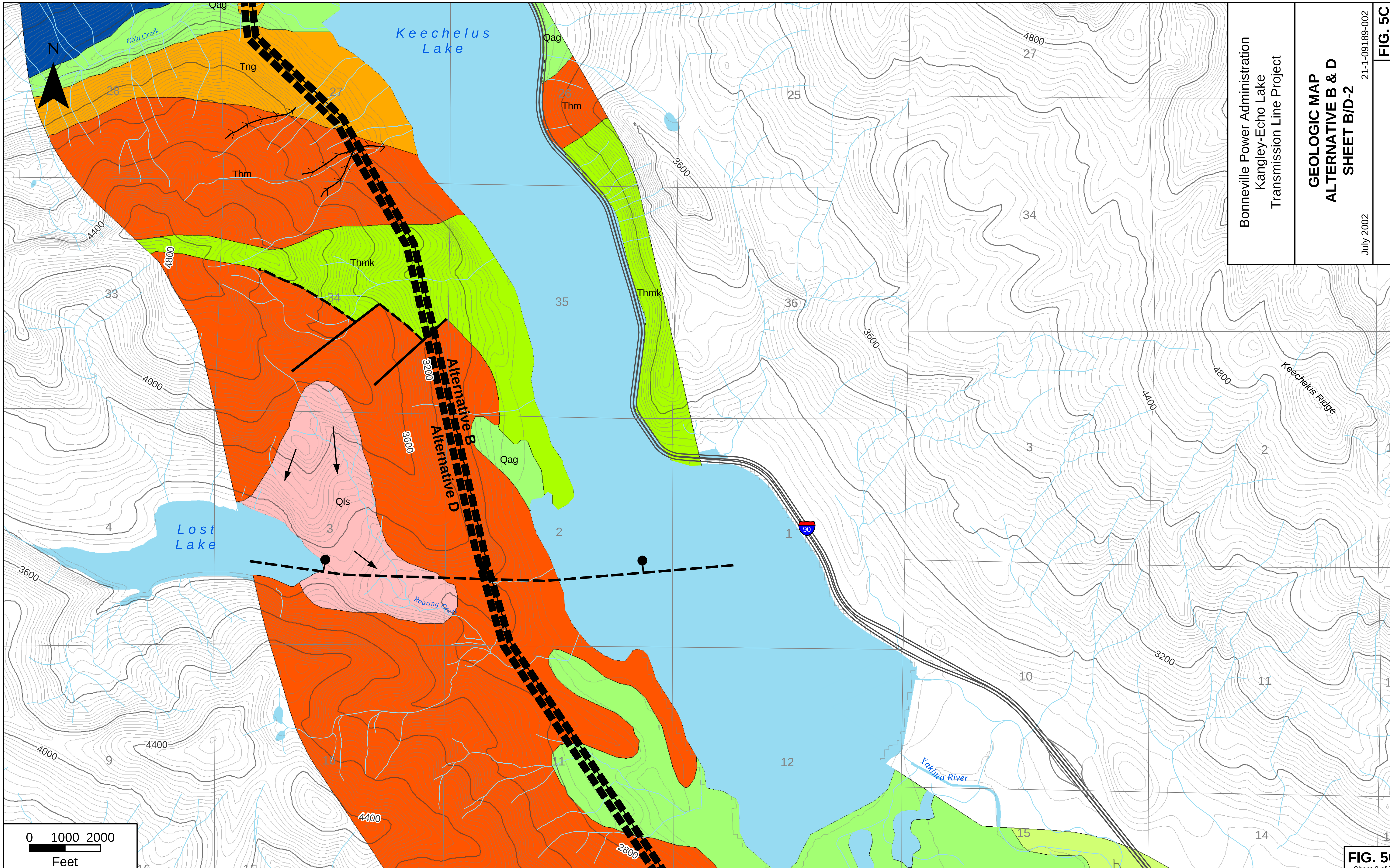
July 2002 21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5B
Sheet 3 of 3



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-1
July 2002
21-1-09189-002
FIG. 5C
Sheet 1 of 7
N
0 1000 2000
Feet
Alternative B
Alternative D
Existing Transmission Line
Yakima River
Meadow Creek
Mosquito Creek
Thm
Qag
Qt
Qb
Qa
Tnr
Tn
90



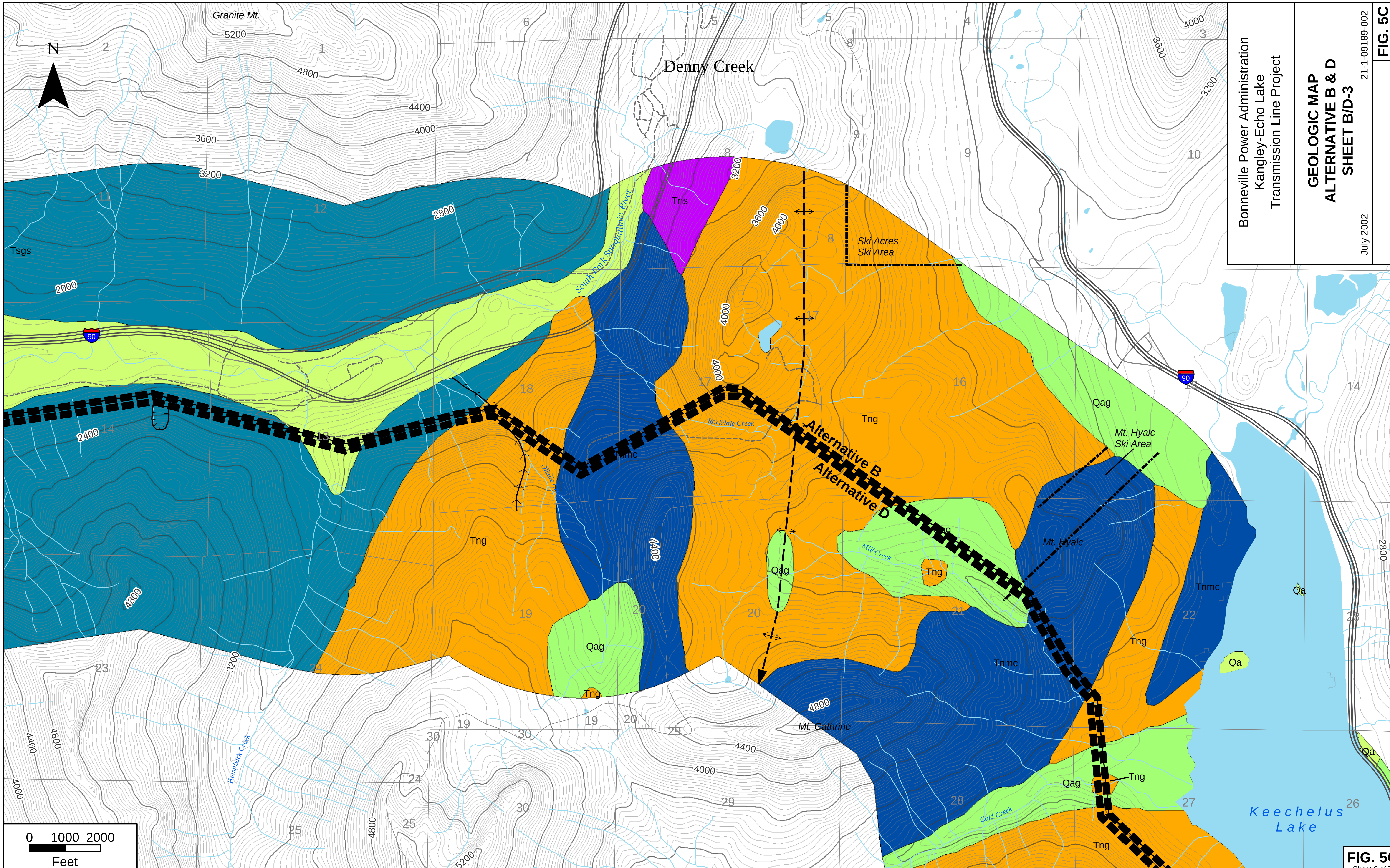
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-2

July 2002

21-1-09189-002

FIG. 5C
Sheet 2 of 7



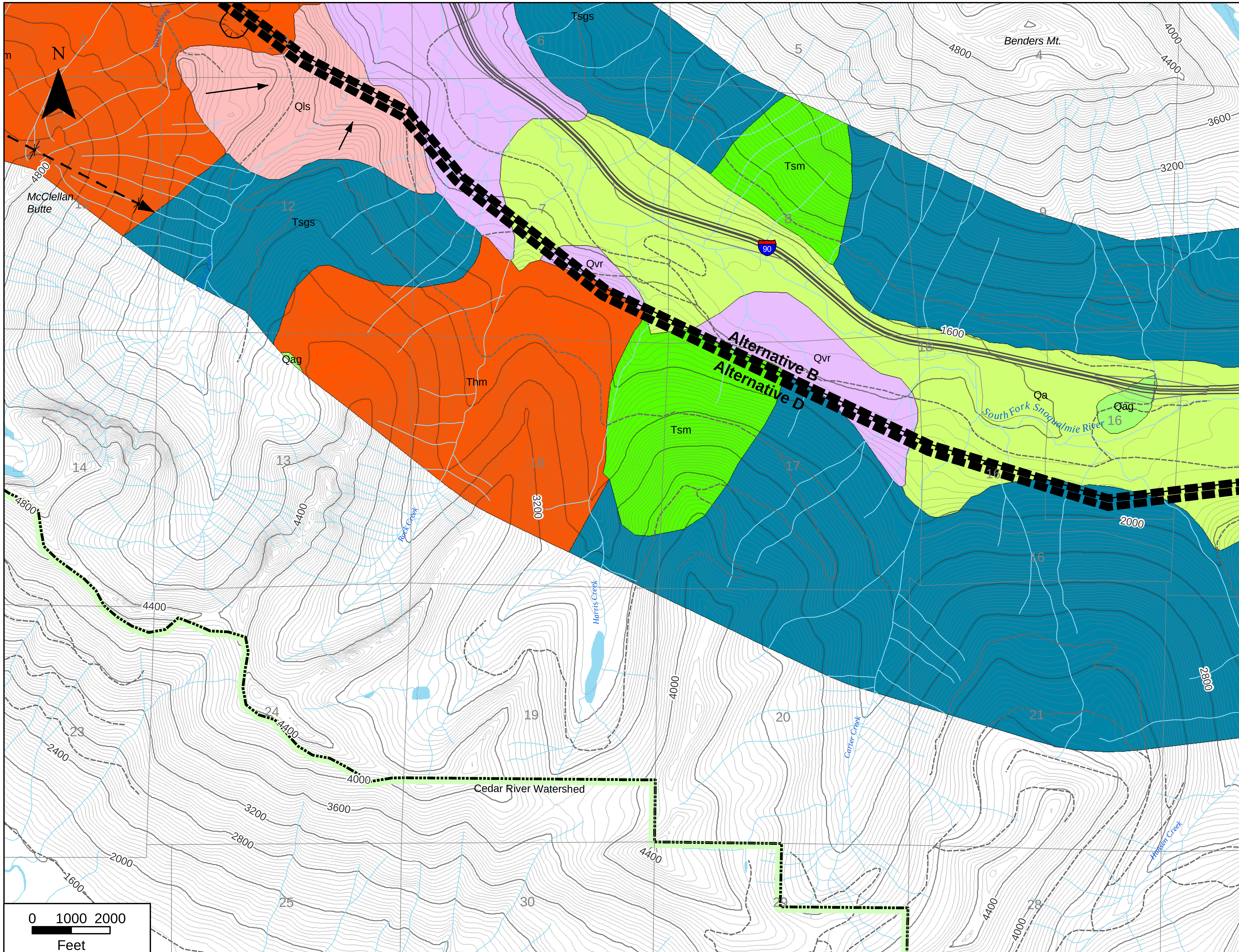
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-3

July 2002

21-1-09189-002

FIG. 5C
Sheet 3 of 7



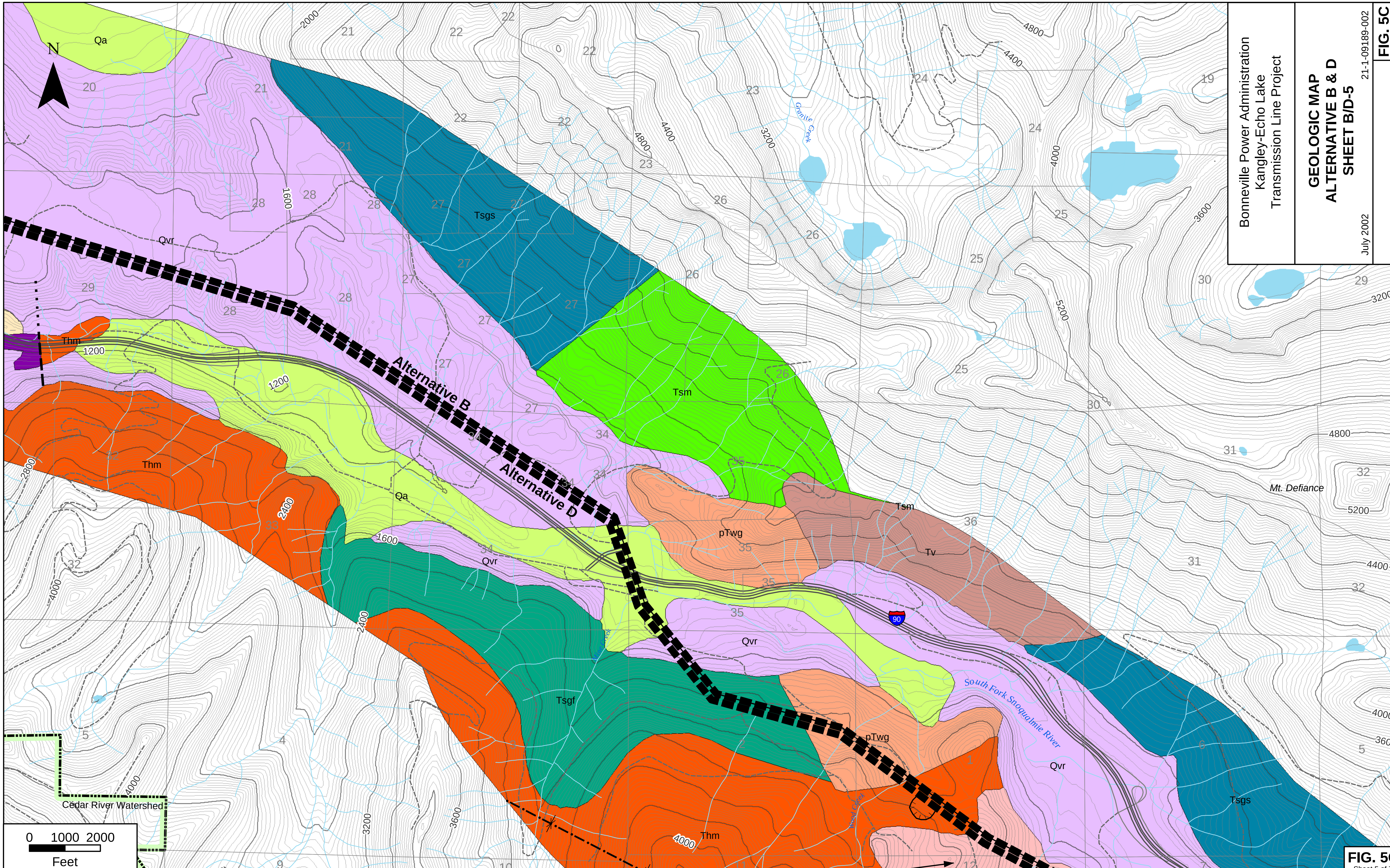
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-4

July 2002 21-1-09189-002

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5C
Sheet 4 of 7



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-5

July 2002

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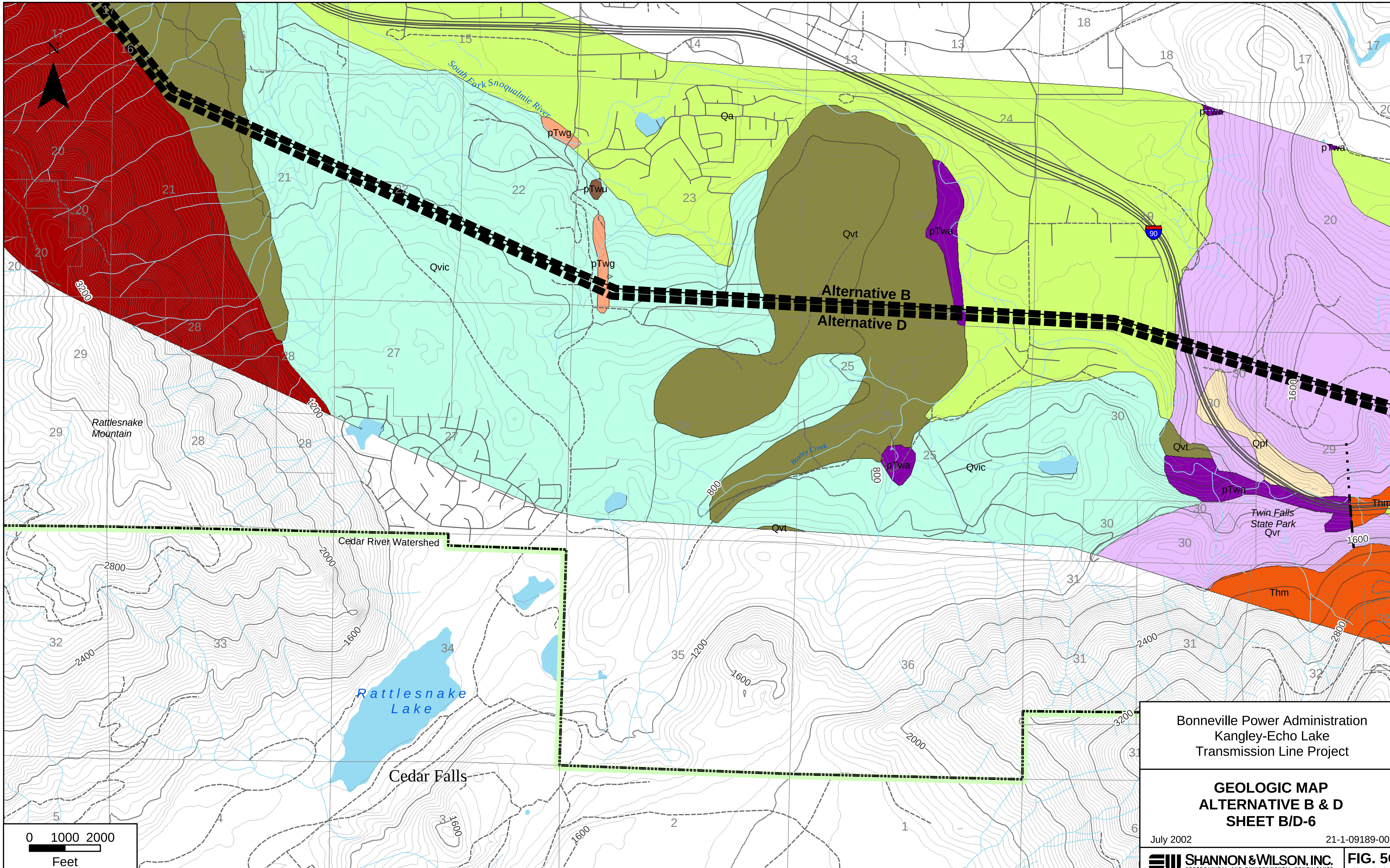
FIG. 5C
Sheet 5 of 7



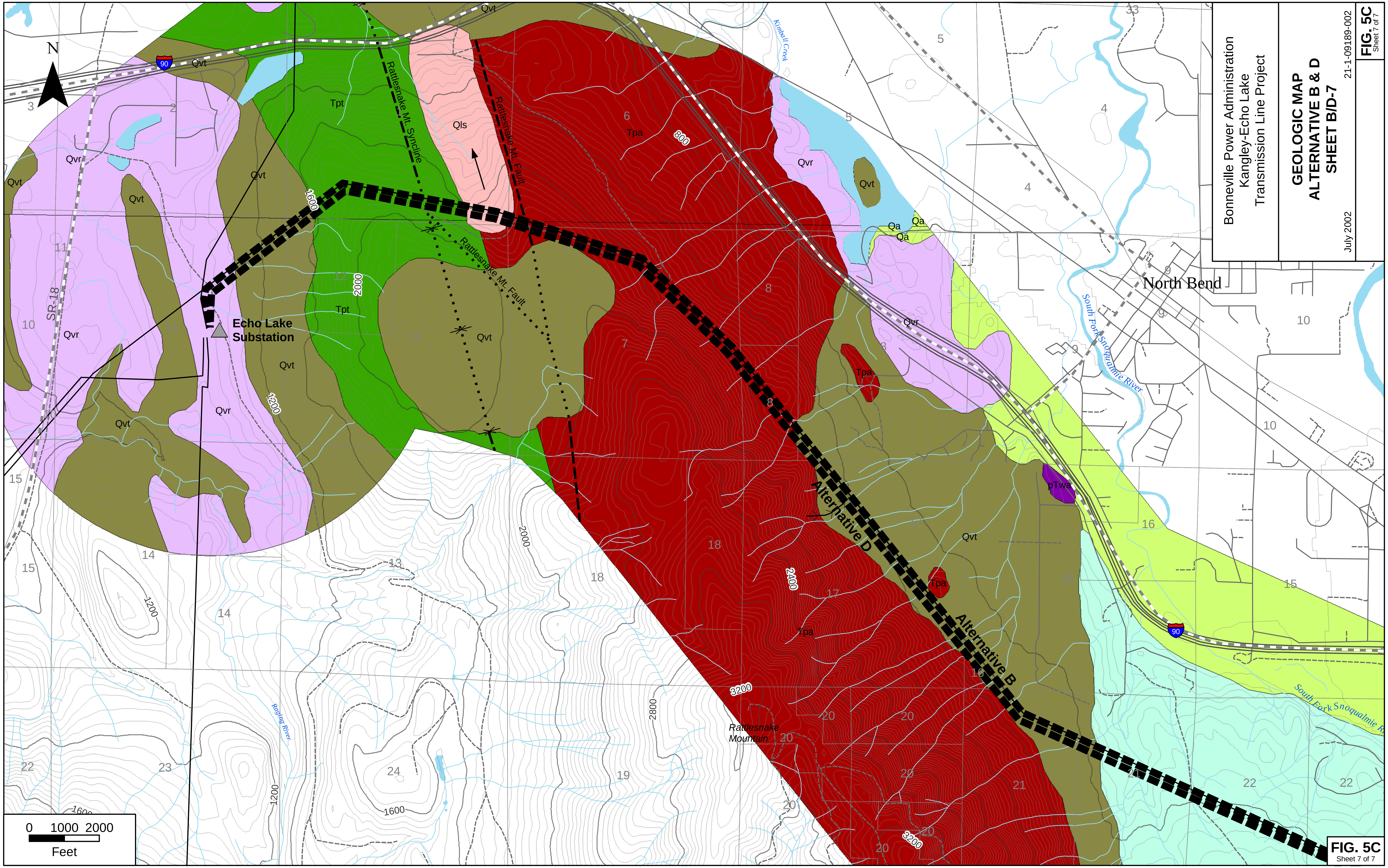
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

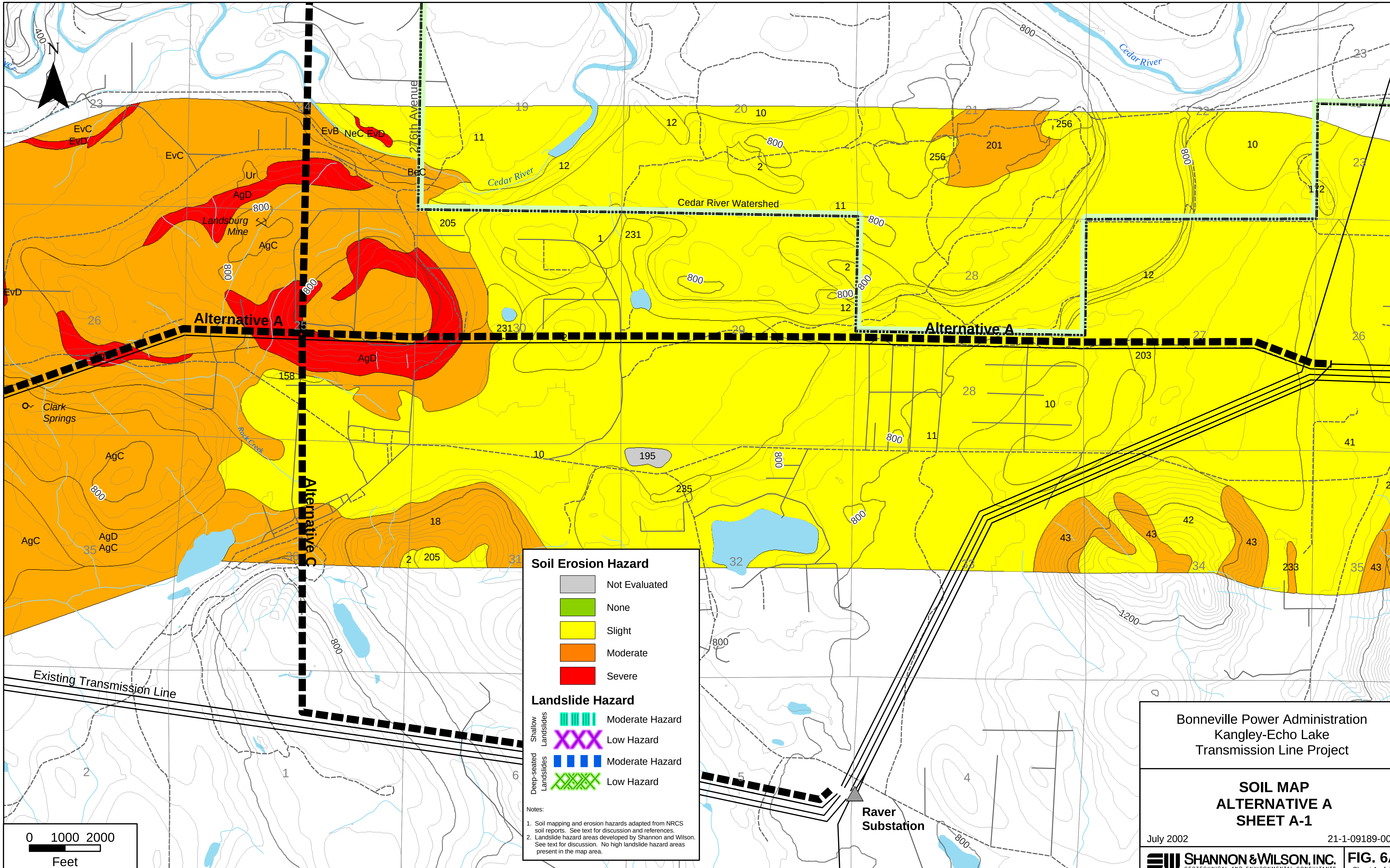
**GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-6**

July 2002 21-1-09189-002

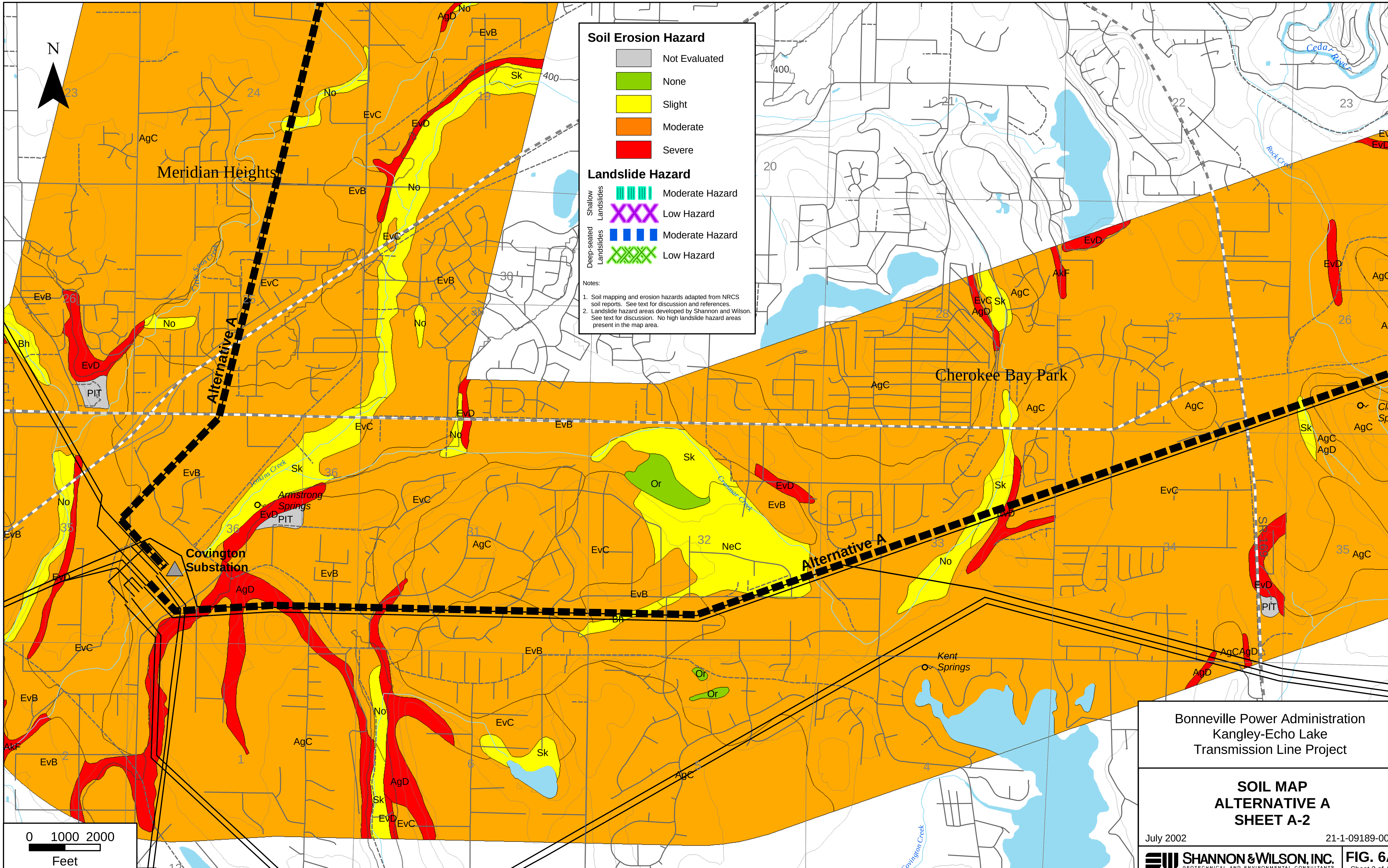
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 5C
Sheet 6 of 7

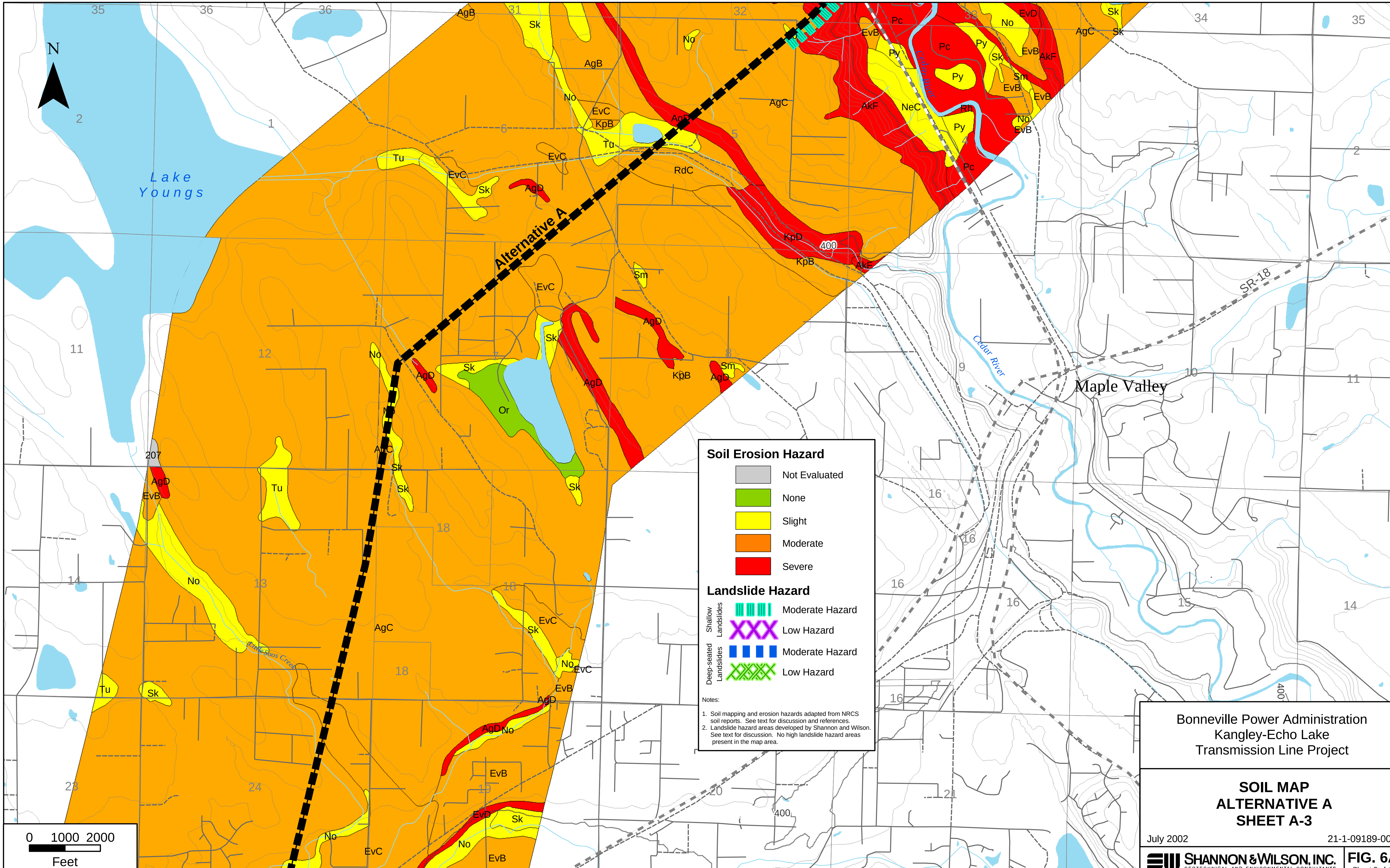

Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
GEOLOGIC MAP
ALTERNATIVE B & D
SHEET B/D-7
July 2002
21-1-09189-002
FIG. 5C
Sheet 7 of 7
N
Echo Lake
Substation
North Bend
Rattlesnake Mt. Syncline
Rattlesnake Mt. Fault
Alternative D
Alternative B
Rattlesnake
Mountain
SR-18
Kimball Creek
South Fork Snoqualmie River
Raging River
Qvt
Qvr
Tpt
Qls
Tpa
Qa
pTwa
0 1000 2000
Feet
FIG. 5C
Sheet 7 of 7



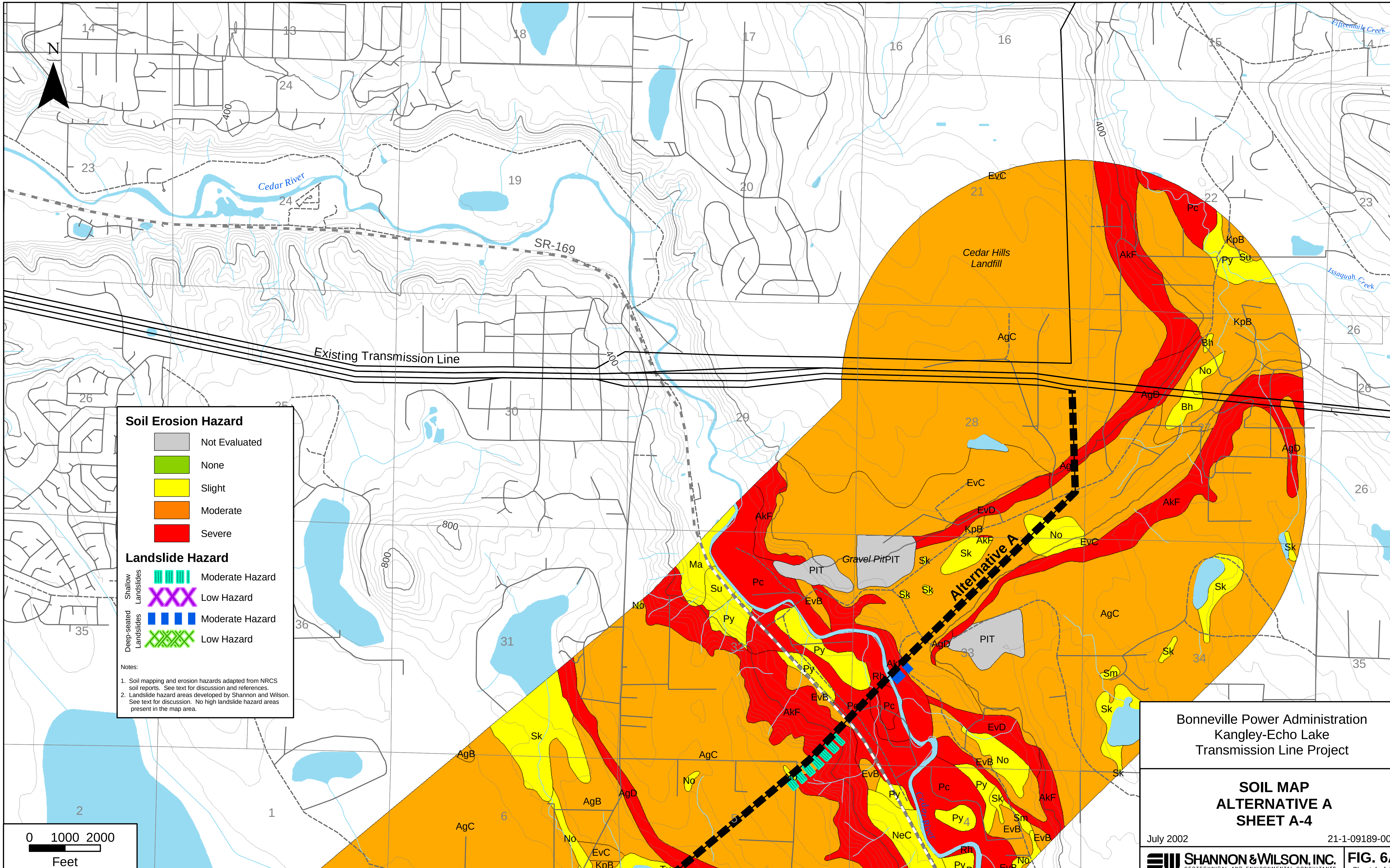
N
Alternative A
Alternative C
276th Avenue
Cedar River
Cedar River Watershed
Landsburg Mine
Clark Springs
Rock Creek
Existing Transmission Line
Raver Substation
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE A
SHEET A-1
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6A
Sheet 1 of 4

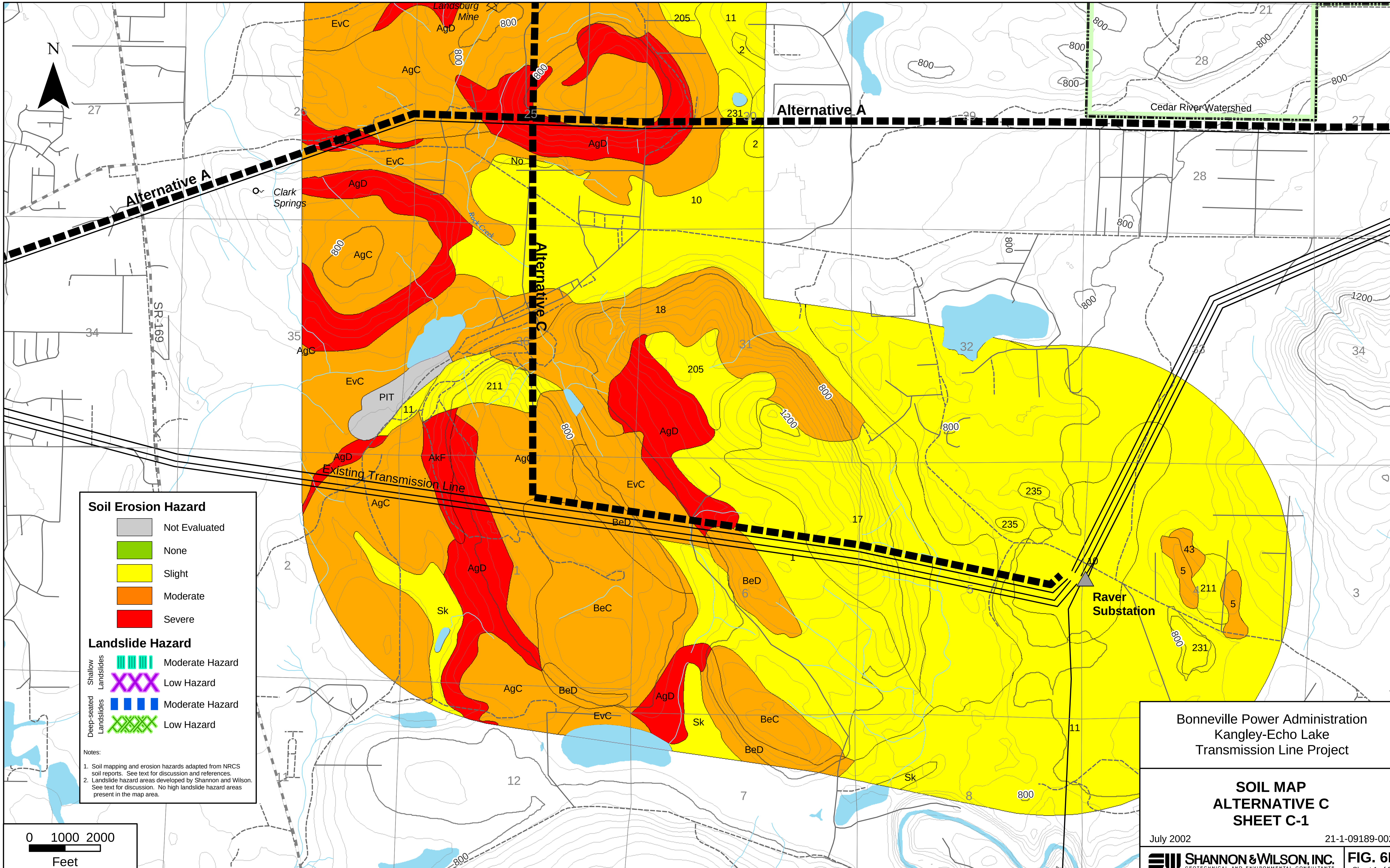


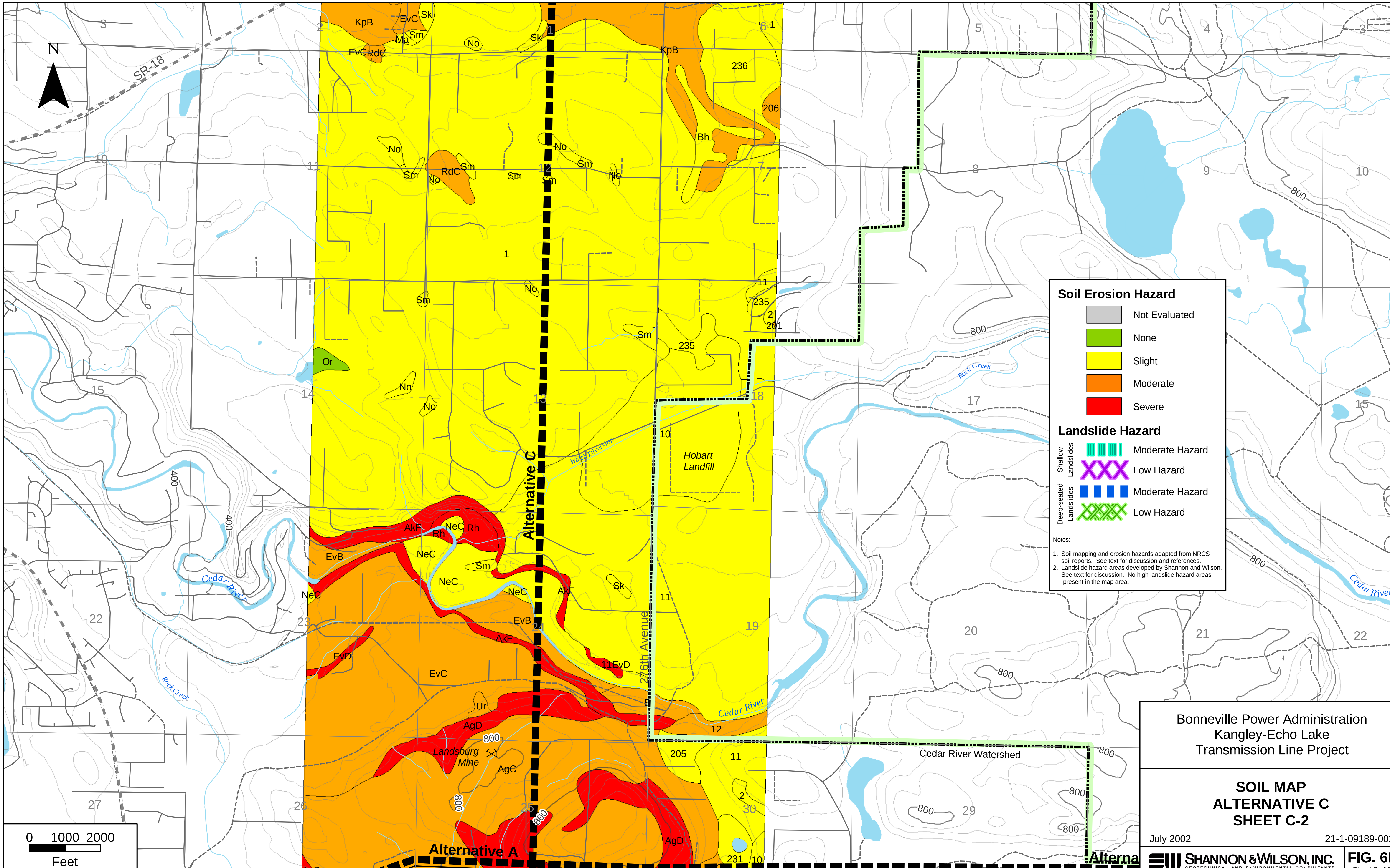
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
Meridian Heights
Cherokee Bay Park
Alternative A
Covington Substation
Armstrong Springs
Kent Springs
0 1000 2000
Feet
N
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE A
SHEET A-2
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6A
Sheet 2 of 4

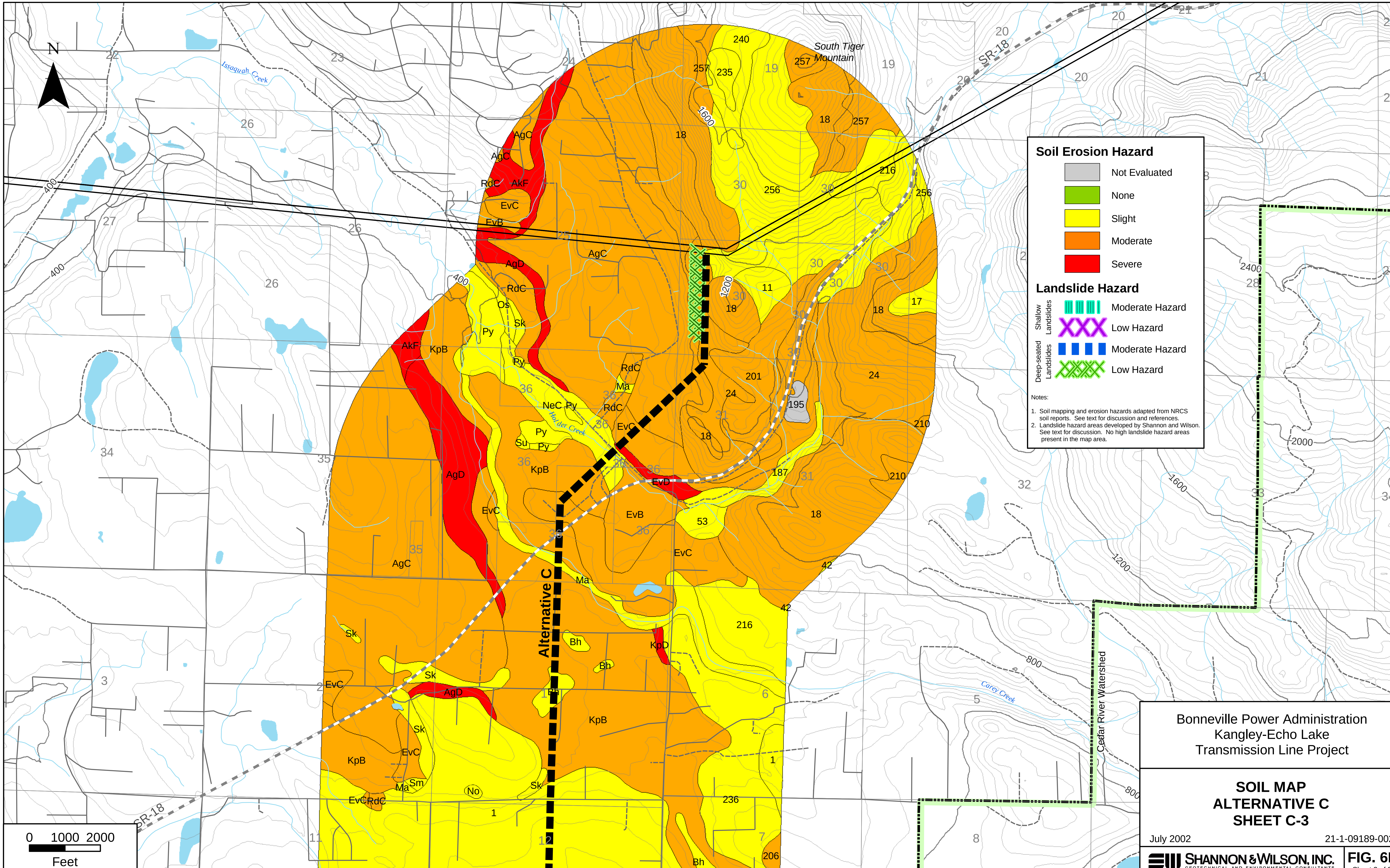


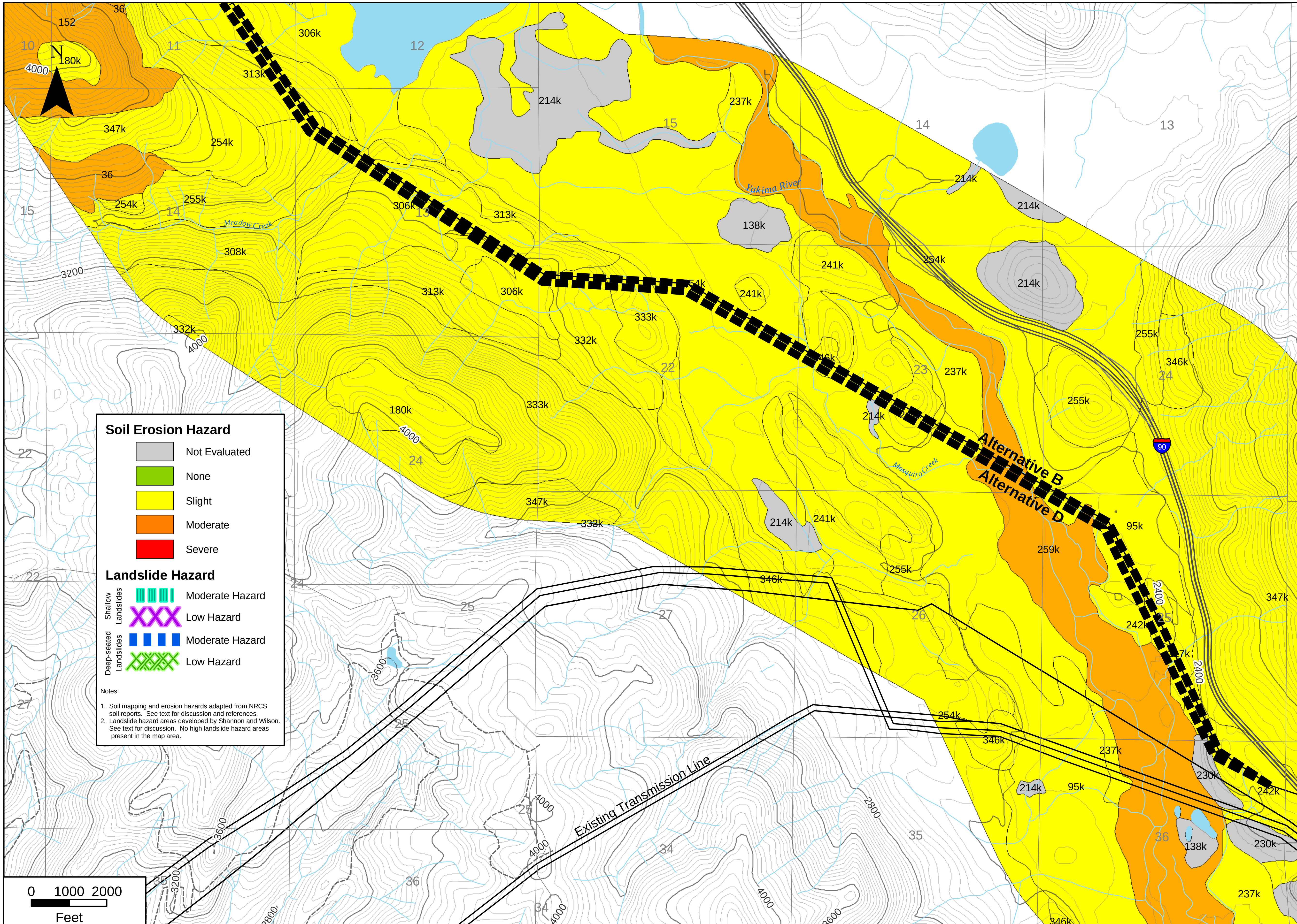
N
Lake Youngs
Alternative A
Maple Valley
Cedar River
SR-18
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE A
SHEET A-3
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6A
Sheet 3 of 4


N
Cedar River
SR-169
Existing Transmission Line
Cedar Hills Landfill
Gravel Pit
Alternative A
Issaquah Creek
Fifteenmile Creek
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE A
SHEET A-4
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6A
Sheet 4 of 4


N
Alternative A
Alternative C
Existing Transmission Line
Clark Springs
Landsburg Mine
Rock Creek
SR-169
Raver Substation
Cedar River Watershed
PIT
AgC
AgD
AkF
BeC
BeD
EvC
Sk
No
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE C
SHEET C-1
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6B
Sheet 1 of 3


N
SR-18
Alternative C
Alternative A
276th Avenue
Hobart Landfill
Landsburg Mine
Cedar River
Rock Creek
Cedar River Watershed
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE C
SHEET C-2
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6B
Sheet 2 of 3


N
South Tiger Mountain
Issaquah Creek
Holder Creek
Carey Creek
SR-18
Alternative C
Cedar River Watershed
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE C
SHEET C-3
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6B
Sheet 3 of 3



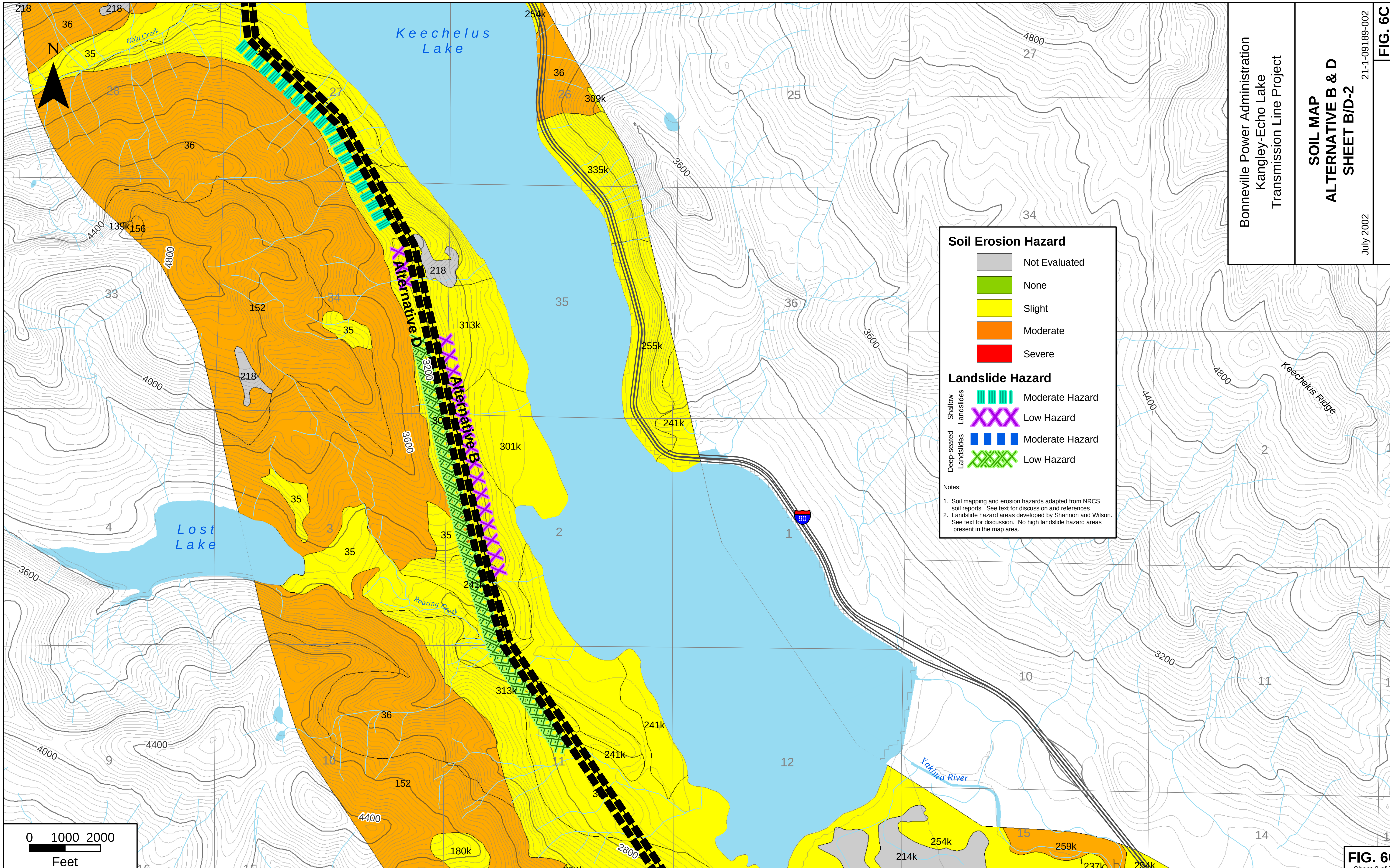
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

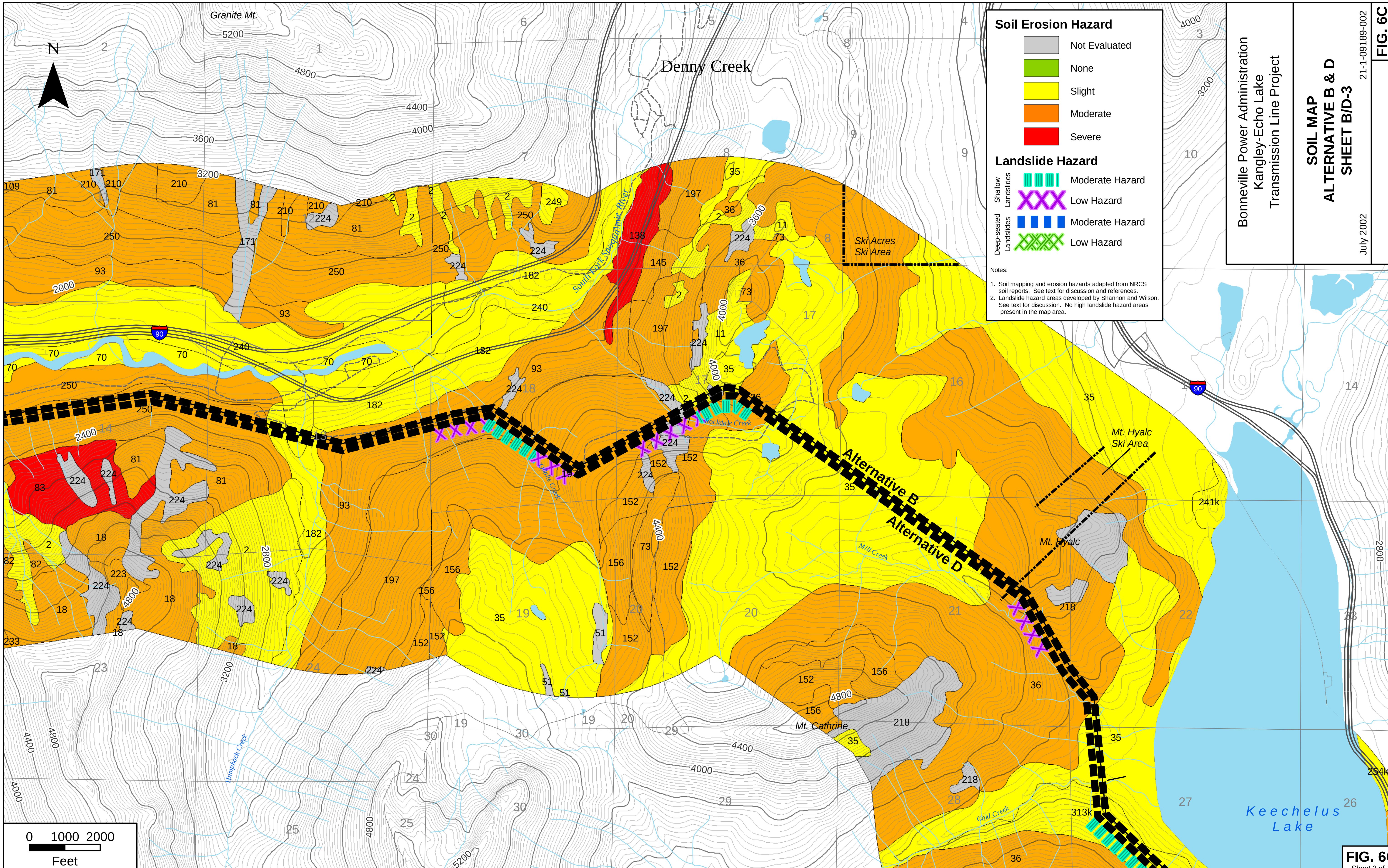
SOIL MAP
ALTERNATIVE B & D
SHEET B/D-1

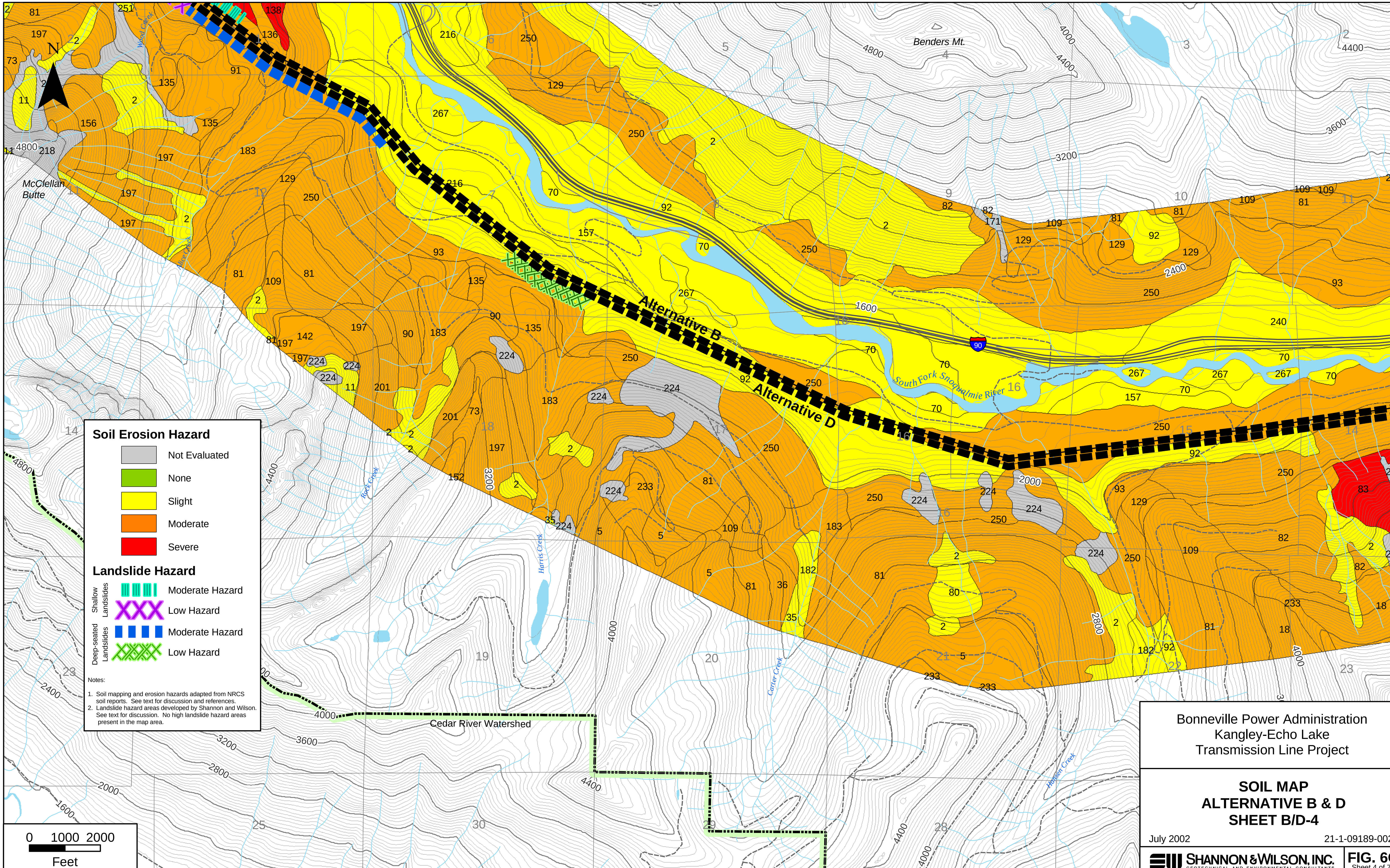
July 2002

21-1-09189-002

FIG. 6C
Sheet 1 of 7


Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE B & D
SHEET B/D-2
July 2002
21-1-09189-002
FIG. 6C
Sheet 2 of 7
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
Keechelus Lake
Lost Lake
Cold Creek
Roaring Creek
Yakima River
Keechelus Ridge
Alternative D
Alternative B
N
0 1000 2000
Feet
FIG. 6C
Sheet 2 of 7


Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE B & D
SHEET B/D-3
21-1-09189-002
July 2002
FIG. 6C
Sheet 3 of 7
N
Granite Mt.
Denny Creek
South Fork Snoqualmie River
Ski Acres
Ski Area
Rockdale Creek
Alternative B
Alternative D
Mill Creek
Mt. Hyalc
Ski Area
Mt. Hyalc
Mt. Cathrine
Humpback Creek
Cold Creek
Keechelus
Lake
0 1000 2000
Feet
FIG. 6C
Sheet 3 of 7



Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project

SOIL MAP
ALTERNATIVE B & D
SHEET B/D-4

July 2002

21-1-09189-002

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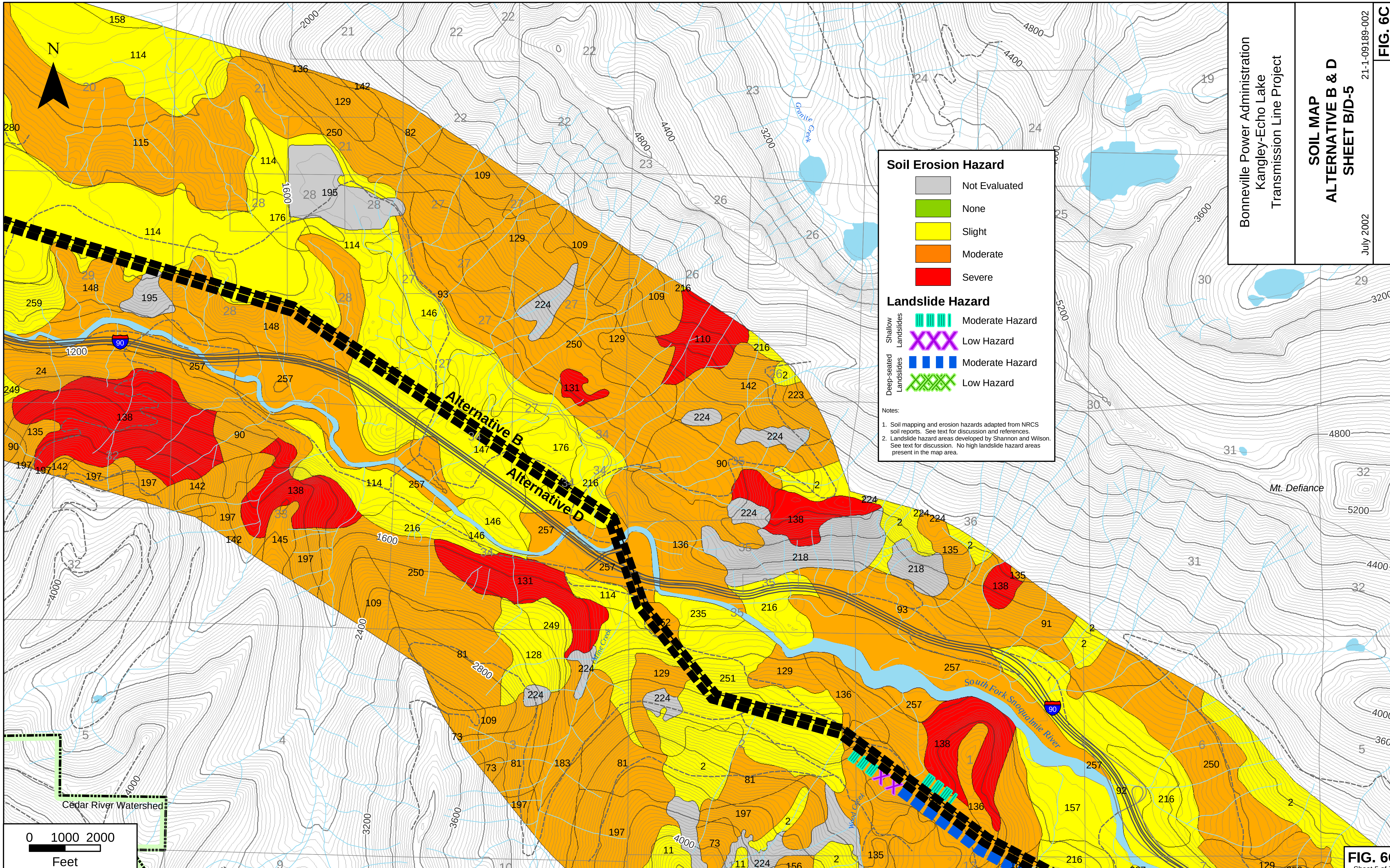
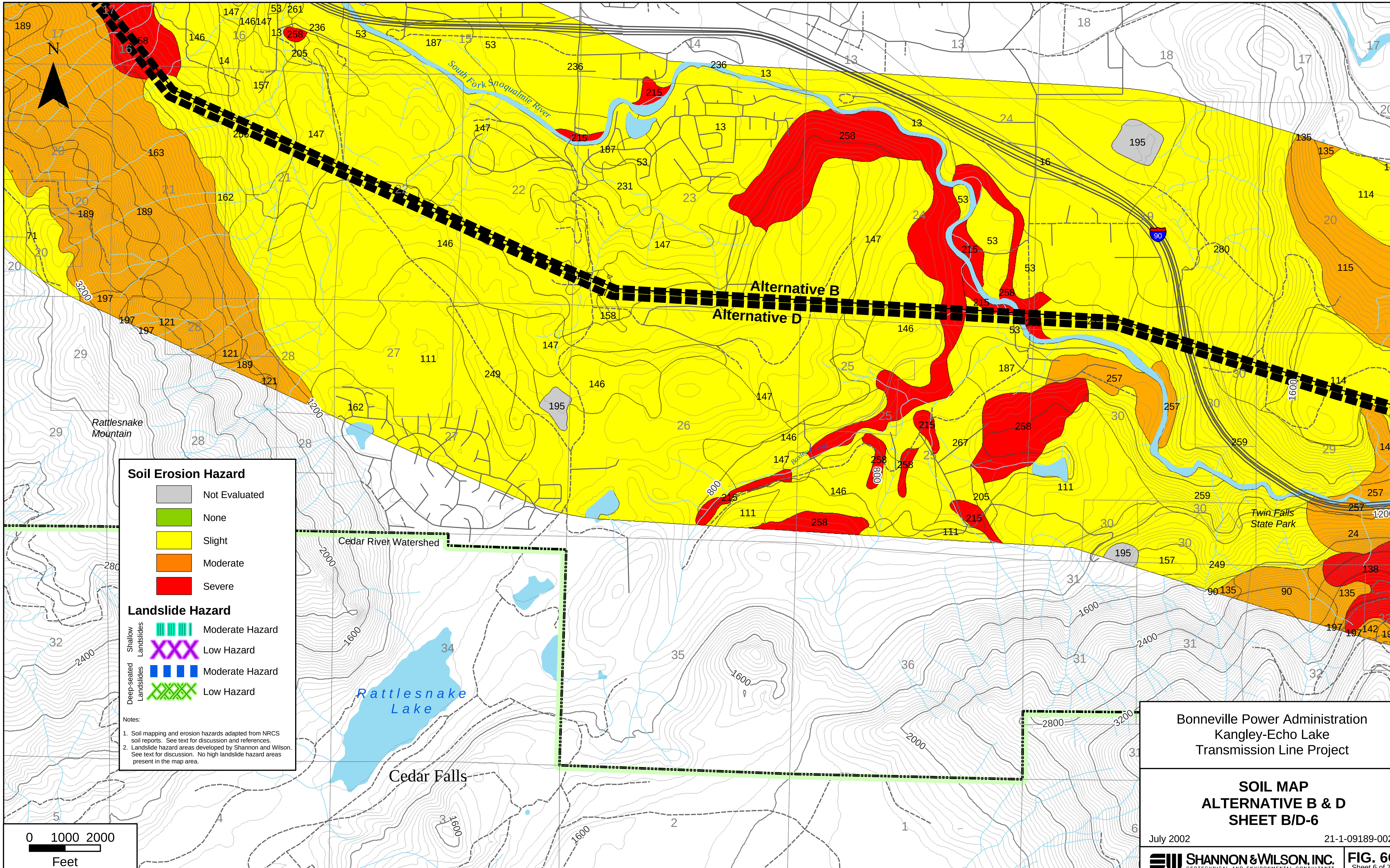
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

FIG. 6C
Sheet 4 of 7



Bonneville Power Administration
Kangley-Echo Lake Transmission Line Project
SOIL MAP
ALTERNATIVE B & D
SHEET B/D-5
July 2002
21-1-09189-002
FIG. 6C
Sheet 5 of 7
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
N
Alternative B
Alternative D
South Fork Snoqualmie River
Mt. Defiance
Cedar River Watershed
Granite Creek
0 1000 2000
Feet
FIG. 6C
Sheet 5 of 7



N
Alternative B
Alternative D
South Fork Snoqualmie River
Rattlesnake Mountain
Cedar River Watershed
Rattlesnake Lake
Cedar Falls
Twin Falls State Park
Soil Erosion Hazard
Not Evaluated
None
Slight
Moderate
Severe
Landslide Hazard
Shallow Landslides
Moderate Hazard
Low Hazard
Deep-seated Landslides
Moderate Hazard
Low Hazard
Notes:
1. Soil mapping and erosion hazards adapted from NRCS soil reports. See text for discussion and references.
2. Landslide hazard areas developed by Shannon and Wilson. See text for discussion. No high landslide hazard areas present in the map area.
0 1000 2000
Feet
Bonneville Power Administration
Kangley-Echo Lake
Transmission Line Project
SOIL MAP
ALTERNATIVE B & D
SHEET B/D-6
July 2002
21-1-09189-002
SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
FIG. 6C
Sheet 6 of 7

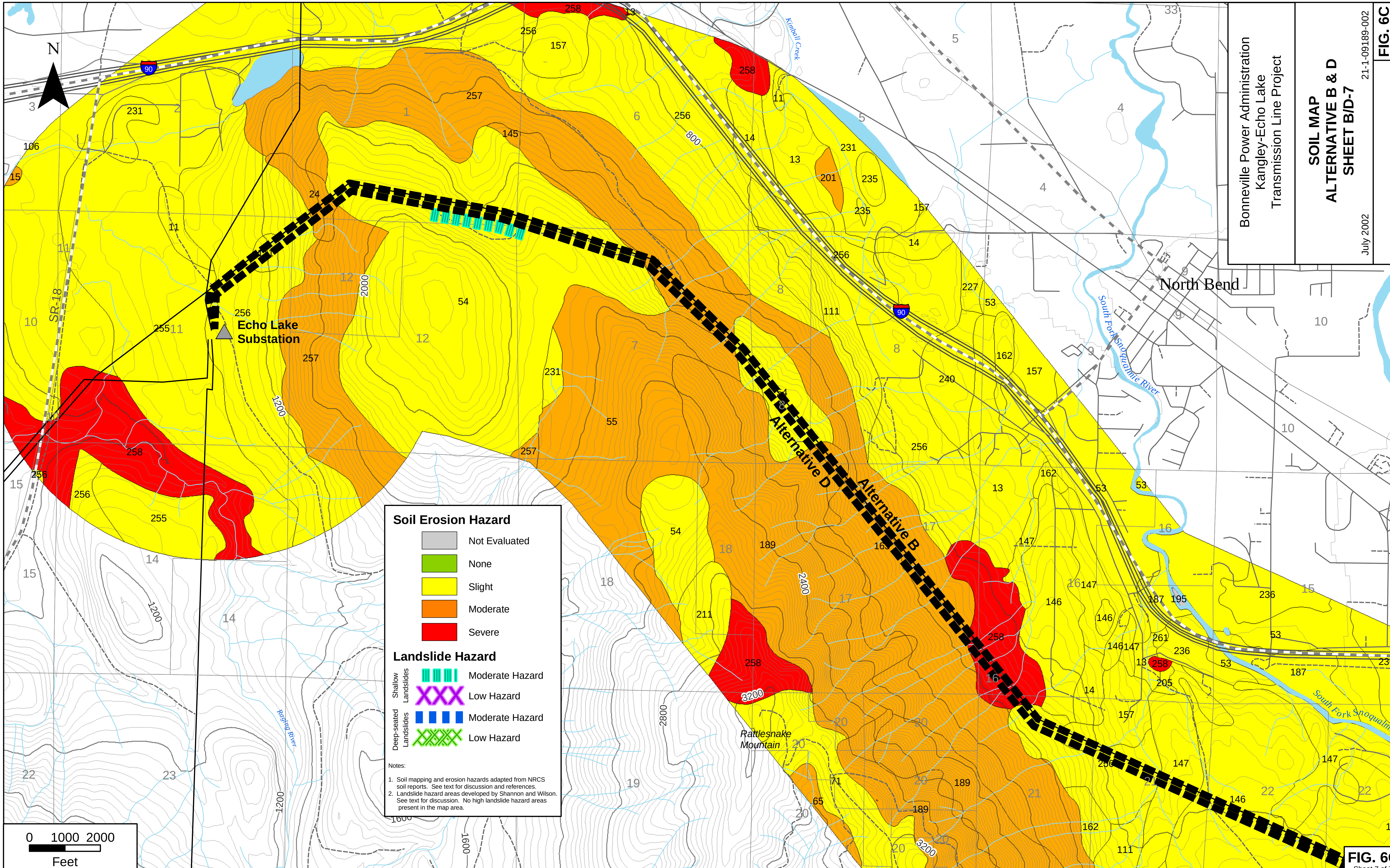


FIG. 6C
Sheet 7 of 7

APPENDIX

IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL REPORT

Appendix G Assessment of Research Regarding EMF and Health Effects

KANGLEY – ECHO LAKE PROJECT

APPENDIX G

ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH EFFECTS

January 2001

Prepared by

Exponent™

and

T. Dan Bracken, Inc.

for

Bonneville Power Administration

Table of Contents

ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH

1.0 Introduction

Numerous scientific studies have been designed to determine whether exposure to power-frequency electric and magnetic fields (EMF) at 50/60 hertz (Hz) is a cause of cancer or has other detrimental effects on health. Research on this topic developed 30 years ago, but gained momentum after 1979, with the publication of results from epidemiology studies of people exposed to fields from the power lines that bring electricity into their residences. Those studies suggested that childhood cancer occurred more often in those who lived in homes where the power lines outside were presumed to carry higher currents.

The results of these epidemiology studies prompted additional research, both epidemiology and laboratory studies. This research has focused on magnetic fields because electric fields from external sources are shielded by conductive materials such as buildings, fences, and trees. As a result, there is little opportunity for long-term human exposure to electric fields from power lines, and electric fields are presumed to be an unlikely explanation for the associations with long-term health effects reported in the epidemiology studies.

In 1998, the National Institute of Environmental Health Sciences (NIEHS) completed a comprehensive review of research on health effects of EMF. The NIEHS had been managing a research program that was funded by Congress in 1996, in response to questions that had been raised regarding exposure to EMF from power sources. The program was known as the RAPID Program (Research and Public Information Dissemination Program). The NIEHS convened a panel of scientists known as the Working Group to review and evaluate the RAPID Program research and other research conducted. Their report, Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields, was completed in July 1998 (NIEHS, 1998).

The purpose of this report is to update the conclusions of the NIEHS, and to review the more recent major research studies published after the NIEHS report was completed. This update concentrates on the recent major research studies, to explain how they contribute to the assessment of effects of EMF on health. As in the previous RAPID report, the focus is on both epidemiologic and laboratory research, because each is pertinent for determining whether an environmental exposure can affect human health.

2.0 Update of the NIEHS Report and the RAPID Program

The NIEHS report (1998) was one of the end results of the RAPID program. Subsequently, the director of the NIEHS prepared a health risk assessment of EMF and submitted his report to Congress in June 1999 (NIEHS, 1999). Experts at NIEHS, who had considered the previous Working Group report, reports from four technical workshops, and research that became available after June 1998, concluded as follows:

> The scientific evidence suggesting that ELF-EMF [extremely low frequency-electric and magnetic field] exposures pose any health risk is weak. The strongest evidence for health effects comes from associations observed in human populations with two forms of cancer: childhood leukemia and chronic lymphocytic leukemia in occupationally exposed adults …. In contrast, the mechanistic studies and animal toxicology literature fail to demonstrate any consistent pattern…No indication of increased leukemias in experimental animals has been observed….The lack of consistent, positive findings in

> animal or mechanistic studies weakens the belief that the association is actually due to ELF-EMF, but it cannot completely discount the epidemiology findings….The NIEHS does not believe that other cancers or other non-cancer health outcomes provide sufficient evidence of a risk to currently warrant concern (pp. 9-10).

Although the results of the RAPID research are described in some detail in the 1998 report, many of the studies had not been published in the peer-reviewed literature. Recognizing the need to have these results reviewed and considered for publication, the NIEHS arranged for a special edition of the journal *Radiation Research* (Radiation Research, 153(5), 2000) to be devoted to this topic.[1]

3.0 Update of Research Related to Cancer

3.1 Epidemiology Studies of Children

The question of power lines and childhood cancer has been based on the assumption that the relevant exposure associated with power lines was the magnetic field, rather than the electric field. This assumption rests on the fact that electric fields are shielded from the interior of homes (where people spend the vast majority of their time) by walls and vegetation, while magnetic fields are not. The magnetic field in the vicinity of a power line results from the flow of current; higher currents result in higher levels of magnetic fields.

The larger studies of EMF have not reported convincing statistical associations between power lines and childhood leukemia (e.g., Linet et al., 1997; McBride et al., 1999). The term "statistical association" is used to describe the tendency of two things to be linked or to vary in the same way, such as level of exposure and occurrence of disease. However, statistical associations are not automatically an indication of cause and effect, because the interpretation of numerical information depends on the other factors as well. The following discussion briefly describes recent major studies.

- The United Kingdom Childhood Cancer Study, the largest study to date, included 1073 total childhood leukemia cases (UKCCS, 1999). Exposure was assessed by spot measurements in the home (bedroom and family room) and school, and summarized by averaging these over time. No evidence was found to support the idea of an increased risk of leukemia from exposures to magnetic fields from power sources inside or outside of the home. Despite the larger sample size, these studies usually had a limited number of cases exposed over 2 or 3 milligauss (mG).

- A study conducted in Ontario, Canada reported on the magnetic-field exposure of a smaller group of children (Green et al., 1999a). No increased risk estimates were found with the average magnetic fields in the bedroom or the interior, or any of the three methods of estimating exposure from wire configuration codes[2]. A still smaller group of 88 children with leukemia and their controls wore personal monitors to measure magnetic fields (Green et al., 1999b). Associations with magnetic fields were reported in some of the analyses, but most of the risk estimates had a

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[1] See, for instance, the articles cited in the **List of References** under Balcer- Kubiczek, Boorman, Loberg, and Ryan.

[2] Wire configuration codes, or wire codes, are a surrogate method for estimating exposure to magnetic fields. Wire codes consist of three to five categories, from highest to lowest, based on those characteristics of power lines that are presumed to predict the magnetic fields that they produce in nearby homes. The main characteristics are distance from the homes and thickness of the lines.

broad margin or error. The small size of this study, and concerns about some of the methods used, made it difficult to interpret.

Recently, researchers reanalyzed the data from previous epidemiology studies of magnetic fields and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). In each of these analyses, the researchers pooled the data on individuals from each of the studies, creating a study with a larger number of subjects and therefore greater statistical power than any single study. In addition, pooling the individual data is preferable to other types of *meta-analyses* (where the results from several studies are combined from grouped data reported in the published studies). The analysis focused on studies that assessed exposure to magnetic fields, using 24-hour measurements or calculations based on the characteristics of the power lines and current load. Both Greenland et al. and Ahlbom et al. used exposure categories of < 0.1 microtesla (µT) (< 1 mG) as a reference category. Ahlbom et al. combined 9 studies, and Greenland et al. used 12 studies of magnetic fields; 8 of these overlapped. Both studies included acute lymphocytic leukemia (ALL) as well as other forms of leukemia. The Greenland et al. study did not include the recent, very large study from the United Kingdom (UKCCS, 1999). The statistical results of these analyses can be summarized as follows**:**

- The pooled analyses provided no indication that wire codes are more strongly associated with leukemia than measured fields.
- Pooling these data corroborates an absence of an association between childhood leukemia and magnetic fields for exposures below 0.3 µT (3 mG).
- Pooling these data results in a statistical association with leukemia for exposures greater than 0.3 or 0.4 µT (3-4 mG).

Magnetic fields above 0.3 µT in residences are estimated to be rather rare, about 3 percent in the U.S. The authors are appropriately cautious in the interpretation of their analyses, and they clearly identify the limitations in their evaluation of the original studies. One limitation is the sparse data: too few cases to adequately characterize a relationship between magnetic fields and leukemia at higher environmental levels. Another limitation is the uncertainty related to pooling different magnetic-field measures without evidence that all of the measures are comparable.

3.2 Epidemiology Studies of Adults

Studies of adults in their residences have reported associations for certain types of cancer, such as brain cancer, breast cancer, or leukemia in adults, but results have not been consistent across studies (e.g., Feychting and Ahlbom, 1994; Li et al., 1997; Feychting et al., 1998). Contradictory results among studies argue against a conclusion that the association is cause-and-effect. Studies that include more people, obtain more detailed and individual exposure assessments, or include people who have higher exposures are weighed more heavily in the scientific assessment of risk, as seen in the following examples:

- A study of 492 adult cases of brain cancer in California included measurements of magnetic fields taken in the home, and at the front door, and considered the types of power line wiring (Wrench et al., 1999). The authors report no evidence of increased risk with higher exposures, no association with type of power line, and no link with levels measured at the front door.
- Three studies of electric blanket use found no evidence that long-term use increased the risk of breast cancer. Electric blankets are assumed to be one of the strongest sources of EMF exposure in the home. Gammon et al. (1998) reported that, even for those who kept the blanket on most of the time, no increase in risk was found for those who had longer duration of use (measured in

months). A study of 608 breast cancer cases also found no evidence of increased use of electric blankets or other home appliances in cases compared to controls, and no indication of increasing risk with a longer time of use (Zheng et al., 2000). In a cohort of over 120,000 women nurses, data were obtained on known risk factors for breast cancer as well as electric blanket use (Laden et al., 2000). Women who developed breast cancer reported no difference in total use of electric blankets, use in recent years, or use many years in the past.

3.3 Laboratory Studies of EMF

Laboratory studies complement studies in humans because heredity, diet, and other health-related exposures can be better controlled or eliminated in laboratory studies. The assessment of EMF and health, as for any other exposure includes chronic, long-term studies in animals (*in vivo* studies) and studies of changes in genes or other cellular processes observed in isolated cells and tissues in the laboratory (*in vitro*).

Although the results of the RAPID Program are described in some detail in the NIEHS reports (NIEHS, 1998), many of the studies had not been published in the peer-reviewed literature. The RAPID research program included studies of four biological effects, each of which had been observed in only one laboratory. These effects are: effects on gene expression, increased intracellular calcium in a human cell line, proliferation of cell colonies on agar, and increased activity of the enzyme ornithine decarboylase (ODC). Some scientists have suggested that these biological effects are signs of possible adverse health effects of EMF. It is standard scientific procedure to attempt to replicate results in other laboratories, because artifacts and investigator error can occur in scientific investigations. Replications, often using more experiments or more rigorous protocols, help to ensure objectivity and validity. Attempts at replication can substantiate and strengthen an observation, or they may discover the underlying reason for the observed response.

Studies in the RAPID program reported no consistent biological effects of EMF exposure on gene expression, intracellular calcium concentration, growth of cell colonies on agar, or ODC activity (Boorman et al., 2000). For example, Loberg et al. (2000) and Balcer-Kubiczek et al. (2000) studied the expression of hundreds of cancer-related genes in human mammary or leukemia cell lines. They found no increase in gene expression with increased intensity of magnetic fields. To test the experimental procedure, they used X-rays and treatments known to affect the genes. These are known as positive controls and, as expected, caused gene expression in exposed cells.

Scientists have concluded that the combined animal bioassay results provide no evidence that magnetic fields cause, enhance, or promote the development of leukemia and lymphoma, or mammary cancer (e.g., Boorman et al., 1999; McCormick et al., 1999; Boorman et al., 2000 a, b).

3.4 Summary Regarding Cancer

The latest epidemiologic studies of childhood cancer do not demonstrate that leukemia in children is causally associated with magnetic fields measured at the home or with wire codes. Two recent pooled analyses reported no association between childhood cancer and magnetic fields below 3 mG. Although some association was reported for fields about this level, most residences are believed to be below 3 or 4 mG. The authors of the larger analysis list several biases and problems that render the data inconclusive, and prevent resolution of the inconsistencies in the epidemiologic data. For this reason, laboratory studies can provide important complementary information. Most of the animal studies provide evidence for a lack of carcinogenicity or a lack of promotion, or provide no basis to conclude that EMF increases leukemia, lymphoma, breast, or any other type of cancer.

4.0 Research Related to Reproduction

Previous epidemiologic studies reported no association with birth weight or fetal growth retardation after use of sources of relatively strong magnetic fields, such as electric blankets, or sources of weaker magnetic fields such as power lines (Bracken et al., 1995; Belanger et al., 1998).

A recent epidemiology study examined miscarriages[3] in relation to exposures to magnetic fields from electric bed heating (electric blankets, heated waterbeds and mattress pads), which result in higher exposures than residential fields in general. The researchers assessed exposure prior to the birth (a prospective study), included information to control for potential confounding factors (other exposures and conditions that affect the risk of miscarriage). This study had a large number of cases and high participation rates. Miscarriage rates were lower among users of electric bed heating (Lee et al., 2000).

Studies of laboratory animals exposed to pure 60-Hz fields have shown no increase in birth defects, no multigenerational effects, and no changes that would indicate an increase in miscarriage or loss of fertility (e.g., Ryan et al., 1999; Ryan et al., 2000). Exposed and unexposed litters were no different in the amount of fetal loss and the number and type of birth defects, indicating no reproductive effect of EMF.

In summary, the recent evidence from epidemiology and laboratory studies provides no indication that exposure to power-frequency EMF has an adverse effect on reproduction, pregnancy, or growth and development of the embryo. The results of these recent studies are consistent with the conclusion of the NIEHS.

5.0 Other Recent Reviews by Scientific Advisory Groups

The decision of the NIEHS regarding health effects from long-term exposures at environmental levels is consistent with the conclusions of other interdisciplinary panels of scientists that have evaluated the literature. One of the most recent of these major reviews was that of the Institution of Electrical Engineers (IEE) of Great Britain (IEE, 2000).

The IEE set up a Working Party in 1992, whose eight members review the relevant scientific literature and prepare reports of their views. Their conclusion is based on recent major epidemiologic studies and the scientific literature built up over the past 20 years. In May 2000 the Working Party concluded "…that there is still not convincing scientific evidence showing harmful effects of low level electromagnetic fields on humans." (IEE, 2000:1)

[3] The medical term for miscarriage is spontaneous abortion.

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List of Preparers

Linda S. Erdreich, Ph.D., is a Managing Scientist in the Health Group at E[x]ponent. She received her Ph.D. in Epidemiology and an M.S. in Biostatistics and Epidemiology from The University of Oklahoma Health Sciences Center. Dr. Erdreich is an epidemiologist with specific expertise in biological and health research related to non-ionizing radiation, both radiofrequency and power frequency fields. Formerly, she was Acting Section Chief and Group Leader of the Methods Evaluation and Development Staff at the U.S. Environmental Protection Agency (EPA) and Senior Epidemiologist of the Environmental Criteria and Assessment Office at the EPA. While at the EPA, she developed methods in quantitative health risk assessment, coordinated the drafting of federal guidelines and participated in science policy decisions.

Both in government and private industry, she has provided rigorous evaluations of the impact on public health or occupational health of a variety of chemicals, therapeutic drugs, and physical agents, including electric and magnetic fields. As a member of the Institute of Electrical and Electronics Engineers (IEEE) Standards Coordinating Committees on Non-Ionizing Radiation, Dr. Erdreich is chairman of a working group to evaluate epidemiologic data on radiofrequency exposures (3 kHz–300 Ghz). She has been appointed as a member of the Committee on Man and Radiation (COMAR) of the IEEE's *Engineering in Biology and Medicine Society*. Dr. Erdreich serves as Adjunct Associate Professor at the University of Medicine & Dentistry of New Jersey.