Schultz-Hanford Area Transmission Line Project

Final Environmental Impact Statement

Appendices

Bonneville Power Administration
U.S. Department of Energy

Bureau of Land Management
Bureau of Reclamation
Fish and Wildlife Service
U.S. Department of Interior

Department of Army
U.S. Department of Defense

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Description and Comparison of Impacts Along Segment A Reroute

Bonneville Power Administration
Schultz-Hanford Area Transmission Line Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97232

Prepared By:

Parsons Brinckerhoff Quade & Douglas
400 SW Sixth Avenue, Suite 802
Portland, Oregon 97204

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1.0 Rationale for Segment A Reroute

As can happen with transmission projects such as the Schultz-Hanford Area Transmission Line Project, an original proposal can change to accommodate new information. BPA proposed the Segment A Reroute in October 2001 as a response to new information. Specifically, the reroute was developed in response to anticipated delays or the inability to acquiring a new right-of-way easement and in renewing the right-of-way easement for the existing Schultz-Vantage line across a tribal allotment.

Negotiations between BPA and the allottees include discussions with the Bureau of Indian Affairs (BIA). These government-to-government agreements have been known to take a great deal of time and result in short-term agreements (10 years for example). BPA's right-of-way easements are typically perpetual or at least for 50 years; therefore, an easement in the range of 10 years for a transmission line that is expected to last at least 75 years is not practical for BPA. The Segment A Reroute was included in the DEIS in order to obtain environmental clearance for that potential reroute if the negotiations with the allottees fail.

2.0 Description of Segment A Reroute

The Segment A Reroute is an optional alignment for a small portion of Segment A, referred to as Segment A1 in this report. (Map 1, *Segment A Reroute*) It is not part of the Preferred Alternative identified in the Schultz-Hanford Area Transmission Line Project FEIS.

The Segment A Reroute was developed to avoid parcels owned by tribal allottees and was designed to minimize the reroute distance. Shortly after crossing into the NW quarter of section 6, township 18N range 20E, the existing Schultz-Vantage line and the proposed new line would be rerouted to the south of the existing Schultz-Vantage alignment. This Segment A Reroute would start about ½ mile southeast of the point where the existing Schultz-Vantage line crosses the north-south alignment of Coleman Road (SE quarter of section 36, T19N R19E). The lines would run south/southeast until roughly Cooke Canyon Road, at which point the lines would head east until re-joining the existing Schultz-Vantage alignment just west of Colockum Road (SE quarter of section 6, T18N R20E). The proposed location of the re-aligned Schultz-Vantage line and the proposed new line are shown on Map 1, *Segment A Reroute*. Segment A1, the portion of Segment A being rerouted, is also identified on Map 1, *Segment A Reroute*.

The Segment A Reroute would be 1.27 miles in length, as opposed to 1.04 miles along the Segment A alignment between the beginning and end of the reroute points. The right-of-way width needed for the Segment A Reroute would total 350 feet. Both the Schultz-Vantage line and the new line would be located in this 350 feet; 75 feet of edge distance from the centerline of each alignment to the outer edge of the right-of-way and 200 feet between the two centerlines. If the Segment A Reroute were chosen, the new line and the relocated existing line would be constructed within this 350 feet and the existing Schultz-Vantage line would be removed from its current location across the tribal allotment. BPA has estimated that it would cost approximately $1,000,000 more to construct the new line along Segment A Reroute than to construct it along Segment A1. To dismantle and relocate the existing Schultz-Vantage line would cost an additional $1,000,000.

2.1 Structures

The Segment A Reroute would use Delta 500-kV single-circuit steel lattice structures. See Figure 1, *Proposed Structures*. The height of each structure would vary by location and surrounding landforms, with an average height of 135 feet. It is estimated that a total of 12 transmission line towers would be required for the Segment A Reroute, six for the re-routed existing Schultz-Vantage line and six for the proposed new line. Three of the six structures on each line would be angle point structures (or deadends), one at each end and one roughly mid-way along the alignments.

2.2 Conductors

The single-circuit transmission lines would be made up of three sets of wires called conductors. Conductors are not covered with insulating material, but rather use the air for insulation. Conductors are attached to the structure using porcelain or fiberglass insulators. Insulators prevent the electricity in the conductors from moving to other conductors, the structure, and the ground.

Two smaller wires, called overhead ground wires, are attached to the top of transmission structures. Overhead ground wires protect the transmission line from lightning damage. To disseminate the electrical power from lightning, the power is routed to the ground at each tower through wires called counterpoise.

2.3 Clearing

Vegetation within the right-of-way is restricted by height. This is required for the safe and uninterrupted operation of the line. It is not anticipated that a large number of trees will need to be cleared for this alignment; however, because of safety considerations, there may be some trees at water crossings that would need to be cut.

At the structure sites, all trees and brush would be cut and removed within roughly a 1/3 acre area (100-by-150-foot area or 0.34 acres), with root systems being removed from a 50-by-50-foot area for the tower footings. A portion of the site would be graded, if necessary, to provide a relatively level work area. The Segment A Reroute would require roughly 4.1 acres to be cleared for the anticipated structure sites (12) along the 1.27-mile route.

Woody debris and other vegetation would either be left lopped and scattered, piled, or chipped, or would be taken off-site. Burning would not be used.

2.4 Access Roads

No permanent access roads are proposed to serve the Segment A Reroute.

2.5 Pulling and Reeling Areas

Pulling and reeling areas would be needed for the installation of the conductor. Pulling and reeling sites are also needed at angle points, because the tension is too great to be able to pull conductor at large angles. Each pulling and reeling area would be roughly ¼ acre in size and located every 2.5 miles. Due to the need for an angle point at roughly the mid-point of the

Segment A Reroute alignment, two temporary pulling and reeling areas would be needed on either side of this angle point.

2.6 Staging Areas

No staging areas are proposed along the Segment A Reroute.

2.7 Substations

The Segment A Reroute would be located between two existing substations, Schultz and Vantage.

2.8 Communication Equipment

Fiber optic cable is not attached to the Schultz-Vantage line and would not be installed as part of this project. No communication equipment would be installed along the proposed new line in the vicinity of the Segment A Reroute.

2.9 Maintenance

BPA would perform routine, periodic maintenance and emergency repairs on structures, substations, and accessory equipment. These activities typically include replacing insulators, inspecting structures, and vegetation control.

A large part of maintenance activities is vegetation control. In central Washington, this primarily focuses on the spread of noxious weeds. Tall growing vegetation would also need to be managed in and adjacent to the right-of-way, primarily where the line crosses water bodies. Vegetation maintenance activities would follow the guidelines set in the BPA Transmission System Vegetation Management Program EIS. When vegetation control is needed, a vegetation management checklist would be developed for the right-of-way. It would identify sensitive resources and the methods to be used to manage vegetation.

3.0 AFFECTED ENVIRONMENT

This section describes the existing environment that may be affected by the Segment A Reroute. Each section describes a specific resource, with the natural environment first and then the human environment.

3.1 Water Resources

3.1.1 Precipitation

The average annual precipitation of nearby Ellensburg is 8.86 inches (2001 Washington State Yearbook).

3.1.2 Watersheds

The Segment A Reroute is within the Upper Yakima watershed. Water from Cooke Creek and drainages along the Segment A Reroute eventually flows into the Yakima River. Thirteen springs are believed to be located near the Segment A Reroute: North Cooke, House Pond, Front Pond, Vancil, Wagon Wheel, Aspen, Teepee, Meadow, Calf, N. Coyote, S. Coyote, E. Flasch, and W. Flasch. The nearest spring to the proposed reroute is North Cooke, approximately 1,000 feet south.

3.1.3 Water Quality

Cooke Creek is a part of the Upper Yakima watershed. The Upper Yakima watershed as a whole is below state or tribal water quality standards; however, within the Segment A Reroute, Cooke Creek is not listed as Water Quality Limited under section 303(d) of the federal Clean Water Act.

3.1.4 Shorelines

The Segment A Reroute would not cross a designated shoreline.

3.1.5 Aquifers

In the Ellensburg Basin unconsolidated deposits that are as much as 1,000 feet thick and Miocene basaltic rocks that underlie the unconsolidated deposits provide thousands of gallons of water through wells for public supply, domestic and commercial use, and agriculture. Typical well depths in Kittitas County are less than 100 to 1,300 feet below land surface. Well yields in Kittitas County can range from less than 500 to 4,800 million gallons per minute. Large yields from wells are common in the Ellensburg area (Whitehead, 1994).

3.2 Floodplains and Wetlands

3.2.1 Floodplains

The Segment A Reroute crosses the Cooke Creek floodplain through an area consisting of five to six narrow, rocky creek channels in a relatively flat area.

3.2.2 Wetlands

Cooke Creek runs through a relatively flat area and consists of five to six narrow, rocky creek channels. The dominant woody species along Cooke Creek are black cottonwood, black hawthorn, and willows. National Wetland Inventory maps indicate that Cooke Creek has a wetland classification of palustrine, forested wetland, seasonally flooded.

3.3 Soils and Geology

The Segment A Reroute would cross a portion of the broad plateau that extends from the BPA Schultz substation area north of Ellensburg, Washington to the Saddle Mountains in the northern portion of the Yakima Training Center. Soils from the Schultz substation area to the Vantage substation vary from shallow to deep, are well drained, and formed in a variety of parent materials including ***loess***[1], ***residuum***[2], ***alluvium***[3], and basaltic ***colluviums***[4] (Washington State University 1998). The Segment A Reroute would cross five soil map units: Camaspatch, Brysill, Weirman, Ackna-brysill, and Maxhill. The Weirman units are hydric soils.

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1 ***Loess*** is a windblown deposit of fine-grained silt or clay.
2 ***Residuum*** is unconsolidated weathered mineral material that accumulated as consolidated rock and disintegrated in place.
3 ***Alluvium*** is sedimentary material deposited by flowing water as in a delta or riverbed.
4 ***Colluvium*** is soil and/or rock fragments moved by creep, slide, and/or local wash and deposited at the base of steep slopes.

The Brysill, Ackna, and Maxhill soil map units would be considered prime and unique farmland if irrigated. See Section 5 for a further discussion of prime and unique soils. Brysill and Weirman soil map units are potentially highly erodible by wind erosion and Ackna-Brysill is potentially highly erodible by both wind and water erosion.

3.4 Vegetation

3.4.1 Washington Natural Heritage Program (WNHP) High Quality Plant Communities

There are no WNHP High Quality Plant Communities located along the Segment A Reroute.

3.4.2 Vegetation Cover Types

The area around the Segment A Reroute consists mostly of shrub-steppe vegetation dominated by sagebrush. Riparian areas along Cooke Creek exist as thin strips of small black cottonwoods, black hawthorn, willows and other shrubs following five or six individual stream channels.

3.4.3 Weed Species

Detailed weed surveys have not been done along the Segment A Reroute because permission to enter and conduct environmental surveys on nearly 80 percent of the private property along the reroute alignment has not been granted.

3.4.4 Rare Plants

Detailed rare plant surveys have not been done along the Segment A Reroute because permission to enter and conduct environmental surveys on nearly 80 percent of the private property along the reroute alignment has not been granted.

3.5 Wildlife

The wildlife habitat present along the Segment A Reroute is primarily shrub-steppe. Wildlife populations along the Segment A Reroute are generally typical of shrub-steppe habitats. The area is used as wintering grounds by large herds of mule deer. Cooke Canyon is a migration corridor for the Quilomene elk herd. East of Cooke Canyon, a sharp-tailed grouse sighting within 1 mile of the proposed line was recorded in 1981. The area east of Cooke Canyon is also known to harbor nesting long-billed curlews (WDFW, 2001a).

The Segment A Reroute crosses Cooke Creek in an area of five to six small channels lined with narrow low-growing riparian species. Wildlife species such as bald eagles, osprey, hawks, cavity-nesting birds and bats typically found in well established riparian areas nearby would occur infrequently near the Segment A Reroute due to the limited and low-growing riparian habitat of the area.

3.5.1 Threatened and Endangered Species

Bald eagles, listed as a Threatened species, are known to winter along some of the streams in this area and may use larger trees along Cooke Creek for roosting and perching. They may use the area of the Segment A Reroute that crosses Cooke Creek. However, because no areas of large riparian trees are present along the Segment A Reroute, eagle use would most likely be temporary and transitory.

3.5.2 Federal and State Listed Species

Federal and State Listed species present along the Segment A Reroute are listed on Table 1 in section 4.4 of this document.

3.6 Fish Resources

Segment A Reroute crosses Cooke Creek approximately 0.3 mile south of Coleman Road. The stream is divided into five or six small channels in this area. The stream flows through an open shrub-steppe area with riparian vegetation consisting of narrow strips of small trees and shrubs. Stream flow is good in this area, although the split channels may limit available fish habitat. It is possible that rainbow, cutthroat, or brook trout may be encountered near where the project crosses (Renfrow, 2001). No anadromous fish are present this high in Cooke Creek (WDFW, unpub.).

3.6.1 Threatened and Endangered Species

No Threatened or Endangered fish species are currently present in the area of the Segment A Reroute. Middle Columbia River Steelhead may rear in the lowest reaches of Cherry Creek, which Cooke Creek is a tributary to, approximately 13 miles downstream of the project area, however stream blockages and diversions prevent them from reaching the project area.

3.7 Land Use

The Segment A Reroute is located entirely within Kittitas County. The roughly 1.3-mile reroute would cross public lands (less than 0.1 mile of BLM land) and private lands (approximately 1.2 miles). Open space rangeland is the only identified land use along the 1.3 miles and within the proposed 350-foot right-of-way. Rural residences and some agricultural uses are located on some of the same properties that would be crossed by the reroute; however, these uses are located south of the proposed alignments, outside the proposed right-of-way.

3.8 Socioeconomics

Socioeconomic data were compiled at the county and state levels of analysis. The Segment A Reroute is located entirely within Kittitas County and has similar socioeconomic conditions as other portions of the project that are located in Kittitas County. The Kittitas County affected environment is summarized below.

3.8.1 Population

Population is located in sparsely populated rural areas, with Ellensburg being the nearest population center. Caucasians are the dominant race of people living in Kittitas County. Population growth over the past has been unsteady, but is recently experiencing large increases.

3.8.2 Economy

Government provides almost one-third of the jobs in Kittitas County and almost half of the wage and salary earnings. Kittitas County has the lowest median household income ($32,546) compared to Grant, Yakima, and Benton Counties. Household incomes in Kittitas County comprise approximately 59 percent earnings, 22 percent interest and dividends, and 17 percent transfer payments. The average unemployment rate in Kittitas County for 2001 was 6.5 percent.

3.8.3 Taxes

The amount of the retail sales and use tax varies by locality. The state tax base is 6.5 percent, above which each locality can assess 0.5 to 2.1 percent additional tax. Combined state and local tax rates for the study area range from 7.6 to 8.0 percent.

The average state property tax rate is $3.16 per $1,000 of assessed property value (Washington State DOR, 2002). Local tax rates vary depending on regular and special levies. The state average for local property tax rates is $12.96 per $1,000 assessed value (Washington State DOR, 2002).

Other taxes such as the business and occupation (B&O) tax, local excise taxes (on fuels, tobacco products, liquor, timber, and rental cars), hotel/motel taxes, municipal business taxes and licenses also generate revenue for the state and local municipalities.

3.9 Visual Resources

The Segment A Reroute crosses the edge of rural, agricultural lands near the base of the Wenatchee Mountains and is a relatively flat to rolling area of sagebrush and rabbit brush. Typical views in this area are ***foreground***[5] and ***middleground***[6] views of the agricultural and sagebrush/rabbitbrush lands. Background views are of the Wenatchee, Boylston and Saddle Mountains and sky. Viewers are residents of the low-density, scattered rural homes, dispersed recreationalists and motorists on Coleman Creek, Cooke Canyon and Gage Roads. The Segment A Reroute would be in the foreground or middleground for most viewers.

3.10 Recreation Resources

No ***dedicated recreation***[7] sites have been identified within 1 mile of the proposed Segment A Reroute.

Dispersed recreation[8] activities that have been identified as occurring on the properties that would be crossed by the proposed Segment A Reroute include such activities as hunting, fishing, hiking, horseback riding, snowshoeing, snowmobiling, camping, broom hockey, and off-road and all-terrain vehicle use. These activities take advantage of the creeks, ponds, and open spaces of the area. Persons participating in these recreation activities are predominately full-time residents of the properties and their guests or approved visitors.

3.11 Cultural Resources

Literature search has indicated that the area, which includes the Segment A Reroute, has the potential to contain sites that may have cultural value. No cultural resource surveys were done on the Segment A Reroute since permission to enter and conduct environmental and cultural resource surveys on nearly 80 percent of the private property along the reroute alignment has not been granted.

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5 ***Foreground*** is within 0.25 to 0.5 mile of the viewer.

6 ***Middleground*** is from the foreground to about 5.0 miles from the viewer.

7 ***Dedicated Recreation*** refers to activities that are limited to a finite geographic location and are supported by improvements that commit the resource to a specific recreational activity.

8 ***Dispersed Recreation*** refers to recreation activities that are not limited to a finite location. These types of activities do not require improvements that commit resources to a particular type of recreation.

3.12 Public Health and Safety

3.12.1 Electric and Magnetic Fields

Transmission lines, like all electrical devices and equipment, produce ***electric and magnetic fields***[9] (EMF). The voltage, or force that drives the ***current***[10], is the source of the electric field. The strength of magnetic field depends on the current, design of the line, and the distance from the line. Field strength decreases rapidly with distance. Electric fields can be reduced significantly by the presence of conducting objects. Thus, inside houses and automobiles, electric fields are lower than outside because of shielding. Unlike electric fields, magnetic fields from outside power lines are not reduced in strength by trees and building material. Because of this, transmission lines can be a major source of magnetic field exposure throughout a home located close to the line. Along Segment A Reroute there are no residences within 1,000 feet of the proposed transmission lines.

There are currently no national standards in the United States for electric and magnetic fields from transmission lines. The state of Washington does not have limits for either electric or magnetic fields from transmission lines. The BPA has maximum allowable electric fields of 9-kV/m on the ROW and 5-kV/m at the edge of the ROW. The 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.

Both electric and magnetic fields induce currents in conducting objects, including people and animals. The magnitude of the induced current in objects under lines depends on the electric- or magnetic-field strength and the size and shape of the object. The currents induced in people, even from the largest transmission lines, are generally too weak to be felt. However, under certain circumstances, contact to a grounded object by a well-insulated person in a high electric field can result in a perceived nuisance shock or spark discharge. Transmission lines are designed and built so that such shocks occur infrequently and, if they do, are no higher than the nuisance level.

The possibility of health effects from long-term exposure to 60-Hz electric or magnetic fields has been researched for several decades. The consensus of scientific panels reviewing this research is that the evidence does not support a causal relationship between electric or magnetic fields and any adverse health outcomes, including childhood cancer, adult cancer, reproductive outcome, or other diseases. However, investigation of a statistical association between magnetic field exposure and childhood leukemia continues.

3.12.2 Transmission Line Noise

Audible noise can be produced by transmission line ***corona***[11]. In a small area 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.

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9 ***Electric and magnetic fields*** (EMF) are the two kinds of fields produced around the electric wire or conductor when an electric transmission line or any electric wiring is in operation.

10 ***Current*** is the amount of electrical charge flowing through a conductor.

11 ***Corona*** is an electrical discharge, at the surface of a conductor. Corona-generated noise can be characterized as a hissing, crackling sound.

3.12.3 Radio and TV Interference

Corona on transmission line conductors can generate electromagnetic noise in the frequency bands used for radio and television signals. In rare circumstances, corona-generated ***electromagnetic interference*** (***EMI***)[12] can also affect communication systems and sensitive receivers. Interference with electromagnetic signals by corona-generated noise is generally associated with lines operating at voltages of 345-kV or higher.

Radio reception in the AM broadcast band (535 to 1,604 kilohertz (kHz)) is most often affected by corona-generated EMI. FM radio reception is rarely affected. Generally, only residences very near transmission lines can be affected by radio interference. Corona-caused television interference occurs during foul weather and is generally of concern only for conventional receivers within about 600 feet of a line. Cable and satellite television receivers are not affected.

3.12.4 Toxic and Hazardous Materials

Areas along the Segment A Reroute where human activities are concentrated are the most likely to have hazardous materials issues. However, hazardous materials could be encountered anywhere along the proposed route and could include such things as illegally dumped waste, spilled petroleum products, pesticides, and other wastes. No hazardous materials sites have been identified along the Segment A Reroute.

3.12.5 Fire

Numerous wildfires have occurred on private and public land in central Washington over the past several years. They may have been caused by human actions such as vehicle ignitions from roads, unattended campfires, burning of adjacent agricultural lands and arson, or by natural causes such as lightning.

Farmers throughout the state, including those in central Washington near the line segments, burn agricultural fields to remove the remaining plant material after harvest and prepare for planting the next crop. In order to meet the requirements of the Washington State Clean Air Act of 1991, a statewide agricultural burning permit program has been implemented.

3.13 Air Quality

The Washington State Department of Ecology, Central Regional Office works to control, monitor and prevent air pollution in Kittitas County, the location of the proposed Segment A Reroute. Data from air quality monitoring sites has shown that air quality is improving across the State of Washington. Still, there are a few ***nonattainment areas***[13] in the state. The Segment A Reroute would not be located in one of the nonattainment areas. In addition, there are no designated ***Class 1***[14] areas within the vicinity of the proposed right-of-way.

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[12] ***Electromagnetic interference (EMI)*** is high-frequency electrical noise that can cause radio and television interference.

[13] A ***nonattainment area*** is a geographic region designated by EPA in which federal air quality standards are not or were not met by a certain date. There are six air pollutants that are monitored; particulate matter (PM), carbon monoxide (CO), ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and lead (Pb).

[14] Section 160 of the federal Clean Air Act requires the preservation, protection, and enhancement of the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic or historic value. The 1977 Clean Air Act amendments called for a list of existing areas to be protected under section 160. These are called ***Class 1* areas**.

4.0 ENVIRONMENTAL CONSEQUENCES

Parsons Brinckerhoff's environmental team used a variety of methods to study the Segment A Reroute, including aerial photography review, literature research and review, state and federal database queries, and contact with local, state, and federal agency representatives.

The entire Segment A Reroute was not subjected to field visits because BPA and its consultants were denied permission by private property owners to enter private property along roughly 80 percent of the reroute, thereby limiting the effectiveness of the field visits. Without access to a portion of the proposed reroute alignment conclusions on potential environmental impacts along this area were based on aerial photography, details contained in available databases and in the literature, and knowledge of the private property from local, state, and federal agency representatives.

To analyze potential impacts from construction, operation and maintenance activities, resource specialists have analyzed actions using a scale with four impact levels: high, moderate, low, and no impact. The level of detail for the impact discussions of each resource depends on that resource's character, and the significance of the issue.

Construction of the alternatives would be typical of other BPA transmission line projects. Typical transmission line construction activities include:

- Clearing right-of-way;
- Preparing structure sites;
- Excavating and installing structure footings;
- Delivering structures to the sites (steel, insulators, conductors, and other miscellaneous equipment);
- Assembling and erecting structures;
- Stringing and tensioning conductor, ground wire, and fiber optic cable; and
- Installing counterpoise.

At the site of the structures all vegetation would be removed and sites would be graded, if needed, to provide a level work area. An average area of about 100 feet by 150 feet would be disturbed at each structure site. The footprint of the structures would be considered permanent disturbance. The average footprint would be 27 by 27 feet. Each leg of a tower has a footing. Footings for suspension towers generally occupy an area of about 6 feet by 6 feet, to a depth of 12 feet. Footings at angle points would be larger and deeper, about 15 feet by 15 feet and 16 feet deep.

If the Segment A Reroute were to be chosen, a little more than 1 mile of the existing Schultz-Vantage line would be removed. In order to remove and reroute the existing Schultz-Vantage line, deadend structures would be built on either end of the section to be removed. These heavy steel structures would be able to support the stresses of the conductor at angles introduced by the reroute. The conductor would then be cut and taken off of the structures to be removed. The structures would be dismantled and trucked offsite. The area around the structure legs would be excavated in order to cut the steel off below ground, approximately 2 feet below the surface. The existing footings for the structures would remain. The holes would be backfilled and the ground smoothed and graded.

Impacts associated with the Segment A Reroute, which would add 0.23 mile to Segment A, would not substantially change the overall impacts associated with the 58- to 70-mile alternatives. Further details concerning impacts to specific resources are provided below.

4.1 Water Resources, Soils, and Geology

The construction of the Segment A Reroute would disturb 4.3 acres of soil surface, impair soil productivity, remove 0.3 acres of land from production and could have the potential for additional erosion, sedimentation, and runoff near Cooke Creek. Erosion and sediment releases from the construction area are unlikely to directly enter Cooke Creek, because towers would be placed on either side of the creek, no access roads would cross the creek, revegetation would occur after construction and the topography of the land surrounding Cooke Creek generally slopes parallel to the creek (the creek is on an alluvial fan).

It is anticipated that the construction of the Segment A Reroute would have a low to no impact to groundwater. Groundwater, if shallow, should remain at its current level. The Segment A Reroute would have moderate erosion, loss of productive soils, and potential for some increased runoff and sedimentation.

4.2 Floodplains and Wetlands

The Segment A Reroute would have minimal impacts on the floodplain associated with Cooke Creek because the project would span the floodplain (towers would be located on either side of the floodplain). Some small riparian trees may need to be removed from the reroute right-of-way and the relocation of the existing Schultz-Vantage line right-of-way, but these would have only a minimal impact on stream stability and floodplain function.

4.3 Vegetation

The small riparian vegetation along the reroute would require removal of only a few small trees, if any, for line clearances. The relocation of the existing Schultz-Vantage transmission line may also require removal of a few small trees for line clearance. Approximately 4.3 acres of shrub-steppe would be cleared for tower locations. Some disturbance from temporary vehicle travel would occur, however no permanent access roads would be constructed. Removal of the existing Schultz-Vantage line would cause additional impacts to shrub-steppe vegetation along 1.01 miles from equipment passage and tower removal, although no shrub-steppe or riparian trees would be cleared. Overall impacts to shrub-steppe and riparian vegetation from the Segment A Reroute would be low.

4.4 Wildlife

A search of the Washington Natural Heritage Program database and discussions with Washington Department of Fish and Wildlife (WDFW), Washington State Department of Natural Resources (WDNR), United States Fish and Wildlife Service (USFWS), and independent botanists and biologists, did not indicate that the area of the Segment A Reroute harbored fish and wildlife species or plant assemblages unique to the region or substantially different than the surrounding areas. (BPA was denied permission to enter roughly 80 percent of the private property along the Segment A Reroute to conduct detailed biological surveys.) Table 1 identifies the potential impacts to federal and state listed species that might result from the Segment A Reroute.

Table 1
Potential Impact to Federal and State Listed Species on Segment A Reroute

Species Name	Federal Status	State Status	Documented Occurrence Type	Potential Impact
Riparian, Open Water and Wetland Species				
Perching and Cavity-Nesting Birds				
Bald eagle	FT	ST	W	N
Osprey		SM	B	N
Great blue heron		SM	B	N
Black-crowned night heron		SM	B	N
Lewis' woodpecker		SC	B	N
Olive-sided flycatcher	FSC		P	N
Little willow flycatcher	FSC		P	N
Bats				
Pacific western big-eared bat	FSC	SC	P	N
Long-eared myotis	FSC	SM	P	N
Long-legged myotis	FSC	SM	P	N
Fringed myotis	FSC	SM	P	N
Western small-footed myotis	FSC	SM	P	N
Yuma myotis	FSC		P	N
Pallid bat		SM	P	N
Herpetofauna				
Spotted frog	FC	SE	P	Mn
Shrub-Steppe Species				
Raptors and Migratory Birds				
Northern goshawk	FSC	SC	M	Mn
Golden eagle		SC	B	Mn
Ferruginous hawk	FSC	ST	B	Mn
Swainson's hawk		SM	B	Mn
Prairie falcon		SM	B	Mn
Peregrine falcon	FSC	SE	B	Mn
Turkey vulture		SM	B	Mn
Western bluebird	FSC	SM	B	Mn
Sagebrush-Dependent Birds				
Sage sparrow		SC	B	M
Sage thrasher		SC	B	M
Long-billed curlew	FSC	SM	B	M
Western sage grouse	FSC	ST	B	M
Loggerhead shrike	FSC	SC	B	M
Sharp tailed grouse	FSC	ST	H	M
Mammals				
White-tailed jackrabbit		SC	B	M
Small Burrowing Species				
Northern grasshopper mouse		SM	P	M
Sagebrush vole		SM	P	M
Merriam's shrew		SC	B	M
Herpetofauna				
Sagebrush lizard	FSC		B	M
Striped whipsnake		SC	B	M

Federal Status: FE = Endangered; FT = Threatened; FC = Candidate; D = Delisted; FSC = Species of Concern
State Status: SE = Endangered; ST = Threatened; SS = Sensitive; SC = Candidate; SM = Monitor
Documented Occurrence Type: P = Present (general presence); B = Breeding; M = Migrant; W = Winter Resident; N = Not Present
Potential Impact: H = High; M = Moderate; L = Low; Mn = Minimal; N = None; H = Historically Present, Not Currently Present

4.4.1 Threatened & Endangered Species

The proposed Segment A Reroute would have no impact on bald eagles because no large cottonwoods and willows, preferred by eagles for roosting, would need to be removed.

4.5 Fish Resources

The Segment A Reroute would cross Cooke Creek approximately 0.3 mile south of Segment A. Fish species present in Cooke Creek include rainbow trout, cutthroat trout, and brook trout. No anadromous salmonids are present due to downstream obstructions (WDFW, unpub.). No Threatened or Endangered fish species are currently present in the area of the Segment A Reroute. Steelhead may rear in the lowest reaches of Cherry Creek, which Cooke Creek is a tributary to, but no impacts to water resources and fish would occur that far downstream as a result of this project. The creek in this area has five or six channels lined with low-growing riparian vegetation. Tower sites would be located well back from any channels of Cooke Creek on the Segment A Reroute and no access roads would cross the creek. The topography of the area slopes parallel to Cooke Creek, ensuring that no sediments or pollution resulting from construction in upland areas would flow directly into the creek. Best management practices proposed for construction near streams would prevent sediments and pollutants from leaving construction sites. Overall impacts to fish resources from the Segment A Reroute would be minimal to none.

4.6 Land Use

During construction heavy machinery would temporarily disrupt any land use activities occurring near the construction area and within the proposed right-of-way. Because this disturbance would be temporary and pre-construction conditions would be re-established, the impact to land uses from construction would be low.

Open space rangeland is the only identified land use along the 1.3-mile Segment A Reroute. It is estimated that 12 transmission line towers would be required along the reroute. The towers would impact roughly 4.3 acres of rangeland, 0.3 of which would be permanently under the tower footprint. Unlike agricultural lands that may have limitations on the types of crops located under the transmission lines, the land uses associated with open space rangeland could continue within the proposed right-of-way, around the proposed structures, and under the conductors. As a result, the impact to the open space rangeland would be low.

4.7 Socioeconomics

Impacts on socioeconomics were evaluated for the study area as a whole, which included four counties: Benton, Grant, Kittitas, and Yakima.

4.7.1. Population

Constructing a new transmission line would not encourage population growth in the area, but rather would be a response to growth that is already occurring in central Washington and the Pacific Northwest. No impact to the population would occur as a result of the proposed project.

4.7.2 Economy and Industry

Because transmission line construction requires specialized labor, construction crews would likely be brought in from outside the local area. Construction would likely occur over 1 year, with one or two primary contractors. About 100 people would be needed to construct a project of this scale on this timeline. This would be a positive impact on employment in general, but not necessarily a local impact if workers do not come from the study area.

Constructing a new transmission line would not impact the distribution of jobs within industry sectors, personal and household incomes, or industry earnings.

4.7.3 Housing and Public Services

Socioeconomic impacts to temporary housing facilities are relatively minor for transmission line construction projects in most areas. Because of the relatively small number of construction crews who would build the project, there should be few negative impacts to the temporary housing supply in the area.

Impacts to public services such as police, fire, and medical response, would be of short duration during the construction phase.

4.7.4 Retail Sales and Use Tax

The major cost of any transmission line project is labor and materials. A combined state and local sales and use tax would be levied on materials purchased for the project by the contractor. This would be a positive impact to local and state revenues.

4.7.5 Business and Occupation Tax and Public Utility Tax

For Business and Occupation (B&O) tax purposes, contractors performing work for BPA are classified as government contractors and are subject to the B&O tax. The gross contract price is subject to this tax. This would be a positive impact to state revenues.

4.7.6 Property Tax

BPA, as a federal agency, is exempt from paying local property taxes, except in the case of acquiring real property to build a new substation. No real property acquisition is expected to occur in Kittitas County.

4.7.7 Property Value

Any new transmission line or access road easements would be appraised, and landowners would be offered the fair market value for these land rights. The new line is not expected to cause overall long-term adverse effects on property values. See Appendix E, *Property Impacts*, of the FEIS for more information on impacts to property values.

4.7.8 Land Taken Out of Production

Activities such as farming, which do not interfere with the transmission line or endanger people, are usually not restricted. In cases where productive lands cannot be avoided, some land may be taken out of production. Landowners would be compensated for any lands taken out of production. No actively cultivated land would be affected by the Segment A Reroute.

4.7.9 Other Taxes

Other state taxes that would be assessed include ***excise***[15] taxes on fuel, cigarettes, tobacco products, liquor, timber, and rental cars. Revenues generated from these miscellaneous taxes would have a positive impact on state and local revenues, but are expected to be small due to the limited crew size involved in this type of construction.

[15] ***Excise*** taxes are internal taxes imposed on the production, sale, or consumption of a commodity or the use of a service.

4.8 Visual Resources

The visual importance of the area around the Segment A Reroute is identified as "Visually Sensitive" due to the number of residences, and thus sensitive viewers, with foreground views of the proposed transmission line project(s). Views from residences south of the proposed lines would be dominated by, or at least clearly include, the new transmission towers.

Visual impacts of the Segment A Reroute would be high at viewpoint locations within 0.5 mile and moderate for residential properties between 0.5 mile and 5.0 miles of the Segment A Reroute due to the introduction of the new delta towers (average 135-foot height) into this area, which does not currently contain transmission structures.

4.9 Recreational Resources

During construction dispersed activities occurring within the Segment A Reroute right-of-way would be temporarily impacted. For safety reasons, these activities would not be allowed within the construction area. The overall impact to these activities during construction, however, would be low because the nature of these activities does not limit them to a specific area. Once construction was complete the activities could resume adjacent to and within the transmission line right-of-way.

Permanent impacts to recreation activities would be low. The two proposed transmission lines would not prevent the identified dispersed recreation activities, such as camping, broom hockey, and all-terrain vehicle riding, from occurring elsewhere on the properties along the alignment, including within the transmission line right-of-way.

4.10 Cultural Resources

The Phase 1 cultural survey, which was a literature and database search of known sites, indicated that the Segment A Reroute has a potential to contain culturally significant sites. A ground survey was only completed on the preferred alternative (which did not include Segment A Reroute); therefore, no further details on the existence of cultural resources along the Segment A Reroute are known.

4.11 Public Health and Safety

There are no residences within 1,000 feet of the new right-of-way. Impacts from electric and magnetic fields would be low. Activities presently occurring within what would become the right-of-way would not change, as they are activities associated with open fields. Calculated levels for electric and magnetic fields are shown below.

Table 2
Calculated Electric Fields
New 500-kV and Rerouted Vantage–Schultz 500-kV Lines Operated at Maximum Voltage

ROW width, ft.	350			
Line	New 500-kV		Rerouted Vantage – Schultz 500 kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, kV/m	8.6	5.8	8.6	5.0
Edge of ROW, kV/m	2.5	2.4	2.5	2.4

Table 3
Calculated Magnetic Fields
New 500-kV and Rerouted Vantage–Schultz 500-kV Lines Operated at Maximum Current

ROW width, ft.	350			
Line	New 500-kV		Rerouted Vantage – Schultz 500 kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, mG	234	159	114	76
Edge of ROW, mG	68	59	38	33

Impacts from the noise of the new and rerouted lines would be low/moderate. The predicted median foul-weather audible noise levels at the edge of the right-of-way would be 50 dBA. This is roughly the same level of noise expected from moderate rainfall on foliage. Since there is presently no transmission line along this right-of-way the introduction of a noise producing line creates an impact. The lack of residence immediately surrounding the new right-of-way lowers the impact rating.

More information is available in Appendix I, Electrical Effects, Addendum 2 of the Schultz-Hanford Area FEIS.

Noise impacts would result from construction activities. However, this noise would be short term, occurring mostly during daylight hours. It would typically occur for only a few days at any one location.

Corona on transmission line conductors can also generate electromagnetic noise in the frequency bands used for radio and television signals. This noise can cause radio and television interference (RI and TVI). 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. If interference should occur, there are various methods for correcting it, and BPA has an active program to identify, investigate, and mitigate legitimate RI and TVI complaints. Therefore, the anticipated impacts of corona-generated interference on radio, television, or other reception would be minimal.

Several common construction materials (e.g., concrete, paint, etc.) and petroleum products (e.g., fuels, lubricants, and hydraulic fluids) would be used during construction. BPA would follow strict procedures for disposal of these or any hazardous materials. No impacts would occur.

Contaminated media (soil, surface water or groundwater), if unexpectedly encountered during construction of the project, may present potential risk/liability to BPA. Potential risk and liability includes workers health and safety, management of contaminated materials and/or exacerbation of contaminated media (soil, surface water, or groundwater).

Should contaminated media be unexpectedly encountered during construction of the project, work will be stopped and an environmental specialist will be called in to characterize the nature and extent of the contamination and to determine how the work may safely be completed. Work will proceed only after measures approved by the WDOE are put in place to prevent the spread of contaminated materials and protect the health and safety of workers.

It can be expected that some construction activities will occur during summer when the weather is hot and dry. During the summer months, the potential for wildfires is high due to dry vegetation, such as sagebrush and grasses, along the right-of-way. The fire risk increases even more with the increased use of vehicles and other motorized equipment used during construction. The addition of construction workers in the area also elevates the potential for fire. Vehicles would carry fire suppression equipment. After construction, to prevent fires and other hazards, BPA maintains a safe clearance between the tops of trees and power lines.

4.12 Air Quality

Construction vehicles and heavy equipment would emit pollutants. However, emissions would be short-term and would have a low or no impact on air quality in the region. Windblown dust from the construction sites and clearing activities would also create a short-term low impact on air quality.

Long-term impacts to air quality would come from the new lines themselves. The limited air emissions can result from a breakdown of the air at the surface of the conductors, called corona. The proposed Segment A Reroute is designed to have lower corona levels than the existing older 500-kV lines in the area and would not result in an impact to air quality.

5.0 PRIME FARMLAND

The Farmland Protection Policy Act directs federal agencies to identify and quantify adverse impacts of federal programs on farmlands. The Act's purpose is to minimize the number of federal programs that contribute to the unnecessary and irreversible conversion of agricultural land to non-agricultural uses.

The location and extent of prime farmlands designated by the Natural Resources Conservation Service (NRCS) were obtained from NRCS soil survey information. Lists of unique, statewide, and locally important farmlands in Washington are in the process of being updated and were unavailable for consideration.

In Kittitas County farmland soils are classified in one of three ways: always prime farmland, prime farmland if irrigated, or not prime farmland. As shown in Table 4, roughly 0.8 mile or 4,190 linear feet of land with the designation of "prime soils if irrigated" would be crossed by the proposed alignment.

Table 4
Distance of Farmland Soil Classifications Crossed by Segment A Reroute

Classification	Approximate Linear Distance Crossed
Always prime farmland	0 mile (0.0 feet)
Prime farmland if irrigated	0.8 mile (4,190 feet)
Not prime farmland	0.5 mile (2,491 feet)
TOTAL	**1.3 miles (6,681 feet)**

Prime farmland would be permanently affected if any structures were located on designated soils that are being irrigated. Prime farmland would not be affected if the transmission facility could span the designated soils that are being irrigated. Estimated tower locations for the proposed new transmission line and rerouted existing transmission line place seven towers (four along the new line and three along the re-routed existing Schultz-Vantage line) on soils classified as prime farmland if irrigated.

Any prime farmland that would be converted to nonagricultural uses requires approval by the NRCS.

6.0 DIRECT COMPARISON OF SEGMENT A REROUTE AND SEGMENT A1

In order to achieve a better understanding of the differences in impacts between using Segment A as proposed in the FEIS, and Segment A using the Segment A Reroute, a direct comparison of the impacts between the reroute and the portion of Segment A that it would replace, Segment A1, is provided below.

Table 5
Segment A Reroute vs. Segment A1

	Segment A Reroute	Segment A1
Length	1.27 miles	1.04 miles
Width of ROW	350 feet	200 feet
Number of New Transmission Lines	2; Realigned Existing Schultz-Vantage and new line	1; New line 200 feet north of existing Schultz-Vantage
Est. Number of Structures	12; 6 on existing Schultz-Vantage and 6 on new line	4
Est. Number of Angle Point Structures Required	6; 2 at each end and 2 near the midpoint of the alignment	0
Est. Acres of Disturbance from New Structures	4.3 acres	1.4 acres
Est. Acres of Disturbance from Removed Structures	1.4 acres	0
Acres within new ROW	53.9 acres	25.2 acres

While the Segment A Reroute is roughly 0.23 mile longer than Segment A1, and would disturb approximately 4.3 more acres of land area due to the need for eight additional towers, Parsons Brinckerhoff has concluded that in many cases the impacts to resources along the Segment A Reroute would be similar to those reported for Segment A1.

Table 6
Segment A Reroute and Segment A1 Impact Comparison

Resource	Summary of Impacts	
	Segment A Reroute	**Segment A1**
Water Resources, Soils, and Geology	Moderate erosion, loss of productive soils, and potential for some increased runoff and sedimentation.	Low to moderate erosion and loss of productive soil. Some increased runoff and sedimentation.
Floodplains and Wetlands	Minimal to no impacts to floodplains and wetlands because towers would be located on either side.	Impacts would be similar to the Segment A Reroute.
Vegetation	Low impacts to shrub-steppe, grasslands and riparian vegetation.	Low impacts to shrub-steppe and grasslands and moderate impacts to riparian vegetation.
Wildlife	Low impacts to shrub-steppe species, minimal impacts to bald eagles, other raptors, cavity-nesting birds and bats.	Low impacts to shrub-steppe species, bald eagles, other raptors, cavity-nesting birds and bats.
Fish	Minimal impacts from construction and removal of small riparian vegetation along Cooke Creek.	Low impacts from removal of large riparian trees.
Land Use	The impact to open space rangeland, the only identified land use within the proposed right-of-way, would be low.	Impacts would be similar to the Segment A Reroute.

Table 6
Segment A Reroute and Segment A1 Impact Comparison

Resource	Summary of Impacts	
	Segment A Reroute	**Segment A1**
Socioeconomics	No impacts to local population compositions or distributions are expected to occur. A positive impact to local and state tax revenues and local economies would result from construction-related jobs and expenditures.	Impacts would be similar to the Segment A Reroute.
Visual	Visual impacts would be high to moderate due to no existing line along proposed right-of-way and because the new lines would be in the foreground or middleground for most viewers.	Visual impacts would be moderate because of existing lines already in the area.
Recreation	Impacts to recreational resources would be low. Dispersed recreation activities would be temporarily impacted during construction. Activities could resume within the right-of-way and around the structures after construction is complete.	Impacts would be similar to the Segment A Reroute.
Cultural	The Phase 1 cultural survey, which was a literature and database search of known sites, indicated that the Segment A Reroute has a potential to contain culturally significant sites.	Impacts would be similar to the Segment A Reroute.
Public Health and Safety	Impacts from electric and magnetic fields would be low. Fields from the relocated existing line would be lower than the current fields from that line. Impacts from the noise of the new and rerouted lines would be low/moderate. Predicted median foul-weather audible noise at edge of ROW would be 50 dBA. Low/moderate impact due to new lines in an area currently without lines.	Impacts from electric and magnetic fields would be low. Impacts from the noise of the new line would be low. Predicted median foul-weather audible noise at edge of ROW would be 65 dBA. Has a lower impact level due to existing line already creating noise in the area.
Air Quality	Impacts from construction equipment and wind blown dust during construction would be low and temporary. No long-term impacts to air quality would occur.	Impacts would be similar to the Segment A Reroute.
Prime Farmland	Roughly 0.8 mile or 63 percent of the Segment A Reroute would cross soils designated as “prime farmland if irrigated,” with an estimated seven structures on these soils	Roughly 0.6 mile or 58 percent of the Segment A1 would cross soils designated as “prime farmland if irrigated,” with an estimated three structures on these soils.

As shown in Table 6, the impact to the following resources would experience similar impacts on the Segment A Reroute as compared to those on Segment A1:

- Floodplains and Wetlands

- Land use
- Socioeconomics
- Recreation
- Cultural
- Air quality

For those resources where the anticipated impacts are expected to be different between the Segment A Reroute and Segment A1, a brief discussion comparing the two segments and explaining the cause of the variation in impact has been provided below.

6.1 Water Resources, Soils, and Geology

Although the Segment A Reroute would cross the same soil units as Segment A1, the construction of the Segment A Reroute would disturb additional soil surface, with the relocation of the existing line and the addition of the new line, and have the potential for additional erosion, sedimentation, and runoff at or near Cooke Creek; impair soil productivity; and remove 0.3 acre of land from production. Although, the Segment A Reroute impacts would be within the Segment A1 assigned impact of low to moderate, impacts would potentially be on the more moderate side than low for the reroute.

6.2 Vegetation

The Segment A Reroute would reduce impacts to forested lands and grasslands and increase the impacts to shrublands compared to Segment A1. The reduction of impacts to forested land is due to fewer large cottonwoods and willows that would need to be removed on the Segment A Reroute as opposed to the original route. The original route crosses an area of large cottonwoods and willows, a number of which would need to be removed for line clearance purposes.

6.3 Wildlife

Bald eagles, other raptor species, cavity-nesting birds, and bats all use large riparian trees such as cottonwoods and willows. Segment A1 would cause minimal impacts due to some of these trees being removed for line clearance purposes. No large trees would need to be removed along the Segment A Reroute, so no habitat for the species mentioned above would be removed. Table 7 compares the potential impacts to federal and state listed species between the Segment A Reroute and Segment A1.

Table 7
Comparison of Impacts to Federal & State Listed Species on Segment A Reroute and Segment A1

Species Name	Federal Status	State Status	Documented Occurrence Type	Potential Impact Segment A Reroute	Potential Impact Segment A1
Riparian, Open Water and Wetland Species					
Perching and Cavity Nesting Birds					
Bald eagle	FT	ST	W	N	Mn
Osprey		SM	B	N	Mn
Great blue heron		SM	B	N	Mn
Black-crowned night heron		SM	B	N	Mn
Lewis' woodpecker		SC	B	N	Mn
Olive sided flycatcher	FSC		P	N	Mn
Little willow flycatcher	FSC		P	N	Mn
Bats					
Pacific western big-eared bat	FSC	SC	P	N	Mn
Long-eared myotis	FSC	SM	P	N	Mn
Long-legged myotis	FSC	SM	P	N	Mn
Fringed myotis	FSC	SM	P	N	Mn
Western small-footed myotis	FSC	SM	P	N	Mn
Yuma myotis	FSC		P	N	Mn
Pallid bat		SM	P	N	Mn
Herpetofauna					
Spotted frog	FC	SE	P	Mn	Mn
Shrub-Steppe Species					
Raptors and Migratory Birds					
Northern goshawk	FSC	SC	M	Mn	Mn
Golden eagle		SC	B	Mn	Mn
Ferruginous hawk	FSC	ST	B	Mn	Mn
Swainson's hawk		SM	B	Mn	Mn
Prairie falcon		SM	B	Mn	Mn
Peregrine falcon	FSC	SE	B	Mn	Mn
Turkey vulture		SM	B	Mn	Mn
Western bluebird	FSC	SM	B	Mn	Mn
Sagebrush-Dependent Birds					
Sage sparrow		SC	B	M	M
Sage thrasher		SC	B	M	M
Long-billed curlew	FSC	SM	B	M	M
Western sage grouse	FSC	ST	B	M	M
Loggerhead shrike	FSC	SC	B	M	M
Sharp-tailed grouse	FSC	ST	H	M	M
Mammals					
White-tailed jackrabbit		SC	B	M	M
Small Burrowing Species					
Northern grasshopper mouse		SM	P	M	M
Sagebrush vole		SM	P	M	M
Merriam's shrew		SC	B	M	M
Herpetofauna					
Sagebrush lizard	FSC		B	M	M
Striped whipsnake		SC	B	M	M

Federal Status	State Status	Documented Occurrence Type	Potential Impact
FE = Endangered	SE = Endangered	P = Present (general presence)	H = High
FT = Threatened	ST = Threatened	B = Breeding	M = Moderate
FC = Candidate	SS = Sensitive	M = Migrant	L = Low
D = Delisted	SC = Candidate	W = Winter Resident	Mn = Minimal
FSC = Species of Concern	SM = Monitor	N = Not Present	N = None
			H = Historically Present, Not Currently Present

6.3.1 Threatened & Endangered Species

The proposed Segment A Reroute would have less of a potential effect on Bald eagles than Segment A1 because fewer large cottonwoods and willows, preferred by eagles for roosting, would need to be removed.

6.4 Fish

Overall, impacts to fish species present in Cooke Creek would be slightly less on the Segment A Reroute than along the Segment A1 alignment, but not enough to change overall impacts to fish species along Segment A. Because no large trees would need to be removed on the Segment A Reroute, impacts to water quality and large woody debris sources would be slightly lower than the Segment A1 alignment, where several large riparian trees would need to be removed.

6.4 Visual Resources

The Segment A Reroute would have a slightly higher impact on visual resources than Segment A1 because it would be located in a right-of-way that currently has no existing transmission lines and it would be in the foreground or middleground for most viewers. Impacts from Segment A1 would be moderate, but impacts from the Segment A Reroute would be high for viewpoint locations within 0.5 mile and moderate for the viewpoints between 0.5 mile and 5.0 miles.

6.5 Public Health and Safety

6.5.1 Segment A1

There are no residences within 1,000 feet of the right-of-way. Impacts from electric and magnetic fields would be low. Activities presently occurring within what would become the right-of-way would not change, as they are activities associated with open fields. Calculated levels for electric and magnetic fields are shown below.

Table 8
Calculated Electric Fields
New 500-kV and Existing Vantage–Schultz 500-kV Lines Operated at Maximum Voltage

ROW width, ft.	350			
Line	New 500-kV		Vantage – Schultz 500-kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, kV/m	8.7	5.8	8.5	5.1
Edge of ROW, kV/m	2.5	2.5	5.3	4.1

Table 9
Calculated Magnetic Fields
New 500-kV and Existing Vantage–Schultz 500-kV Lines Operated at Maximum Current

ROW width, ft.	350			
Line	New 500-kV		Vantage – Schultz 500-kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, mG	229	155	151	95
Edge of ROW, mG	71	62	88	66

Impacts from the noise of the new and existing lines would be low. The predicted median foul-weather audible noise levels at the edge of right-of-way would be 65 dBA. The noise level would be more than that of normal conversation indoors (60 dBA) and less than that of a gas lawnmower at 100 feet (70 dBA). Because the closest residents are more than 1,000 feet from the existing right-of-way, it is not expected that they would perceive any increased noise levels from the new line.

6.5.2 Segment A Reroute vs. Segment A1

As shown in Tables 10 and 11, the calculated electric fields for the proposed new line would be practically the same along the Segment A Reroute vs. Segment A1. However, the magnetic fields would have a slightly higher peak field and a slightly lower edge of right-of-way field. The calculated electric and magnetic fields for the existing Vantage-Schultz line would decrease along the Segment A Reroute.

Table 10
Calculated Electric Fields
Difference Between Segment A Reroute and Segment A1 at Maximum Voltage

ROW width, ft.	350			
Line	New 500-kV		Vantage – Schultz 500-kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, mG	-0.1	0.0	+0.1	-0.1
Edge of ROW, mG	0.0	-0.1	-2.8	-1.7

Table 11
Calculated Magnetic Fields
Difference Between Segment A Reroute and Segment A1 at Maximum Current

ROW width, ft.	350			
Line	New 500-kV		Vantage – Schultz 500-kV	
Clearance	Min.	Avg.	Min.	Avg.
Peak field, mG	5	4	-37	-19
Edge of ROW, mG	-3	-3	-50	-33

Impacts from the noise of the new and relocated existing lines would be slightly higher for the Segment A Reroute (low/moderate vs. low) due to the fact that the Segment A Reroute would be locating lines in an area that currently has no transmission lines. Along either alignment, the Segment A Reroute or Segment A1, the closest residents would be more than 1,000 feet from the right-of-way and it is not expected that they would perceive any increased noise levels from either alignment.

6.6 Prime Farmlands

Both the Segment A Reroute and Segment A1 would cross lands designated as "prime farmland if irrigated." However, the Segment A Reroute would have the potential to affect a greater amount of prime farmland because it would cross roughly 0.2 mile of additional designated soils and would require an estimated seven new transmission line structures to be located on these designated soils; Segment A1 would require an estimated three new structures on these designated soils. As a result, the maximum estimated area of impact (0.34 acre per structure) to lands designated as "prime farmland if irrigated" from the Segment A Reroute would be 2.38 acres versus 1.03 acres for Segment A1 - a potential difference of roughly 1.35 acres.

REFERENCES

Bracken, T. Dan. July 2002. Addendum #2 to Appendix I, *Electrical Effects*.

Renfrow, Brent. 2001. Habitat Biologist, Washington Department of Fish and Wildlife. Personal Communication.

Washington State Department of Fish and Wildlife. 2001. Washington Department of Fish and Wildlife Priority Habitats and Species. Priority Habitats and Species Database Search Results. April 3, 2001. Olympia, Washington.

Washington State Department of Fish and Wildlife. Unpublished. Yakima River Basin Stream Catalog. Yakima, Washington.

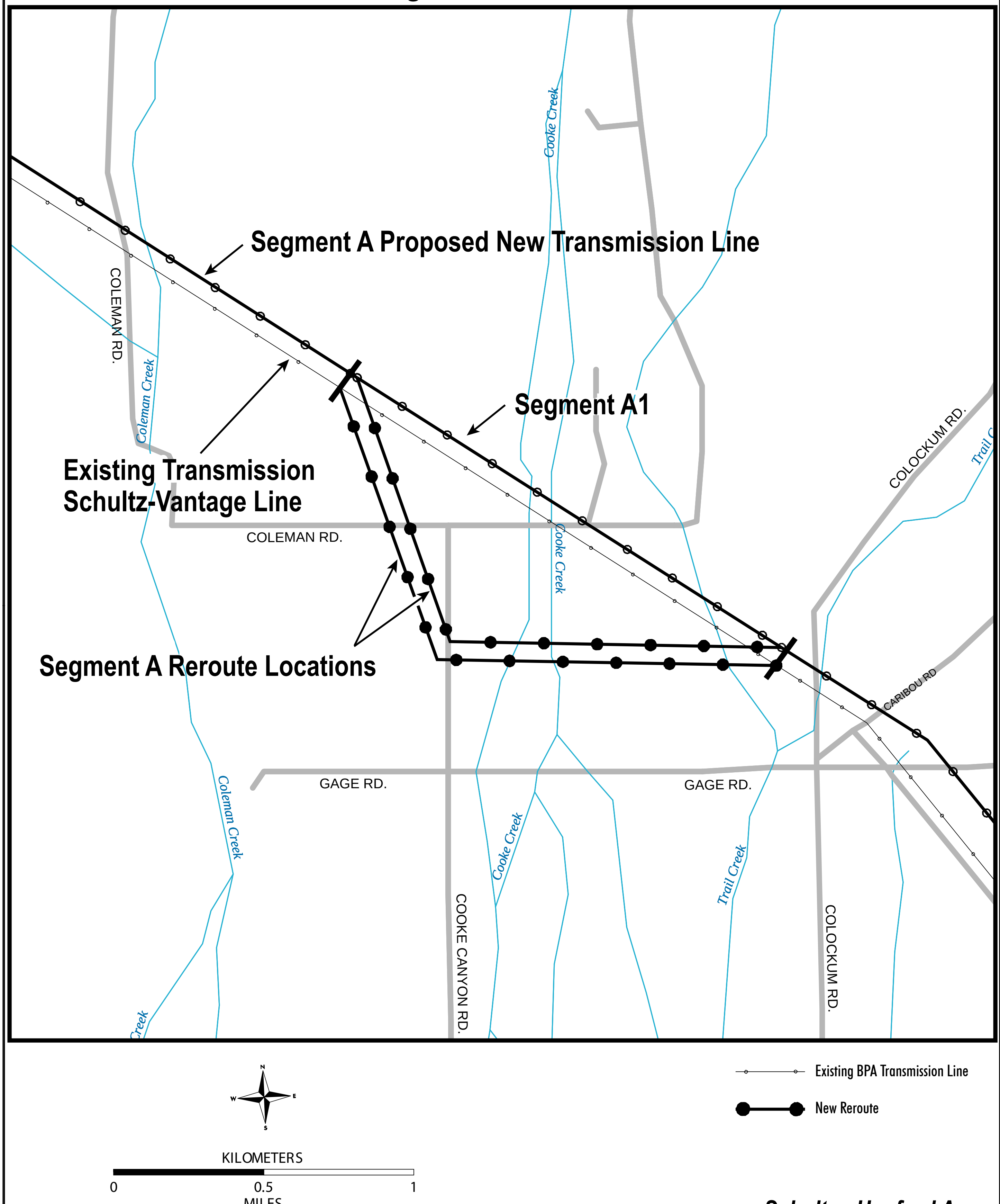
Washington State Department of Revenue. 2002. Tax Statistics 2001. Olympia, Washington.

Washington State University. March 2001. Washington State Soils, Remote Sensing and GIS Lab, Crop and Soil Science. http//remotesens.css.wsu.edu/washingtonsoil/index.html (updated 1998)

Washington State Yearbook. 2001. Dwyer, Scott D., and Mary B. Dwyer, eds. 2001 Washington State Yearbook: The Evergreen State Government Directory.

Whitehead, R.L. 1994. U.S. Geological Survey: Ground Water Atlas of the United States- Idaho, Oregon, Washington. United States Department of the Interior.

Segment A Reroute



Schultz - Hanford Area
Transmission Line Project

Map 1

Schultz-Hanford Area Transmission Line Project
Segment A Reroute

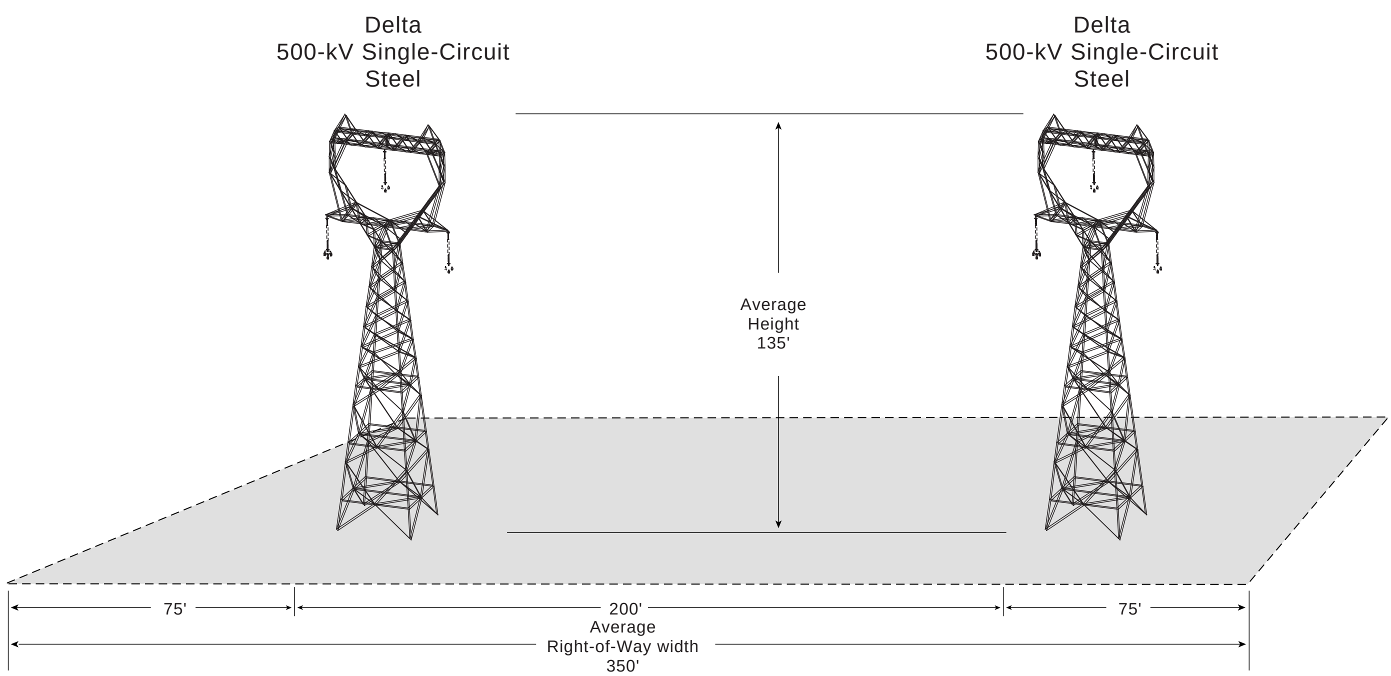


Figure 1
Proposed Structures

Line Separation

Background

While it is generally desirable to build lines on the same corridor side by side for environmental and land use reasons, the likelihood and consequences of outage of two or more lines due to a common event must be considered by transmission planners. The loss of multiple circuits into a load area will result in increased demand over the remaining circuits and can result in area blackout unless load and/or generation (sometimes a sizable amount) is tripped off to balance flow with remaining transmission capacity. Transmission planning is done on the basis of *not* interrupting customer load for the more common system transmission line outage events since high voltage grid interruptions have the potential to affect a large number of customers and critical load such as hospitals, emergency services, and other essential or sensitive loads.

The Western Electricity Coordinating Council (WECC), formerly the Western Systems Coordinating Council (WSCC), is the organization that sets transmission system reliability standards for the Western U.S. The WECC, of which BPA is a member, has established performance criteria applicable to loss of multiple lines. In the case of the more likely multi-contingency events (loss of two lines or all lines in a corridor) standards exist related to allowed electrical performance as well as admissible countermeasures such as load or generator tripping. Successive loss of transmission lines and attendant load and generation, like falling dominoes (called “cascading”) is not allowed. In the case of even less likely events (sometimes called unplanned or extreme events), reliance is placed on containment measures such as load shedding, system islanding (separating areas of the system from one another), and other means to limit cascading.

Simultaneous loss of two adjacent lines is considered to be a likely (credible) event and therefore must be planned for in outage studies. Simultaneous loss of two or more lines built on separate rights-of-way is generally considered to be a non-credible event. Provision has been made for specific cases to classify loss of two lines on the same right-of-way as a non-credible event based on line design; length; location, e.g., whether forested, agricultural, mountainous, etc; outage history; operational guidelines; and separation between circuits. This is understood by referring to the North American Electric Reliability Council (NERC)/WSCC Planning Standard WSCC-S2 on the following page.

WSCC-S2 The NERC Category C.5 initiating event of a non-three phase fault with normal clearing shall also apply to the credible common mode contingency of two adjacent circuits on separate towers. The credibility of such an outage depends upon the credibility of the common mode failure. The credible outrage of two circuits could result from a lightning storm or forest fire. Considerations in the determination of credibility should include line design; length; location, whether forested, agricultural, mountainous, etc.; outage history; operational guidelines; and separation between circuits.[1]

A process has been established to evaluate situations on a case-by-case basis to determine if a higher or lower standard is applicable. Contingencies with an estimated Mean Time Between Failure (MTBF) of greater than 300 years are not held to the standard of "no cascading." These provisions are covered in standards WSCC-S5 and WSCC-S6.

WSCC-S5 For contingencies involving existing or planned facilities, the Table W-1 performance category can be adjusted based on actual or expected performance (e.g. event outage frequency and consideration of impact) after going through the WSCC Phase I Probabilistic Based Reliability Criteria (PBRC) Performance Category Evaluation (PEC) Process.[1]

WSCC-S6 Any contingency adjusted to Category D must not result in a cascading outage unless the MTBF is greater than 300 years (frequency less than 0.0033 outages/year) or the initiating disturbances and corresponding impacts are confined to either a radial system or a local network.[1]

Line Spacing Requirements

There is not any single criteria or rule that establishes minimum circuit spacing requirements to qualify as very low likelihood (not credible) because the importance of various risk factors is not the same in all cases. However, cases within WSCC of minimum separation of 2,000 feet have been accepted as not credible. The following list represents risks that are mitigated by line separation. To the extent that these can be mitigated by design or maintenance measures, the need for separation may be reduced.

1. One tower falling into an adjacent line;
2. A snagged shield wire from one line being dragged into the adjacent line (span length);
3. An aircraft flying into more than one circuit;

4. Fire on the right-of-way or smoke (ionized particles) enveloping more than one circuit causing temporary failure; and
5. Lightning strokes affecting more than one line.

The risk of lightning-caused events can be mitigated by the use of shield wires (a target instead of the energized conductors), and by modifying protective control circuits (relaying).

Risks 1 through 3 are generally mitigated by increased spacing between lines. Some organizations use separation by more than the span length as adequate to designate the circuits as being in separate corridors.[2,3] Span lengths for 500-kV lines are typically 1,000 to 1,500 feet, depending on terrain.

The risk of fire or smoke affecting two lines can be managed by right-of-way maintenance practices and notification procedures. Increased spacing reduces the risk that multiple circuits will be affected and increases time for notification and corrective dispatcher action. Terrain is important in terms of the amount and volatility of combustible materials.

When Is Corridor Separation Needed?

As noted, the NERC/WSCC Planning Standards make allowance for mitigating action for multi-contingency outages affecting lines on the same right-of-way. However, it is BPA and general utility practice that two-line outages should *not* rely on interruption of customer load except for very unusual operating conditions such as adverse cold weather or a weakened transmission system. Generator tripping may be used as a countermeasure in some cases for two-line outages but it also becomes objectionable if the requirements are excessive or impractical.

Summary - As a matter of practice, construction on separate rights-of-way is necessary when a multi-circuit outage on a common corridor must be considered a credible event and corrective action for this outage would require excessive or impractical countermeasures.

Risk Considerations

Historical data over a 15-year period for the BPA system has been analyzed according to cause for overlapping outages of lines on the same corridor. This information for 125 events across 6,636 corridor miles is illustrated in Table 1.

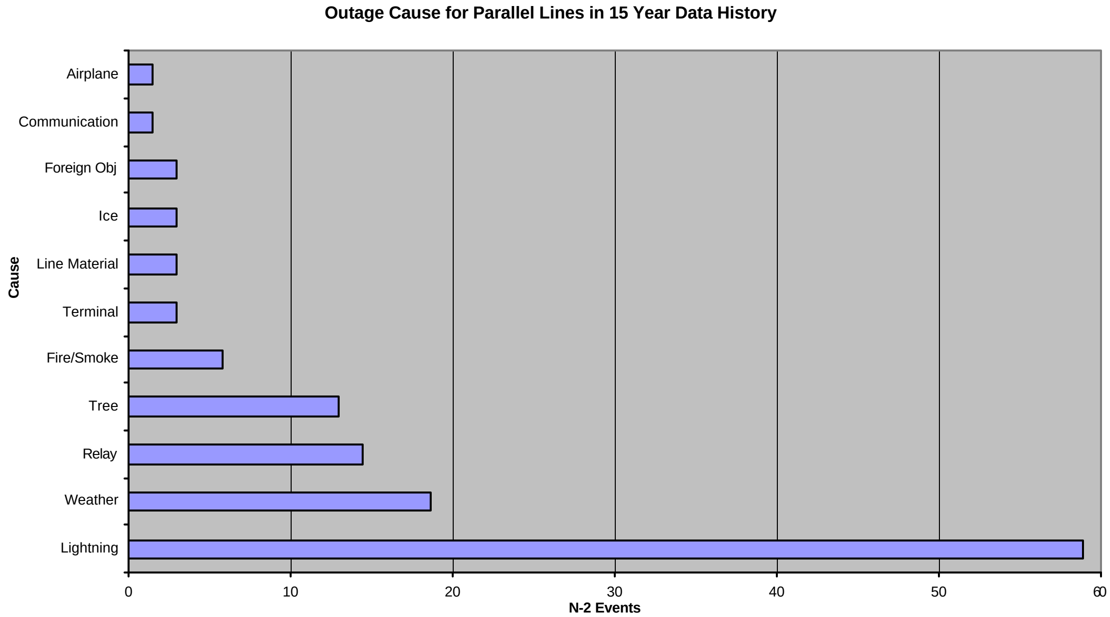


Table 1. Summary of overlapping outages on common corridor by cause. Unknown events are distributed pro-rata to other causes.

The line proximity-related risk elements are: airplane, foreign object, ice, line material, fire/smoke, tree, weather, and lightning. The outage rate of a two-line outage between Schultz and Vantage may be estimated by normalizing the line-related outage components to 35 miles and normalizing the terminal-related components to one terminal pair (Schultz) relative to just over 1,000 terminal pairs in the database. This results in an expected outage Mean Time Between Failure (MTBF) of about 28 years, which is insufficient to meet the WECC standard of 300 years.

While there is not a sufficient database to accurately quantify the effect of separation distance on the outage rate of two parallel lines, separation of lines by a distance corresponding to the average span length or more significantly reduces the risk factors due to a common mode event. In such cases it is assumed that the outage risk is limited to that of terminal-related causes. WECC has not required planning for outage of both lines when separated except on an exploratory basis.

Experience has borne out the benefit of separation in the case of the 148-mile Captain Jack – Olinda 500-kV line, which was built with a separation of more than one span length from the Malin-Round Mountain 1&2 500-kV lines, which had in the past experienced numerous two-line outage events, some with serious system consequences. Since energization of the Captain Jack-Olinda line in 1993 there has not been a single case of simultaneous outage of all three lines, notwithstanding a number of outages of the 95-mile Malin-Round Mountain 1&2 500-kV lines.

Cases considered in applying separation to the Captain Jack – Olinda line [2] include:

- Aircraft causing simultaneous outage of two 500-kV circuits, three 230-kV circuits, and a 66-kV circuit on September 13, 1973;
- Sabotage and/or vandalism incidents involving the bulk power system;
- Numerous simultaneous overlapping outages of adjacent lines caused by smoke or fire;
- Lightning strike on one line creating voltage fluctuations on the adjacent line to cause sympathetic arc-over of adjacent circuits (example of May 1, 1979 on the Malin-Round Mountain lines); and
- Wind and ice events occurring in various situations.

Similar justification was used as a basis for plans to construct the Los Banos – Gates 500-kV line (also in California) with separation of approximately 2000 feet from the existing 500 kV lines [3]. This reference cites a case where more than 5 million customers in five western and southwestern states were affected by outages associated with gale force winds when a 500-kV tower fell laterally into a tower on an adjacent 500-kV line.

Attachment 1 identifies risk factors, design variables, and mitigation that can be considered to increase system reliability.

References:

[1] NERC/WSCC Planning Standards, Board of Trustees Approved April 18, 2002, available from the WECC web page at: www.wecc.biz/documents/standards/recently_approved_standards.html

[2] Corridor Separation for the California-Oregon Transmission Project, California Oregon Transmission Project Power System Studies Committee Report, October 1985, pages 10-12.

[3] Los Banos – Gates Environmental Report and Technical Appendices, September 1996, page 2-3 through 2-5.

Attachment 1 Robust Line Design Features

Background

With more demands for use of land there is increasing difficulty in opening up new rights-of-way (ROW) for transmission. At the same time it is essential that the transmission system be developed from the standpoint of ensuring adequate system reliability. Accordingly, objective guidelines are needed for making decisions affecting these factors. This policy addresses design and planning considerations in relationship to risk of common mode multiple-line outages with the goal of improving expectations of what can be expected in terms of line outage performance and complementing probabilistic methods.

Risk Factors

The following is a list of risk factors to be considered in ROW planning for cases where it is the goal that the N-2 outage be of very low probability. Generally risk increases with common ROW distance.

R1 Risk of fire affecting both lines
R2 Risk of one tower falling into another line
R3 Risk of a conductor from one line being dragged into another line
R4 Risk of lightning strikes tripping both lines
R5 Risk of an aircraft flying into both lines
R6 Risk of station-related problems resulting in loss of two lines for a single event
R7 Risk of snow or earth slides
R8 Risk of loss of two lines due to an overhead crossing

Design Variables

The following are design variables that affect the credibility of each of the above Risk Factors:

V1 Substation breaker configuration (R6)
V2 Circuit centerline spacing (R1, R2, R3, R8)
V3 Span length (R3)
V4 Tower design (R2, R7, R8)
V5 Use of shield wires for lightning (R4)
V6 Conductor support systems (R8)
V7 Use of deadend versus suspension towers (R3)
V8 Use of single pole reclosing (R4)
V9 Vegetation management (R1)

V10 Fire watch curtailments (R1)
V11 Shortening of line on common ROW (R1 through R8)
V12 Tower grounding (R4)
V13 Protective relaying design and settings (R6)

Example Mitigation

The following guidelines are based on either eliminating the risk of each factor or reducing its risk such that the combined MTBF is maximized, enabling upgrading of case classification.

Centerline Spacing (elimination of risk)
Lines separated by more than the height of the adjacent tower structure where fire exposure risk is minimal and the ROW is not in an area of expected air traffic. Wider separation of 1,000 to 2,000 feet in areas where dry fuels would be present to support a fire affecting both lines before it could be detected and loading reduced.

Line Crossings (elimination of risk)
Use of robust tower and conductor support systems of overhead line.
Spacing of lines by more than one span length in cases where dropping of a conductor is a credible risk.
Overhead line cannot cascade into crossing.

Substation Configuration (elimination of risk)
Substations configured such that a fault on one line followed by breaker failure will not result in a loss of the parallel line.

Locational Hazards (elimination of risk)
In areas where risk is increased due to locational hazards, the centerline spacing is increased.
Proximity to flight traffic pattern (increase centerline spacing to not less than one span length).
Proximity to slide areas (increase centerline spacing to be clear of slide area).

Vegetation Management (elimination of risk)
Procedures in place for increased vegetation management in areas where accumulation of combustible fuel could result in line tripping in less than 30 minutes from initiation of a fire.
Operational procedures in place which can allow reporting of fire and reduction of transfer levels within 30 minutes.

Lightning Mitigation (reduction of risk)

Use of overhead shield wires to minimize risk of loss of two lines due to lightning.

Single-pole reclosing to minimize risk of loss of both lines due to a strike affecting both circuits.

Estimate MTBF from typical area statistics:

- Probability of common mode lightning event/year/mile with and without shield wire.
- Probability of common mode event resulting in three-pole trip of both circuits with/without SPR.

Protective Relaying (elimination of risk)

Certification that settings and design are such that a single-fault condition will not result in loss of more than one parallel line.

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Property Impacts

BPA construction alternatives include acquiring easements for approximately 55 to75 miles of new 500-kV transmission line right-of-way. The new right-of-way would either parallel existing transmission line corridors, being offset by up to 1375 feet, or be routed in a new corridor location. BPA would utilize its existing access road system where possible, however, it is anticipated that additional access road easements would need to be acquired. For the Schultz-Wautoma alternative, BPA would also need to acquire fee title to property for a substation. BPA would pay market value to nonfederal landowners for any new land rights required for this project.

The landowners would be offered market value, established through the appraisal process, for the transmission line or access road easements, or for the fee acquisition of property needed for the substation. The appraisal process takes all factors affecting value into consideration including the impact of transmission lines on property value. The appraisals may reference studies conducted on similar properties to add support to valuation considerations. The strength of any appraisal is dependent on the individual analysis of the property, utilizing neighborhood specific market data in order to determine market value.

Impacts to property for new rights-of-way for transmission lines and access roads are discussed below.

New transmission line right-of-way: The predominant land use for the new transmission line right-of-way consists of irrigated and non-irrigated agricultural land, with a small portion being comprised of rural residential properties.

BPA's transmission line easement documents encumber the right-of-way area with land use limitations. The easement specifies, "the present and future right to clear the right-of-way and to keep the same clear of all trees, whether natural or cultivated, and all structure supported crops, other structures, trees, brush, vegetation, fire and electrical hazards, except non-structure supported agricultural crops less than 10 feet in height." The landowner may grow most crops or graze livestock. Special written agreements may be entered into between BPA and the landowner to allow Christmas, ornamental or orchard trees, and structure supported crops. Heights of the trees/crops and access must be controlled to maintain safe distances.

The impact of introducing a new right-of-way for transmission towers and lines can vary dramatically depending on the placement of the right-of-way in relation to the property's size, shape, and location of existing improvements. A transmission line may diminish the utility of a portion of property if the line effectively severs this area from the remaining property (severance damage). Whether a transmission line introduces a negative visual impact is dependent on the placement of the line across a property as well as each individual landowners' perception of what is visually acceptable or unacceptable.

If the transmission line crosses a portion of the property in agricultural use such as pasture or cropland, little utility is lost between the towers, but 100% of the utility is lost within the base of the tower. Towers may also present an obstacle for operating farm equipment, and controlling weeds at tower locations. To the extent possible, new transmission lines are designed to minimize the impact to existing and proposed (if known) irrigation systems. If the introduction of a transmission line creates a need to redesign irrigation equipment or layout, BPA compensates the landowner for this additional cost.

These factors as well as any other elements unique to the property are taken into consideration to determine the loss in value within the easement area, as well as outside the easement area in cases of severance. For those portions of the project route that require up to 1375 foot separation between the new and existing 500-kV transmission lines, the appraiser will analyze whether there is an impact to the property's utility in this 1450 foot wide area.

Market value would be paid for any timber to be cut on the new right-of-way, as well as for any trees off the right-of-way that need to be cut for construction purposes or that pose a danger of falling into the line or across the access roads.

New access roads: If BPA acquires an easement on an existing access road and the landowner is the only other user, market compensation is generally 50% of full fee value or something less than 50% if other landowners share the access road use. For fully improved roads, the appraiser may prepare a cost analysis to identify the value of the access road easement. If BPA acquires an easement for the right to construct a new access road and the landowner has equal benefit and need of the access road, market compensation is generally 50% of full fee value. If the landowner has little or no use for the new access road to be constructed, market compensation for the easement is generally close to full fee value.

New Substation: If the Schultz-Wautoma alternative is selected, BPA would offer market value for the fee acquisition of approximately 47 acre parcel needed for the Wautoma Substation.

Property Value Impacts. The proposed transmission line is not expected to have long-term impacts on property values in the area. Whenever land uses change, the concern is often raised as to the effect the change may have on property values nearby. Zoning is the primary means that most local governments use to protect property values. By allowing some uses and disallowing others, or permitting them only as conditional uses, conflicting uses are avoided. Some residents consider transmission lines to be an incompatible use adjacent to residential areas; however, this feeling is not universal.

The question of whether nearby transmission lines can affect residential property values has been studied numerous times in the United States and Canada over the last twenty years or so, with mixed results. In 1995, BPA contributed to the research when it looked at the sale of 296 pairs of residential properties in the Portland, Oregon metropolitan area (including Vancouver, Washington) and in King County, Washington. The study evaluated properties adjoining 16 BPA high voltage transmission lines (subjects) and compared them with similar property sales located away from transmission lines (comps). All of the sales were in 1990 and 1991 and adjustments were made for time and other factors. The results of the study showed that the subjects in King County were worth approximately 1% less than their matched comps, while the Portland/Vancouver area subjects were worth almost 1.5% more (Cowger et al. 1996).

BPA recently updated this earlier study using 1994/95 sales data. The sales of 260 pairs of residential properties in King County and Portland/Vancouver metropolitan areas were reviewed. The information confirmed the results of the earlier study, i.e., that the presence of high voltage transmission lines does not significantly affect the sale price of residential properties. The residential sales did, however, identify a small but negative impact from 0 to 2% for those properties adjacent to the transmission lines as opposed to those where no transmission lines were present. Although this study identified a negative effect, the results are similar to the earlier study and the differences are relatively small (Cowger et al., 2000).

Studies of impacts during periods of physical change, such as new transmission line construction or structural rebuilds, generally have revealed greater short-term impacts than long-term effects. However, most studies have concluded that other factors, such as general location, size of property, improvements, condition, amenities and supply and demand factors in a specific market area are far more important criteria than the presence or absence of transmission lines in determining the value of residential real estate.

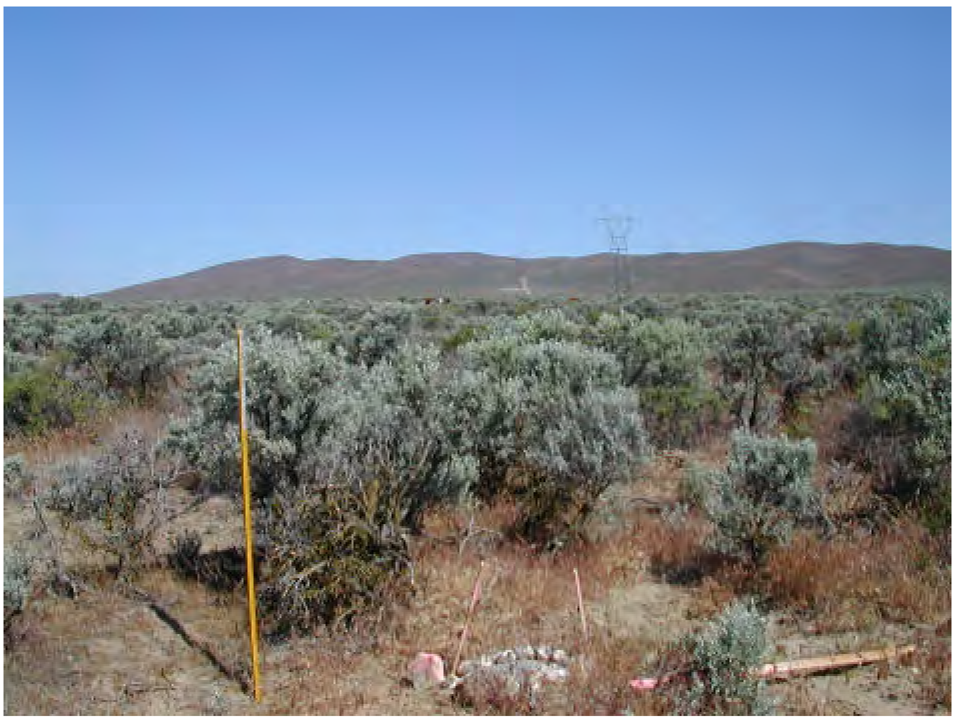
As a result of the proposed project, some short-term adverse impacts on property values (and salability) might occur on an individual basis; however, these impacts would be highly variable, individualized, and unpredictable. Constructing the transmission line is not expected to cause long-term adverse effects to property values along the right-of-way or in the general vicinity. Non-project impacts, along with other general market factors, are already reflected in the market value of properties in the area. These conditions are not expected to change appreciably. Therefore, no long-term impacts to property values are expected as a result of the proposed project.

Mitigation:

Existing transmission line right-of-way: One of the alternatives would be to tear down portions of the existing Vantage-Midway 230-kV transmission line and replace those portions with a double circuit line. The new structures would generally be placed in the same locations as the existing lattice steel structures, or if possible, and desired by the affected landowner, be placed in more convenient locations. Since the existing right-of-way in this area is 100 feet in width, this alternative would require BPA to acquire easements for additional width along the existing transmission line right-of-way. Land types along the existing right-of-way include rural residential and irrigated as well as non-irrigated agricultural properties. The existing transmission line right-of-way has already imposed land use limitations on the land uses along the right-of-way by the physical presence of the lines and structures, as well as by the use limitations imposed by the original easements. Overall, the impact of acquiring additional width right-of-way along scattered portions of the transmission line corridor is expected to be minimal in respect to acreage affected as well as impact to land uses and resources since the impact is already evident with the existing transmission line.

Rare Plant Survey for the Preferred Alternative
Bonneville Power Administration
Schultz-Hanford Area Transmission Line Project
Central Washington

September 25, 2002



Prepared By:

Beck Botanical Services
1708 McKenzie Avenue
Bellingham, WA 98225

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1.0 EXECUTIVE SUMMARY

Beck Botanical Services, subcontractor to Parsons Brinckerhoff, conducted a survey for federally listed and state listed (Threatened, Endangered and Sensitive) plant species along the preferred alternative of the proposed Bonneville Power Administration Schultz-Wautoma transmission line. The preferred alternative includes Segments A, B_{south} and D. The survey project area included the 150 feet wide right-of-way (ROW) and proposed and existing access roads for the transmission line. The objective of the survey was to map occurrences of rare plant species within the project area. In addition, an evaluation of potential habitat and searches for federally listed species was done on the proposed fiber optic line.

The 63.7-mile long project area is located in Kittitas, Grant and Benton Counties, Washington. It begins at the Schultz Substation north of Ellensburg, traverses state, private and DOD lands to the Vantage Substation, then travels though private, BLM and DOE lands before it terminates at the proposed Wautoma Substation approximately two miles southwest of Cold Creek. The 32-mile long proposed fiber optic line would be affixed to the existing Vantage-Columbia transmission line that begins at the Vantage Substation and terminates at the Columbia Substation approximately 12 miles southeast of Wenatchee. It is in Grant and Douglas Counties.

Prior to the survey, a list was compiled of rare plant species with the potential to occur in the project area using lists for each county the proposed transmission line crosses. These lists are maintained by the WNHP and BLM. In addition, a data request was made to the WNHP for occurrences of high quality plant associations and rare plants. Rare plant surveys occurred in August 2001 and April through July 2002. While all plants were searched for, the primary focus was to locate populations of Federal listed and candidate plants. The project area was surveyed by walking meander transects. Areas with likely rare plant habitat were surveyed at a higher intensity. The rare plant survey did not include Segments B_{north} C, E and F that were not part of the Preferred Alternative.

The rare plant survey documented the presence of 14 populations of six rare plant species in the Schultz-Wautoma project area. Some of these were known occurrences tracked by the WNHP and some of these were previously unknown. These were found on BLM, DOD, DOE, private, and State lands. Several of these occurrences are quite large. No populations of Federally listed, proposed or candidate species were located in the Schultz-Wautoma project area.

2.0 INTRODUCTION

Beck Botanical Consulting, a subconsultant to Parsons Brinckerhoff conducted a survey for threatened, endangered and sensitive plant species (rare plants) along the Preferred Alternative (Segments A, B_{south} and D) of the proposed Bonneville Power Administration Schultz-Hanford Area transmission line. The East Cascades and Lower Columbia Basin geographic area has numerous endemic and rare plant species. The list of potential rare plant species varied somewhat depending on land ownership. Both Federal and State listed species were searched for on federal and state lands. BLM rare plant species were searched for on BLM lands. Federally listed plants, including “federal species of concern” were searched for on private lands and along the proposed fiber optic line. Federal species of concern are those whose conservation standing is of concern to the USFWS, but for which status information is still needed (WNHP 1997). There are extensive sections of federally owned lands along the proposed line.

The objective of the survey was to map occurrences of rare plant species within the project area. BPA would use the information on rare plants in the proposed ROW and access roads to determine the impacts of proposed constructions activities. These surveys would also provide information and recommendations for possible mitigation, construction methods and avoidance.

3.0 PROJECT AREA DESCRIPTION

The preferred alternative for the proposed Schultz-Wautoma transmission line is comprised of Segments A, B_{SOUTH} and D. The 63.7-mile long project area is located in Kittitas, Grant and Benton Counties, Washington. It begins at the Schultz Substation north of Ellensburg, traverses private and DOD lands to the Vantage Substation, then travels though private, BLM and DOE lands before it terminates at the proposed Wautoma Substation approximately two miles southwest of Cold Creek. A 32-mile long proposed fiber optic line would be affixed to the existing Vantage-Columbia transmission line that begins at the Vantage Substation and terminates at the Columbia Substation approximately 12 miles southeast of Wenatchee. It is in Grant and Douglas Counties.

For purposes of the rare plant survey, the project area included the 150 feet wide ROW and proposed and existing access roads. The project centerline was staked in the field prior to the beginning of surveys. Proposed and existing access roads were marked on field maps. A description of vegetation communities in the project area is provided starting in Section 3.4.2.1. The rare plant survey did not include Segments B_{north} C, E and F as described in Section 3.4.2. Since existing access roads would be used to construct the fiber optic line, an intensive rare plant survey was not necessary. Instead, a field reconnaissance for rare plants was conducted along the existing transmission line and access roads.

4.0 METHODS

The rare plant survey of the Schultz-Wautoma project area was performed using commonly accepted botanical survey methods to ensure a high likelihood of locating and identifying rare plant populations. Rare plant survey methods are straightforward, and involve visually searching the project area for rare plant species. Timing for field surveys are based on flowering times of potential rare plant species. In general, upland plant species were searched for earlier in the field season than plants that occur in wetland habitats, because they typically bloom earlier. Some areas were visited more than once to search for both early and late blooming rare plant species.

Table 1 presents rare plant taxa that have a reasonable potential to occur in the project area (WNHP 1997). These include Federal and State listed plants and BLM rare plant species. Most rare plant species require a technical key for positive identification. The status of the listed plant taxa reflects the most current information available; however, the status of a particular rare plant taxon is subject to change by the WNHP and/or the USFWS. While most scientific names follow Hitchcock and Cronquist (1973), some updated taxonomy is included.

Rare plant survey strategies included: habitat searches when rare plants were identifiable, visits to known occurrences of rare plants, literature review, and herbarium research for additional information and species verification. Surveys were conducted by walking meander transects.

The vast majority of the project area that supports native vegetation was surveyed, as rare plant species are potentially present in all of the habitat types. A GPS unit was used to help accurately map rare plant populations. Some photographs were taken of rare plant species (close-ups of individual plants and more general habitat shots). Plant collections were made when it was deemed necessary to identify a plant. A complete species list was compiled for the project area.

Depending on the habitat, survey intensities employed in the field while walking meander transects were light, moderate or complete, as defined below:

> Light: light search intensity in an area with degraded habitat or low potential for rare plant species.
>
> Moderate: moderate search intensity through an area, with higher intensity surveys in the portions of the areas which appear unique or which appear to have a high potential for rare plant populations.
>
> Complete: close searching in areas with rare plant populations or with habitat with a higher potential of having rare plant populations.

In order to determine the survey intensity level that would be used for any given area, the likelihood the area would serve as rare plant habitat, habitat quality, vegetation density, terrain and expected visibility of the target species were all taken into account. Most of the project area received moderate survey intensity. The fiber optic line was field evaluated for habitat for federally listed species. It did not however receive a full rare plant survey.

When a rare plant population was located, it was mapped on aerial photomaps and USGS maps and its population size was estimated. When the population covered a large area, the locations where it intersected the ROW were mapped. Additional information collected included: distance and bearing to nearest BPA transmission line towers, GPS readings, associated plant species, information for completion of WNHP siting forms, and recommendations for construction methods, avoidance and mitigation. Notes were also taken on habitat conditions, plant communities, dominant grass and shrub species, plant phenology and other pertinent observations.

5.0 RESULTS

Surveys of the Schultz-Wautoma project area were conducted on August 21-23, 2001 for late-blooming species and to identify potential habitat and plan for field surveys in 2002. Early season surveys were done in April 9–12, 2002. Most of the project area was visited in May and June depending on elevation, aspect and target plant species (May 8-18, May 22-26, June 11-13). Late season surveys occurred in July (July 17-19, July 24-25). The fiber optic line was surveyed during the July visits.

Although it was evaluated in the field for habitat for federally listed species, the proposed fiber optic line did not receive a formal rare plant survey. The only federally listed species that was deemed to have habitat along the fiber optic line was Ute ladies'-tresses. Wetland areas were searched for this species in July. Upland areas along the proposed line were spot-checked for rare plants.

5.1 Rare Plant Species

The following six rare plant species were encountered in the project area (Segments A, B_{south} and D): Columbia milk-vetch, gray cryptantha, Hoover's desert-parsley, piper's daisy, tufted evening-primrose, and desert cryptantha, (Table 1), Number of rare plant populations within the Schultz-Wautoma Project area and along the fiber optic line).

Three populations of state sensitive rare plant species were located along the fiber optic line: gray cryptantha, beaked spike-rush, and Geyer's milk-vetch. Although several populations of rare plants were located along the fiber optic line, a formal survey of the line was not done. Low quality habitat for Ute ladies'-tresses was located and searched. Potential habitat for other federally listed species was not present along the fiber optic line.

A WNHP siting form was filled out for each new rare plant population. In addition to siting forms, maps would be provided to the WNHP. A brief description of each rare plant species and its populations within the project area are provided below.

Table 1 Rare plant populations within project area and fiber optic line*.

Common Name / ***Scientific Name***	**Federal Status**	**State Status**	**A**	**B_{SOUTH}**	**D**	**Fiber optic line**
Columbia milk-vetch *Astragalus columbianus*	Species of Concern	Threatened			4?	
Gray cryptantha *Cryptantha leucophaea*	Species of Concern	Sensitive			4	1
Hoover's desert-parsley *Lomatium tuberosum*	Species of Concern	Threatened			2	
Geyer's milk-vetch *Astragalus geyeri*	--	Sensitive				1
Desert cryptantha *Cryptantha scoparia*	--	Sensitive		1		
Beaked spike-rush *Eleocharis rostellata*	--	Sensitive				1
Piper's daisy *Erigeron piperianus*	--	Sensitive			1	
Tufted evening-primrose *Oenothera cespitosa ssp. cespitosa*	--	Sensitive		1	1	

* Number of rare plant populations along access roads and within the proposed Schultz-Wautoma ROW.

Federal Species of Concern. Species whose conservation standing is a concern to USFWS, but status information is needed.

Threatened. Taxa that are likely to become Endangered in the state within the near future if factors contributing their decline continue.

Sensitive. Taxa that are vulnerable or declining, and could become Endangered or Threatened without active management or threat removal.

Information from the Washington Natural Heritage Program Information System. The status of all the plant taxa listed in this table reflects the most current information available; however, the status of a particular rare plant taxon is subject to change by the WNHP and/or the FWS.

5.1.1 Columbia milk-vetch (*Astragalus columbianus*)

Columbia milk-vetch is a member of the legume family, Fabaceae. It is considered Threatened in Washington and is a Federal species of concern. It is a local endemic found in Yakima, Kittitas and Benton counties in south-central Washington. Columbia milk-vetch is a short-lived perennial forb with white to cream colored flowers. It normally flowers in April and May. The pods are distinctive and allow the plant to be recognizable for several months after flowering. It usually grows in well-drained sandy and gravelly loams, lithosols and cobbly sand in big sagebrush/bluebunch wheatgrass and big sagebrush /Sandberg's bluegrass community types. Its populations are often quite extensive.

Two known and two new populations of Columbia milk-vetch were located in the project area. One is an extensive population on the south and north slopes of Umtanum Ridge, another is a large population on the south and north slopes of Yakima Ridge. The other two populations are in between the two ridges in the Cold Creek Valley near Highway 24. The populations on Yakima Ridge and the Cold Creek Valley in particular are quite weedy in places. The spatial distribution of plants in these populations ranges from scattered patchy to very widely scattered. Collectively, the four Columbia milk-vetch populations are many square miles in size and intersect over 3 miles of the proposed line.

5.1.2 Gray cryptantha (*Cryptantha leucophaea*)

Gray cryptantha is considered Sensitive in Washington and a Federal species of concern. It is a regional endemic known from the western Columbia Basin down to The Dalles, Oregon. Gray cryptantha is a large, showy perennial forb in the borage family (Boraginaceae). It has white flowers and is recognizable between May and June. The species is more or less restricted to slopes and swales of unstabilized to semi-stabilized sand dunes with low vegetative cover. It is typically associated with the bitterbrush/ Indian ricegrass plant association.

Two known and two new populations of gray cryptantha were located in the project area. These are in sandy areas south of the Vantage Substation, between Wanapum Village and the base of the north slope of the Saddle Mountains. One population is on BLM land, while the rest are on private lands. The spatial distribution of plants in these populations ranges from scattered patchy to very widely scattered. Collectively, the four gray cryptantha populations are several square miles in size and intersect over 1 mile of the proposed line.

While two groups of gray cryptantha plants were located along the fiber optic line in sandy areas north of the Vantage Substation, the entire population was not mapped. Appropriate habitat for this species along the fiber optic line is extensive north of the Vantage Substation.

5.1.3 Hoover's desert-parsley (*Lomatium tuberosum*)

Hoover's desert-parsley is considered Threatened in Washington and is a Federal species of concern. It is a local endemic that is only found in Benton, Grant, Kittitas and Yakima Counties in south-central Washington. Hoover's desert-parsley is a tuberous rooted perennial in the parsley family (Apiaceae) with small purple flowers and distinctive blue-green leaves. It blooms in March and April and grows in crevices of steep basalt talus slopes, in areas that have low vegetation cover. The surrounding vegetation community is generally big sagebrush/bluebunch wheatgrass.

The proposed ROW intersects small portions of two very large known occurrences of Hoover's desert-parsley. These are on the steep north-facing slopes of Umtanum Ridge on DOE land and Saddle Mountains on BLM land. In both locations, the patches of plants are located between structures on steep slopes in basalt talus.

5.1.4 Geyer's milk-vetch (*Astragalus geyeri*)

Geyer's milk-vetch is considered Sensitive in Washington where it is disjunct from its main range in the Great Basin and Snake River Plains. It is a small, annual forb in the pea family (Fabaceae) with whitish to purplish flowers. It is generally recognizable from April to July, depending on local rainfall patterns. This species is distinctive because it is one of the few annual species of milk-vetch. The general habitat of Geyer's milk-vetch includes depressions in mobile or stabilized dunes, sandy flats, valley floors, draws in gullied hills and margins of alkaline sandy playas.

A large population of Geyer's milk-vetch was recently located in sandy areas just north of the Vantage Substation. The population is several square miles in size and intersects several miles of the proposed fiber optic line. The spatial distribution of the plants ranges from scattered patchy to very widely scattered.

5.1.5 Desert cryptantha (*Cryptantha scoparia*)

Desert cryptantha is a regional endemic that is most common on the Snake River Plains of Idaho and is disjunct in a few counties in Washington. It is a small annual forb in the borage family (Boraginaceae) with tiny white flowers and unusual, hooked nutlets. Its habitat is dry, open slopes and flats typically within the big sagebrush/ bluebunch wheatgrass plant association. Although this species is currently included on the WNHP Review Group 1 list, it would be added to the Sensitive list when the WNHP updates its list later in 2002.

One small population of 20 plants was located on YTC, along a portion of the John Wayne Trail that would be used as an access road. Plants are at the base of the steep south-facing riprap slope.

5.1.6 Beaked spike-rush (*Eleocharis rostellata*)

Beaked spike-rush is a Sensitive species in Washington. It is a rhizomatous plant in the sedge family (Cyperaceae). Its flowers are not showy, although the species is unusual in that it produces above-ground stolons. When walking through a patch of beaked spike-rush, the stolons make a distinctive popping sound as one's foot catches on and snaps the stolons. Beaked spike-rush is known from alkaline or highly calcareous substrates around streambanks, springs, lake margins, and in marshes. It grows in moist silty soils with lots of organic material.

One small population of beaked spike-rush was located on marshy ground immediately north of the Vantage Substation. The population is between towers on the edge of the ROW of the proposed fiber optic line.

5.1.7 Piper's daisy (*Erigeron piperianus*)

Piper's daisy is a Sensitive species in Washington. It is a regional endemic found only in the Columbia Basin. It is a small yellow-flowered perennial in the composite family (Asteraceae) that blooms from May through June. It occurs most commonly in the winterfat/ Sandberg's bluegrass and big sagebrush/ bluebunch wheatgrass plant communities. It grows on level ground to moderate slopes of all aspects. Soils are well drained and are generally somewhat alkaline.

The proposed line intersects a portion of a large occurrence of Piper's daisy on both north and south-facing slopes on the Hanford Site. Plants have a discontinuous distribution within the population; they are scattered patchy to widely scattered. This survey substantially enlarged the boundaries of the existing population to the north and to the south. The Piper's daisy population is several square miles in size and intersects approximately 5000 feet of the proposed line.

5.1.8 Tufted evening-primrose (*Oenothera cespitosa* subsp. *cespitosa*)

Tufted evening-primrose is a Sensitive species in Washington where it is peripheral to its main range. It is a perennial in the evening- primrose family (Onagraceae) with large, showy white flowers that turn pink with age. This species favors dry, open slopes, occurring as individuals or colonies on clay soils, rocky slopes composed of shales, volcanics and sandstones, bluffs and exposed rocky ridges. It also colonizes roadcuts in grasslands and sagebrush.

There are two populations of tufted evening-primrose in the project area, one known and one newly located. The known population is on the YTC, along the built up portions of the converted railway right-of-way John Wayne Trail. Plants grow in loose substrate on top of the roadbed and on steep, unstable south facing slopes composed of basalt riprap. The proposed ROW utilizes a portion of the John Wayne Trail as an access road. Tufted evening-primrose plants occur along sections of this portion of the John Wayne Trail.

The newly located population is on the steep west-facing slopes above Lower Crab Creek. While most of the plants are outside of the ROW, some plants are in the ROW, some are along an existing road that would be used by the proposed project as an access road, and some plants are growing in a gravel pit adjacent to the access road.

5.2 Federal Status Plant Species

No populations of Federally listed, proposed or candidate species were located along the Preferred Alternative (Segments A, B_{SOUTH} and D) of the proposed Schultz-Hanford Area transmission line project area or the fiber optic line. The following section describes the five federal status plant species with potential to occur in the Schultz-Wautoma study area. It includes information on their habitat, ecology, range (Table 2), and where rare plant surveys for them occurred within the Project area. No federal status plant species were located along the.

Table 2. Federal Status Plant Species Potentially Occurring in Study Area

Common Name *Scientific Name*	Federal Status	Habitat Preference and Plant Associations	Known Occurrence(s) in the Vicinity of the Study area
Ute ladies'-tresses *Spiranthes diluvialis*	Threatened	Low elevation wetlands in valleys - associated with spike-rushes, sedges, grasses, and rushes	None
Wenatchee Mountains checker-mallow *Sidalcea oregana* var. *calva*	Endangered	Grows in meadows that are moist into the summer – associated with quaking aspen, black hawthorn, snowberry, and serviceberry.	Approximately 25 miles north of the north end of Segment A.
Basalt daisy *Erigeron basalticus*	Candidate	Grows in crevices in basalt cliffs on canyon walls facing north, east, or west, from 1,250 to 1,500 feet in elevation - associated with a few grass and forb species	None within 1 mile of line segments. Occurs within Kittitas and Yakima counties along the Yakima River and Selah Creek; within the YTC, approximately 10 miles west of Segment C.
Umtanum desert buckwheat *Eriogonum codium*	Candidate	Found on the exposed tops of a ridgeline that is composed of basalt, from 1,100 to 1,320 feet in elevation - associated with cheatgrass and a variety of forbs.	One known population, on part of Umtanum Ridge, in Benton County.
Northern wormwood *Artemisia campestris* var. *wormskioldii*	Candidate	Grows only within the floodplain of the Columbia River in relatively level, arid, shrub-steppe, on basalt, compacted cobble, and sand - associated with sagebrush and grasses	None within 1 mile of line segments. Several occurrences within the floodplain of the Columbia River, several miles south of the Segment B river crossing.

5.2.1 Ute Ladies'-Tresses (Spiranthes diluvialis Sheviak)

The proposed project falls within the range of Ute ladies'-tresses, which was listed as Threatened by the USFWS on January 17, 1992 because of habitat loss and modification and hydrological modifications of existing and potential habitat areas (57 FR 2048 2054). No critical habitat has been designated for Ute ladies'-tresses.

Habitat and Ecology
Though little is known about the specific life history characteristics of Ute ladies'-tresses, orchids generally require symbiotic associations with mycorrhizal fungi for seed germination. Plants of some species of ladies'-tresses (*Spiranthes*) are initially saprophytic, persisting underground for several years before emerging above ground. Research has shown that Ute ladies'-tresses can remain dormant for several growing seasons, or produce only vegetative shoots (USFWS, 1995). It requires insect pollinators to set seed (Sheviak, 1984). Plants in Washington typically flower from mid-July to mid-August. Ute ladies'-tresses is a perennial, terrestrial orchid with stems 8 to 20 inches tall with showy spikes of white flowers, arising from thickened roots (WNHP, 1999). Despite their distinctive spikes of white flowers, blooming plants can be extremely difficult to see in the dense herbaceous vegetation they are associated with.

Ute ladies'-tresses exist in mesic and wet meadows and riparian/wetland habitats near springs, seeps, lakes or perennial streams. Soils may be inundated early in the growing season, which normally become drier but retain subsurface moisture through the season. It occurs primarily in areas where the canopy vegetation is relatively open and not dense or overgrown (USFWS, 1995). Populations tend to decline if trees and shrubs invade the habitat. The known sites in Washington include a periodically flooded alkaline flat (moist meadow) and riparian fringe and moist meadow adjacent to a large river. Plant associations adjacent to all four Washington occurrences include Ponderosa pine/Douglas fir woodlands and shrub-steppe dominated by big sagebrush, bitterbrush and rabbitbrush.

Specific impacts to Ute ladies'-tresses habitat include urban and agricultural development, stream channelization, water diversions and other watershed and stream alterations that degrade natural stream stability and diversity (WNHP, 1999).

Presence in Project area
Ute ladies'-tresses is currently known to occur in Colorado, Idaho, Montana, Nebraska, Utah, Washington and Wyoming. In Washington, there are four known population; three small occurrences near the Columbia River in Chelan County and one occurrence in Okanogan County. Surveys for Ute ladies'-tresses were conducted in late summer of 2001 and again in July and August 2002. Areas searched included the Columbia River crossings, Lower Crab Creek and wetlands associated with perennial creeks in Segment A. No occurrences of this species were found during any of the surveys.

5.2.2 Wenatchee Mountains Checker-mallow *(Sidalcea oregana* var. *calva)*
The proposed project falls within the range of the Wenatchee Mountains checker-mallow, which was federally listed as an Endangered species on December 22, 1999 (64 FR 71680-71687). Approximately 6,135 acres near Camas Meadows in Chelan County, Washington has been designated as critical habitat for the Wenatchee Mountains checker-mallow (66 FR 46536).

Habitat and Ecology
The Wenatchee Mountains checker-mallow is a perennial that grows from a stout taproot. The taproot gives rise to several stems from 8 to 60 inches tall. The leaves are thick and fleshy and the flowers are light to deep pink (Hitchcock et al., 1961). Wenatchee Mountains checker-mallow is most abundant in moist meadows that have surface water or saturated upper soil profiles into early summer. These meadows vary in size from greater than 100 acres to approximately 1 acre in size. The plant is also found in somewhat open coniferous stands dominated by Douglas fir or

Ponderosa pine. Individuals begin to flower in mid- to late June. Flowering peaks in mid- to late July. Some individuals, however, have flowers present in mid August. Fairly well-developed fruits are present by early August (WNHP, 2002).

Presence in Project area
Wenatchee Mountains checker-mallow is currently known to occur at only six sites in the Wenatchee Mountains (located north and west from the project area) in Chelan and Kittitas Counties (66 FR 46537). The nearest population is approximately 25 miles north of the project area. No suitable habitat or occurrence of Wenatchee Mountain checker- mallow is known to exist within or near the project area.

5.2.3 Basalt Daisy *(Erigeron basalticus* Hoover)
The proposed project falls within the range of the basalt daisy, a candidate for federal listing (64 FR 57533-57547) No critical habitat has been designated for the basalt daisy.

Habitat Requirements and Ecology
Basalt daisy is a perennial, taprooted herb with one to several sprawling or pendent stems per plant. Stems are 4 to 6 inches long with lobed leaves clustered especially toward the tip. Flowers are daisy-like with white to lilac ray flowers.

Basalt daisy blooms from early May to the middle of June. It is restricted to cracks in basalt cliffs on canyon walls with northerly, easterly and westerly aspects. Total vegetative cover is generally less than 1%. The vegetation in these cracks may contribute to the fracturing of the basalt. Threats and management concerns include basalt mining, homesite development, spray drift from adjacent agricultural fields and railroad and highway construction and maintenance activities (WNHP 1999).

Presence in Project area
Basalt daisy is a narrow endemic known only to Washington in an area approximately 10 miles long and 2 miles wide in and adjacent to Yakima Canyon, in Yakima and Kittitas counties (WNHP 1999). Surveys of suitable habitat (basalt cliffs) along the proposed project alignment during summer 2001 and 2002 did not identify occurrences of this species.

5.2.4 Umtanum Desert Buckwheat *(Eriogonum codium* Reveal, Caplow & Beck)
The proposed project falls within the range of the Umtanum desert buckwheat, a candidate for federal listing (64 FR 57533 57547). No critical habitat has been designated for the Umtanum desert buckwheat.

Habitat Requirements and Ecology
Umtanum desert buckwheat is a low, tufted herbaceous perennial shrub with aboveground woody stems forming highly branched mats 8 to 28 inches across (WNHP 1997). The lemon-yellow flowers are tightly clustered in a ball on top of a leafless flowering stem.

Umtanum desert buckwheat blooms from May through late August. Individual plants are known to reach an age of nearly 100 years. Although seeds readily germinate, seedling mortality is extremely high, resulting in very low population recruitment (Dunwiddie, et.al., 2001). The only known population grows on flat to gently sloping microsites near the top of the steep, north-facing basalt cliffs overlooking the Columbia River (Reveal, et al., 1995). Vegetative cover is sparse. Its substrate is composed of fine, reddish to blackish, gravelly basalt pumice. Surrounding upland areas support arid shrub-steppe vegetation.

Threats and management concerns include illegal off-road vehicle traffic and public use within the general area, livestock grazing and wildfire. A recent wildfire burned a large portion of the Umtanum desert buckwheat population in 1996, resulting in a substantial increase in annual weedy species and significant mortality. Umtanum desert buckwheat does not survive scorching or resprout after a fire (Dunwiddie, et al., 2001).

Presence in Project area
Umtanum desert buckwheat is a narrow endemic plant species known from only one occurrence in Benton County, Washington. It grows in a narrow, discontinuous population approximately 1 mile long. Segment D of the proposed project passes near the population on the top of Umtanum Ridge, although the nearest individuals of the population are over 750 feet east of the centerline of the project. The nearest individuals are approximately 35 feet from an existing access road that would be improved for the projects.

5.2.5 Northern Wormwood (*Artemisia campestris* L. ssp. *borealis* Hall & Clem. var. *wormskioldii* (Bess.) Cronquist)
The proposed project falls within the range of Northern wormwood, a candidate for federal listing (50 FR 39526-39584). No critical habitat has been designated for Northern wormwood.

Habitat Requirements and Ecology
Northern wormwood is a low biennial or perennial shrub, with a taproot and basal leaves in crowded rosettes. Northern wormwood blooms from early April and reaches its peak by mid-April whereas other members of the genus do not flower until much later in the season (WNHP, 1997). The plant grows on basalt, compacted cobble and sand on relatively flat terrain within in the floodplain of the Columbia River (WNHP, 1997). It presumably withstands occasional short periods of inundation. Vegetative cover is sparse at both known sites, with less than 1% cover. Surrounding upland areas support arid shrub-steppe vegetation.

Threats and management concerns include weed invasions and recreational use and vehicle compaction of known sites. Flooding may also pose a threat due to the limited population size and limited habitat availability.

Presence in Project area
Northern wormwood is a regional endemic known from two widely disjunct sites along the Columbia River in Washington, one each in Klickitat and Grant Counties (WHNP, 1999). The Beverly population in Grant County is along the Columbia River and on several islands just downstream of the where the proposed project crosses the river. Intensive surveys for Northern wormwood were conducted along the proposed alignment near the Columbia River crossings during the April of 2002. No individuals or populations of the species were found within the project area.

6.0 RECOMMENDATIONS

To protect rare plants and high quality native plant communities within the proposed Schultz-Wautoma ROW, certain impact mitigations and minimization measures would be implemented. In general, the best way to protect rare plants is to protect the native plant communities they grow in and to minimize the introduction of weeds. Native species provide habitat and food for wildlife, while resisting invasion by non-native species. The native plant communities along the ROW should be disturbed as little as possible. All construction and vehicular travel would be restricted to the ROW and access roads. Where disturbance to native plant communities is unavoidable, disturbed areas should be promptly reseeded with native grass and/or shrub species to minimize the possibility of invasion by non-native species, including noxious weeds. Flagging the beginning and end points of rare plant populations along the proposed line would indicate the presence of rare plants to construction crews. Specific mitigations as they relate to native plant communities, rare plants and weed control are presented below.

6.1 Native Plant Communities

Impacts to high quality plant communities would be minimized by locating structures and roads outside them, where possible. Maps of high quality communities would be provided to engineers designing the proposed line. Impacts to native plant communities would be minimized during construction by implementing the following practices:

- Construction activities would be restricted to the area needed to work effectively. Construction crews would be instructed to restrict vehicles to designated areas.

- Designated areas would be used to store equipment and supplies. The contractor would follow state and federal regulations to protect plant communities.

  - In areas of known sensitive species, topsoil would be stockpiled when the footings of structures are put in place or an area for placement of a structure is graded. After construction, the topsoil would be replaced on the surface of the soil and the surface would be restored to the former grade, where possible.

  - After construction, disturbed areas not needed for ongoing access or maintenance would be reseeded.

  - Construction specifications would designate which species are appropriate for reseeding in certain areas. Inquiries would be made to determine which commercially available native seed has been used with some success.

6.2 Rare Species

Rare plant species habitat would be avoided if possible and unavoidable impacts would be minimized as much as possible. Maps of all rare species occurrences would be provided to engineers designing the proposed line. Structures and roads would be placed to avoid impacting rare species occurrences if possible. Impacts to rare species would be minimized during construction and subsequent maintenance, by implementing the following practices:

- Boundaries of rare species populations would be flagged in the field with an appropriate buffer, to ensure areas that are designated to be avoided during construction are not impacted.

- If impacts are temporary, it may be sufficient to restrict the time of year that various activities take place. Many plants in the study area flower and fruit very early in the spring, then remain dormant under the ground for much of the year. The underground parts may not be disturbed during certain time periods by certain types of activities, such as driving through an area.

- Information on rare plant species occurrences would be given to BPA maintenance personnel to be considered during the planning and implementation of future maintenance activities. The location of rare plant occurrences would be placed on BPA maps and documents so that maintenance personnel are aware of their location. A written description of restrictions, precautions, or special procedures within rare plant habitat would be attached to maps and documents for that area.

- On state and federal land where rare plants are known to occur, the procedures used to control weeds would be restricted to those that minimize harm to rare plant species. The decision on the best actions to take to control weeds would be made on a case-by-case basis with consultation with the respective state or federal land manager.

6.3 Weeds

Throughout the project, efforts would be made to minimize the introduction or spread of weeds, by implementing the following activities and practices. These activities and practices would be included in a Weed Management Plan for this project:

- To determine the extent of the weed problems along the Preferred Alternative, a pre-construction weed survey would be done to document current conditions.

- Some weed control or eradication activities may occur prior to construction or even during the weed survey if construction would exacerbate an existing weed problem.

- After construction, the seeding of disturbed areas would help decrease weed invasion by providing competition for space.

- A post construction weed survey would be done so that pre- and post-construction weed distributions can be compared. If weed problems exist or are increasing over pre-construction conditions, BPA would cooperate with county weed boards or federal land management agencies to eradicate or control any species that invade disturbed areas.

- To control weeds, BPA would use the procedures outlined in the BPA's Transmission System Vegetation Management Program Record of Decision (August 2000) to address weed problems in subsequent maintenance activities.

- Because weeds can be spread by vehicles, BPA would restrict access to the newly constructed access roads where possible, by using gates.

7.0 REFERENCES

Beck, Kathryn. September 2001 Botanist, Personal Communication.

Camp, Pam, 2001. BLM Botanist, Wenatchee District, Personal Communication.

Cowardian, L.M., V. Carter, F. C. Golet and E. T. La Roe. 1979. Classification of Wetlands and Deep Water Habitats of the United States. U.S. Department of the Interior, US Fish and Wildlife Service, FWS/OBS-79/31.

Daubenmire, R. 1970. Steppe Vegetation of Washington. Wash. Agric. Exp. Stn. Tech. Bull. 62.131p.

Franklin, J.F. and C.T. Dyrness. 1973. Natural Vegetation of Oregon and Washington. U.S.D.A. Forest Service General Technical Report PNW-8. 417p.

Gonzales, David. April 12, 2001. U.S. Fish and Wildlife Service, Hanford Reach National Monument. Personal Communication.

Hitchcock, C.L. and A. Cronquist, 1973. Flora of the Pacific Northwest. University of Washington Press, Seattle, Washington.

Hitchcock, C. L., A. Cronquist, M. Ownbey, and J.W. Thompson. 1955. Vascular Plants of the Pacific Northwest, reference Vol. 1-5.

Moody, Sandra, 2001. Botanist, Washington Natural Heritage Program. Personal Communication.

The Nature Conservancy of Washington. 1999. Biodiversity Inventory and Analysis of the Hanford Site Final Report: 1994-1999. Unpublished report for the Department of Energy. Seattle, Washington.

Pacific Northwest National Laboratory. Hanford Site Ecosystem Monitoring Project Web Site. (Hanford Site Vegetation Data Link) http://www.pnl.gov/ecology/ecosystem/Veg/Veg.html.

Pounds, Margaret. 2001. Wildlife Program Manager, Yakima Training Center. Personal Communication.

Quigley, Thomas, M. et al. 1999. The Interior Columbia Basin Ecosystem Management Project Scientific Assessment (CD-ROM). Pacific Northwest Research Station, Portland, Oregon.

Rickard, W.H. et. al., 1988. Shrub-steppe, Balance in a Semi-arid Terrestrial Ecosystem. Battelle Memorial Institute, Pacific Northwest Laboratories, Richland, WA.

Sackschewsky, Michael S. 2001. USDOE Pacific Northwest National Laboratory Botanist, Personal Communications.

St. Hilaire, Kimberly R. 2001. Field Observations, February and June, 2001.

Taylor, Ronald, J. 1992. Sagebrush Country, A Wildflower Sanctuary. Mountain Press Publishing Company, Missoula, Montana.

U.S. Department of Defense, Army, 1996. Yakima Training Center Cultural and Natural Resources Management Plan. Fort Lewis, Washington.

U.S. Department of Energy (USDOE), 1999. Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (EIS). Richland Operations Office, Richland, Washington.

U.S. Department of Energy, September 2000. Hanford Site National Environmental Policy Act (NEPA) Characterization. Prepared for the U.S. Department of Energy by Pacific Northwest National laboratory, Richland, WA (PNNL-6415 Rev. 12).

U.S. Department of Energy (USDOE), October 2000. Hanford Site Draft Biological Resources Management Plan. DOE/RL 96-32, Richland, Washington. (www.pnl.gov/ecology/ecosystem/compliance/comp.html)

U.S. Department of Interior, U.S. Fish & Wildlife Service. July 2001. Federally Listed, Proposed, Candidate and Species of Concern with potential to occur in Schultz-Hanford project area, Ephrata Sub-Office, Ephrata, Washington. Fax dated 7/5/2001.

Washington Natural Heritage Program. 1997. Endangered, Threatened and Sensitive Vascular Plants of Washington – with Working Lists of Rare Non-Vascular Species. Department of Natural Resources, Forest Resources Division, Olympia, Washington.

Washington Natural Heritage Program. 2000. Field Guide to Washington's Rare Plants. A Cooperative Project Between WNHP, the Washington Department of Natural Resources and Spokane District U.S. Department of Interior, Bureau of Land Management. Olympia, Washington.

Washington Natural Heritage Program website. 2001.
Definitions: http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/lists/stat&rank.html
High Quality Plant Communities:
http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/lists/commmunitiesxco
Rare Plant Status: http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/lists/plantrnk.html
County Rare Plant Lists: http://www.wa.gov/dnr/htdocs/fr/nhp/refdesk/lists/plantsxco

Washington State Department of Fish and Wildlife. April 2, 2001. Sensitive Information Report, Quad Name: Beverly, Washington.

Washington State Department of Fish and Wildlife. April 3, 2001. Sensitive Information Report, Quad Name: Emerson Nipple, Washington.

Washington State Noxious Weed Control Board Website. 2002.Weed list: http://www.wa.gov/agr/weedboard/weed_list/weed_listhome.html

8.0 PLANT NAMES

Table 8-1 gives the scientific and common names for plants discussed in the EIS.

Table 8-1. Common and Scientific Plant Names

Common Name * = non-native species	*Scientific Name*
*Annual beardgrass	*Polypogon monospeliensis*
Balsamroot	*Balsamorhiza* species
*Barnyard-grass	*Echinochloa crusgalli*
Basalt daisy	*Erigeron basalticus*
Basin wildrye	*Leymus (Elymus) cinereus*
Beaked cryptantha	*Cryptantha rostellata*
Beaked spike-rush	*Eleocharis rostellata*
Big sagebrush	*Artemisia tridentata*
Bitterbrush	*Purshia tridentata*
Bitterroot	*Lewisia rediviva*
Black cottonwood	*Populus trichocarpa*
Black greasewood	*Sarcobatus vermiculatus*
Black hawthorn	*Crataegus douglasii*
Bluebunch wheatgrass	*Pseudoroegneria (Agropyron) spicata*
Blue elderberry	*Sambucus cerulea*
Bristle-flowered collomia	*Collomia macrocalyx*
*Bulbous bluegrass	*Poa bulbosa*
*Bull thistle	*Cirsium vulgare*
Bulrush	*Scirpus* species
*Canada thistle	*Cirsium arvense*
Canadian St. John's-wort	*Hypericum majus*
Carey's balsamroot	*Balsamorhiza careyana*
Cattail	*Typha latifolia*
Cespitose evening-primrose	*Oenothera cespitosa ssp. cespitosa*
Chaenactis	*Chaenactis douglasii*
*Cheatgrass	*Bromus tectorum*
*Chicory	*Cichorium intybus*
Chokecherry	*Prunus virginiana*
Columbia milk-vetch	*Astragalus columbianus*
Common blue-cup	*Githopsis specularioides*
Common reed	*Phragmites australis*
Common snowberry	*Symphoricarpos albus*
Common spike-rush	*Eleocharis palustris*
Common St. John's-wort	*Hypericum perforatum*
Cottonwood (=black cottonwood)	*Populus trichocarpa*
Curve-pod milk-vetch	*Astragalus speirocarpus*
Cushion daisy	*Erigeron poliospermus*
Cusick's bluegrass	*Poa cusickii*
* Dalmatian toadflax	*Linaria dalmatica* ssp. *dalmatica*
Desert buckwheat	*Eriogonum* species
Desert Cryptantha	*Cryptantha scoparia*
Desert-parsley species	*Lomatium* species

Common Name * = non-native species	*Scientific Name*
*Diffuse knapweed	*Centaurea diffusa*
Douglas' buckwheat	*Eriogonum douglasii*
Dwarf evening-primrose	*Camissonia pygmaea*
Eriogonum	*Eriogonum* species
Field bindweed	*Convolvulus arvensis*
Filaree	*Erodium cicutarium*
Geyer's milk-vetch	*Astragalus geyeri*
Globepodded hoarycress	*Cardaria pubescens*
Golden currant	*Ribes aureum*
Gray Cryptantha	*Cryptantha leucophaea*
Grays' desert parsley	*Lomatium grayi*
Gray rabbitbrush	*Ericameria (Chrysothamnus) nauseosa*
Green-banded star-tulip	*Calochortus macrocarpus*
Green rabbitbrush	*Chrysothamnus viscidiflorus*
Hoary aster	*Machaeranthera canescens*
Hood's phlox	*Phlox hoodii*
Hoover's desert-parsley	*Lomatium tuberosum*
Hoover's tauschia	*Tauschia hooveri*
Idaho fescue	*Festuca idahoensis*
Indian ricegrass	*Oryzopsis hymenoides*
*Johnsongrass	*Sorghum halepense*
*Kochia	*Kochia scoparia*
Longsepal globemallow	*Iliamna longisepala*
Lyall's milk-vetch	*Astragalus lyallii*
Milk-vetch species	*Astragalus* species
Mint	*Mentha arvensis*
Mockorange	*Philadelphus lewisii*
Mountain monardella	*Monardella odoratissima*
Munro's globemallow	*Sphaeralcea munroana*
**Musk thistle*	*Carduus nutans*
Naked-stemmed evening-primrose	*Camissonia scapoidea*
Needle-and-thread grass	*Hesperostipa (Stipa) comata*
Narrowleaf goldenweed	*Haplopappus stenophyllus*
Northern wormwood	*Artemisia campestris var. wormskioldii*
Nuttall's sandwort	*Minuartia nuttallii var. fragilis*
Oceanspray	*Holodiscus discolor*
Oregon sunshine	*Eriophyllum lanatum*
Pauper milk-vetch	*Astragalus misellus var. pauper*
Penstemon	*Penstemon* species
*Perennial pepperweed	*Lepidium latifolium*
*Perennial sowthistle	*Sonchus arvensis*
Persistentsepal yellowcress	*Rorippa columbiae*
Phlox	*Phlox* species
Piper's daisy	*Erigeron piperianus*
Ponderosa pine	*Pinus ponderosa*
Prairie junegrass	*Koeleria macrantha (cristata*)
*Puncturevine	*Tribulus terrestris*

Common Name * = non-native species	*Scientific Name*
*Purple loosestrife	*Lythrum salicaria*
Purple sage	*Salvia dorrii*
Quaking aspen	*Populus tremuloides*
Redosier dogwood	*Cornus sericea (stolonifera)*
*Reed canarygrass	*Phalaris arundinacea*
Rock buckwheat	*Eriogonum* species
Rocky Mountain iris	*Iris missouriensis*
Rose	*Rosa* species
*Rush skeletonweed	*Chondrilla juncea*
Rush species	*Juncus* species
*Russian knapweed	*Acroptilon (Centaurea) repens*
*Russian olive	*Elaeagnus angustifolia*
*Russian thistle	*Salsola kali (iberica)*
Sagebrush	*Artemisia* species
*Saltcedar	*Tamarix ramosissima*
Saltgrass	*Distichlis spicata*
Sandberg's bluegrass	*Poa secunda (sandbergii)*
Sand dock	*Rumex venosus*
Sand dropseed	Sporobolus cryptandrus
* Scotch thistle	*Onopordum acanthoides*
Sedge	*Carex* species
Serviceberry	*Amelanchier alnifolia*
*Siberian elm	*Ulmus pumila*
Slenderbush buckwheat	*Eriogonum microthecum*
Spikerush	*Eleocharis* species
*Spiny cocklebur	*Xanthium spinosum*
Spiny hopsage	*Grayia (Atriplex) spinosa*
*Spotted knapweed	*Centaurea biebersteinii (maculosa)*
Sprangletop	*Leptochloa fascicularis*
Stiff sagebrush	*Artemisia rigida*
Stinging nettle	*Urtica dioica*
Suksdorf's monkey-flower	*Mimulus suksdorfii*
*Teasel	*Dipsacus sylvestris*
Threetip sagebrush	*Artemisia tripartita*
Thurber's needlegrass	*Achnatherum (Stipa) thurberianum*
Thyme-leaved buckwheat	*Eriogonum thymoides*
Tufted evening-primrose	*Oenothera cespitosa ssp. cespitosa*
*Tumble mustard	*Sisymbrium altissimum*
Umtanum desert buckwheat	*Eriogonum codium*
Ute ladies'-tresses	*Spiranthes diluvialis*
Wallflower	*Erysimum* species
Wanapum crazyweed	*Oxytropis campestris var. wanapum*
Wavy-leaved alder	*Alnus sinuata*
Wax currant	*Ribes cereum*
Wenatchee Mountains checker-mallow	*Sidalcea oregana var. calva*
White buckwheat	*Eriogonum niveum*
*White mulberry	*Morus alba*

Common Name * = non-native species	*Scientific Name*
White sagebrush	*Artemisia ludoviciana*
White-stemmed evening primrose	*Oenothera pallida*
*White sweetclover	*Melilotus alba*
Wild rose	*Rosa* species
Wouldow	*Salix* species
Winterfat	*Krascheninnikovia (Eurotia) lanata*
Wyoming big sagebrush	*Artemisia tridentata* ssp. *wyomingensis*
Wood's rose	*Rosa woodsii*
Yarrow	*Achillea millefolium*
Taxonomy follows Hitchcock and Cronquist, 1973. Some updated taxonomy is included.	

NOTE: This report was prepared in 2001 and last updated on January 9, 2002. Many comments received on the project caused BPA to further develop the Agency Proposed Action and the alternatives, which are not reflected in this report. However, the body of the FEIS does reflect these changes.

Fish and Wildlife Technical Report

Bonneville Power Administration
Schultz-Hanford Area Transmission Line Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97232

Prepared By:

Parsons Brinckerhoff Quade & Douglas
400 SW Sixth Avenue, Suite 802
Portland, Oregon 97204

Revised January 9, 2002

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1.0 INTRODUCTION

1.1 Bonneville Power Administration

The Bonneville Power Administration (BPA), a federal agency, owns and operates over 15,000 circuit miles of transmission lines throughout the Northwest. BPA markets power to direct service industries and to utilities that provide electricity for homes, businesses, and farms in the Pacific Northwest. BPA also uses the transmission system to provide power to other regions, such as Canada and California.

1.2 Transmission System

The BPA transmission system moves power from generation sites to major load areas. Generation sites are primarily the dams on the Columbia and Lower Snake Rivers, and major load areas are Seattle, Portland, Canada (during cold seasons), and California (during hot seasons). During spring and early summer months, the Northwest and Canada usually have an abundance of water from snowmelt in the mountains. The power generated from this water serves Northwest loads, and the surplus electricity is typically sent to southern markets, such as California.

1.3 Need for Capacity

The need for more capacity (i.e., a new transmission line) occurs during spring and early summer. The spring and early summer months are when juvenile salmon travel down rivers, and dams along the Lower Snake and Columbia Rivers (e.g., Lower Granite to Bonneville) spill large amounts of water to help transport juvenile salmon to the ocean. Spilling water over the dams causes less water to go through the turbines, and less power is generated. As a result, dams along the Mid- and Upper-Columbia River in Washington (e.g., Grand Coulee and Chief Joe) and dams in Canada (e.g., Mica and Revelstoke) generate most of the power needed during spring and early summer months. The large amount of power generated in the northern parts of the region and Canada moves south through central Washington to reach load centers, such as Portland and the Southern Intertie, which leads to California. This causes congestion on the transmission system in central Washington (north of Hanford) because there is not enough transmission capacity to move this large amount of power. BPA needs to increase transmission capacity in this area, to relieve existing constraints on the transmission system.

1.4 Proposed Action

To meet the need for new capacity, BPA is proposing to construct a new 500-kV transmission line between the Schultz Substation north of Ellensburg, Washington, and a substation near Hanford. Depending on the route alternative chosen, the project may terminate at the existing Hanford Substation, or at the proposed new Wautoma Substation located west of the Hanford Site, near Blackrock. Figure 1.4-1 shows the proposed routes.

1.5 Fish and Wildlife Resource Surveys

The purpose of this document is to identify fish and wildlife resources that may be affected by the proposed project. Fish species and habitats are discussed in Section 2, and wildlife species and habitats are addressed in Section 3. Each section describes the affected environment and assesses the impacts that are likely to occur to fish and wildlife species from construction and operation of the project.

2.0 FISH

2.1 Fish Affected Environment

This section discusses the fish habitats and species that may be affected by the proposed project. Only those streams or waterbodies with perennial flows that are affected by the project are discussed here. Some intermittent streams may have fish present at some time during the year, but usually in limited areas near a source of perennial water.

2.1.1 Study Area

The study area for the fish component of the Schultz-Hanford project includes creeks, lakes and other water bodies that may support fish along each of seven proposed line segments that make up the four possible route alternatives.

2.1.2 Methodology

The fish section was developed using field visits, literature sources, state and federal database queries, and contact with agency biologists.

2.1.2.1 Field Visits

A field visit to identify streams and ponds where suitable fish habitat might be present took place in February 2001. The proposed line segments were located in the field and the different streams and lakes that each segment passed through were identified. No fish species were observed.

2.1.2.2 Literature Sources

Journal articles, reference books, public agency management plans, agency internet sites and unpublished documents were used to determine species presence, life histories, habitat characteristics, and other information used in this section. Aerial photographs of each route, overlaid with National Wetland Inventory data were developed by the BPA and used to supplement the field visits. The WDFW catalog of Yakima basin streams and fish presence (unpublished) was used as well.

2.1.2.3 Database Queries

The US Fish and Wildlife Service (USFWS) was contacted and asked to provide a list of Threatened and Endangered fish species that might be present near the proposed project. A list of Township, Ranges and Sections within one mile of the proposed project was entered into their database. One Threatened Species (bull trout) was identified as possibly occurring near the proposed project.

The Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species Program was contacted and asked to provide a map of state Threatened and Endangered fish species that might be present near the proposed project. The same area was input into this database as for the USFWS database query. The National Marine Fish Service website (NMFS, 2001) was referenced to determine threatened or endangered anadromous salmonid presence. Two endangered stocks (Upper Columbia River Spring Chinook salmon and Upper Columbia River Steelhead trout) and one threatened stock (Middle Columbia River Steelhead trout) were identified.

2.1.2.4 Agency Contacts

Agency biologists from the WDFW were contacted regarding the presence of threatened or endangered fish species along the proposed route segments. A meeting was also held in Yakima with representatives from WDFW that identified a number of areas where fish species were known to exist.

2.1.3 Regulations and Management Plans

A number of Federal acts and management plans regulate impacts to fish from projects such as that proposed here. Section 7 of the Endangered Species Act of 1972 (as amended) requires federal agencies to ensure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat. In practical terms, this means that projects that have federal involvement must consult with USFWS and/or NMFS to determine if their actions will cause a “take” of a species listed (or proposed for listing) under the act. “Take” is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.”

A management plan has been developed for the YTC that affects fish resources. The YTC management plan states that the following measures (relevant to the proposed project) will be taken to protect fish habitat and resources on the YTC grounds:

Protection

- Protection of soils to improve percolation and reduce overland flow
  -Protection of groundwater infiltration areas
  -Erosion control structures on roads
  -Enhancement of upland vegetation
- Protection and enhancement of riparian areas
  -Bank stabilization
  -Riparian plantings
- Stream channel bed control
  -Gabion weirs
  -Boulder clusters
  -Large woody debris
  -Beavers
  -Stormwater detention facilities
  -Maintenance of hardened crossings and culverts to ensure fish passage

Maintenance

- Large woody debris placement

- Log/rock weir construction
- Boulder cluster placement
- Riparian plantings (large woody debris recruitment)
- Beaver introductions (at later date)
- Fish plantings
  -In ponds
  -In streams

Future management actions related to fish enhancement or protection on the YTC may have implications for the project, should it be constructed along the YTC alignment. Project design and construction should meet these management objectives for construction in the YTC.

2.1.4 Regional Context

The study area lies at the western edge of the Interior Columbia Basin. The area lies in the rain shadow of the Cascade Mountain, and thus receives very little precipitation (6 inches in the eastern lowest areas to 22 inches in the higher elevations in the west). Much of the precipitation occurs in the winter in the form of snow. With the exception of the Columbia River, which bisects the study area, water is scarce. Streams are generally small and intermittent. The northern part of the study area near Ellensburg drains into the Yakima River. The remainder of the project contains a number of local drainages that drain directly into the Columbia River.

2.2 Fish Habitats and Species

The proposed route from Schultz Substation to Hanford Substation (or proposed new Wautoma Substation) was broken into seven proposed alternative line segments (Segments A, B_{north}, B_{south}, C, D, E and F). In this section, a discussion of the fish habitats and species present along each line segment is given. Each perennial water feature is discussed. Intermittent streams or wetlands are not discussed. The most significant fish resources found within the project area are endangered anadromous salmonids such as salmon and steelhead. These fish are born and rear in small streams, then migrate down the Columbia River to the ocean. After several years in the ocean, they migrate upstream back to their native streams to spawn. Resident salmonids such as bull trout and rainbow trout are also important resources, as are a number of other cold and warm water fish species.

2.2.1 Unique Fish Habitats and Species of Each Line Segment

The following sections describe the habitats and fish species present along each line segment. Each perennial waterbody is addressed separately. The discussion of habitats present along each route was taken from personal observations, WDFW Priority Habitats and Species data, unpublished data from WDFW and conversations with agency biologists. Table 2.2-1 summarizes fish species presence by segment and perennial water body.

Table 2.2-1 Fish Species Presence

Perennial Water Name[1]	Segment Intercepting Waterbody A	B_{north}	B_{south}	C	D	E	F	Fish Species Present In Waterbody[2]	Comments
Wilson Creek	X							**Chinook salmon (Federal Endangered, State Candidate)**, **Mountain sucker (State Candidate)**, Rainbow trout, Cutthroat trout, Brook Trout, Mountain whitefish, 3-Spine stickleback, Speckled dace, Longnose dace, Redside shiner, Torrent sculpin, Brook lamprey	Wilson Creek has high quality fish habitat in the project area. Chinook salmon are only present in the lowest mile of the creek, and not in the project area. Mountain suckers are probably found in the project area.
Naneum Creek	X							**Chinook salmon (Federal Endangered, State Candidate)**, **Mountain sucker (State Candidate)**, Rainbow trout, Cutthroat trout, Brook Trout, Mountain whitefish, 3-Spine stickleback, Speckled dace, Longnose dace, Redside shiner, Torrent sculpin, Brook lamprey	Naneum Creek has high quality fish habitat in the project area. Chinook salmon are only present in the lowest mile of the creek, and not in the project area. Mountain suckers are probably found in the project area.
Cave Canyon Creek	X							None	Fish habitat is present, but fish are not documented in this creek.
Schnebly Creek	X							Rainbow trout	Rainbow trout are present in the project area.
Coleman Creek	X							**Chinook salmon (Federal Endangered, State Candidate)**, **Bull trout (Federal Threatened, State Candidate)**, Rainbow Trout	Chinook salmon habitat is high quality, but limited to the lowest three miles of the stream. Bull trout have not been observed since 1970.
Cooke Creek	X							Rainbow trout, Cutthroat Trout, Brook trout	Cooke Creek is split into several small channels in the project area, which may limit the available fish habitat.
Caribou Creek	X							Rainbow trout	Caribou Creek has marginal fish habitat in the project area.
Parke Creek	X							Rainbow trout	Rainbow trout are likely present in the project area.
Middle Canyon Creek		X	X	X				Rainbow trout	Project crosses the intermittent headwaters of Middle Canyon Creek. It is unlikely that habitat in this area is utilized by fish.

Perennial Water Name[1]	Segment Intercepting Waterbody							Fish Species Present In Waterbody[2]	Comments
	A	B_{north}	B_{south}	C	D	E	F		
Johnson Creek		X	X	X				**Chinook salmon (Federal Endangered, State Candidate)**, **Steelhead trout (Federal Endangered/Threatened, State Candidate)**, Rainbow trout, 3-Spine stickleback, Prickly sculpin, Large scale sucker, Redside shiner	Juvenile chinook salmon only use the lowest reach of the stream for resting as they migrate down the Columbia River. Steelhead may spawn and rear in the lowest reach near the mouth. Resident fish habitat is degraded in the project area due to military operations, grazing and fires, but fish are present.
Hanson Creek				X				**Chinook salmon (Federal Endangered, State Candidate)**, Rainbow trout, Brook trout	Juvenile chinook salmon only use the lowest reach of the stream for resting as they migrate down the Columbia River. Resident fish habitat is degraded in the project area due to military operations, grazing and fires, but fish are present.
Alkali Canyon Creek				X				**Chinook salmon (Federal Endangered, State Candidate)**, Rainbow trout, Brook trout	Juvenile chinook salmon only use the lowest reach of the stream for resting as they migrate down the Columbia River. Resident fish habitat is degraded in the project area due to military operations, grazing and fires, but fish are present.
Corral Canyon Creek				X				**Chinook Salmon (Federal Endangered, State Candidate)**	Juvenile chinook salmon only use the lowest reach of the stream for resting as they migrate down the Columbia River. Resident fish habitat is degraded in the project area due to military operations, grazing and fires, and fish are not present.
Cold Creek				X	X			None	Cold Creek is intermittent in the project area, and no fish are present.
Crab Creek					X	X	X	**Chinook salmon (Federal Endangered, State Candidate), Steelhead trout (Federal Endangered/Threatened, State Candidate)**, Rainbow trout, Brown trout, Various warmwater fish species	Crab Creek supports a wide variety of fish, including many of those found in the Columbia River.

Perennial Water Name[1]	Segment Intercepting Waterbody							Fish Species Present In Waterbody[2]	Comments
	A	B_{north}	B_{south}	C	D	E	F		
No Wake Lake						X		Various warmwater species	Private waterskiing lake
Nunnaly Lake							X	Rainbow trout, various warmwater species	Nunnaly Lake is stocked with Rainbow trout for sportfishing.
Saddle Mountain Lake						X		Various warmwater species	Saddle Mountain Lake is an irrigation return flow lake.
Columbia River		X	X		X	X	X	**Chinook salmon (Federal Endangered, State Candidate)**, **Steelhead trout (Federal Endangered/Threatened, State Candidate)**, **Pacific lamprey**, Brook lamprey, Various warmwater species (40 different species all together)	The Columbia River supports 44 known species of fish, and is the major migration corridor for anadromous species.

[1] Only streams or lakes that contain water year around are listed here.

[2] Fish species that may be present in the waterbody. In some cases fish may be present somewhere in the waterbody, but not where the proposed project crosses it. Bold species are federal or state listed species.

2.2.1.1 Fish Habitat and Species of Segment A

Segment A crosses eight fish-bearing streams that drain the Wenatchee Mountains north of the project area. These streams are all part of the Wilson-Naneum Creek subbasin, a part of the Yakima basin. The major fish issue facing these streams is the lack of access between the Yakima River and the headwater areas due to obstructions from irrigation and agricultural operations in the lower sections. All streams in the Wilson-Naneum subbasin are heavily diverted on the Kittitas valley floor and have been channelized into an intricate drainage/irrigation system. There are over 200 unscreened diversions in this drainage (WDFW, unpub.). The riparian zone of the valley portions of these streams is extensively impacted by grazing and other agricultural practices. In their upper reaches these streams flow through timbered canyons with good year-round flows.

2.2.1.1.1 Wilson-Naneum Creek Crossing

The Wilson-Naneum Creek complex is one of the more productive small streams in the project area. Fish species present in the Wilson-Naneum Creek complex include steelhead, spring chinook salmon, western brook lamprey, rainbow trout, cutthroat trout, brook trout, mountain whitefish, three spine stickleback, speckled dace, longnose dace, bridgelip sucker, mountain sucker, redside shiner, and torrent sculpin (WDFW, 2001). There is currently no adult anadromous salmonid or lamprey spawning in the upper part of the creek due to migration barriers downstream, but juvenile salmonids use the lower two miles as rearing habitat. At the site of the proposed crossing, there are no anadromous fish present, however the non-anadromous species mentioned above are likely to be present.

Since the proposed crossing is at the very upper edge of the Kittitas Valley, the stream at this point is relatively unaffected by irrigation withdrawals and other agricultural activities. However, the creek is listed on the 303 (d) list for temperature and fecal coliform. The habitat conditions near the proposed crossing are good, with clean substrate, good water quality and good instream flows (personal observation, 2001). The riparian zone is in good condition with mature cottonwoods and a diverse assemblage of riparian shrubs. Large woody debris recruitment potential is higher in this area than in most of the rest of the watershed due to the presence of large cottonwoods. The high quality of this particular section of Wilson and Naneum Creeks can be attested to by the fact that the area supports a number of wintering bald eagles. The bald eagles rely on the large cottonwood trees for roosting and may use the open water areas of the stream to catch fish.

2.2.1.1.2 Schnebly Creek Crossing-

Schnebly Creek is a small stream with little suitable fish habitat near the project area. In its upper reaches, the stream supports rainbow trout (WDFW, 2001a), but it is unlikely to harbor fish where the project crosses it.

2.2.1.1.3 Coleman Creek Crossing

Fish species present in Coleman Creek are similar to those in Wilson and Naneum Creeks, and include steelhead, spring chinook salmon, western brook lamprey, rainbow trout, cutthroat trout, brook trout, mountain whitefish, three spine stickleback, speckled dace, longnose dace, bridgelip sucker, mountain sucker, redside shiner, and torrent sculpin. Bull trout were last observed in 1970 (WDFW, unpub.). Coleman Creek has been channelized and diverted into Naneum Creek and no longer has its natural mouth. There is currently no adult anadromous salmonid spawning in this creek due to obstructions, but the lower 0.5 miles of Coleman Creek has some of the best salmonid rearing habitat in the northern Kittitas Valley area (WDFW unpub.).

Higher upstream, the riparian zone of the valley portions of this stream is extensively impacted by grazing and other agricultural practices. The proposed crossing of Coleman Creek is just above the Kittitas Valley floor. The stream flows through a shallow canyon with a narrow riparian area. Stream habitat is good, with clean substrates, good water quality and good year-round flows. WDFW PHS data (WDFW, 2001a) indicates that fish are present only from the mouth upstream to a point approximately two miles below where the proposed route crosses. However, Renfrow (2001), and WDFW (unpub.) indicated that the stream near the proposed crossing probably contains many of the species present lower in the system, except anadromous fish.

2.2.1.1.4 Cooke Creek Crossing

Fish species present in Cooke Creek include rainbow trout, cutthroat trout, and brook trout. No anadromous salmonids are present due to downstream obstructions (WDFW, unpub.).

The project crosses Cooke Creek at Coleman Canyon Road. The stream is divided into multiple small channels in this area. A good riparian area with large cottonwoods and willows exists upstream of Coleman Canyon Road. Downstream of the road, the riparian vegetation consists of smaller shrubs and trees. Stream flow is good in this area, although the split channels may limit available fish habitat. Stream substrate appears clean and the riparian areas are good, although livestock are present in the area upstream of the crossing. Cooke Creek is listed on the 303 (d) list for temperature, fecal coliform and dissolved oxygen. Like Coleman Creek, the WDFW PHS data (WDFW, 2001a) indicates that fish species are probably only present downstream several miles from the proposed crossing. However, Renfrow (2001) indicated that the three trout species were probably present higher in the drainage above the project area, and may be present where the proposed ROW crosses.

2.2.1.1.5 Caribou Creek Crossing

Fish species present in Caribou Creek are probably limited to rainbow trout (WDFW, 2001a, WDFW unpub.). No anadromous salmonids are present due to downstream obstructions

The project crosses Caribou Creek adjacent to a large cultivated field. The creek here is very narrow, with a marginal riparian area and low flows. Fish habitat is marginal. It is unlikely that rainbow trout are present in large numbers in this area.

2.2.1.2 Fish Habitat and Species of Segment B_{north}

The proposed project would cross two perennial drainages and the Columbia River between the northern terminus of Segment C and the Vantage Substation. The perennial drainages drain the northeastern corner of the YTC. Extensive past grazing, military maneuvers and other disturbances have caused changes in flow regimes and a general reduction in the quality of fish habitat within the two perennial drainages.

2.2.1.2.1 Middle Canyon Creek

The only fish species known to exist in Middle Canyon Creek is rainbow trout (US Army, 1996). However, the proposed route crosses the intermittent headwaters area of Middle Canyon, where suitable trout habitat, if available would only be present during the wet season.

2.2.1.2.2 Johnson Creek

Fish species present in Johnson Creek include rainbow trout, possibly steelhead, chinook salmon, 3-spine stickleback, prickly sculpin, large scale sucker, and redside shiner (US Army,1996). Chinook salmon utilize only the lower end of the creek near the Columbia River for juvenile rearing and steelhead may be present in the lower reaches (Renfrow, 2001).

Base flows in Johnson Creek are low due to an increase in storm runoff and a reduction in infiltration caused by compacted unvegetated soils from years of cattle grazing and military land uses. A general lack of riparian vegetation coupled with low base flows causes high water temperatures during the warmer months which may limit the distribution of some species, particularly salmonids.

The proposed route crosses in the middle reach of Johnson Creek, thus anadromous salmonids are unlikely to be present, although the other species known to exist in the creek are likely to be present.

2.2.1.2.3 Columbia River Crossing

The Columbia River near the project area supports populations of approximately 44 known species of fish. Chinook salmon, sockeye salmon, steelhead and Pacific lamprey use the Columbia River near the project site as a migration corridor between the ocean and areas upstream for spawning and rearing. Fish commonly pursued for sport include whitefish, small-mouth bass, sturgeon, catfish, walleye and perch. Rough fish such as squawfish, carp, suckers and shiners are also present in large numbers (US DOE, 1999).

The Wanapum dam tailrace, located directly underneath the proposed crossing, is an important fall chinook salmon spawning area (US DOE, 1999). The Columbia River is on the 303 (d) list of pH, temperature, and dissolved gas.

2.2.1.3 Fish Habitat and Species of Segment B_{south}

Proposed Segment B_{south} crosses Middle Creek and Johnson Creek, both described in the Segment B discussion.

2.2.1.4 Fish Habitat and Species of Segment C

The proposed project crosses six major drainages, all of which drain the interior of the YTC directly to the Columbia River. Fish are present in five of the six drainages crossed (no fish are present in Cold Creek). Extensive past grazing, military maneuvers and other disturbances have caused changes in flow regimes and a general reduction in the quality of fish habitat within the two perennial drainages. In recent years, severe fires have damaged riparian vegetation and reduced the amount of vegetative cover on upland areas.

2.2.1.4.1 Middle Canyon Creek

The only fish species known to exist in Middle Canyon Creek is rainbow trout (US Army, 1996). However, like Segment B_{north} and B_{south}, the proposed route crosses the intermittent headwaters area of Middle Canyon, where suitable trout habitat, if available would only be present during the wet season.

2.2.1.4.2 Johnson Creek

Fish species present in Johnson Creek include rainbow trout, possibly steelhead, chinook salmon, 3-spine stickleback, prickly sculpin, large scale sucker, and redside shiner (US Army, 1996). Chinook salmon utilize only the lower end of the creek near the Columbia River for juvenile rearing. Steelhead may be present in the lower reaches of Johnson Creek (Renfrow, 2001). The proposed route crosses in the middle reach of Johnson Creek, thus anadromous salmonids are unlikely to be present, although the other species known to exist in the creek are likely to be present.

2.2.1.4.3 Hanson Creek

Fish species present in Hanson Creek include eastern brook trout and fall chinook (US Army, 1996). Chinook salmon utilize only the lower reach of the creek near the Columbia River for juvenile rearing, and are not present near the proposed crossing.

2.2.1.4.4 Alkali Canyon

Fish species present in Alkali Canyon Creek include rainbow trout, eastern brook trout and fall chinook (US Army, 1996) . Chinook salmon utilize only the lower reach of the creek near the Columbia River for juvenile rearing, and are not present near the proposed crossing

2.2.1.4.5 Corral Canyon

The only fish species present in Corral Canyon Creek is chinook salmon. They only utilize the extreme lower reach of the creek near the Columbia River for juvenile rearing, and are not present near the proposed crossing (US Army, 1996).

2.2.1.4.6 Cold Creek

No fish are known to be present in Cold Creek.

2.2.1.5 Fish Habitat and Species of Segment D

Segment D crosses three drainages; Crab Creek, the Columbia River and Cold Creek. A series of irrigation canals and drains are crossed on the Wahluke Slope, however these are not considered fish habitat. Depending on conditions and the availability of stable flows, fish could exist temporarily in some canals, however they would most likely be introduced into the canals by humans or carried by birds from other water bodies and would not persist.

2.2.1.5.1 Crab Creek

Fish species present in Lower Crab Creek include rainbow trout, brown trout, chinook salmon, and possibly a remnant steelhead population (WDFW, 2001a, Renfrow, 2001). The proposed project crosses the extreme lower reach of Crab Creek just upstream of its confluence with the Columbia River. Lower Crab Creek could be used by a most of the 40 Columbia River fish species on a temporary basis as well. Crab Creek is listed on the 303 (d) list for pH, temperature, PCB's, and DDE.

2.2.1.5.2 Columbia River

The Columbia River near the proposed Segment D crossing contains approximately 44 species of fish. Like the Segment B crossings, chinook salmon, sockeye salmon, steelhead and Pacific lamprey use the Columbia River near the project site as a migration corridor to upstream spawning areas and for spawning and rearing. Fish commonly pursued for sport include whitefish, small-mouth bass, sturgeon, catfish, walleye and perch. Rough fish such as squawfish, carp, suckers and shiners are also present in large numbers (US DOE, 1999).

The area directly under the proposed crossing, just upstream from the Vernita Bridge, is an important spawning area for fall chinook salmon and Upper Columbia River steelhead. This area represents the northern extent of the naturally spawning Hanford Reach population of fall chinook, which is approximately 50-60% of the total fall chinook runs in the Columbia River (US DOE, 1999). The Columbia River is on the 303 (d) list of pH, temperature, and dissolved gas.

2.2.1.5.3 Cold Creek

No fish are known to be present in Cold Creek where proposed Segment D crosses it.

2.2.1.6 Fish Habitat and Species of Segment E

Segment E crosses two major drainages; Crab Creek and the Columbia River. Like Segment D, a series of irrigation canals and drains are crossed on the Wahluke Slope, however these are not considered fish habitat.

2.2.1.6.1 Crab Creek
Proposed Segment E crosses Crab Creek several hundred meters upstream of proposed Segment D. Fish habitat and species will be similar to those discussed in the Segment D section.

2.2.1.6.2 Saddle Mountain Lake
Saddle Mountain Lake contains only warmwater fish species such as yellow perch, pumpkinseed, bluegill and crappie.

2.2.1.6.3 Columbia River
The proposed route crosses the Columbia River near the middle of the Hanford Reach. The fish species and habitats are similar to the crossing described for Segment D. Important spawning areas for fall chinook and Upper Columbia River steelhead are present downstream from the proposed crossing.

2.2.1.7 Fish Habitat and Species of Segment F

Proposed Segment F crosses only two major drainages, Crab Creek and the Columbia River, and a lake.

2.2.1.7.1 Nunnaly Lake
Nunnaly Lake is a pothole lake in the Crab Creek valley. It is a high use recreational area. Rainbow trout are stocked for sport fishing purposes. Warmwater species such as, yellow perch, pumpkinseed, bluegill, and crappie may be present.

2.2.1.7.2 Crab Creek
Proposed Segment E crosses Crab Creek several hundred meters upstream of proposed Segment D and E. Fish habitat and species will be similar to those discussed in the Segment D section.

2.2.1.7.3 Columbia River
The proposed Segment F crossing of the Columbia River uses the same alignment as proposed Segment E, and has similar fish habitat and species to that discussed in Segment D.

2.2.2 Threatened and Endangered Fish Species

The project area is within the range of three species (which includes three Evolutionarily Significant Units, or ESU's and one Distinct Populations Segment, or DPS) of threatened or endangered fish: Upper Columbia River spring-run chinook salmon, Upper Columbia River steelhead, Middle Columbia River steelhead, and bull trout.

2.2.2.1 Chinook Salmon (Upper Columbia River Spring-Run ESU)

The proposed project area is located within the ESU of the Upper Columbia River spring-run chinook salmon, a federally listed Endangered Species. Critical habitat for this ESU includes all river reaches accessible in Columbia River tributaries between Rock Island Dam and Chief Joseph Dam in Washington, excluding the Okanogan River. Also included is the Columbia River from the mouth upstream to Chief Joseph dam (and adjacent riparian zones and estuarine areas). These fish exhibit a "stream-type" life history, meaning that the juveniles spend a year or more in the freshwater streams they were born in, as opposed to "ocean-type" chinook, which migrate to the ocean or estuaries shortly after emerging from the gravel (Myers, et. al., 1998).

The Upper Columbia River spring-run chinook spawn across a geographic area that encompasses several diverse ecosystems. Fish ascend to the upper reaches of the river systems, and in some cases, access to these areas is only possible during the high spring river flows from snowmelt and spring storms. The use of smaller tributaries for spawning and extended juvenile rearing by stream-type chinook salmon increases the potential for disturbance from human activities.

Human activities have significantly influenced the distribution of the Upper Columbia River spring-run chinook salmon. When Grand Coulee Dam was constructed, a significant area of spawning and rearing habitat was permanently blocked. Fish that were originally bound for points above the dam were transferred to other rivers such as the Methow, Entiat, and Wenatchee Rivers, which had their own distinct stocks. The unique traits of the native stocks were diluted by the addition of the new stocks, and the continued hatchery supplementation of those stocks (Myers, et. al., 1998). The native stocks were adapted to local conditions within each river system and were better suited for those systems than were the transferred stocks. This may have contributed to the overall decline in the species. Hydroelectric dams and/or irrigation diversions affect virtually every river and stream containing Upper Columbia spring-run chinook salmon. Blockage or losses of spawning and rearing habitat, direct mortality by stranding or upstream and downstream passage injury, and changes in thermal regimes have resulted (Myers, et. al., 1998).

Spawning chinook require areas of clean gravel with good subsurface flow. If subsurface flow is adequate, chinook will spawn in areas with a wide variety of stream depths, flows and gravel sizes (Healey, 1998). Preferred spawning habitat is often at pool tailouts or medium riffles with one to three feet of fast-flowing water, probably since these areas often have good subsurface flows. Juvenile chinook salmon typically require structurally diverse habitat, including deep pools, undercut banks, rocks, large woody debris, and good vegetative cover on stream banks.

Within the proposed project area, Upper Columbia spring-run chinook will only be encountered in the Columbia River, which juveniles and adults use as a migration corridor between the ocean and the headwater streams where they spawn and rear.

2.2.2.2 Steelhead Trout (Upper Columbia River ESU)

The Upper Columbia River steelhead ESU is listed as Endangered. Critical habitat is designated to include all accessible river reaches in Columbia River tributaries upstream of the Yakima River, Washington, and downstream of Chief Joseph Dam. Also included is the Columbia River from the mouth upstream to Chief Joseph dam and its adjacent riparian zones and estuarine areas.

Upper Columbia River steelhead exist in an area that sees extremes in temperatures and precipitation. Most precipitation falls in the mountains as snow. Streamflow in this area is provided by melting snowpack, groundwater, and runoff from alpine glaciers and is thus very cold and generally not as productive as other warmer streams and rivers. Upper Columbia River steelhead have been documented spending up to seven years in freshwater before migrating to the ocean, probably due to the cold temperatures and the low stream productivity (Busby, et. al. 1996). Most steelhead in this ESU, like those of the Middle Columbia River ESU, spend two years in freshwater prior to migrating downstream to the ocean and one year in freshwater prior to spawning.

Upper Columbia River steelhead are limited by habitat blockages from Chief Joseph and Grand Coulee Dams, and smaller dams on tributary rivers. Irrigation diversions and hydroelectric dams, and degraded riparian and instream habitat from urbanization and livestock grazing have resulted in severe impacts to steelhead habitat. Hatchery fish that escape to naturally spawn are widespread and outnumber native fish in several major river systems. This ESU might not exist today if there were not hatchery production. However, the unique traits of the original native stocks have been diluted by the addition of stocks that originally spawned and reared above Chief Joseph and Grand Coulee dams before they were constructed, and the continued hatchery supplementation of the original native stocks (Busby, et. al., 1996). The original native stocks were adapted to local conditions within each river system and were better suited for those systems than were the transferred stocks. This dilution of the native stocks with outside stocks less suited for local conditions may have contributed to the decline in the native populations of Upper Columbia River steelhead

Steelhead typically spawn in streams with well oxygenated areas of small and medium sized gravels free of fine sediment deposition. Juvenile steelhead typically require structurally diverse habitat, including deep pools, undercut banks, large woody debris, refuges from high flows such as off channel habitat, and areas of groundwater upwelling.

The project may affect Upper Columbia River steelhead or designated critical habitat where it crosses the Columbia River on Segments B_{north}, B_{south}, D, E, and F, or small tributaries on the Yakima Training Center along Segment C. Upper Columbia River steelhead are known to spawn in the Hanford Reach of the Columbia River near where Segments D, E and F cross (USDOE, 2001).

2.2.2.3 Steelhead Trout (Middle Columbia River ESU)

The Middle Columbia River steelhead is listed as Threatened. Critical habitat is designated to include all accessible river reaches in Columbia River tributaries (except the Snake River) between Mosier Creek in Oregon and the Yakima River in Washington (including the Yakima River). Also included is the Columbia River from the mouth upstream to the Yakima River and its adjacent riparian zones and estuarine areas.

Middle Columbia River steelhead exist in some of the driest areas of the Pacific Northwest. Vegetation in this region is generally shrub-steppe. Streams and rivers in the area are often subject to low flows and high temperatures, thus minor changes in vegetation or water quality can cause habitat degradation. Since most middle Columbia River steelhead spend two years in freshwater before migrating to the ocean, and a year in freshwater after returning from the ocean but before spawning, they may be more sensitive to changes in water quality and habitat than other anadromous species that spend less time in freshwater. Middle Columbia River steelhead may be limited by high summer and low winter temperatures in many streams in this region. Low flows, extreme temperature conditions, water withdrawals and overgrazing have seriously impacted available fish habitat in this ESU (Busby, et. al., 1996). There is little or no late summer flow in sections of the lower Umatilla and Walla Walla Rivers. Riparian vegetation is heavily impacted by overgrazing and other agricultural practices, timber harvest, road building, and channelization. Instream habitat is also affected by these same factors, as well as by past gold dredging and severe sedimentation due to poor land management practices. A major present threat to genetic integrity for steelhead in this ESU comes from past and present hatchery practices. (Busby, et. al., 1996)

Steelhead typically spawn in streams with well oxygenated areas of small and medium sized gravels free of fine sediment deposition. Juvenile steelhead typically require structurally diverse habitat, including deep pools, undercut banks, large woody debris, refuges from high flows such as off channel habitat, and areas of groundwater upwelling.

The project may affect Middle Columbia River steelhead or designated critical habitat in small tributaries of the Yakima River north and east of Ellensburg, along Segment A.

2.2.2.4 Bull Trout (Columbia River Basin DPS)

The proposed project area is located within Columbia River Basin DPS for bull trout. The Columbia River Basin Bull Trout DPS includes all naturally spawning populations in the Columbia River Basin within the United States and its tributaries, excluding bull trout found in the Jarbidge River, Nevada. Bull trout in the Columbia River Basin DPS are a federal threatened species.

Bull trout were once widely distributed throughout the Pacific Northwest, but they have been reduced to approximately 44 percent of their historic range (ICBEMP 1997). Bull trout have more specific habitat requirements in comparison to other salmonids and are most often associated with clear and cold headwater streams and rivers with undisturbed habitat and diverse cover and structure.

Key factors in the decline of bull trout populations include harvest by anglers, impacts to watershed biological integrity, and the isolation and fragmentation of populations. Changes in sediment delivery (particularly to spawning areas), aggradation and scouring, shading (high water temperature), water quality and low hydrologic cycles adversely affect bull trout. Therefore, impacted watersheds are negatively associated with current populations. Additionally, the bull trout appear to be negatively affected by other non-native trout species through competition and hybridization (ICBEMP 1997).

Bull trout spawning and rearing is restricted to relatively pristine cold streams, often within the headwater reaches (Rieman and McIntyre 1993), although adults can reside in lakes or reservoirs and in coastal areas, they can migrate to saltwater (63 FR 31647). Bull trout distribution is patchy within watersheds, most likely due to the need for cold water (63 FR 31648). Juveniles are usually located in shallow backwater or side channels areas, while older individuals are often found in deeper water pools sheltered by large organic debris, vegetation, or undercut banks (63 FR 31467). Water temperature is a critical factor for bull trout, and areas where water temperature exceeds 15 degrees Celsius (59 degrees Fahrenheit) are thought to limit distribution (Rieman and McIntyre 1993).

The project may affect bull trout or designated critical habitat in small tributaries of the Yakima River north and east of Ellensburg, along Segment A.

2.3 Impacts to Fish Species

Impacts to fish species and habitat are assessed for each alternative proposed for the project. Various segments described in Section 2.2.1 are combined to form each alternative.

2.3.1 Fish Species Impact Levels

High impacts to fish would occur when an action creates a significant adverse change in fish habitat, populations or individuals. High impacts might result from actions that:

- cause the take of a federally listed or proposed threatened or endangered fish species;
- cause a significant long-term (more than two years) adverse effect on the populations, habitat or viability of a federal or state listed fish species of concern or sensitive species, which would result in trends towards endangerment or the need for federal listing; or
- harm or kill a significant number of individuals of a common fish species at the local (stream reach or small watershed) level.

Moderate impacts to fish would occur when an action creates a moderate adverse change in fish habitat, populations or individuals. Moderate impacts might result from actions that:

- without causing a take, cause a temporary (less than two months) reduction in the quantity or quality of localized (stream reach or small watershed) aquatic resources or habitats at a time when federally listed threatened, endangered or proposed fish species are **not likely** to be present (i.e., during non-spawning or rearing times);
- cause a short-term (up to two years) localized (stream reach or small watershed) reduction in population, habitat and/or viability of a federal or state listed fish species of concern or sensitive species, without causing a trend towards endangerment and the need for federal listing; or
- harm or kill a small number of individuals of a common fish species at the local (stream reach or small watershed) level.

Low impacts to fish would occur when an action creates a minor or temporary adverse change in habitat, populations or individuals. Low impacts might result from actions that:

- cause a temporary (less than two months) localized (stream reach or small watershed) reduction in the quantity or quality of aquatic resources or habitats of state listed fish species of concern or sensitive species, without causing a trend towards endangerment and the need for federal listing; or
- cause a short-term (up to two years) disturbance or displacement of common fish species at the local (stream reach or small watershed) level.

No impacts to fish would occur when an action has no effect or fewer impacts than the low impact level on fish habitat, populations or individuals.

2.3.2 Impacts to Fish Species Common to All Action Alternatives

The construction, operation and maintenance of the proposed transmission line will impact fish populations that reside in or near the study area. The extent of impact would depend on the fish species, its distribution, its habitat requirements and the availability of suitable habitat in and around the project area.

2.3.2.1 Construction Impacts

Short-term construction disturbances, depending on the time of year and the location, could impact various fish species by causing sedimentation, habitat and/or individual fish disturbance, or the release of hazardous materials into a waterway. The following would be potential short-term impacts:

- Damage to fish (e.g. gill abrasion, fin rot), from construction sediments entering streams;
- Soil from roads, cleared areas, excavations, stockpiles or other construction sources might enter streams and cause an increase in sediment load and/or sediment deposition in spawning gravels or fish habitat, or damage to food organisms;
- Concrete washing or dumping might allow concrete waste to enter streams and cause an increase in sediment load and local fish toxicity;
- Other construction materials (metal parts, insulators, wire ends, bolts, etc.) might enter streams and cause changes in flow or other unknown effects;
- Mechanical disturbance of fish habitat from equipment operating in, crossing, or passing streams;
- Streambank compaction and/or sloughing might reduce the streambank's ability to support vegetation, or cause sediment input or increased runoff;
- Heavy equipment moving across a stream (or repeated travel by light equipment) might cause substrate disturbance, including sediment release or substrate compaction;
- Riparian vegetation destruction or removal (this would be incidental only; planned vegetation removal for ROW and roads is a long-term impact) may cause a loss of fish habitat (cover), loss of stream shading, removal of large woody debris sources, and reduction in buffer capacity;
- Disturbance of individual fish from equipment operating in or near streams;
- Vibration or shock from equipment operating in or near streams would drive fish to less suitable habitat or to areas where predation is more likely. In marginal conditions such as extreme low flows and high water temperatures, stress from repeated disturbance may cause death;
- Mechanical injury or death from equipment crossing or operating in streams could result, especially to fish that live in or on the bottom of the stream (such as sculpins);
- Injury or death of fish or their prey from hazardous materials spills; or
- Petroleum fuel products, hydraulic oil, and other hazardous materials typically associated with construction activities may enter the stream, causing fish kills, aquatic invertebrate kills, and death or injury to a number of other species that fish depend on for food. Spills may also create pollution "barriers" to fish migration between stream reaches.

Depending on the location and the fish species present, short-term impacts would range from low to high. Short-term disturbances such as those listed above would constitute a high or medium impact on most species. However, since most of the project construction will occur away from streams and include mitigation (such as construction timing restrictions and spill prevention and erosion measures), short-term construction-related disturbances should result in low impacts to all fish species.

2.3.2.2 Operation and Maintenance Impacts

Long-term impacts resulting from ongoing operation and maintenance would result mostly from habitat alteration due to clearing of riparian vegetation, changes in runoff and infiltration patterns (from upland vegetation clearing), sedimentation from cleared areas, and maintenance access across streams.

Since the transmission line would span narrow riparian areas or be located upslope of stream channels, little or no riparian vegetation would be removed for line clearance. Where access roads are required to cross streams, riparian vegetation may be removed. Since riparian areas are extremely important in providing stream shading and cover for fish, and are a source of large woody debris in streams, any clearing of stream-side riparian vegetation for ROW clearance or access road construction would likely cause moderate to high impacts to fish species, should they be present.

The area cleared for tower construction and access roads in upland areas could change runoff and infiltration patterns to the extent that flow regimes in creeks would be altered, especially in smaller drainages. A decrease in groundcover from vegetation removal can cause an increase in sheet flow during storm events, with correspondingly less infiltration. This can cause higher flood flows in creeks and reduce the amount of infiltrated water that can support base flows. Higher flood flows cause more erosion and deposition of fine materials, which may affect fish habitats or cause physical damage to fish through gill abrasion. Lower base flows, in areas where base flows are already low, may cause streams to dry up in some places or result in warmer water temperatures, which can cause harm or be lethal to fish.

Clearing for roads and tower sites increases the risk of sediment input due to the erosion of soil that is normally stabilized by vegetative cover. Sedimentation of streams can cause a degradation of spawning areas, by filling the interstitial spaces in spawning gravels. This reduces the flow of oxygenated water necessary for egg and alevin survival.

Creating new vehicle access across streams can cause bank compaction, repeated sediment disturbance, disturbance or physical damage to fish (if present), a conduit for sediment input, and the possible release of automotive wastes such as fuel or hydraulic oil into a stream. Stream crossings of intermittent drainages would be accomplished by constructing fords where possible. Ford construction would involve removing a portion of the streambed below grade, then backfilling it with crushed rock or other suitable rocky material to the original streambed level. Ford approaches would be stabilized with crushed rock to reduce erosion and provide an all-weather surface. Drainages that are too incised or steep to ford may be fitted with culverts or bridges to provide water and debris passage.

Perennial streams would be crossed using existing crossings, where possible. In areas where adequate crossings or alternative routes do not currently exist, bridges or culverts would be used to maintain fish passage and stream flows, while providing vehicle access. Approaches to crossings would be stabilized with crushed rock to reduce erosion and provide an all-weather surface. Access roads would experience intense use during construction, but use should not increase much over current threshold levels once construction is complete.

Operation of the proposed project would be limited to energizing the conductors. Normal operation of the project would have no impact on fish species.

Maintenance of the project might include periodic vehicle and foot inspections, helicopter surveys, tower and line repair, ROW clearing, and other disturbances. Depending on the time of year and location, maintenance activities could impact fish species or habitat. Periodic ROW clearing will be mostly limited to riparian areas, where the impact might be high. Maintenance impacts will be similar to those impacts related to short-term construction.

2.3.3 Impacts to Fish Species Specific to Each Alternative

Impacts to fish species are assessed for each action alternative.

2.3.3.1 Alternative 1- Schultz-Hanford (Segments A, B_{north} or B_{south}, E)

2.3.3.1.1 Segment A

Segment A would cross 28 intermittent drainages and seven perennial streams, six of which are known to be fish bearing. Wilson Creek, Naneum Creek, Schnebly Creek, Coleman Creek, Cooke Creek, Caribou Creek and Parke Creek are all known to contain fish. Cave Canyon Creek does not contain fish.

Both Wilson Creek and Naneum Creek are in steep canyons. Towers would be placed high up and well away from both streams. Access would be through existing fords. Since no new construction would occur near the streams, impacts to fish are expected to be low. The increase in traffic along the existing roads would be insignificant.

Schnebly Creek has an existing crossing and Coleman Creek does not require a crossing. The towers would be constructed high up and away from the creek edges. No impacts to fish are expected.

Cooke Creek, near the proposed crossing, has several channels and lies in a wide floodplain that is mostly pasture. An existing County road provides access. Removal of riparian vegetation may be required for overhead clearance. This would create a moderate impact to rainbow trout, cutthroat trout and brook trout. With mitigation (see Section 2.4), this impact could be reduced to low.

Caribou Creek has an existing farm road ford. Towers would be located away from the creek. Impacts to fish are expected to be low.

Parke Creek has access from either side of the creek, eliminating the need for a new crossing. Towers would be located well away from both creeks. No impacts to fish are expected.

The proposed reroute of Segment A would cross Cooke Creek approximately 0.3 miles south of the original alignment in an area with very little riparian vegetation and multiple small channels. Removal of riparian vegetation in this area would not be required, minimizing the impacts to fish.

2.3.3.1.2 Segments B_{north} and B_{south}

Segments B_{north} and B_{south} would cross five intermittent drainages, two fish-bearing perennial streams (Middle Canyon Creek and Johnson Creek), and the Columbia River, which is also fish bearing.

Middle Canyon Creek and Johnson Creek would both be crossed in their headwaters, where conditions are generally unsuitable for fish survival during most times of the year. Therefore, there would be no direct impacts to fish (injury, disturbance from equipment, etc.).

Middle Canyon Creek would need to be crossed with a ford, and the streambed would be disturbed during creation of the ford, which would have the potential to cause increased sediment input, bank destabilization and riparian vegetation removal. Also, hazardous materials spills from equipment traveling across the ford could move downstream to where fish are present, should the stream be flowing. Thus, indirect impacts to fish could be high depending on the nature and quantity of a spill and the time of year it occurs. With mitigation such as construction during work windows spill control and erosion controls, (see Section 2.4), impacts to fish in Middle Canyon Creek should be low.

Johnson Creek has an existing culvert crossing, therefore impacts to fish are expected to be low.

The Columbia River would be crossed by a long span, with towers set well away from the banks. Since the towers and access roads would be far away from the edge of the river, sediment or other materials would not be able to reach the water. Therefore, there would be no impacts to any fish species in the Columbia River along Segment B_{north} or B_{south}.

2.3.3.1.3 Segment E

Segment E crosses eight intermittent streams, four canals or drains, two lakes, one perennial stream and the Columbia River. Both lakes, the stream, and the Columbia River contain fish. Segment E would parallel Segment D from the Vantage Substation to the top of the Saddle Mountains, then head southeast into the Hanford Site.

The Crab Creek crossing would have towers placed over 200 feet from the stream bank. Access would be from either side, so no new crossings of Crab Creek are proposed. Some riparian vegetation may need to be cleared. No new construction will occur near Crab Creek, therefore impacts to fish (Chinook salmon, steelhead, rainbow trout, brown trout and warm water fish) are expected to be low.

Saddle Mountain Lake would be crossed at its eastern end, near where the overflow channel (Saddle Mountain Wasteway) exits. An existing access road crosses the wasteway and could be used for access. Towers would be placed over 200 feet from either side of the edge of the lake. Riparian vegetation is relatively low, although some trees may need to be removed for overhead access. The lake supports warm water fish only. Since no new access roads would be built, towers would be located away from the lake. No sensitive fish species are present, so impacts would be low.

The Columbia River crossing into the Hanford Site would be accessed from either side of the river. Towers would be placed well back from the edge of the river. There is very little riparian vegetation in this area and none of it would need to be cleared. There would be no impacts to fish species in the Columbia River at this location.

2.3.3.2 Alternative 1A Schultz-Hanford (Segments A, B_{north} or B_{south}, F)

Impacts to fish resources along Segments A, B_{north} and B_{south} would be the same as described for Alternative 1 (see Section 2.3.3.1.1 and 2.3.3.1.2)

Segment F would cross 30 intermittent drainages, one canal, two lakes, one perennial stream and the Columbia River. Nunnaly Lake, Crab Creek, Saddle Mountain Lake and the Columbia River all contain fish.

Segment F would use the same crossing of the Columbia River as described in Segment E, so impacts to fish would be similar to those described in that section.

Nunnally Lake is a closed depression north of Crab Creek that has been filled with water and contains rainbow trout and various warmwater fish species. It is managed as a recreational fishery. Access roads would be routed around the lake, and towers would be located on either side, over 200 feet from the edge of the lake. Since no new access roads would be constructed near the lake, towers would be placed far away from the edge. No riparian vegetation would be removed, so the impact to fish in Nunnally Lake would be low to none.

2.3.3.3 Alternative 2 Schultz-New Wautoma Substation (Segments A, B_{north} or B_{south}, D)

Impacts to fish resources along Segments A, B_{north} and B_{south} would be the same as described for Alternative 1 (see Sections 2.3.3.1.1 and 2.3.3.1.2).

Segment D crosses 11 intermittent drainages, nine canals or drains, one lake, one perennial stream and the Columbia River. No Wake Lake, Crab Creek and the Columbia River all contain fish.

No Wake Lake is a private constructed lake used for water skiing. It contains warm water species of fish. Towers may be placed close to the water, but access would be from either side. The land surrounding the lake is relatively flat, which would limit the erosion potential from tower and access road construction and limit the potential for spills to enter the lake. No impacts to fish are expected at this location.

Since Segment D would cross Crab Creek near the location where Segment E crosses, impacts would be similar to those described for Segment E (Section 2.3.3.1.3).

The proposed crossing of the Columbia River would parallel existing transmission lines. The towers would be set over 200 feet from the edge of the river, and access would be from existing roads on either side of the river. Since no new access roads near the river would be built and there is sufficient distance from the towers to the river, no sediments spills or other materials would be able to easily enter the river. Impacts are expected to be low.

2.3.3.4 Alternative 3 Schultz-New Wautoma Substation YTC Route (Segments A, C)

Impacts to fish resources along Segment A would be the same as described for Alternative 1 (see Section 2.3.3.1.1).

Segment C construction would cross 40 intermittent drainages and six perennial steams, five of which are fish bearing. Middle Canyon Creek, Johnson Creek, Hanson Creek, Alkali Canyon Creek and Corral Canyon are all known to contain fish. No fish are present in Cold Creek.

Middle Canyon Creek and Johnson Creek would be crossed with fords in their headwater sections. Impacts to fish in these two creeks would be similar to those described for Segment B (Section 2.3.3.1.2).

Hanson Creek and Alkali Canyon Creek both contain rainbow trout and brook trout throughout their lower and middle reaches. Both of these creeks and Corral Canyon Creek support chinook salmon in their very lowest reaches near the Columbia River. These creeks are in steep canyons, so the towers would be placed on either side of the canyons well above the creek. No impacts are expected from tower construction and placement. However, all three of these streams would need to have bridges or culverts placed in them to allow vehicular access. Impacts to fish, especially chinook salmon, from construction of these access roads and structures could be high, depending on when the construction occurs, if sediments or spills enter the creek, and if fish are present. With mitigation such as doing in-water work during work windows, erosion and spill control measures, and construction of structures that allow fish passage (see Section 3.4), impacts to rainbow trout, brook trout and chinook salmon would be low.

2.3.3.5 No Action Alternative

No impacts to fish resources are expected under the No Action Alternative.

2.3.4 Impacts to Threatened and Endangered Fish Species

Table 3.3-2 lists federally listed fish species that are present within the study area. A Biological Assessment is being prepared separately, which will present effects determinations for each of these species.

Table 3.3-2 Impacts to Threatened and Endangered Fish Species

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Documented Occurrence Type	Potential Impact	Mitigated Impact
Chinook Salmon (Upper Columbia River Spring Run ESU)	FE	SC	B_{north}, B_{south}, C, D, E, F	P	Moderate	Low
Steelhead Trout (Middle Columbia River ESU)`	FT	SC	A	P	Moderate	Low
Steelhead Trout (Upper Columbia River ESU)	FE	SC	B_{north}, B_{south}, C, D, E, F	P	Moderate	Low
Bull Trout	FT	SC	A	H	Moderate	Low
FE = Endangered SC = Candidate P = Present (general presence) FT = Threatened H = Historically Present, Not Currently Present						

2.3.4.1 Chinook Salmon (Upper Columbia River Spring Run ESU)

Upper Columbia River chinook salmon (a federally listed endangered species) are present in the study area only in the Columbia River, where line Segments B_{north}, B_{south}, D, E and F cross it and possibly in some of the lower reaches of streams crossed by Segment C. The construction and operation of Segment A would have no impact on Upper Columbia River chinook salmon, since they are not present in the Yakima River basin and the streams that these segments cross.

Construction of any of the three Columbia River crossings associated with Segments B_{north}, B_{south} D, E and F would also have no impact on Upper Columbia River chinook salmon. This is because towers would be built far enough away from the river bank and riparian areas to eliminate the potential for sediments, spills or other materials to enter the river. New towers at river crossings would parallel existing towers, which range from 200 to1,000 feet from the edge of the river. Access to the towers would be limited to the landside of the towers and would not enter the riparian zone. Riparian vegetation removal would not be required at any of the Columbia River crossings. The streams crossed by Segment C are in steep, narrow canyons and would need stream crossings constructed across them. Chinook may be present at certain times of year in the lowest reaches and could be affected by sediment and pollutants moving downstream from construction areas. Therefore, the impacts to Upper Columbia River chinook salmon could be moderate.

2.3.4.2 Steelhead Trout (Upper Columbia River ESU)

Upper Columbia River ESU steelhead (a federally listed endangered species) are present in the lower reaches of streams crossed by Segments B_{north}, B_{south} and C. They also exist in the Columbia River where Segments B_{north}, B_{south}, D, E, and F cross it.

The Columbia River crossings (described in the chinook salmon sections above) would have no impact on Upper Columbia River steelhead. Crossings of Middle Creek and Johnson Creek on Segments B_{north}, B_{south} and C would not directly impact Upper Columbia River steelhead, since this creek does not support steelhead where these proposed segments cross it. However, the lower reach of Middle and Johnson Creeks may support steelhead, and moderate to high indirect impacts could occur from sediments, spills or other materials entering the creek, or removal of upland and riparian vegetation that might change flow regimes and increase stream temperatures. The area of Crab Creek where Segments D, E and F cross it may support steelhead, however the construction of towers and access roads would not occur within 200 feet of Crab Creek, and no riparian vegetation would be removed. With mitigation (see Section 3.4), impacts to Upper Columbia River steelhead are expected to be low.

2.3.4.3 Steelhead Trout (Middle Columbia River ESU)

Middle Columbia River ESU steelhead (a federally listed threatened species) are present in the Yakima River basin, but are not known to exist in the upper reaches of streams where Segment A crosses. However, these streams are federal designated critical habitat.

Construction near streams along Segment A could cause sediments or other materials to enter the streams and have minor impacts to water quality. This would cause moderate impacts to Middle Columbia River steelhead. However, with mitigation (see Section 3.4), impacts to Middle Columbia River Steelhead are expected to be low.

2.3.4.4 Bull Trout Columbia River DPS

Bull trout (a federally listed threatened species) are not known to currently exist within any of the streams, lakes or rivers crossed by the project, although all streams and rivers are designated as critical habitat. Coleman Creek, near Ellensburg, is known to have historically contained bull trout, but none have been observed since 1970 and it is unknown whether any are still present. No historical records of bull trout are documented in any of the other proposed stream crossings. No new access roads would be constructed across Coleman Creek and the towers would be placed well away from the creek. Since construction would occur far from the creek, and no sediments, spills or other materials would be likely to enter the creek, the project would have no impact on bull trout.

2.3.5 Impacts to Special Status Wildlife Species

Table 3.3-2 lists state and federal special status species that USFWS and WDFW have identified as possibly occurring within the project area and indicates the possible impact the project may have on them.

Table 3.3-3 Impacts to Special Status Fish Species

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Documented Occurrence Type	Potential Impact	Mitigated Impact
Coastal Cutthroat Trout	FP		None	N	None	None
Westslope Cutthroat Trout	FSC		A	P	Moderate	Low
Interior Redband Trout (Rainbow)	FSC		All Segments	P	High	Low
Margined Sculpin	FSC	SS	None	N	None	None
Pacific Lamprey	FSC		B_{north}, B_{south}, D, E, F	P	Low	None
River Lamprey	FSC	SC	A	P	Low	None
Federal Status FP = Proposed for Listing FSC = Species of Concern		State Status SC = Candidate SS = Sensitive		Presence P = Present (general presence) N = Not Present		

2.3.6 Cumulative Impacts to Fish Species

The proposed action may contribute to localized, short-term and long-term disturbance to fish resources, because of increased sediment input and possible hazardous materials spills. Erosion and sedimentation of streams within the study area has increased over the past 100 years due to land use practices such as grazing, agriculture, road building, land clearing, military operations and other disturbances. This has contributed to a reduction in the quality and availability of fish habitat in many streams. Increased access and human activity around streams during this time period has also increased the frequency of hazardous material spills entering streams. While spill events are relatively rare and generally confined to a single stream or stream reach, their effects can be devastating to fish resources.

Riparian vegetation has been significantly reduced from historic levels in Washington and much of the remaining habitat is heavily disturbed by grazing, fire, and other land uses. Small areas of riparian habitat would be lost because of the proposed project, adding cumulatively to the existing degradation of habitat.

Overall, with mitigation, the project is unlikely to cause significant long-term impacts to fish. However, even small impacts may contribute cumulatively to further degradation of fish habitat and species health.

2.4 Recommended Fish Species Mitigation Measures

The following mitigation measures would be implemented in order to reduce or eliminate impacts to fish species from the construction, operation and maintenance of the proposed project.

2.4.1 Tower Construction Mitigation

To minimize short- and long-term impacts to fish from tower construction:

- To reduce the possibility of sediments or spills entering streams or lakes, towers would be placed over 200 feet (where possible) from the edge of streams or lakes that are known to contain fish.
- Sediment and stormwater controls including silt fence, waterbars, temporary seeding, soil pile covering, and dust control would be implemented on construction sites located near fish bearing water bodies.
- To prevent spills from entering streams and/or groundwater, a spill prevention and spill response plan would be developed and implemented prior to construction. Spill kits would be carried in all construction equipment and vehicles.
- To prevent erosion and sediment movement, vegetation removal would be limited to the amount required for safe working conditions and tower placement. Where possible, vegetation (even if temporarily disturbed but not destroyed) would be left in place.
- To reduce the amount of exposed soils that could be eroded, site restoration would occur as soon as possible following construction. Disturbed areas would be graded to their original contours and planted with native vegetation suitable for the local area. Vegetation would be planted only during appropriate spring or fall growing seasons.

2.4.2 Access Road Mitigation

To minimize short- and long-term impacts to fish from access road construction and use during maintenance activities:

- To protect certain life-stages of fish species, in-water work would only occur during WDFW in-water work windows, or as otherwise authorized or directed by WDFW.

- To prevent damage to stream banks and reduce the potential for sediment or hazardous material input to streams, access roads would be placed as far away from creeks as terrain and ROW will allow.
- Where fish-bearing streams must be crossed, existing access roads would be used where available. New crossings would be constructed using culverts or bridges that allow for uninterrupted fish passage. Fords would be limited to intermittent non-fish-bearing streams and the intermittent headwaters of fish-bearing streams.
- Approaches to stream crossings would be rocked with crushed gravel or other material suitable to prevent erosion and minimize road damage from vehicles and equipment during wet conditions.
- Temporary sediment controls such as silt fence would be installed prior to construction, and monitored for proper function until completion of construction and site restoration. Permanent stormwater and sediment controls like ditches and waterbars would be installed on slopes and maintained periodically.
- Vegetation removal would be limited to only the amount required to safely construct new access roads. Riparian vegetation would be removed only where absolutely necessary.
- Site restoration of cutbanks, fill banks, and other areas of disturbed soils other than the traveled way would be restored as soon as possible after completion of construction. Native vegetation suitable for the area would be planted during the next appropriate growing season following construction.
- Access control structures such as gates, large waterbars and eco blocks would be placed at access road entrances, to limit the amount of vehicular traffic that might create erosion problems or other disturbance to streams containing fish. Signs would be placed on new and existing roads to prevent human encroachment.

3.0 WILDLIFE

3.1 Wildlife Affected Environment

This section discusses the wildlife habitats and species that may be affected by the proposed project.

3.1.1 Study Area

The study area for the wildlife component of this project includes an area approximately two miles on either side of each of the seven proposed line segments that make up the four possible routes. The study area encompasses the northern edge of the Kittitas Valley, the eastern edge of the Yakima Training Center, portions of the middle Columbia River, Lower Crab Creek, the central Saddle Mountains, the Wahluke Slope and the northern edge of the Hanford Reach National Monument.

3.1.2 Methodology

The wildlife section was developed using field visits, literature sources, state and federal database queries, and contact with agency biologists.

3.1.2.1 Field Visits

A field visit to characterize major habitat areas took place in February 2001. The proposed line segments were located in the field and the different habitat types each segment passed through were identified. Few species were observed due to the time of year, however those observations that were made are included in this section. More detailed wildlife surveys will take place during the appropriate time of year once a final route has been selected.

3.1.2.2 Literature Sources

Journal articles, reference books, public agency management plans, agency internet sites and unpublished documents were used to determine species presence, life histories, habitat characteristics, and other information used in this section. Aerial photographs of each route, overlaid with National Wetland Inventory data and plant and wildlife species occurrence data were developed by the BPA and used to supplement the field visits to determine habitat types.

3.1.2.3 Database Queries

The US Fish and Wildlife Service (USFWS) was contacted and asked to provide a list of Threatened and Endangered Wildlife Species that might be present near the proposed project. USFWS provided a list of species that were known to occur in Benton, Grant, Kittitas and Yakima Counties. One Threatened Species (Bald Eagle) and three Candidate Species (Western Sage Grouse, Washington Ground Squirrel and Mardon Skipper) were identified as possibly occurring near the proposed project.

The Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species Program was contacted and asked to provide a map of state Threatened and Endangered species that might be present near the proposed project. WDFW provided quad maps showing rare species and habitat occurrences near the project area. The discussion of species unique to each area within a line segment is drawn mostly from this information.

3.1.2.4 Agency Contacts

Agency biologists from the USFWS, BLM, and WDFW were contacted regarding the presence of threatened or endangered species or other species along the proposed route segments. A meeting was held in Yakima with representatives from the above agencies as well as DNR and BOR that identified a number of areas where such species were known to exist.

3.1.3 Regulations and Management Plans

A number of Federal acts regulate impacts to wildlife from projects such as that proposed here. First, Section 7 of the Endangered Species Act of 1972 (as amended) requires federal agencies to insure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat. In practical terms, this means that projects that have federal involvement must consult with USFWS and/or NMFS to determine if their actions will cause a “take” of a species listed (or proposed for listing) under the act. “Take” is defined as “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.”

Second, the Migratory Bird Treaty Act of 1918 (as amended) prohibits the killing, capture, or “take,” of migratory birds, which includes most bird species, including waterfowl, songbirds and hawks. In some cases (such as hunting), permits may be issued for the killing or collection of certain bird species.

Third, the Bald Eagle Protection Act of 1940 (as amended) prohibits, except under certain specified conditions, the taking, possession and commerce of Bald Eagles.

Management Plans have been developed for a number of areas along the proposed project, most notably for the YTC and Hanford Reach National Monument areas.

The YTC management plan states that the following actions (relevant to the proposed project) will be taken to protect wildlife habitat and resources on the YTC grounds:

- Protect male and female western sage grouse habitat;
- Protect and restore bald eagle wintering habitat;
- Protect ferruginous hawk sites;
- Establish and implement cooperative agreements with state and local agencies, including Western Sage Grouse Conservation Agreement (SGCA);
- Work with WDFW to coordinate and control hunting;
- Protect riparian habitat for wildlife use;
- Avoid and protect habitats used by threatened and endangered species;
- Restrict all activities in a 1-kilometer radius around SGCA-specified leks from March 1 to May 15 between 2400 and 0900;

The Hanford Management Plan indicates that the area over which the power line crosses (with the exception of a small part leading up to the Hanford Substation on the south side of the Columbia River), is designated as a "preservation" land use zone. According to the plan, "preservation" areas are managed

> "…for the preservation of archeological, cultural, ecological, and natural resources. No new consumptive uses (i.e., mining or extraction of non-renewable resources) would be allowed within this area. Limited public access would be consistent with resource preservation. Includes activities related to Preservation uses."

Despite this plan designation, the Hanford National Monument Proclamation and Background Paper of June 9, 2000, specifically mentions that a new BPA transmission line in the approximate alignment proposed in this EIS would not be prohibited.

3.1.4 Regional Context

The study area lies at the western edge of the Interior Columbia Basin. This area is dominated by low shrub-steppe vegetation typical of the region. With the exception of a few riparian and agricultural areas, trees are nonexistent. Elevation ranges from approximately 400 feet asl at the Columbia River, to 3000 feet asl at the Saddle Mountain crest in the YTC and the area north of Ellensburg. In the higher elevations, dwarf shrub-steppe and grassland vegetation exists. Most of the proposed line segments lie within undeveloped areas, although the area between Vantage Substation and Midway and Hanford Substations is heavily agricultural. Transmission line towers are the most dominant human element in much of the study area.

3.2 Wildlife Habitats and Species

The proposed route from Schultz Substation to Hanford Substation (or proposed new Wautoma Substation) was broken into seven proposed line segments. In this section, a general discussion of the habitats and wildlife species common to all line segments is presented, followed by a more detailed discussion of each segment. Each line segment is described based on the discrete geographic areas that exist along the line. The major wildlife habitats that exist within each discrete geographic area are described, and any unique or unusual populations of wildlife (such as the presence of Threatened or Endangered species) are discussed.

3.2.1 Wildlife Habitat Common to All Line Segments

The majority of the study area lies within the dry shrub-steppe ecoregion of eastern Washington. Shrub communities dominated by sagebrush represent the majority of the habitat available in the study area, although the density and species composition of the shrub layer varies considerably. To a lesser extent, grassland habitats are also present. Most of the shrub-steppe vegetation within the study area has been heavily disturbed by cattle grazing, fires, off-road vehicles, clearing, colonization by invasive species and other human-caused disturbance, and thus may provide only marginal habitat for shrub-steppe dependant species. All segments cross areas of riparian vegetation, which are mostly limited to narrow areas on either side of small streams or the Columbia River. Like the shrub-steppe vegetation, these riparian areas have been subjected to heavy disturbance, and have been largely destroyed in some areas. Large trees such as cottonwoods are generally sparse in the riparian areas, with the majority of the vegetation composed of small trees and shrubs in the early seral stages. Agricultural areas exist within some line segments. Wetland areas are limited to river and stream crossings, as well as the lower Crab Creek and the Saddle Mountain Lake area.

3.2.2 Wildlife Species Common to All Line Segments

Approximately 150 wildlife species (birds, mammals, reptiles and amphibians) are known to use the shrub-steppe habitat type for a some part of their life cycle (Johnson and O'Neil, 2001). The shrub-steppe and shrub-steppe grassland habitat type represents the majority of the available wildlife habitat within the project area. Of these 150 wildlife species, only approximately 50 are closely associated with shrub-steppe habitat, the remaining species use shrub-steppe habitat occasionally for some stage of their life cycle. These 150 species, however, do not represent the total number of species that may be encountered within the proposed project area. For example, a study of the Hanford Site documented 195 bird species in the general area where the project is proposed (Nature Conservancy, 1999). Many of these species were associated with the open water habitats along the Columbia River or were using the area temporarily as they migrated along the Pacific Flyway.

3.2.2.1 Mammal Species

Common large mammal species occupying the shrub steppe communities include mule deer and elk. These species are often present only in the winter in this habitat, with the exception of the Hanford elk herd and a mule deer herd located on the northern section of the Hanford Reach National Monument. Mountain lions may be present in the northern section of the project, closer to mountainous terrain. Rock outcrops, cliffs and talus slope habitats in some areas of the shrub-steppe may be used by bobcats and occasionally by California bighorn sheep.

Smaller mammals inhabiting the shrub-steppe habitat include the coyote, raccoon, badger, striped skunk, black-tailed and white-tailed jackrabbits, mountain cottontail rabbit, least chipmunk, several species of ground squirrels, Great Basin pocket mouse, deer mouse, grasshopper mouse, northern pocket gopher, sagebrush vole, and Merriam's shrew. Yellow-bellied marmots and bushy-tailed wood rats may occur in rocky areas. Approximately fifteen bat species including the western small-footed bat, little brown bat, big brown bat, pallid bat, and several myotis bat species roost in cliffs and talus slopes and feed along riparian drainages

Issues facing shrub-steppe mammal species include conversion of shrub-steppe to agriculture and habitat fragmentation from road building, clearing and other development. Agricultural development in the shrub-steppe region has occurred primarily in areas of deep soils. Species that require deep soils for burrowing such as badgers, ground squirrels, and rabbits have been disproportionately affected and in the case of the Washington ground squirrel and the pygmy rabbit, severely impacted (Johnson and O'Neil, 2001). Fragmentation of habitat may have profound effects on small mammal populations since dispersal patterns are disrupted and areas of suitable habitat are opened up to predators, parasites, and invasion of exotic plant and animals species (Johnson and O'Neil, 2001).

3.2.2.2 Bird Species

Birds commonly associated with the shrub-steppe habitat within the study area include the sage sparrow, western meadowlark, Brewer's sparrows, sage thrasher, horned lark, common raven, magpie, rock wren, burrowing owl and northern and loggerhead shrike. Sage grouse and sharp-tailed grouse, once common throughout the shrub-steppe habitat, are now limited to small isolated ranges. Raptor species include red-tailed hawk, ferruginous hawk, Swainson's hawk, rough-legged hawk, Northern harrier, golden eagle, bald eagle, and prairie falcon. Rare migrants such as the common loon, and black tern as well as a wide variety of waterfowl and shorebirds may occur along the Columbia River, Crab Creek, or near other open water areas (Johnson and O'Neil, 2001).

Most species of birds that breed in the shrub-steppe habitat are neotropical migrants such as loggerhead shrike, sage and Brewer's sparrows and sage thrasher. Year-round residents include sage and sharp-tailed grouse, ravens, and magpies. Winter residents include birds that breed in northern sites but do not migrate as far south as the neotropical migrants, such as rough-legged hawks and northern shrikes. Bald eagles also winter near the Columbia River and other streams.

Issues facing shrub-steppe bird species are similar to those facing mammals, such as habitat fragmentation and shrub-steppe conversion to agriculture. Some bird species, such as the sage sparrow and the sage thrasher are extremely dependant on intact sagebrush communities with a dense shrub component; therefore disturbances such as clearing and fire may reduce the availability of this habitat. Large, intact patches of sagebrush may also be important to shrub-steppe bird species, especially sage and Brewer's sparrows (Johnson and O'Neil, 2001).

3.2.2.3 Reptile and Amphibian Species

The shrub-steppe area of central Washington supports approximately 20 native reptile species but only about 10 amphibian species. About half of the reptile species are lizards and the other half snakes. Lizard species include western fence lizard, short horned lizard, sagebrush lizard and side-blotched lizard. Gopher snake, western rattlesnake, garter snake, racer and rubber boa are some of the more common snake species, while striped whipsnake and nightsnake are relatively rare. Painted turtles may be present in slow moving water or ponds. Amphibians are generally found only around water, the exception being the Great Basin spadefoot toad, which may be found several kilometers from open water. Western toads and Pacific tree frogs are relatively common near water while tiger salamanders and long-toed salamanders may be found in some wetland areas. Woodhouse's toad is a rare species, but can be found near wetlands in the northern Hanford Reach National Monument (Johnson and O'Neil, 2001).

Reptiles face many of the same threats from habitat fragmentation and conversion to agriculture that shrub-steppe birds and mammals do. Some amphibian species may have benefited from some of the open water and marsh habitats created by irrigation projects. However, the introduction of exotic warmwater species such as bass and bullfrogs has impacted other amphibian species.

3.2.3 Unique Wildlife Habitats and Species Of Each Line Segment

The following sections describe the habitats and species present along each line segment. Each line segment was broken into several distinct areas, generally based on geography. The general types of wildlife habitats and any unusual habitats within each of the areas are described, followed by a discussion of any unique wildlife species or congregations of common species that may be present. The discussion of habitats present along each route was taken from personal observations, WDFW Priority Habitats and Species data, and several management plans and other studies.

3.2.3.1 Wildlife Habitat and Species of Segment A

The proposed Segment A ROW includes two separate segments. An approximately two mile line segment will be constructed running northeast of the Schultz Substation and paralleling the existing Rocky Reach-Maple Valley 345kV line to connect to the existing Sickler-Schultz line. This will eliminate a crossing approximately five miles east of the Schultz Substation. The remainder of Segment A will parallel the Schultz-Vantage 500kV line on the north side for approximately 24.3 miles southeast to a point near Boylston where proposed segments B_{north}, B_{south} and C begin. The total Segment A length is 29.4 miles.

3.2.3.1.1 Wenatchee Mountains Foothills

The Sickler-Schultz connection line would be located in the foothills of the Wenatchee Mountains north of Ellensburg and the Kittitas Valley. The route would cross Wilson and Naneum Creeks, which are both located in steep canyons. The new Schultz-Hanford line would cross the lowest edge of the slope leading up to the Wenatchee Mountains, crossing Schnebly Creek, Colockum Creek, Cooke Creek and Caribou Creek on its way. Several outlying agricultural areas, such as irrigated hay fields and pastures are crossed.

3.2.3.1.1.1 Habitat

The upland areas between the Wilson and Naneum Creek canyons is characterized by mostly shrub-steppe vegetation, although some ponderosa pine and Douglas Fir are present in the northern part of the line segment. The riparian areas of these streams, although limited in width and disturbed by grazing are important wildlife habitats, since the larger trees and shrubs provide structural diversity needed by nesting birds, small mammals and other species. A mix of shrub-steppe and grass/forb communities exists along the remainder of the proposed segment.

3.2.3.1.1.2 Unique Wildlife Populations

Wildlife populations in this area are generally typical of shrub-steppe habitats. The area is used as wintering grounds by large herds of mule deer (WDFW, 2001a). The riparian areas of Wilson and Naneum Creeks provide winter roosting and foraging habitat for bald eagles (Personal Observation, 2001). A sagebrush vole was sighted near Schnebly Canyon (WDFW, 2001a). Colockum Creek Canyon is a migration corridor for the Quilomene elk herd. East of Cooke Canyon, a sharp tailed grouse sighting within one mile of the proposed line was recorded in 1981 (WDFW, 2001a). The area east of Cooke Canyon is also known to harbor nesting long-billed curlews (WDFW, 2001a).

3.2.3.1.2 Vantage Highway/I90

South of Caribou Creek, the proposed Segment A route crosses through the rolling terrain around the Vantage Highway and Interstate 90, north of the Boylston Mountains. Segment A ends near Cheviot (an old railroad place name) approximately eight miles south of Interstate 90.

3.2.3.1.2.1 Habitat

The majority of the vegetation in this area is shrub-steppe habitat with typical shrub-steppe species. Sagebrush density varies, with areas in low spots, washes and north slopes tending to be denser, and the upland areas more open with grass and forbs between widely spaced shrubs. The terrain is rolling to flat, with few areas of rocky outcroppings or cliffs.

3.2.3.1.2.2 Unique Wildlife Populations

This area serves as winter habitat for the Quilomene deer and elk herds (WDFW, 2001a). Sage grouse have been repeatedly observed in the area surrounding the proposed line (Clausing, 2001). A sage grouse lek was observed in 1983 less than one mile southwest of the southern end of the line segment (WDFW, 2001a). White-tailed jackrabbits have been observed near the southern end of the proposed segment (WDFW, 2001a).

3.2.3.2 Wildlife Habitat and Species of Segment B_{north}

The proposed ROW would parallel the existing 500 kV line from the northern terminus of the YTC proposed route east 9.5 miles to the Vantage Substation. The proposed ROW crosses three distinct areas. The majority of the proposed line crosses through the shrub-steppe of the YTC. At the eastern end of the segment, the line crosses the steep cliffs and narrow riparian area of the Columbia River. The Vantage Substation lies on a plateau at the top of the east bank of the Columbia River.

3.2.3.2.1 Northern Yakima Training Center

The Yakima Training Center area of Segment B_{north} runs from the end of Segment A to the edge of the Columbia River canyon through mostly rolling terrain with some steeper canyons of Johnson Creek and Middle Canyon.

3.2.3.2.1.1 Habitat

The majority of the vegetation along this segment is shrub-steppe habitat with typical shrub-steppe species. The proposed route passes through the upper Badger Creek complex and the Johnson Creek and Middle Canyon drainages that contain some limited riparian areas. These canyons also provide rocky outcrops, ridge tops and steep slopes representing a small but significant component of the available habitat (US Army, 1996).

3.2.3.2.1.2 Unique Wildlife Populations

The WDFW (Clausing, 2001) has indicated that sage grouse may be present in the area surrounding the proposed ROW. Also, loggerhead shrike, sage thrashers, sage sparrows, and Swainson's hawks are known to occur in the general vicinity of the proposed ROW (Stepniewski, 1998, US Army, 1996).

3.2.3.2.2 Columbia River

Segment B_{north} crosses the Columbia River just below the Wanapum Dam. The Columbia River sits in a canyon approximately 300 feet deep, with steep cliffs on the west side. The east side of the river, below the Vantage Substation features a flat depositional bar elevated from the main channel approximately 40 feet, leading to a moderate slope that climbs approximately 400 feet to a plateau where the Vantage Substation sits.

3.2.3.2.2.1 Habitat

The area on west side of the Columbia is characterized by steep rocky cliffs, some with talus slopes along the bottom edge. A narrow riparian area composed mostly of grasses exists next to the Columbia River. The east side includes a narrow grassy riparian area with scattered trees, a flat depositional bar covered in sagebrush and grasses, followed by a moderately steep area of alternating cliffs and steep slopes with scattered shrubs and grasses. The riparian areas are subject to frequent changes in water level due to the operations of Wanupum dam several hundred meters upstream. The area surrounding the river receives a high amount of recreational use, especially during the summer months, and existing habitats are subjected to frequent human disturbance.

3.2.3.2.2.2 Unique Wildlife Populations

Numerous species more often associated with wetlands and riparian habitats are found in this area. Ring- billed and California gulls, Caspian and Forster's terns, and Canada geese are present. This section of the Columbia River is located within the Pacific flyway and, during the spring and fall months, the area serves as a resting point for neotropical migrants, migratory waterfowl, and shorebirds. During the fall and winter months, large numbers of migratory ducks (>100,000) and geese (>10,000) find refuge in the Wanapum reservoir (WDFW, 2001a). Other species present during winter months include American white pelicans, double-crested cormorants, and common loons. Bald eagles winter along the Columbia River (Personal Observation, 2001). An historical sighting of a desert nightsnake within one mile of the proposed project was made on the west shore of the Columbia River (WDFW, 2001a).

3.2.3.2.3 Vantage Substation Area

The Vantage Substation sits on a plateau above the east rim of the Columbia River canyon. Transmission lines enter the substation from the north and south. A small depression north of the substation contains a wetland complex.

3.2.3.2.3.1 Habitat

The area surrounding the Vantage Substation contains a unique complex of basalt cliffs, sand dunes, shrub-steppe and small wetlands. High quality riparian vegetation exists within the wetland areas.

3.2.3.2.3.2 Unique Wildlife Populations

Species of special note recorded as using the area surrounding the Vantage Substation include the striped whipsnake and the desert nightsnake (WDFW, 2001a). Bird species often found along the Columbia River (see Columbia River Section 3.2.3.2.2.) also utilize the wetland areas.

3.2.3.3 Wildlife Habitat and Species of Segment B_{south}

Segment B_{south} generally parallels Segment B_{north}, therefore the wildlife habitat and species are similar to those discussed under Segment B_{north} (Section 3.2.3.2.). The total distance of Segment B_{south} is 10.4 miles.

3.2.3.4 Wildlife Habitat and Species of Segment C

The proposed ROW cuts south from the existing 500 kV Vantage-Raver line at an area approximately eight miles south of Interstate 90 and travels 29.8 miles to the proposed Wautoma substation near Blackrock. Seven distinct areas characterize this route: the northern YTC area, the Saddle Mountains, the central YTC area (including four drainage complexes), Umtanum Ridge, Cold Creek, Yakima Ridge, and the Dry Creek Valley

3.2.3.4.1 Northern Yakima Training Center

The Yakima Training Center area of Segment C runs from the end of Segment A to the bottom of the Saddle Mountains. The proposed ROW crosses Johnson Creek through mostly rolling terrain. Wildlife habitat and species in this area is similar to that discussed in the Segment B_{north} discussion (Section 3.2.3.2.) of the Northern Yakima Training Center area.

3.2.3.4.2 Saddle Mountains (West of Columbia River)

The Saddle Mountains are one of three anticlines in the YTC running east west (Saddle Mountains, Umtanum Ridge and Yakima Ridge). The proposed Segment C ROW crosses the Saddle Mountains at approximately the 3100-foot elevation. The Saddle Mountains rise abruptly 1500 feet above the surrounding landscape. The mountains are high enough to catch and retain snowfall, which may accumulate to three feet or more during some winters.

3.2.3.4.2.1 Habitat

The slopes of the Saddle Mountains are mostly vegetated, but very steep with rocky outcrops and talus slopes interspersed throughout. The rocky areas provide habitat for raptor species, marmots, bobcats and lizards.

3.2.3.4.2.2 Unique Wildlife Populations

Loggerhead shrike, golden eagle, ferruginous hawk, Swainson's hawk, prairie falcon, and sage thrasher are all known to use the northern slope of the Saddle Mountains (Stepniewski, 1998).

3.2.3.4.3 Central Yakima Training Center

From the bottom of the south side of the Saddle Mountains, the proposed ROW cuts across three drainage complexes (Hanson Creek, Alkali Canyon, and Corral Canyon) to the bottom of Umtanum Ridge. The terrain is hilly, with steep canyons and ridges trending east west.

3.2.3.4.3.1 Habitat

Wildlife habitat in the Central Yakima Training Center area includes riparian areas, steep rocky cliff areas, and upland areas of shrub-steppe vegetation. The riparian vegetation of Hanson Creek, Alkali Canyon and Corral Canyon are important wildlife habitats, since large trees, shrub species (other than sagebrush), and grasses and forbs are present that provide nesting and perching habitat. The open water areas of the creeks provide an important water source for birds and mammals, especially larger mammals such as deer and coyote.

3.2.3.4.3.2 Unique Wildlife Populations

The area between the Saddle Mountains and Umtanum Ridge is home to approximately 70 percent of the YTC mule deer population (300-400 deer) (US Army, 1996). The upland areas near Hanson Creek supports over 75% of the breeding populations of loggerhead shrike on the YTC, and supports Swainson's hawks (US Army, 1996). The Hanson Creek riparian area on either side of the proposed ROW has documented bald eagle winter roost sites (WDFW, 2001a, US Army, 1996). Lewis's woodpeckers are also known to exist in the Hanson Creek Riparian area (US Army, 1996). Alkali Canyon complex supports an historic sage grouse lek and known populations of nesting prairie falcons (US Army, 1996). Cliffs in Corral Canyon downstream of the proposed ROW also have documented prairie falcon nests (US Army, 1996, WDFW, 2001a). Breeding burrowing owls were sighted approximately 1.5 miles southwest of the proposed ROW between Corral Canyon and Sourdough Canyon in 1993 and 1994, but the nest was unoccupied in 1995-1997 (WDFW, 2001a). Sage sparrows have been observed in the Corral Canyon area as well (US Army, 1996). Long billed curlews have been observed in the Corral Canyon complex near the proposed ROW (Stepniewski, 1998).

3.2.3.4.4 Umtanum Ridge

The second anticline in the YTC, Umtanum Ridge, runs east west like the Saddle Mountains. The proposed ROW crosses Umtanum Ridge approximately three miles west of the Priest Rapids Dam. The ROW climbs approximately 1300 feet up the steep rocky north face where it crests the ridge at approximately the 3000-foot elevation. The south side is a gentler slope that drops approximately 900 feet to Cold Creek. This side of the ridge is intersected with small drainages running south to Cold Creek. Umtanum Ridge, like the Saddle Mountains, collects significant snowfall in most winters.

3.2.3.4.4.1 Habitat

Umtanum Ridge, like the Saddle Mountains, has a steep northern slope covered mostly with shrub-steppe vegetation. Some rocky outcroppings on the north side provide habitat for raptors. The gentler south side has flat areas along the ridgelines between the small canyons draining south to Cold Creek that have relatively undisturbed shrub-steppe vegetation. These areas provide good habitat for sage grouse.

3.2.3.4.4.2 Unique Wildlife Populations

Breeding sage grouse have been observed on the flatter areas of the south side of Umtanum Ridge. Several leks are located less than one mile west of the proposed ROW. WDFW (Clausing, 2001) and Schroeder et. al. (2000), indicate that this area is considered the core area of one of the two remaining sage grouse populations in Washington. Merriam's shrews were caught in research traps at the top of Umtanum Ridge, near the proposed ROW (Wunder et. al., 1994).

3.2.3.4.5 Cold Creek

Between Umtanum Ridge and Yakima Ridge lies the Cold Creek canyon. The canyon is approximately 900 feet deep and parallels the ridges running east-west. Both sides of the canyon are relatively gentle slopes, although the south side (north side of Yakima Ridge) has some steeper outcroppings, particularly near Cairn Hope Peak, just west of the proposed ROW.

3.2.3.4.5.1 Habitat

The riparian area of Cold Creek provides more structurally diverse habitat than the surrounding shrub-steppe in the form of shrubs, trees, wetland areas and open water. The Cold Creek canyon contains an important mixture of native shrub-steppe vegetation and riparian areas between the Hanford Reach National Monument area and the YTC that acts as a corridor for wildlife moving to and from these locations. In addition, the Cold Creek canyon is one of the most important flyways in Washington for migrating birds (Stepniewski, 1998, Visser, 2001).

3.2.3.4.5.2 Unique Wildlife Populations

Elk, deer, sage grouse, loggerhead shrike and jackrabbits all use the Cold Creek canyon as a local migration corridor between the Hanford Reach National Monument and the YTC. Neotropical migrants, waterfowl, raptors and many other bird species use the canyon as a migration corridor as part of their longer journeys between regions north and south of Central Washington (Stepniewski, 1998). Many of these migrants may stop and temporarily use the riparian or upland habitats. Breeding Swainson's hawks and loggerhead shrikes have been documented within one mile of the proposed ROW (WDFW, 2001a, US Army, 1996).

3.2.3.4.6 Yakima Ridge

The third anticline in the YTC, Yakima Ridge, runs east west like the Saddle Mountains and Umtanum Ridge. The proposed ROW crosses Yakima Ridge diagonally to the southeast. The ROW climbs approximately 800 feet up the north face where it crests the ridge at approximately the 2800-foot elevation. The ROW crosses several drainages running to the east, then drops down the south side approximately 1800 feet to Dry Creek. Like Umtanum Ridge, Yakima Ridge has drainages down either side that form steep canyons running perpendicular to the ridge.

Snowfall in the area of the proposed ROW can be significant, but is somewhat less than the Saddle Mountains or Umtanum Ridge since the area is further south and east, and is on the downslope side of Yakima Ridge.

3.2.3.4.6.1 Habitat

Yakima Ridge, like the Saddle Mountains and Umtanum Ridge, has slopes covered mostly with shrub-steppe vegetation. Some rocky outcroppings on both sides of the ridge in small canyons provide habitat for raptors and species such as marmots and wood rats that prefer rocky habitats and scree slopes. The gentler south side has flat areas along the ridgelines between the small canyons draining south to Cold Creek that have deeper soils and relatively undisturbed shrub-steppe vegetation.

3.2.3.4.6.2 Unique Wildlife Populations

The entire eastern end of Yakima Ridge is considered a part of the Cold Creek migration corridor (see discussion above). On the south side of the ridge breeding prairie falcons were observed in 1988 within one mile of the proposed ROW (WDFW, 2001a). Multiple sightings of breeding burrowing owls have been made in an area adjacent to Highway 24 where the proposed ROW crosses (WDFW, 2001a).

3.2.3.4.7 New Wautoma Substation

The proposed new substation sits at the southern base of Yakima Ridge, in the shallow, broad valley of Dry Creek.

3.2.3.4.7.1 Habitat

The vegetation surrounding the new substation is heavily disturbed shrub-steppe vegetation. The area is open and relatively flat. Dry Creek, true to its name, is intermittent. Due to the presence of some water during parts of the year, the creek bottom has a higher density of shrubs than the surrounding areas but does not contain a true riparian community. Some surrounding areas have some of the highest quality shrub-steppe vegetation in the state of Washington, including the top of the Yakima Ridge .75 miles north of the site and a large area of shrub-steppe vegetation 2.5 miles east of the site in the Fitzner-Eberhardt Arid Lands Ecology (ALE) Reserve portion of the Hanford Reach National Monument. However, the area within and immediately surrounding the site is highly degraded from fires, livestock grazing and past agricultural practices.

3.2.3.4.7.2 Unique Wildlife Populations

A small colony of burrowing owls was observed 0.5 miles east of the new substation site (Personal Observation, 2001). Prime elk wintering habitat for the Hanford elk herd is located several miles east of the site along Dry Creek in the ALE Reserve. The Hanford elk herd, unique among elk herds because it exists exclusively in shrub-steppe habitat, travels at least as far upstream as the proposed substation, as evidenced by elk dropping on the site (Personal Observation, 2001). These elk probably travel much further, since the numbers of elk has dramatically increased over the past several years and numerous reports of straying animals are documented (WDFW, 2000).

3.2.3.5 Wildlife Habitat and Species of Segment D

The proposed ROW for Segment D would parallel and double circuit the existing Vantage-Midway 230-kV line then parallel the existing Big Eddy-Midway line southwest to the proposed new substation, a total of 27.3 miles. This proposed route segment crosses ten distinct areas which are, from north to south: the Vantage Substation area, the Beverly area, Lower Crab Creek, the Saddle Mountains, the Wahluke Slope, the Columbia River, Umtanum Ridge, the Cold Creek drainage, Yakima Ridge, and Dry Creek.

3.2.3.5.1 Vantage Substation Area

The proposed line exits the Vantage Substation to the south. This area is discussed in the section describing Segment B_{north} (Section 3.2.3.2.).

3.2.3.5.2 Beverly Area

The proposed ROW of Segment D cuts south diagonally across the gentle east edge of the Columbia River canyon then east of the town of Beverly on the flats where Crab Creek Coulee enters the Columbia River. The area is primarily shrub-steppe vegetation, although several agricultural areas lie on either side of the proposed line.

3.2.3.5.2.1 Habitat

The habitat along this section of Segment D is mostly shrub-steppe vegetation. Several roads and a railroad intersect the proposed ROW, and agricultural operations are located within 0.5 miles of each side of the ROW. A high degree of disturbance exists in this area, which limits the quality of the available habitat. The proposed ROW is next to the Columbia River, which is an important winter habitat for waterfowl and a bird migration corridor (described in more detail in Segment B discussion).

3.2.3.5.2.2 Unique Wildlife Populations

Nightsnakes and striped whipsnakes have been documented adjacent to and under the proposed ROW (WDFW, 2001a). Bird species associated with the Columbia River may be incidental visitors to this area (see Segment B_{north} Section 3.2.3.2.discussion).

3.2.3.5.3 Crab Creek

The proposed ROW crosses Crab Creek just east of its confluence with the Columbia River and approximately four miles south of the Vantage Substation.

3.2.3.5.3.1 Habitat

Crab Creek and its associated wetlands and riparian areas offer high quality habitat for many species of wildlife. Open water areas such as Nunnally Lake, Crab Creek and other smaller wetlands are present, and provide excellent waterfowl habitat. Willows, shrubs and large areas of sedges, reeds and grass provide greater structural diversity than the surrounding shrub-steppe vegetation.

3.2.3.5.3.2 Unique Wildlife Populations

The lower Crab Creek area is one of the most important waterfowl breeding grounds in Washington, and an important wintering ground (Clausing, 2001, WDFW, 2001a). Many bird species also use the open water and wetlands for resting and feeding on their annual migrations along the Pacific Flyway. Beaver are found in some open water areas. A small isolated population of Ord's kanagaroo rat may occupy sandy habitats on either side of Crab Creek.

3.2.3.5.4 Saddle Mountains

Immediately after crossing Crab Creek, the proposed ROW climbs approximately 1500 feet up the steep northern side of the Saddle Mountains and crests at approximately the 2100-foot elevation. The line continues to the southeast over the crest of the Saddle Mountains and down the gentler southern side towards the Wahluke Slope.

3.2.3.5.4.1 Habitat

The Saddle Mountain area provides a variety of wildlife habitats, including cliffs, talus slopes, benches, open grassy slopes and shrub-steppe habitats. The steep north side has many steep rocky outcroppings, mostly located on the top third of the slope. Habitat for bats, and raptors is abundant here. The crest of the Saddle Mountains has a unique dwarf shrub-steppe vegetation community with a number of rare plant species (Fisher, 2001). The south side contains some high quality shrub-steppe vegetation that is relatively undisturbed. A designated sage grouse movement corridor exists along the south slope of the Saddle Mountains, although no sage grouse have been observed recently in the area (Schurger, 2001, Visser, 2001)

3.2.3.5.4.2 Unique Wildlife Species

Large populations of Brewer's vesper, and sage sparrows, sage thrasher and other passerine bird species can be found in the spring and summer on the south side of the Saddle Mountains. The cliffs on the north and west side of the Saddle Mountains are home to many raptor species, including red-tailed, Swainson's, ferruginous and rough-legged hawks; prairie falcons; American kestrels; bald and golden eagles, and ravens (WDFW, 2001a). A golden eagle nest site is located less than one mile west of the proposed line in the Sentinel Bluffs, which lie above and just east of the Columbia River. A prairie falcon nest site is located on the north slope of the Saddle Mountains just below the crest within 0.25 miles of the proposed line (WDFW, 2001a). A striped whipsnake was sighted at the crest of the Saddle Mountains near the proposed line in 1979 (WDFW, 2001a).

3.2.3.5.5 Wahluke Slope

The proposed ROW crosses the Wahluke Slope just east of the town of Mattawa. The Wahluke Slope, as its name implies, is a broad, gentle slope that stretches from the base of the Saddle Mountains south to the Columbia River. The landscape is generally flat, with few terrain features.

3.2.3.5.5.1 Habitat

This area of the Wahluke Slope is heavily farmed, with very little remaining native shrub-steppe habitat. Circle-irrigated crops, cherry, peach and apple orchards, and vineyards provide the majority of the available wildlife habitat. Irrigation provides some small wetland areas associated with canals, irrigation return flows or wells, but these areas are very limited in size.

3.2.3.5.5.2 Unique Wildlife Species

Mammal species present are limited to those species that can tolerate high levels of disturbance, such as coyotes, raccoons, and a variety of rodent species. Structures such as barns and sheds provide roosting habitat for a number of bat species. Bird species present on the Wahluke Slope are also limited to those species that can tolerate high levels of human disturbance. Red-tailed hawks, American kestrels, crows and ravens are present, as well as a number of songbirds. Pheasant and quail utilize croplands. Red-winged and yellow-headed blackbirds may use the limited wetland areas associated with irrigation practices. Near the southern end of the area a breeding loggerhead shrike was observed within a mile of the proposed ROW in 1993 (WDFW, 2001a).

3.2.3.5.6 Columbia River

The proposed ROW crosses the Columbia River just west of the Vernita Bridge on Highway 24. Three existing transmission lines cross the Columbia River at this location, and Highway 243 parallels the north side of the river. The Columbia River in this area is in a wide, shallow canyon.

The north edge of the canyon is an old gravel bar with an area of sand dunes. The south side is also an old gravel bar (China Bar). The Midway Substation is located on the China Bar below the steep cliffs of Umtanum Ridge. This area is the upstream end of the Hanford Reach, the last free-flowing, non-tidal section of the Columbia River in the United States.

3.2.3.5.6.1 Habitat

A unique area of sand dunes and Indian rice grass exists north of the Columbia River crossing (WDFW, 2001a). This area receives moderate recreational use and the sand dunes and the surrounding native shrub-steppe vegetation has been disturbed by ORV use. The China Bar area on the south side is mostly shrub-steppe vegetation that has also been disturbed by recreational use. The riparian areas on either side of the open water of the Columbia River are narrow and composed mostly of grasses and forbs, with some trees. These riparian areas are subject to regular inundation as water levels fluctuate due to operations at Priest Rapids Dam several miles upstream. The section of the Columbia River where the proposed ROW crosses is at the upstream end of the Hanford Reach, an important spawning area for chinook salmon. These salmon provide a high quality food source that attracts various species of wildlife including bald eagles.

3.2.3.5.6.2 Unique Wildlife Species

Like the Columbia River crossings described in Segment B, this section of the Columbia River supports large numbers of wintering waterfowl. This section of the Columbia River (like the Segment B crossings), is located within the Pacific flyway and, during the spring and fall months, the area serves as a resting point for neotropical migrants, migratory waterfowl, and shorebirds. Bald eagles are present throughout the Hanford Reach during the winter, feeding on waterfowl and salmon carcasses WDFW, 2001a). Several Swainson's hawk nests have been documented on the China Bar south of the Columbia River approximately one mile east of the proposed ROW (WDFW, 2001a).

3.2.3.5.7 Umtanum Ridge

Directly south of the Midway Substation, the proposed ROW climbs approximately 950 feet up the steep north facing slope of Umtanum Ridge to approximately the 1380 foot elevation, then travels down the much gentler south slope of the ridge into the Cold Creek drainage.

3.2.3.5.7.1 Habitat

The steep northern side of Umtanum Ridge is a mixture of rocky outcroppings, talus slopes and cliffs interspersed with areas of shrub-steppe vegetation. The top of Umtanum Ridge and the south side is gently rolling shrub-steppe habitat.

3.2.3.5.7.2 Unique Wildlife Species

The cliffs of the north side of Umtanum Ridge harbor a large number of raptor species. The proposed ROW passes close to a known prairie falcon nest (WDFW, 2001a). Other known prairie falcon nests are located within one or two miles on both sides of the proposed ROW (WDFW, 2001a). A loggerhead shrike was sighted at the crest of Umtanum Ridge in 1994 (WDFW, 2001a). On the south slope of Umtanum Ridge, a Swainson's hawk nest was observed in 1990 within the proposed ROW (WDFW, 2001a). Three other Swainson's hawk nests are located within one mile of the proposed ROW (WDFW, 2001a).

3.2.3.5.8 Cold Creek

The proposed ROW crosses Cold Creek between Umtanum Ridge and Yakima Ridge. Cold Creek is in a broad, almost flat valley here, unlike the steeper canyon upstream where proposed Segment C crosses. Highway 24 roughly parallels Cold Creek.

3.2.3.5.8.1 Habitat

The broad valley of Cold Creek in this area contains a mixture of grassy shrub-steppe and agriculture. Cold Creek itself contains little riparian habitat in this area, but does have areas of relatively undisturbed shrub-steppe vegetation. As discussed in Segment C, Cold Creek acts as an important migration corridor of relatively undisturbed shrub-steppe habitat between the YTC and the Hanford Site exists along Cold Creek. The Cold Creek Valley is also a major bird migration corridor.

3.2.3.5.8.2 Unique Wildlife Species

The Cold Creek migration corridor is used by elk, mule deer, sage grouse, jackrabbits, songbirds and other animals traveling between the YTC and the Hanford Site (WDFW, 2001a, Clausing, 2001, Stepniewski, 1998). Neotropical migrants, waterfowl, raptors and many other bird species use the canyon as a migration corridor as part of their longer journeys between regions north and south of Central Washington (Stepniewski, 1998). Many of these migrants may stop and temporarily use the upland habitats. Nesting burrowing owls have been observed next to the proposed ROW near Highway 24 (WDFW, 2001a). Prairie falcons, golden eagles, Swainson's hawks and Lewis' woodpeckers have all been observed using the Cold Creek valley for nesting or foraging near where the ROW crosses (Stepniewski, 1998).

3.2.3.5.9 Yakima Ridge

From Cold Creek, the proposed ROW climbs gently up the north slope of Yakima Ridge approximately 550 feet to the 1550 foot elevation, then drops steeply approximately 500 feet into the proposed new Substation. The hills are smooth, with few rocky outcroppings.

3.2.3.5.9.1 Habitat

Both sides of Yakima Ridge under the proposed ROW are relatively undisturbed shrub-steppe, although some agricultural activity has taken place on the north side west of the proposed ROW. The top of Yakima Ridge is a nearly pristine bluebunch wheatgrass community that is partially covered with sage.

3.2.3.5.9.2 Unique Wildlife Species

WDFW PHS database documented no occurrences of unique wildlife populations in the area immediately surrounding the proposed ROW crossing of Yakima Ridge. However, Stepniewski (1998), indicates that grasshopper sparrows, sage sparrows, sage thrashers, golden eagles and ferruginous hawks have been observed close to the proposed ROW.

3.2.3.5.10 New Wautoma Substation

The proposed ROW enters the proposed new substation from the north. This area is previously discussed under Segment C (Section 3.2.3.4.).

3.2.3.6 Wildlife Habitat and Species of Segment E

Segment E parallels Segment D to the east from Vantage to the top of the Saddle Mountains, then turns southeast, crosses the Wahluke Slope, enters the Hanford Reach National Monument and ends at the Hanford Substation. This segment is 23.2 miles long and crosses six distinct areas: the Vantage area, Crab Creek, the Saddle Mountains, the Wahluke Slope, the Hanford Reach National Monument, and the Columbia River.

3.2.3.6.1 Vantage Area

The proposed Segment E ROW parallels proposed Segment D approximately 0.5 miles to the east. The habitats and species present in the Vantage area have been previously discussed in Segment D.

3.2.3.6.2 Crab Creek

The proposed Segment E ROW crosses Crab Creek approximately 0.5 miles east of where proposed Segment D crosses. The habitats and species present in Crab Creek have been previously discussed in Segment D.

3.2.3.6.3 Saddle Mountains

The proposed ROW continues to parallel Segment D as it climbs the steep northern side of the Saddle Mountains immediately after crossing Crab Creek. From the crest of the Saddle Mountains, however, the proposed ROW turns southeast at the crest of the Saddle Mountains and heads across a part of the Wahluke Slope towards Hanford further to the east than Segment D. Habitat and species in the Saddle Mountains for this segment are similar to those existing along Segment D.

3.2.3.6.4 Wahluke Slope

The proposed ROW crosses the central part of the Wahluke Slope. The Wahluke Slope in this area is very gently sloping to the south. Like proposed Segment D, the proposed ROW crosses through an area of the Wahluke Slope that is heavily farmed, with very little remaining native shrub-steppe habitat. Habitats and species are similar to those discussed under Segment D. No unique species are documented in the Wahluke Slope area along proposed Segment E

3.2.3.6.5 Hanford Reach National Monument

Southeast of Highway 24, the proposed ROW crosses into the Hanford Reach National Monument. The area is generally flat, although the line drops into a shallow depression that contains Saddle Mountain Lake. The terrain is slightly rolling and hummocky. Sand dunes and blowouts are scattered throughout the area.

3.2.3.6.5.1 Habitat

The proposed ROW passes through a variety of habitats in the Hanford Reach National Monument. The northwestern end of the line where it crosses Highway 24 generally has a sagebrush-dominated community interspersed with grassy sand dune areas. As the line drops into the shallow basin that contains Saddle Mountain Lake, the vegetation turns to more of a grass dominated habitat, with only sparse shrub areas. A well-developed riparian area surrounds Saddle Mountain Lake and the channel leading east from it. Closer to the Columbia River, the terrain is flat or gently sloped south and covered by a patchwork of shrubby and grassy areas. The USFWS indicates that this area is considered very high quality shrub-steppe habitat (Haas, 2001)

3.2.3.6.5.2 Unique Wildlife Species

Where the proposed line crosses Highway 24 and enters the Hanford Reach National Monument, burrowing owls have been observed, although no nest sites are documented in this area (WDFW, 2001a). Near Saddle Mountain Lake, many observations of Woodhouse's Toads have been made (WDFW, 2001a). A herd of approximately 70 mule deer exists in the area east and south of Saddle Mountain Lake (WDFW, 2001a, Haas, 2001, Personal Observation, 2001). Closer to the Columbia River, near the Saddle Mountain Wasteway, nesting Swainson's hawks and great blue herons have been observed (WDFW, 2001a). Sagebrush lizards and nightsnakes have been documented near the proposed ROW (Nature Conservancy, 2001). Sagebrush voles and pygmy rabbits are also documented in the area surrounding the proposed segment (Brunkal, 2001)

3.2.3.6.6 Columbia River

The proposed ROW crosses the Columbia River in the middle of the Hanford Reach and stops just south of the river at the existing Hanford Substation. The north bank of the Columbia River in this area is not well defined, but slopes gently up from the river. The south bank is steep, but no more than approximately 50 feet high.

3.2.3.6.6.1 Habitat

The riparian area of the Columbia is very narrow and composed mostly of grasses, with a few widely spaced trees. There is little variation in the landscape on the north side, although the steep south bank may provide some suitable denning areas for burrowing mammals. The entire Hanford Reach provides important open water habitat for waterfowl.

3.2.3.6.6.2 Unique Species Present

As with the rest of the Columbia River in central Washington, hundreds of thousands of waterfowl use the open water habitats and wetlands as breeding areas, overwintering areas, or stopovers on spring and fall migrations. These species, as well as neotropical migrants may be present in or near the river. Communal bald eagle roosts are located within three miles of each side of the proposed ROW crossing (WDFW, 2001a).

3.2.3.7 Wildlife Habitat and Species of Segment F

Proposed Segment F heads east for several miles from the Vantage Substation, then turns south, crosses Crab Creek and heads up the steep northern slope to the top of the Saddle Mountains, just east of the where Segments D and E cross the Saddle Mountain crest. From here, the line heads east just south of the crest of the Saddle Mountains for approximately 15 miles. Where the segment intersects the Grand Coulee-Hanford 500kV line, it turns south and parallels it into the Hanford Substation. The segment length is 32.1 miles. The proposed line crosses 6 distinct areas: the Vantage area, Crab Creek, the Saddle Mountains, the Wahluke Slope, the Hanford Reach National Monument and the Columbia River.

3.2.3.7.1 Vantage Area

The proposed ROW heads east out of the Vantage Substation for approximately two miles, then turns south down a gentle slope to Crab Creek, approximately four miles. The area immediately surrounding the substation has been discussed in Segment B and D. However, the area to the east of the substation is flatter and has more agricultural activity associated with it than the other segments.

3.2.3.7.1.1 Habitat

Proposed Segment F crosses through areas composed mostly of shrub communities, although circle irrigation, orchards and vineyards are immediately adjacent to each side of the proposed line.

3.2.3.7.1.2 Unique Species Present
An observation of an Ord's kangaroo rat caught in a trap was made in 1987 (WDFW, 2001a), within the proposed ROW (see the Crab Creek discussion below for more information on Ord's kangaroo rat). A ferruginous hawk nest was observed in 1995 approximately one mile east of the proposed line (WDFW, 2001a).

3.2.3.7.2 Crab Creek
The proposed ROW crosses Crab Creek approximately one mile east of where proposed Segments D and E would cross. More extensive wetlands are present in this area than exist near Segments D and E.

3.2.3.7.2.1 Habitat
As discussed in the Segment D section, Crab Creek and its associated wetlands and riparian areas is one of the most important waterfowl breeding grounds in Washington. Nunnally Lake is important habitat for waterfowl. An area of sand dunes and willows exists just north of Crab Creek.

3.2.3.7.2.2 Unique Wildlife Species
Nunnally Lake supports a large population (3-4000) of wintering ducks (WDFW, 2001a). Quail have been observed using varied habitats along the valley bottom. In addition, within 0.5 miles of the proposed line, a number of Ord's kangaroo rats were caught in 1996 and 1997 (Gitzen, et. al., 2001). This sighting, and the observation made in 1987 two miles north of Crab Creek are significant in that they represent new sightings in areas where this species previously was not recorded.

3.2.3.7.3 Saddle Mountains
The proposed ROW climbs the steep northern side of the Saddle Mountains immediately after crossing Crab Creek. The line parallels proposed Segment E for approximately 0.75 miles, then turns due east for approximately 14 miles along the lower half of the slope to the existing Grand Coulee-Hanford 500kV line.

3.2.3.7.3.1 Habitat
The habitats and species of the western end of the Saddle Mountains has been described in Segments D and E. Segment F is not located far enough from these segments to warrant a separate discussion. However, where Segment F turns east and follows the lower slope of the Saddle Mountains, different habitat conditions are encountered. On the south slope, the vegetation community changes from a sagebrush-dominated community on the west end to a grass-dominated community on the east end. A number of canyons intersect the south slope, providing some rocky outcrop and talus slope habitats.

3.2.3.7.3.2 Unique Wildlife Species
No observations of unique wildlife species have been made in this area, however this may be due to the extremely limited access in the area. WDFW and BLM report that sage grouse were historically present along the Saddle Mountains, and that the relatively intact shrub-steppe vegetation is still considered a migration corridor between the YTC and areas east of the Saddle Mountains (Clausing, 2001, Fisher, 2001). In addition, species such as prairie falcons, ferruginous hawks and loggerhead shrikes have been observed on the crest and the north slope of the Saddle Mountains, within several miles of the proposed line (WDFW, 2001a). The area surrounding the proposed ROW supports one of the largest contiguous areas of occupied habitat for sage sparrows known in Washington (Nature Conservancy, 1999).

3.2.3.7.4 Wahluke Slope

The proposed ROW parallels the Grand Coulee-Hanford 500kV line that crosses the eastern part of the Wahluke Slope. This area of the Wahluke Slope is part of the Hanford Reach National Monument area and is located just east of the heavily farmed area. With the exception of the Wahluke Branch Canal, which runs west to east, the area north of Highway 24 is relatively undisturbed and retains much of its pre-development condition. The area slopes gently to the south.

3.2.3.7.4.1 Habitat

Areas of dense sagebrush dominate the habitat. There are no outstanding terrain features.

3.2.3.7.4.2 Unique Wildlife Species

The dense sagebrush provides nesting habitat for a number of Swainson's hawks. Three nests have been observed within one mile east of the proposed ROW (WDFW, 2001a).

3.2.3.7.5 Hanford Reach National Monument

South of Highway 24, the proposed ROW drops over a steep slope approximately 200 feet into a large depression that to the west contains Saddle Mountain Lake. At the south end of the depression, the line intersects with proposed Segment E, and heads south to cross the Columbia River in the same alignment.

3.2.3.7.5.1 Habitat

The depression south of Highway 24 contains a mixture of sand dunes, blowouts and intermittent wetlands. A mixture of sagebrush and grasslands is present. The steep slope on the northern edge of the depression is composed of soft substrate materials.

3.2.3.7.5.2 Unique Wildlife Species

A Swainson's hawk nest was observed on the top of the slope directly in the path of the proposed ROW (WDFW, 2001a). A herd of approximately 40 mule deer was observed in the central part of the depression (personal observation, 2001). Near the southern end of the proposed segment, immature sage sparrows were observed within one mile of the proposed line in 1987 (WDFW, 2001a). Sagebrush lizards and nightsnakes have been documented near the proposed ROW (Nature Conservancy, 2001).

3.2.3.7.6 Columbia River

The proposed Segment F ROW crossing of the Columbia River follows the same alignment that Segment E does. Wildlife habitats and species will be the same as discussed in Segment E.

3.2.4 Threatened and Endangered Species

This section discusses federally listed Threatened, Endangered and Proposed species and other species that are likely to be listed in the near future that may occur in the project area. These species include the bald eagle, the sage grouse, the Washington ground squirrel, and the Mardon skipper.

3.2.4.1 Bald Eagle

The bald eagle is a federally listed threatened species, but is proposed for de-listing. The Washington Department of Fish and Wildlife is reviewing their status as a state threatened species. There are approximately 650 nesting pairs of bald eagles in Washington and as many as 3,000-4,000 wintering bald eagles.

Bald eagles in Washington are generally migratory. Eagles that nest in Washington usually move north after nesting to feed on early salmon runs in western British Columbia and southeast Alaska. Many of the eagles that winter along rivers in Washington are birds that nest in Alaska, British Columbia or Montana (Stinson et. al., 2001).

Bald eagle nesting parameters in the Pacific Northwest include proximity to water with an adequate food source, large trees with sturdy branching at sufficient height for nesting, and stand heterogeneity both vertically and horizontally (Grubb, 1976). Nest tree structure is more important than tree species, and nest trees are typically among the largest in the stand providing an unobstructed view of an associated water body. Critical nesting activities generally fall between January 1, and August 31.

Wintering bald eagles concentrate in areas where food is abundant and disturbance is minimal (Rodrick and Milner, 1991). Because eagles often depend on dead or weakened prey, spawned salmon are often an important food source for wintering eagles. Rivers, streams and large lakes with spawning salmon and/or waterfowl concentrations are primary feeding areas for wintering bald eagles. Eagles typically perch near their food source during the day and prefer the tallest trees, which afford the best views. Deciduous and dead coniferous trees near the feeding area are preferred for diurnal bald eagle perching (Stalmaster and Newman, 1979). Evening roosts are generally established near the feeding area but may occur inland as well (Peterson, 1986). Wintering activities generally occur between mid-November and mid-March. .

Bald eagles are not known to nest within ten miles of the proposed project area. Bald eagles have attempted to nest along the Hanford Reach of the Columbia River approximately ten miles east of the proposed project area (USDOE, 2001). Wintering bald eagles are present along all segments, including the area north of Ellensburg near Wilson and Naneum creeks, in the YTC near Hanson and Alkali Canyon Creeks, and near the Columbia River crossings at the Vantage, Midway and Hanford Substations. No primary winter roost sites are known to exist within three miles of the proposed project area, although secondary roosts and ground perches have been identified around the area where Segments E and F cross the Columbia River into the Hanford Substation (USDOE, 2001). Surveys of potential winter roost sites will occur along the preferred alternative in winter 2002.

3.2.4.2 Sage Grouse

The sage grouse is a candidate for federal listing. The WDFW lists the sage grouse as Threatened. In Washington, sage grouse historically ranged from the Columbia River, north to Oroville, west to the foothills of the Cascades, and east to the Spokane River (Schroeder, et. al., 2000). The current Washington population of breeding sage grouse is estimated at approximately 1,000 birds roughly divided between two populations. One population of approximately 600 birds is located on mostly private lands in Douglas and Grant Counties, while the other approximately 400 birds exists in Kittitas and Yakima Counties on the YTC (Schroeder, et. al, 2000).

Sage grouse gather in the spring at specific locations, called leks, to perform courtship displays and mating. Leks are most commonly found in a barren area surrounded by sagebrush, but they have been found in a wide variety of open areas such as gravel pits, roads, buttes, dry lake beds and meadows (Hays, et. al., 1998). Nesting occurs in areas of medium to high shrub cover, often with dry grasses. Sage grouse consume sagebrush, grasses, forbs and some insects. Preferred winter habitats are tall dense stands of sagebrush, which provide shelter and forage (Hays, et. al., 1998). Winter sites often face south or west, since less snow generally accumulates in these orientations.

Within the proposed project area, sage grouse are known to exist within the YTC, including sections of Segments A, B_{north}, B_{south} and C. Sage grouse have been observed within each of the six drainages in the YTC the route passes through, and are known to nest in the Alkali Canyon and Corral Canyon drainages. A historic lek in the Johnson Creek drainage has not been used since 1987. Most of the core sage grouse habitat in the YTC is west of the proposed route. Historic sage grouse migration corridors exist along the top of the Saddle Mountains and along Cold Creek, although sage grouse have not been sighted in these areas recently.

3.2.4.3 Washington Ground Squirrel

The Washington ground squirrel was originally common in Washington and Oregon east and south of the Columbia River. Habitat loss and fragmentation has severely reduced its range, and it is listed as both a state and federal Species of Concern. The distribution of the squirrel in Washington has been reduced and become more fragmented in the last 10 years (Betts, 1999).

The Washington ground squirrel prefers a grass and forb dominated habitat with deep, weak soils (Betts, 1990). They feed mostly on grass and forbs, but may also eat bulbs, seed pods and insects. The preference for areas of grasses and forbs rather than brushy areas probably reflects habitat selection based on the total abundance of food sources (Betts, 1990) Washington ground squirrels generally live in colonies of up to 250 individuals.

Much of the proposed project is located west of the Columbia River, outside of the Washington ground squirrels known historic range. Washington ground squirrels most likely do not currently exist within the project area on the east side of the Columbia River, One historical occurrence (pre-1978) was noted near line segment F in the Saddle Mountains (Betts, 1990). An existing population was found on the Hanford Reach National Monument north of the crest of the Saddle Mountains approximately five miles east of Segment F (Nature Conservancy, 1999). This is the nearest known existing population of Washington ground squirrel to the project. Suitable Washington ground squirrel habitat exists within the project area east of the Columbia River especially near Crab Creek (Hill, 2001) and the Wahluke Slope (Nature Conservancy, 1999), but it is not known if these habitats are currently occupied.

3.2.4.4 Mardon Skipper

The Mardon skipper is a small species of butterfly that is a candidate for federal listing. The WDFW has listed it as Endangered. There are two generalized areas where the Mardon skipper occurs: the Puget Prairie area in Thurston and Pierce Counties, and the South Cascades area in Yakima and Klickitat Counties. Only nine of 18 historic sites are currently occupied with a total population of approximately 300 adults estimated in 1998 (Potter, et. al., 1999).

The habitat requirements of the South Cascades populations are generally open fescue grasslands within Ponderosa pine woodlands. Site conditions can range from dry open ridgetops to wetland and riparian areas. Females lay eggs on tufts of bunchgrass (including Idaho fescue), and the larvae feed on the bunchgrass for three or four months. Adults feed on the nectar of a variety of plants, including penstemon, sego lily, and wallflower (Potter, et. al., 1999).

The closest known location of historic and present Mardon skipper populations is approximately 50 miles southwest of the proposed project (Potter, et. al., 1999). The Ponderosa pine/fescue habitat type does not occur within the project area boundaries, although the habitat type may exist near the northern end of the project area. It is unlikely that the Mardon skipper exists within the project area.

3.2.5 Federal Species of Concern and State Listed Species

A list of state and federal listed wildlife species that are known to exist within the four counties crossed by the proposed project is presented in Table 3.2-1. The table indicates which of these species could possibly occur along each line segment.

Table 3.2-1 Possible Presence of State and Federal Listed Species Within Project Area.

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Document Occurrence Type
Birds				
Aleutian Canada goose	FT[1]	ST	B, D, E, F, G	M
Bald eagle	FT	ST	All segments	W
Golden eagle		SC	B, C, D, E, F, G	B
Ferruginous hawk	FSC	ST	All segments	B
Swainson's hawk		SM	All segments	B
Northern goshawk	FSC	SC	All segments	M
Peregrine falcon	FSC	SE	C, D, E, F	B
Swainson's hawk		SM	All segments	B
Osprey		SM	B, D, E, F, G	B
Prairie falcon		SM	All segments	B
Turkey vulture		SM	B, D, E, F, G	B
Prairie falcon		SM	C, D, E, F	B
Burrowing owl	FSC	SC	C, D, E, F	B
Northern Spotted Owl	FT	SE	None	N
Lewis' woodpecker		SC	A, C, D, E, F	B
Sage sparrow		SC	All segments	B
Sage thrasher		SC	All segments	B
Loggerhead shrike	FSC	SC	All segments	B
Long-billed curlew	FSC	SM	A, C, E, F	B
Western bluebird	FSC	SM	All segments	B
Ash-throated flycatcher	FSC	SM	None	N
Olive sided flycatcher	FSC		All segments	P
Little Willow flycatcher	FSC		All segments	P
Grasshopper sparrow	FSC	SM	C	B
Western sage grouse	FSC	ST	A, C, F	B
Sharp tailed grouse	FSC	ST	None	H
American white pelican		SE	B, D, E, F, G	M
Harlequin duck	FSC		B, D, E, F, G	P
Common loon		SS	B, D, E, F, G	M

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Document Occurrence Type
Marbled murrelet	FT	ST	None	N
Black tern	FSC	SM	B, D, E, F, G	M
Caspian tern		SM	B, D, E, F, G	M
Forster's tern		SM	B, D, E, F, G	M
Great blue heron		SM	B, D, E, F, G	B
Black-crowned night heron		SM	B, D, E, F, G	B
Mammals				
Gray wolf	FE	SE	None	N
Canada lynx	FT	ST	None	N
Grizzly bear	FT	SE	None	N
California bighorn sheep	FSC		B, D, E, F, G	P
Pacific fisher	FSC	SE	None	N
Wolverine	FSC	SC	None	N
Western gray squirrel	FSC	ST	None	N
Washington ground squirrel	FC	SC	D, E, F	H
Pygmy rabbit	FSC	SE	None	H
Ord's kangaroo rat		SM	B, D, E, F, G	P
Northern grasshopper mouse		SM	All segments	P
Sagebrush vole		SM	All segments	P
White-tailed jackrabbit		SC	All segments	B
Merriam's shrew		SC	All segments	B
Ord's kangaroo rat		SM	All segments	B
Potholes meadow vole	FSC		None	N
Sagebrush vole		SM	All segments	B
Pacific western big-eared bat	FSC	SC	All segments	P
Long-eared myotis	FSC	SM	All segments	P
Long-legged myotis	FSC	SM	All segments	P
Fringed myotis	FSC	SM	All segments	P
Western small-footed myotis	FSC	SM	All segments	P
Yuma myotis	FSC		All segments	P
Pallid bat		SM	All segments	P
Insects				
Mardon skipper	FC	SE	None	N
Persius' duskywing		SM	E	P
Reptiles & Amphibians				
Cascades frog	FSC		None	N
Larch Mountain salamander	FSC	SS	None	N
Northern leopard frog	FSC	SE	D, E, F	P
Red-legged frog	FSC		None	N
Tailed frog	FSC	SM	None	N
Columbia Spotted Frog	FSC	SE	All segments	P
Night snake		SM	B, D, E, F, G	P
Woodhouse's Toad		SM	E, F	B
Sagebrush lizard	FSC		All segments	B
Night snake		SM	All segments	B
Striped whipsnake		SC	All segments	B

Federal Status	State Status	Presence
FE = Endangered	SE = Endangered	P = Present (general presence)
FT = Threatened	ST = Threatened	B = Breeding
FC = Candidate	SS = Sensitive	M = Migrant
FSC = Species of Concern	SC = Candidate	W = Winter Resident
	SM = Monitor	N = Not Present
		H = Historically Present, Not Present Now
Note 1: To be delisted in 2001		

3.3 Impacts to Wildlife Species and Habitat

Impacts to wildlife species and habitat are assessed for each alternative proposed for the project. Various segments described in Section 2.2.3 are combined to form each alternative.

3.3.1 Wildlife Species Impact Levels

Environmental impact levels to wildlife are defined in four categories:

High impacts would occur when an action creates a significant adverse change in wildlife habitat, populations, or individuals. High impacts may result from actions that:

- cause the take of a federally listed or proposed threatened or endangered wildlife species;
- cause a significant reduction in the population, habitat or viability of a federal or state listed wildlife species of concern or sensitive wildlife species, which would result in trends towards endangerment or the need for federal listing;
- cause a significant long-term (more than two years) reduction in the quantity or quality of habitat critical to the survival of local populations of common wildlife species; or
- harm or kill a significant number of individuals of a common wildlife species.

Moderate impacts would occur when an action creates a moderate adverse change in wildlife habitat, populations or individuals. Moderate impacts may result from actions that:

- create an effect on federally listed or proposed threatened or endangered wildlife species that could be partially mitigated;
- cause a reduction in the population, habitat or viability of a federal or state listed wildlife species of concern or sensitive wildlife species, without resulting in trends towards endangerment or the need for federal listing; or
- harm or kill a small number of individuals of a common wildlife species.

Low impacts would occur when an action creates a minor adverse change in wildlife habitat, populations or individuals. Low impacts may result from actions that:

- create an effect on federally listed or proposed threatened or endangered wildlife species that could be largely or completely mitigated (i.e., seasonal restrictions on construction activities) or are temporary and benign (i.e., temporary disturbance by construction noise);
- cause a minor short-term (less than two years) reduction in the quantity or quality of the habitat of a federal or state listed wildlife species of concern or sensitive wildlife species, without resulting in trends towards endangerment or the need for federal listing; or
- cause a significant short-term (less than two years) reduction in the quantity or quality of habitat critical to the survival of local populations of common wildlife species.

Minimal impacts would occur when an action creates a temporary or minor adverse change in wildlife habitat or individuals. Minimal impacts may result from actions that:

- cause a temporary (less than two weeks) disturbance or displacement of a federal or state listed wildlife species of concern or sensitive wildlife species; or
- cause a short-term (less than one year) disturbance or displacement of a common wildlife species.

No impacts would occur when an action has no effect or fewer impacts than the minimal impact level on wildlife habitat, populations or individuals.

3.3.2 Impacts to Wildlife Species Common to All Action Alternatives

The construction, operation and maintenance of the proposed transmission line would impact wildlife populations residing in or near the proposed study area. The extent of impact would depend on the species, habitat requirements, and availability of suitable habitat in and around the construction and ROW area.

3.3.2.1 Construction Impacts

Construction impacts can be generally categorized as short-term disturbances related to construction noise, dust, human intrusion, or long-term physical habitat changes or harm to individual animals.

Short-term construction disturbances, depending on the time of year and location, could impact a wide variety of species including mule deer, elk, wintering bald eagles, passerine bird species, waterfowl, raptors, small rodents and amphibian species. Nesting raptors are easily disturbed by construction noise and human presence, and may abandon their nests if the disturbance is severe. Short-term disturbance of a federally listed species may constitute a take, which is considered a high impact. However, with mitigation (e.g., construction timing restrictions), short-term construction-related disturbances would result in only low or minimal impacts to wildlife species.

Long-term construction impacts would mostly stem from habitat loss, due to clearing for ROW or roads. Clearing would mostly impact species that use shrub-steppe habitats, although some limited areas of riparian vegetation may need to be removed. Clearing would be required for tower sites, new substations, expanded substations and access roads. Most ROW areas not associated with towers, roads or substations would not need to be cleared, since the shrub-steppe vegetation generally does not grow high enough to exceed line clearance thresholds.

Areas cleared of shrub-steppe vegetation would most likely be invaded by non-native pioneer species, which would preclude the regrowth of native vegetation. In areas of relatively undisturbed, native shrub-steppe habitat, clearing would constitute a high impact, because high-value habitat for state or federally listed shrub-steppe-dependant species (e.g., sage grouse, sage sparrows, sage thrashers and loggerhead shrikes) would be reduced. In areas of degraded shrub-steppe vegetation (e.g., vegetation infested with weed species), clearing would constitute a moderate impact, since the habitat is already degraded. Clearing in areas previously cleared or severely disturbed (such as agricultural lands) would result in minimal impacts to wildlife species.

Clearing areas of native shrub-steppe vegetation, especially linear corridors such as roads can increase the risk of predation for shrub-steppe dependant small mammal, reptile and bird species. With less cover available and an easy corridor for predators to travel into previously unbroken habitat, these species can be at increased risk of predation from coyotes, raptors and other predators (Brunkal, 2001). Species most susceptible to increased predation include jackrabbits, sagebrush voles, sagebrush lizards, striped whipsnakes, nightsnakes, and sage grouse.

Riparian areas are generally located in narrow strips along small streams and often in canyons. Since the proposed transmission line would either span these narrow areas or would be located upslope of stream channels, little or no riparian vegetation would need to be removed for transmission line clearance and tower construction. However, since riparian areas are extremely important wildlife habitat, clearing riparian vegetation for ROW or access road construction would cause moderate to high impacts to wildlife species by disrupting movement corridors, removing nesting or foraging habitat, and compacting stream banks.

3.3.2.2 Operation and Maintenance Impacts

Impacts to wildlife from the operation and maintenance of the proposed project are generally related to the temporary disturbance of wildlife (caused by maintenance equipment and human presence), or the physical presence of the structures.

3.3.2.2.1 Maintenance Impacts

Maintenance of the proposed project may include periodic vehicle and foot inspections, helicopter surveys, tower and line repair, clearing of ROW, and other disturbances. Depending on the time of year and the location, maintenance activities could impact a wide variety of species, including mule deer, elk, wintering bald eagles, passerine bird species, waterfowl, raptors, small rodents and amphibian species. Raptors frequently use transmission line towers for nesting and perch sites, and because the towers are the tallest part of the landscape, they may be the preferred hunting site for some species. Nesting raptors are easily disturbed by equipment noise and human presence and may abandon their nests if the disturbance is severe. Periodic ROW clearing would be limited to riparian areas, where the impact would be high.

3.3.2.2.2 Operation and Avian Collision Impacts

Operation of the proposed project would have the greatest impact on bird species, due to the collision threat posed by towers, transmission lines and grounding wires. Other wildlife species would not be significantly impacted, since the presence of the transmission lines, towers and access roads do not present barriers to migration, create excessive noise, or otherwise cause major behavior changes.

Some bird species, usually waterfowl, are prone to collisions with transmission lines, especially the grounding wires located at the top of the towers (Meyer, 1978, James and Haak, 1979, Beaulaurier, 1981, Beaulaurier et al., 1982, Faanes, 1987). Collisions usually occur near water or migration corridors and more often during inclement weather. Raptor species are less likely to collide with power lines, perhaps due to their excellent eyesight and tendency to not fly at dusk or in low visibility weather conditions (Olendorff and Lehman, 1986). Smaller migratory birds are at risk, but generally not as prone to collision because of their small size, their ability to quickly maneuver away from obstacles, and the fact that they often migrate high enough above the ground to avoid transmission lines. Permanent-resident birds that fly in tight flocks, particularly those in wetland areas, may be at higher risk than other species.

The following four factors influence avian transmission line collisions: the current level of risk, power line configuration, amount of bird use in a particular area, and the tendency of certain bird species to collide with wires.

The existing transmission lines that would be paralleled have a current level of risk for avian collisions. The risk would be less where a new transmission line parallels an existing transmission line. Although risks and mortality would increase in these areas, they wouldn't double since there would already be existing risk. Avian collision risk would be higher for a new transmission line corridor (Segments C and F).

The type and configuration of transmission lines is a factor that influences avian collisions. Generally, ground wires located above the transmission wires and towers cause the majority of the avian collision mortalities (Beaulaurier, 1981, Beaulaurier et al, 1982, James and Haak, 1979). Ground wires would be required on all the segments, due to the risk of lightning strikes, so the proposed line would contribute more to avian collisions than one without ground wires. Line markers have been shown to reduce the incidence of avian collisions (Beaulaurier, 1981, Avian Power Line Interaction Committee, 1994).

The amount of bird use is heaviest at the Columbia River crossings where large numbers of waterfowl congregate, and at Crab Creek where a series of wetlands and open water habitats occur. Segments C and D cross Cold Creek, which is one of the most important migration corridors in Washington for passerines, raptors and other upland bird species (Stepniewski, 1998). The remaining areas of each alternative are generally located in upland areas without large concentrations of birds and outside of major migration corridors.

The types of birds most likely to collide with transmission lines are waterfowl, such as ducks and geese, great blue herons, and birds that form tight flocks such as blackbirds. Raptor species generally do not collide with transmission lines, because they rarely fly in poor weather conditions, and have excellent vision. Migrating passerine species generally fly high enough to avoid transmission lines, however during periods of poor visibility such as storms or fog, they tend to fly lower and may be at risk of collision with transmission lines or towers. Towers with warning lights (e.g., those that may be placed near airports, river crossings or other areas where visual enhancement is necessary) tend to attract birds to them at night during periods of low visibility, and therefore may increase the risk of avian collisions during inclement weather.

Waterfowl and other large species associated with wetland or open water would be placed at a higher risk of collision with the proposed transmission lines at the Columbia River crossings of Segments B_{north}, B_{south}, D, E, and F, and the Crab Creek crossing of Segments D, E and F. Impact levels are expected to be moderate for waterfowl at these locations. Passerine species and other upland migrants would be placed at a higher risk of collision with the proposed transmission line on Segments C and D where they cross the Cold Creek corridor, particularly during poor weather conditions. Impact levels are expected to be moderate for upland bird species at these locations.

Transmission lines and towers provide a beneficial effect to some bird species, especially raptors. Transmission towers are the tallest structures in many areas of the shrub-steppe habitat of eastern Washington and as such, may provide the only suitable perching, roosting and nesting spots for some species. Red-tailed hawks, ferruginous hawks, and Swainson's hawks all utilize tower structures for hunting perches and may build nests in suitable locations. Existing towers have probably contributed to an increase in these species (Johnson and O'Neil, 2001).

Although raptor species may benefit from an increase in habitat from additional towers, the effect to small shrub-steppe dependant species such as jackrabbits, sagebrush voles, sagebrush lizards, striped whipsnakes, nightsnakes, and sage grouse could be detrimental. Increased numbers of predatory raptors coupled with an increase in cleared areas may cause additional predation on these species (Brunkal, 2001).

3.3.3 Impacts to Wildlife Species Specific to Each Action Alternative

Impacts to wildlife species are discussed below for each alternative route. Table 2.3-1 shows the amount of different land area types disturbed by the project for each segment, which gives an indication of overall impact to wildlife species.

Table 2.3-1 Disturbed Area Data

LANDUSE COVER TYPE	COVER TYPE (ACRES)						
	A	B_{north}	B_{south}	C	D	E	F
Commercial, Industrial or Transportation	1.94	0.09	0.09	0.43	1.76	0.26	0.68
Urban, or Recreational Grasses				0.29			
Low Intensity Residential					0.32	0.17	
Deciduous Forest	1.49			2.72	0.29		
Evergreen Forest	3.43				0.14	0.44	
Mixed Forest	0.15				0.22		
Grasslands or Herbaceous Vegetation	12.89	26.17	26.66	106.98	25.92	34.14	58.33
Shrubland	195.36	56.26	63.76	316.50	36.18	112.38	172.97
Pasture/Hay	1.19				17.14	29.95	2.63
Fallow	2.46				0.29	0.17	
Orchard, Crops or Grains	0.30				1.25		
Row Crops					13.05	21.13	0.30
Woody Wetlands				0.29			
Bare Rock, Sand, or Clay				0.29		1.14	1.65
Unknown					0.07	0.44	
Total Acres	**219.21**	**82.52**	**90.51**	**427.50**	**96.63**	**200.22**	**236.56**

3.3.3.1 Alternative 1- Schultz-Hanford (Segments A, B_{north} or B_{south}, E)

3.3.3.1.1 Segment A

Segment A would require approximately 208 acres of shrub-steppe and grassland vegetation to be cleared for tower sites and access road construction and approximately 5 acres of forests. Nesting habitat for sagebrush obligate species such as the sage sparrow and sage thrasher would be removed, as would known nesting habitat for long-billed curlew (moderate impact). Sharp-tailed grouse have been documented in the past near the west end of Segment A, and if they still exist, would be moderately impacted by vegetation removal. Sage grouse are known to exist in the southern end of this segment, although no occurrences have been documented closer than one mile from the proposed ROW. Disturbance to sage grouse from vegetation removal and construction noise may result from this project (moderate to high impact). The increase in risk to raptors, waterfowl and passerine bird species from collision with transmission lines and towers would be low, since no major migration corridors or bodies of water are located along this segment (minimal impact). However, the increase in potential habitat for perching raptors may cause an increase in predation risk for shrub-steppe dependant animals, a moderate risk. If the project were constructed during the winter, the potential for disturbing roosting bald eagles (threatened species) would be high near the Wilson and Naneum Creek crossings (high impact). Also, wintering deer and elk might be temporarily disturbed by construction noise and activity (minimal impact).

3.3.3.1.2 Segments B_{north} and B_{south}

Segment B_{north} would require approximately 82 acres of shrub-steppe and grassland vegetation to be cleared for tower sites and access road construction, while Segment B_{south} would require approximately 90 acres of clearing. If the project were constructed during the winter, the potential for disturbing roosting bald eagles would be high near the Columbia River crossing (high impact). In the upland areas, wintering deer and elk might be disturbed by construction activity (minimal impact). Sage grouse are known to exist near the western end of these segments and might be impacted (moderate to high impact). Night snakes have been observed near the proposed ROW and might be impacted (minimal impact). Near the Columbia River, waterfowl, pelicans and other birds using the area as a migration corridor might be at increased risk of collision with the transmission line spanning the river (moderate impact).

3.3.3.1.3 Segment E

Segment E would require that approximately 146 acres of shrub-steppe and grassland habitat would need to be cleared for tower sites and access roads. Segment E crosses Crab Creek and the Columbia River, which are both migration corridors for birds and areas of high waterfowl concentrations. The risk of avian collisions would be increased in these areas, although the proposed line would be located adjacent to an existing line (moderate impact).

The habitat in the area between the Vantage Substation Crab Creek is mostly shrub-steppe vegetation. Disturbance of this area would cause moderate impacts to shrub-steppe habitat and shrub-steppe dependant species. Nightsnakes and striped whipsnakes have been documented near the ROW and could be disturbed or harmed (a moderate impact).

The Saddle Mountains have documented occurrences of nesting prairie falcons and golden eagles that could be disturbed by construction activities (low to moderate impact). Other species in the Saddle Mountains include the striped whipsnake, chukar, passerine bird species, and a variety of small mammals. Impacts to these species would be moderate, due to the removal of shrub-steppe and dwarf shrub-steppe plant communities.

The area immediately south of the Saddle Mountain crest has not been converted to agriculture. Shrub-steppe-dependant species in this area would be moderately impacted. The line crosses the remainder of the Wahluke Slope over mostly agricultural lands that have little native shrub-steppe habitat present. Construction and operation of the project in this section of the proposed segment would have no impact on species that depend on shrub-steppe habitat, and minimal to no impact on other wildlife species. The project may have a low positive impact for raptor species due to an increase in nesting, perching and roosting habitat. However, the additional habitat available for perching raptors could increase the predation risk for small shrub-steppe dependant species such as sage sparrows, sage thrashers, mice and voles, a moderate impact.

The shrub-steppe habitat in the Hanford Site is relatively undisturbed, although invasive species are present due to past grazing practices. A herd of mule deer, uncommon in the central shrub-steppe region, is present in this area and may be disturbed by construction activity (low impact). Shrub-steppe-dependant species such as the sage sparrow would be disturbed by construction and habitat removal during clearing (moderate impact). Burrowing owls have been documented near the proposed line and may be impacted by clearing and construction (moderate impact). Raptors (including Swainson’s hawks) are present. The project might have a low positive impact for raptors, since the towers are the tallest structures within many miles and make excellent perching, roosting and nesting habitat.

A large wetland complex called Saddle Mountain Wasteway, just west of Segment E, is home to a large numbers of waterfowl, great blue herons and other wetland species. The project would cross a channel and the associated wetland complex leading east from the lake. Woodhouse’s toads have been documented in great numbers within this area and might be impacted (low impact). The proposed line would avoid the riparian area (minimal impact to riparian species), but add an additional line that would increase the collision hazard for waterfowl and other bird species (moderate impact). The crossing over the Columbia River into the Hanford Substation would also increase the collision hazard for waterfowl and other bird species using the migration corridor (moderate impact).

3.3.3.2 Alternative 1A Schultz-Hanford (Segments A, B_{north} or B_{south}, F)

Impacts to wildlife and wildlife habitat along Segments A and B_{north} or B_{south} would be the same as described for Alternative 1, (see Sections 3.3.3.1.1 and 3.3.3.1.2.)

3.3.3.2.1 Segment F

Segment F would require clearing of 231 acres of shrub-steppe and grassland vegetation. Impact levels in the area between the Vantage Substation and the crest of the Saddle Mountains would be similar to those described for Segment E. South of the crest of the Saddle Mountains, the area is relatively undisturbed, with the exception of historic grazing and some motorized recreation activities. An historic sage grouse sighting was made near the study area, and a possible historic (pre-1978) Washington ground squirrel colony was located in the general vicinity of the proposed project. The top of the Saddle Mountains is an historic sage grouse corridor. If either of these species are still present, construction and clearing of the project would cause a high impact to them.

From the Saddle Mountains, Segment F cuts south across the Wahluke Slope. This section of the Wahluke Slope is not used for agriculture and is relatively undisturbed shrub-steppe habitat. Swainson's hawks are known to nest along this section and might be positively impacted by construction and operation of the project (low positive impact). Other shrub-steppe-dependant wildlife species would be moderately impacted by removal of shrub-steppe vegetation during tower placement and road clearing.

After crossing Highway 24, Segment F enters the Hanford Site. The impacts to wildlife in this area would be similar to those impacts associated with Segment E.

3.3.3.3 Alternative 2 Schultz-New Wautoma Substation (Segments A, B_{north} or B_{south}, D)

Impacts to wildlife and wildlife habitat along Segments A and B_{north} or B_{south} would be the same as described for Alternative 1 (see Sections 3.3.3.1.1 and 3.3.3.1.2).

Segment D has the most varied terrain, and thus the most diverse group of habitats of all the proposed segments. Approximately 62 acres of shrub-steppe and grassland habitat would need to be cleared for tower sites and access roads. Segment D crosses Crab Creek and the Columbia River, which are both migration corridors for birds and areas of high waterfowl concentrations. The risk of avian collisions would be increased in these areas, although the proposed line would be located adjacent to an existing line (moderate impact). The Saddle Mountains have documented occurrences of nesting prairie falcons and golden eagles that could be disturbed by construction activities (low to moderate impact). Other species in the Saddle Mountains include the striped whipsnake, chukar, passerine bird species, and a variety of small mammals. Impacts to these species would be moderate, due to the removal of shrub-steppe and dwarf shrub-steppe plant communities.

Segment D crosses the Wahluke Slope over mostly agricultural lands, with no native shrub-steppe habitat present. Construction and operation of the project in this section of the proposed segment would have no impact on species that depend on shrub-steppe habitat and would have minimal to no impact on other wildlife species.

The southern third of Segment D crosses the Columbia River and climbs over Umtanum Ridge. On the steep north face of Umtanum Ridge, nesting prairie falcons and other raptor species have been documented. Construction in this area would cause low to moderate impacts. Swainson's hawks, loggerhead shrikes, and burrowing owls have all been documented nesting near or on the proposed ROW south of Umtanum Ridge. Clearing in this area would cause moderate to high impacts to burrowing owls (depending on tower and road placement) and moderate impacts to other shrub-steppe-dependant species. In addition, the southern end of the proposed line crosses the Cold Creek wildlife migration corridor, which is one of the most important bird migration corridors in Washington and an important corridor for wildlife migrating between the YTC and the Hanford Site. Disturbance to this area could disrupt the migration patterns of these species and increase the hazard of avian collisions with transmission lines and towers (moderate impact).

3.3.3.4 Alternative 3 Schultz-New Wautoma Substation YTC Route (Segments A, C)

Impacts to wildlife and wildlife habitat along Segment A would be the same as described for Alternative 1, see Section 3.3.3.1.1.

Segment C would require approximately 423 acres of shrub-steppe and grassland vegetation and 3 acres of forested land to be cleared for tower sites and access roads. Sage grouse, burrowing owls, wintering bald eagles, and loggerhead shrike are all known to be present near the proposed ROW, and would be impacted by habitat removal and disturbance (high impact). The southern end of the segment crosses Cold Creek, which one of the most important bird migration corridors in Washington. The southern portion is also an important area for deer, elk, coyote, jackrabbit and other species migrating between the YTC and the Hanford Site. Disturbance to this area could disrupt the migration patterns of these species, and increase the hazard of avian collisions with transmission lines and towers (moderate impact).

3.3.3.5 No Action Alternative

The no action alternative would not change any existing conditions, and therefore would have no impact on wildlife species.

3.3.4 Impacts to Threatened and Endangered Wildlife Species

This section describes the impacts that the proposed project would have on the four wildlife species that are either federally listed or proposed for listing: the bald eagle, sage grouse, Washington ground squirrel and the Mardon skipper. A Biological Assessment is being prepared separately, and a determination of the effects for each of these species will be presented in that document.

3.3.4.1 Bald Eagle

Bald eagles are not known to nest within the study area. Wintering bald eagles are present along all segments, including the area north of Ellensburg near Wilson and Naneum creeks, in the YTC near Hanson and Alkali Canyon Creeks, and near the Columbia River crossings at the Vantage, Midway and Hanford Substations. Construction near known bald eagle roost sites might disturb wintering bald eagles (high impact). In areas away from roost sites, the disturbance of bald eagles from construction will result in a minimal impact. It is unlikely that eagle habitat would be removed. With mitigation, the proposed project would have no impact on bald eagles.

3.3.4.2 Sage Grouse

The sage grouse is a candidate for federal listing. The Washington Department of Fish and Wildlife (WDFW) lists the sage grouse as threatened. In Washington, sage grouse have historically ranged from the Columbia River, north to Oroville, west to the foothills of the Cascades, and east to the Spokane River. Within the proposed study area, they are known to exist within each of the six drainages in the YTC that are crossed by sections of Segments A, B_{north}, B_{south} and C. Sage grouse are known to nest in the Alkali Canyon and Corral Canyon drainages. A historic lek in the Johnson Creek drainage has not been used since 1987. Most of the core sage grouse habitat in the YTC is west of the proposed route. Historic sage grouse migration corridors exist along the top of the Saddle Mountains and along Cold Creek, although they have not been sighted in the Saddle Mountain area recently. Construction of Segments A, B_{north}, B_{south} and C and would cause a high impact to sage grouse. Construction of Segments D, E, and F would cause a low impact. With mitigation, construction of Segments A, B_{north}, B_{south} or C would cause a moderate impact to sage grouse. With mitigation, construction of all other segments would cause a low impact.

3.3.4.3 Mardon Skipper

The closest known location of historic and current Mardon skipper populations is approximately 50 miles southwest of the proposed project. The Ponderosa pine/fescue habitat type does not occur within the study area boundaries, although this habitat type may exist near the northern end of the study area. The project would have no impact on the Mardon Skipper.

3.3.4.4 Washington Ground Squirrel

The Washington ground squirrel is listed as both a state and federal species of concern. Much of the proposed project is located west of the Columbia River, outside of the Washington ground squirrels' known historic range. Washington ground squirrels probably do not currently exist within the study area on the east side of the Columbia River. One historical occurrence (pre-1978) was noted near line Segment F in the Saddle Mountains (Betts, 1990). The nearest known existing population is approximately 15 miles east of line Segment F. Suitable Washington ground squirrel habitat may exist within the proposed study area east of the Columbia River, especially near Crab Creek (Hill, 2001). If Washington ground squirrel colonies exist within or adjacent to the proposed study area, construction of the project would cause a high impact. If no colonies exist, the project would have no impact. With mitigation, the proposed project would have a moderate or low impact on any Washington ground squirrel colonies that might exist within the proposed study area.

3.3.5 Impacts to Special Status Wildlife Species

Table 2.3-2 lists state and federal special status species that may be present within each segment of the proposed study area and indicates the possible impact the project may have on them.

Table 2.3-2 Impacts to Special Status Species

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Documented Occurrence Type	Potential Impact	Mitigated Impact
Birds						
Aleutian Canada goose	FT[1]	ST	B_{north}, B_{south}, D, E, F	M	M	M
Bald eagle	FT	ST	All Segments	W	H	L
Golden eagle		SC	B_{north}, B_{south}, C, D, E, F	B	M	L
Ferruginous hawk	FSC	ST	All Segments	B	M	L
Swainson's hawk		SM	All Segments	B	M	L
Northern goshawk	FSC	SC	All Segments	M	N	N
Peregrine falcon	FSC	SE	C, D, E, F	B	L	L
Swainson's hawk		SM	All Segments	B	M	Mn
Osprey		SM	B_{north}, B_{south}, D, E, F	B	L	Mn
Prairie falcon		SM	All Segments	B	M	Mn
Turkey vulture		SM	B_{north}, B_{south}, D, E, F	B	L	Mn
Burrowing owl	FSC	SC	C, D, E, F	B	H	M
Northern Spotted Owl	FT	SE	None	N	N	N
Lewis' woodpecker		SC	A, C, D, E, F	B	M	L
Sage sparrow		SC	All Segments	B	H	M
Sage thrasher		SC	All Segments	B	H	M
Loggerhead shrike	FSC	SC	All Segments	B	M	M
Long-billed curlew	FSC	SM	A, C, E, F	B	H	M
Western bluebird	FSC	SM	All Segments	B	M	M
Ash-throated flycatcher	FSC	SM	None	N	N	N
Olive sided flycatcher	FSC		All Segments	P	M	L
Little Willow flycatcher	FSC		All Segments	P	M	L
Grasshopper sparrow	FSC	SM	C	B	M	M
Western sage grouse	FSC	ST	A, C, F	B	H	M
Sharp tailed grouse	FSC	ST	None	H	N	N
American white pelican		SE	B_{north}, B_{south}, D, E, F	M	M	M
Harlequin duck	FSC		B_{north}, B_{south}, D, E, F	P	M	M
Common loon		SS	B_{north}, B_{south}, D, E, F	M	M	M
Marbled murrelet	FT	ST	None	N	N	N
Black tern	FSC	SM	B_{north}, B_{south}, D, E, F	M	M	M
Caspian tern		SM	B_{north}, B_{south}, D, E, F	M	M	M
Forster's tern		SM	B_{north}, B_{south}, D, E, F	M	M	M
Great blue heron		SM	B_{north}, B_{south}, D, E, F	B	M	M
Black-crowned night heron		SM	B_{north}, B_{south}, D, E, F	B	M	M
Mammals						
Gray wolf	FE	SE	None	N	N	N
Canada lynx	FT	ST	None	N	N	N
Grizzly bear	FT	SE	None	N	N	N
California bighorn sheep	FSC		B_{north}, B_{south}, D, E, F	P	L	L
Pacific fisher	FSC	SE	None	N	N	N
Wolverine	FSC	SC	None	N	N	N
Western gray squirrel	FSC	ST	None	N	N	N
Washington ground squirrel	FC	SC	D, E, F	H	H	M-N
Pygmy rabbit	FSC	SE	D, E, F	H	H	M-N

Species Name	Federal Status	State Status	Possible Presence by Line Segment	Documented Occurrence Type	Potentia l Impact	Mitigated Impact
Ord's kangaroo rat		SM	B_{north}, B_{south}, D, E, F	P	M	L
Northern grasshopper mouse		SM	All Segments	P	H	M
Sagebrush vole		SM	All Segments	P	H	M
White-tailed jackrabbit		SC	All Segments	B	H	M
Merriam's shrew		SC	All Segments	B	H	M
Potholes meadow vole	FSC		None	N	N	N
Pacific western big-eared bat	FSC	SC	All Segments	P	M	M
Long-eared myotis	FSC	SM	All Segments	P	M	M
Long-legged myotis	FSC	SM	All Segments	P	M	M
Fringed myotis	FSC	SM	All Segments	P	M	M
Western small-footed myotis	FSC	SM	All Segments	P	M	M
Yuma myotis	FSC		All Segments	P	M	M
Pallid bat		SM	All Segments	P	M	M
Insects						
Mardon skipper	FC	SE	None	N	N	N
Persius' duskywing		SM	E	P	Mn	Mn
Reptiles & Amphibians						
Cascades frog	FSC		None	N	N	N
Larch Mountain salamander	FSC	SS	None	N	N	N
Northern leopard frog	FSC	SE	D, E, F	P	Mn	Mn
Red-legged frog	FSC		None	N	N	N
Tailed frog	FSC	SM	None	N	N	N
Spotted Frog	FC	SE	All Segments	P	Mn	Mn
Woodhouse's Toad		SM	E, F	B	Mn	Mn
Sagebrush lizard	FSC		All Segments	B	H	M
Night snake		SM	B_{north}, B_{south}, D, E, F	P	H	M
Striped whipsnake		SC	All Segments	B	H	M

Federal Status
FE = Endangered
FT = Threatened
FC = Candidate
FSC = Species of Concern

State Status
SE = Endangered
ST = Threatened
SS = Sensitive
SC = Candidate
SM = Monitor

Presence
P = Present
B = Breeding
M = Migrant
W = Winter Resident
N = Not Present
H = Historically Present, Not Currently Present

Impact
H = High
M = Moderate
L = Low
Mn = Minimal
N = None

3.3.6 Cumulative Impacts to Wildlife Species

The following discussion of cumulative impacts takes into account the linear nature of the proposed route, and any impacts that the proposed project would have on wildlife resources. The proposed project could potentially impact existing environmental conditions of current concern in eastern Washington, especially from the loss and fragmentation of native shrub-steppe plant and dependant wildlife communities.

The shrub-steppe habitat type has been significantly reduced from historic levels in Washington, and much of the remaining habitat is heavily disturbed by grazing, fire, or other land uses. It is generally recognized that preserving large, unbroken tracts of high-quality shrub-steppe vegetation is important for maintaining populations of shrub-steppe dependant species such as sage grouse, sage sparrow, Washington ground squirrel and others (Johnson and O'Neil, 2001).

Construction of towers and access roads through shrub-steppe vegetation would increase the existing levels of habitat fragmentation and reduce the amount of shrub-steppe vegetation available for wildlife habitat. Over time, native shrub-steppe vegetation may recolonize the disturbed areas. However, construction of the proposed project would increase the potential for the linear spread of noxious weeds into previously undisturbed areas. The presence of noxious weeds makes the recolonization of disturbed areas with native vegetation extremely difficult, and generally leads to a long-term reduction in quality wildlife habitat.

Overall, the loss and fragmentation of additional shrub-steppe, grassland and riparian habitat from the proposed project, when added to the existing severe decline of these habitats from industry, road building, agriculture, grazing, military maneuvers, fires and other human-caused disturbance, will contribute cumulatively to a decrease in the amount and productivity of native wildlife habitat. Future transmission lines, road building, agricultural conversion of shrub-steppe and other foreseeable projects will compound this problem.

3.4 Recommended Wildlife Species Mitigation Measures

To reduce the impacts to wildlife associated with the construction, operation and maintenance of the proposed project, a number of mitigation measures would be implemented.

3.4.1 Big Game Disturbance

- Avoid construction on designated portions of Segments A, E, and F during extreme winter weather or unusually heavy snow accumulations, when big-game species are less mobile and more vulnerable to disturbance.

- Coordinate with WDFW to ensure that construction does not significantly interfere with big game wintering or migration.

- Gate and sign new or existing roads to prevent human encroachment into big game wintering areas or significant migration corridors.

3.4.2 Avian Collision Mitigation

- Where possible, line up new structures with existing structures to minimize vertical separation between sets of transmission lines.

- Install appropriate line markers in high risk areas, such as crossings of the Columbia River, Crab Creek, the Cold Creek migration corridor and high ridge crossings such as Saddle Mountains, Umtanum Ridge and Yakima Ridge.

- Monitor potential problem areas after construction to ensure that line markers are functioning properly, and identify any new areas that might require line markers.

- If possible, reduce or eliminate warning lights on towers.

3.4.3 Raptor Disturbance Mitigation

- Prior to initiating ground disturbing activities identify active raptor nest sites by consulting with WDFW and USFWS and conducting raptor nesting surveys if required.

- Time project construction to avoid the critical nesting periods, as determined by USFWS and WDFW.

- Time project construction to avoid disturbing wintering bald eagles. Perennial stream and river crossings and the areas one mile on either side of these crossings should be avoided from early November through mid-March. Known eagle wintering locations include Wilson and Naneum Creeks, which are all Columbia River crossings and perennial creeks in the YTC.

3.4.4 Shrub-Steppe Habitat Loss Mitigation

- Minimize the construction area to the extent possible at tower sites. Install construction "envelopes": silt fencing or other barrier materials surrounding the construction site to prevent vehicle turnaround, materials storage, or other disturbance outside the designated construction area.

- Do not clear vegetation for temporary vehicle travel or equipment storage. Crushing vegetation is preferable to removing it.

- When possible, avoid the use of access roads in steep terrain during unusually wet or muddy conditions or extremely dry conditions.

- Prevent the spread of noxious weeds by revegetating disturbed areas using native seed mix as soon as conditions permit.

- Carry fire fighting equipment in all vehicles and observe seasonal fire restrictions on construction. Park vehicles in areas free from dry grass or other vegetation.

3.4.5 Wildlife Disturbance Mitigation

- Prior to initiating ground-disturbing activities, identify areas of important wildlife populations or colonies such as burrowing owls, sage grouse leks, ground squirrels and other small animal species by consulting with WDFW and USFWS and conducting surveys if required.

- If possible, avoid locating towers, roads, construction staging areas, substations, or other disturbances in known colonies of small animal species.

- Gate and sign new or existing roads to prevent human encroachment into areas containing significant wildlife populations or relatively undisturbed wildlife habitat.

4.0 BIBLIOGRAPHY

Avian Powerline Interaction Committee. 1994. Mitigating Bird Collisions With Transmission lines: The State of the Art in 1994. Edison Electric Institute. Washington DC.

Beaulaurier, D.L. 1981. Mitigation of Bird Collisions With Transmission Lines. Bonneville Power Administration, Portland, Oregon.

Beaulaurier, D.L., B.W. James, P.A. Jackson, J.R. Meyer, and J.M. Lee, Jr. 1982. Pages 539-550 in: Third Annual International Symposium on Environmental Concerns in Rights-Of-Way Management, San Diego, California, 1-18 February, 1982. State College, Mississippi.

Betts, Burr J. 1990. Geographic Distribution and Habitat Preferences of Washington Ground Squirrels *(Spermophilus washingtonii)*. Northwestern Naturalist. 71:27-37.

Betts, Burr J. 1999. Current Status of Washington Ground Squirrels in Oregon and Washington. Northwestern Naturalis 80:35-38.

Busby, Peggy J., Thomas C. Wainwright, Gregory J. Bryant, Lisa J. Lierheimer, Robin S. Waples, F. William Waknitz, and Irma V. Lagomarsino, 1996. Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27

Clausing, Ted, 2001. Washington Department of Fish and Wildlife Habitat Biologist, South Central Region. Personal Communication.

Corkran, Douglas F. 2001. Field Observation, February, 2001

Faanes, C.A. 1987. Bird Behavior and Mortality in Relation to Power Lines in Prairie Habitats. U. S. Fish and Wildlife Service. Fish and Wildlife Technical Report 7.

Federal Register 63FR31647

Gitzen, Robert A., West, Stephen D., Quade, Cheryl A., Trim, Brent E., Leu, Matthias, and Buamgardt, Jeremy A. 2001. A Range Extension for Ord's Kangaroo Rat *(Dipodomys ordii)* in Washington State. Northwestern Naturalist 82:30-32.

Grubb, T.G. 1976. A Survey and Analysis of Bald Eagle Nesting in Western Washington. Masters Thesis. University of Washington, Seattle, Washington.

Haas, Jeffrey. 2001. United States Fish and Wildlife Service. Deputy Project Leader Hanford Reach National Monument, Saddle Mountain Unit. Personal Communication.

Healey, M. C. 1998. Life History of Chinook Salmon. In Pacific Salmon Life Histories, C. Groot and L. Margolis editors. UBC Press, Vancouver, BC.

Hill, Randy, 2001. United States Fish and Wildlife Service. Biologist, Columbia National Wildlife Refuge. Personal Communication.

Interior Columbia Basin Ecosystem Management Project (ICBEMP). May 1997. Eastside Draft Environmental Impact Statement. Prepared for public lands managed by the USDA Forest Service and USDI Bureau of Land Management. Walla Walla, WA.

James, B.W., and B.A. Haak. 1979. Factors affecting Avian Flight Behavior and Collision Mortality at Transmission Lines. Final Report. Bonneville Power Administration, Portland, Oregon.

Johnson, David H., and O'Neil, Thomas A. 2001. Managing Directors. Wildlife-Habitat Relationships in Oregon and Washington. Oregon State University Press, Corvallis, Oregon.

Meyer, J.R. 1978. Effects of Transmission Lines on Bird Flight Behavior and Collision Mortality. Prepared for Bonneville Power Administration Engineering and Construction Division, Portland, Oregon.

Myers, James M., Robert .G. Kope, Gregory J. Bryant, David Teel, Lisa J. Lierheimer, Thomas C. Wainwright, W. Stewart Grant, F. William Waknitz, Kathleen Neely, Steven T. Lindley, and Robin S. Waples 1998. Status review of chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35.

National Marine Fish Service Pacific Region Websit, 2001 http://www.nwr.noaa.gov/1salmon/salmesa/index.htm

Nature Conservancy, The. 1999. Biodiversity Inventory and Analysis of the Hanford Site Final Report: 1994–1999. The Nature Conservancy of Washington, Seattle, Washington.

Olendorff, R. R., A.D. Miller and R. N. Lehman. 1981. Suggested Practices for Raptor Protection on Power Lines. The State of the Art in 1981. Raptor Research Foundation, St. Paul, Minnesota. Prepared for Edison Electric Institute, Washington DC.

Potter, Ann, Fleckenstein, John, Richardson, Scott and Hays, Dave. 1999. Washington State Status Report for the Mardon Skipper. Washington Department of Fish and Wildlife, Olympia, Washington.

Renfrow, Brent. 2001. Washington Department of Fish and Wildlife Habitat Biologist, South Central Region. Personal Communication.

Rieman, Bruce E., John D. McIntyre. 1993. Demographic and Habitat Requirements for Conservation of Bull Trout. In: U.S. Department of Agriculture Forest Service, Intermountain Forest and Range Experiment Station. General Technical Report INT-302.

Rodrick and Milner (technical editors). 1991. Management Recommendations for Washington's Priority Habitats and Species. Washington Department of Wildlife. Olympia, Washington.
Schroeder, Michael A., Hays, David W., Livingston, Michael F., Stream, Leray E., Jacobson, John E., and Pierce, John D. 2000. Changes in the Distribution and Abundance of Sage Grouse in Washington. Northwestern Naturalist 81:104-112.

Stalmaster, M.V., and J.R. Newman. 1979. Perch Site Preferences of Wintering Bald Eagles in Northwest Washington. Journal of Wildlife Management 43:221-224.

Stepniewski, Andy. 1998. Birds of The Yakima Training Center: A Biodiversity Study. Avian Communities, Critical Habitats, and Species of Concern. The Nature Conservancy of Washington. Seattle, WA.

Stinson, D. W., J.W. Watson, K.R. McAllister, 2001. Draft Washington State Status Report for the Bald Eagle. Washington Department of Fish and Wildlife, Olympia, Washington. 90pp.

United States Department of Energy (USDOE), 2001. Hanford Site Biological Resources Management Plan. DOE/RL 96-32 Revision 0. Richland, Washington.

_________, 1999. Final Hanford Comprehensive Land-Use Plan Environmental Impact Statement (HCP EIS), Hanford Site, Richland, Washington. DOE/EIS-0222-F. Richland, Washington.

United States Department of the Army. 1996. Yakima Training Center Cultural and Natural Resources Management Plan. Fort Lewis, Washington.

Visser, Richard, Washington Department of Fish and Wildlife Habitat Biologist, South Central Region. Personal Communication, 2001.

WDFW Unpublished. Washington Department of Fish and Wildlife, Unpublished. Yakima River Basin Stream Catalog. Yakima, Washington.

WDFW 2000. The Rattlesnake Hills (Hanford) Elk Strategic Management Plan. Washington Department of Fish and Wildlife, Olympia, Washington.

WDFW, 2001a. Washington Department of Fish and Wildlife Priority Habitats and Species. Priority Habitats and Species Database Search Results, April 3, 2001. Olympia, Washington.

WDFW, 2001b. Fact Sheet Bald Eagles in Washington. WDFW Website http://www.wa.gov/wdfw/factshts/baldeagle.htm. Washington Department of Fish and Wildlife, Olympia, Washington.

Wunder, Laurie, Young, Asia, Bidlack, Allison, and Carey, Andrew B. 1994. Establishment and Final Report. Shrub-Steppe Biodiversity Studies State Candidate Small Mammal and Passerine Study. Part I. Distribution and Relative Abundance of Merriam's Shrew on the Yakima Training Center, Yakima, Washington. Part II. Ecology, Relative Abundance and Habitat Requirements of Sage Sparrows and Sage Thrashers on the Yakima Training Center, Yakima, WA. Forestry Sciences Laboratory, Pacific Northwest Research Station, Olympia, WA.

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SCHULTZ - HANFORD AREA TRANSMISSION-LINE PROJECT

ADDENDUM TO APPENDIX G:

IMPACTS OF EMF ON AQUATIC ECOSYSTEMS AND SPECIES OF SPECIAL CONCERN

January 8, 2002

Prepared by

Exponent

for

Parsons Brinckerhoff

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1.0 Impacts of EMF on aquatic ecosystems and species of special concern

The proposed 500-kV Schultz-Hanford transmission line will cross the Columbia River in parallel to several other transmission lines. As a result, certain ecological concerns are evaluated regarding the potential impact of EMF associated with the proposed transmission line on the aquatic ecosystems and the aquatic species in the creeks. Species of special concern are Pacific salmon (*Oncorhynchus spp.*), particularly the chinook salmon (*O. tschawytscha*) and the steelhead (*O. mykiss*). (Personal Communication; Doug Corkran, Parsons Brinckerhoff, December 31, 2001). These species spend their adult lives in estuarine or oceanic environments and are well known for their annual spawning runs into freshwater, returning to the home streams and rivers where they were spawned and spent the first few months of their lives (Groot and Margolis, 1998). Pacific salmon are an important part of the history, ecology, and economy of the Pacific Northwest region.

1.1 Potential Exposure to EMF

The proposed 500-kV transmission line crossing over the Columbia River will be a source of magnetic field, but not electric field exposure, for fish in close vicinity to the line. (The water shields the fish from electric fields.) Since the level of EMF decreases with distance from the source, maximum magnetic-field exposures of fish will occur when they are directly under the lines , when spawning on Vernita Bar or when traveling down or up the river during their life cycle. This exposure scenario is evaluated for EMF levels based on the proposed transmission line configuration for current and future use (Bracken, 2001). The minimum clearance over the river will be greater than the minimum clearance over land, leading to exposures in the river well below the maximum of 244 mG for the proposed line at 1 m height above the earth.

2.0 Likely Biological Effects of EMF

2.1 Biological Organisms

More than one hundred studies of the effects of EMF on wildlife and domestic animals have been conducted during the past thirty years. These studies have examined basic life history aspects including survival, growth and reproduction. To date, there is little or no evidence that mammals, birds or fish exhibit any harmful effects when exposed to EMF of frequencies close to or at power frequencies (50-60 Hz), even for a prolonged period of time (NRC, 1997a). Additionally, prolonged exposure is not a critical issue for the species of concern, the salmon, because they are migratory by nature and will only be exposed to EMF associated with the proposed transmission line during the relatively short time they take to swim past or spawn under the line.

The scientific literature does not provide evidence of adverse effects of EMF exposure to living organisms at the levels associated with this project. An additional question is whether EMF exposure can affect salmon's ability to navigate during their spawning run. The Pacific salmon have been thought to navigate by several mechanisms: detecting and orienting to the earth's magnetic field, using a celestial compass (i.e., based on the position of the sun in the sky), and using their innate ability to imprint on their home stream by odor (Groot and Margolis, 1998, Quinn et al, 1981).

Generally, scientific studies have reported that, along with other cues or biological mechanisms, certain species of birds, bees, and fish may have magnetite in certain organs in their bodies, and use magnetite crystals as an aid in navigation (Bullock, 1977; Wiltschko and Wiltschko 1991, Kirschvink, 1993, Walker et al. 1988). Crystals of magnetite have been found in Pacific salmon (Mann et al, 1998; Walker et al, 1998). These magnetite crystals are believed to serve as a compass that orients to the earth's magnetic field. However, other studies have not found magnetite in sockeye salmon (*Oncorhynchus nerka*) fry (Quinn et al, 1981). While salmon can apparently detect the geomagnetic field, their behavior is governed by multiple stimuli as demonstrated by the ineffectiveness of magnetic field stimuli in the daytime (Quinn et al, 1982) and the inability of strong magnetic fields from permanent magnets attached to sockeye salmon to alter their migration behavior (Ueda et al, 1998).

It should be noted that the earth's magnetic field is static (0 Hz), in contrast to the oscillating magnetic field created by the AC (alternating current) transmission lines crossing the Columbia River. Static magnetic fields have fixed polarity, i.e. the earth's magnetic north and south poles. The electrical current that generates the magnetic field in transmission lines constantly alternates its direction, thus, the term "alternating current" (AC). AC transmission lines produce magnetic fields that do not have fixed polarity.

No studies have been conducted to date that specifically examine the effects of AC magnetic fields on the salmon's ability to orient to the earth's magnetic field. Studies on the response of other organisms that also use magnetite crystals as one means of navigation can, however, provide useful insight regarding salmon. Kirschvink, 1993 reports studies of the effects of AC magnetic fields on honeybees, which use magnetite crystals to navigate. In this study, the honeybees only oriented to an AC magnetic field when it was one million times greater in intensity than the DC field needed to elicit the same orientation response. This difference in intensity indicates that the AC magnetic field is less influential than the DC magnetic field in the navigation of honeybees and potentially other organisms that orient to the earth's magnetic field using magnetite crystals (Kirschvink, 1993). The level of AC magnetic fields estimated for the proposed transmission line are well below the levels reported in that study.

2.2 <u>Ecological Systems</u>

Recently, scientists have published the results of long-term monitoring studies designed to determine ecological impacts of extremely-low-frequency (ELF) electric and magnetic fields produced by a United States Navy communication system. Power line fields are also in the ELF range. Specifically, over a period of 13 years, academic researchers in Wisconsin conducted 11 separate experiments examining the impact of ELF EMFs on ecosystems (e.g., wetlands, streams, aquatic ecosystems) and specific organisms (e.g., slime mold, birds, small vertebrates, litter decomposers and microflora, upland flora, pollinating insects, soil arthropods, earthworms, and soil amebas). The fish community examined in this study showed no significant differences in species diversity, biomass or condition when compared to the control site. The results of the other studies also demonstrated no convincing evidence for effects of EMF on any of the organisms or ecosystems they examined (NRC, 1997b).

3.0 Conclusion

The scientific literature does not support the conclusion that the EMF associated with the proposed transmission line will have an adverse impact on the survival, growth, and reproduction of organisms in the ecosystem. There are no data on the effects of AC EMF on salmon navigation, but based on a study with honeybees, it appears that organisms that use magnetite crystals to orient to the earth's magnetic field would be affected only when the field levels are very much greater than the levels expected from the transmission line. Given this evidence and the salmon's ability to navigate using multiple sensory cues, the proposed transmission line crossing the Columbia River is unlikely to have an adverse impact on these species of concern and the aquatic ecosystems of these creeks. No effects on water quality and no ecological impacts of magnetic fields are expected.

4.0 References

Bracken TD. Schultz – Hanford Transmission Line Project. Technical Report, Electrical Effects. T. Dan Bracken, Inc. August 2001.

Bullock TH. Electromagnetic sensing in fish. Neurosciences Res Prog Bull 1977; 15:17-12.

Groot C, Margolis L. (eds.). 1998. Pacific Salmon Life Histories. UBC Press, Vancouver.

Kirschvink, JL; Diaz Ricci, J; Nesson, MH; Kirschvink, SJ Magnetite-based magnetoreceptors in animals: structural, behavioral, and biophysical studies. Palo Alto: Electric Power Research Institute (EPRI), TR-102008, September 1993.

Mann, S.; Sparks, N.H.C.; Walker, M.M.; Kirschvink, J.L. 1988. Ultrastructure, Morphology and Organization of Biogenic Magnetite from Sockeye Salmon, Oncorhynchus nerka: Implications for Magnetoreception. Journal of Experimental Biology, 140:35-49.

National Research Council; Commission on Life Sciences; Board on Radiation Effects Research; Committee on the Possible Effects of Electromagnetic Fields on Biologic Systems. Possible Health Effects of Exposure to Residential Electric and Magnetic Fields. Washington, DC: National Academy Press. 1997a.

National Research Council. An Evaluation of the U.S. Navy's Extremely Low Frequency Communications System Ecological Monitoring Program. National Academy Press, Washington, D.C. 162 pp. 1997b.

Quinn TP, Merrill RT, Brannon EL. Magnetic field detection in Sockeye salmon. Journal of Experimental Zoology. 1981; 217:137-142.

Quinn, T.P.; Brannon, E.L. 1982. The Use of Celestial and Magnetic Cues by Orienting Sockeye Salmon Smolts. Journal of Comparative Physiology, 147:547-552.

Ueda, H.; Kaeriyama, M.; Mukasa, K.; Urano, A.; Kudo, H.; Shoji, T.; Tokumitsu, Y.; Yamauchi, K.; Kurihara, K. 1998. Lacustrine Sockeye Salmon Return Straight to their Natal Area from Open Water Using Both Visual and Olfactory Cues. Chemical Senses, 23:207-212.

Walker MM, Quinn TP, Kirschvink JL, Groot C. Production of single-domain magnetite throughout life by sockeye salmon, *oncorhynchus nerka.* J Exp Biol 1988; 140:51-63.

Wiltschko W, Wiltschko, R. Orientation by the earth's magnetic field in migrating birds and homing pigeons. pp. 31-43. In: Effects of Atmospheric and Geophysical Variables in Biology and Medicine: Biometeorology. H. Lieth (ed). 1991. SPB Academic Publishing, The Hague, The Netherlands.

Consistency With State and Local Government Regulations

Bonneville Power Administration
Schultz-Hanford Area Transmission Line Project

Prepared for:

Bonneville Power Administration
905 NE 11th Avenue
Portland, Oregon 97232

Prepared By:

Parsons Brinckerhoff Quade & Douglas
400 SW Sixth Avenue, Suite 802
Portland, Oregon 97204

Revised January 9, 2002

Consistency with State and Local Government Regulations

The Schultz-Hanford Area Transmission Line Project crosses Kittitas, Yakima, Grant, and Benton Counties in central Washington. The facilities could be located in a number of zoning districts within these jurisdictions.

1.1 State

No conflicts with state land use plans or programs are anticipated. BPA would work with state agency representatives to minimize conflicts between proposed activities and land use plans, and would strive to meet or exceed the substantive standards and policies of the following regulations.

1.1.1 State Environmental Policy Act

The state of Washington has adopted a State Environmental Policy Act (SEPA), which is intended to ensure that environmental values are considered during decision-making by state and local agencies. The objectives and requirements of SEPA are similar to those of NEPA.

All action alternatives for the transmission line would cross land owned by Washington Department of Natural Resources. To grant BPA an easement or sell the right-of-way across state property, DNR would have to document compliance with SEPA. The sale or easement grant would constitute an "action" under SEPA (Washington Administrative Code [WAC] 197-11-704(2)(ii). SEPA allows the use of NEPA documents to meet SEPA requirements (WAC197-11-610). DNR may adopt the NEPA EIS prepared for the project or prepare separate documents in accordance with their SEPA regulations.

1.1.2 Growth Management Act (GMA)

The Growth Management Act of 1990 (GMA, RCW 36.70A) requires all cities and counties to plan for future growth while protecting natural resources (Washington Department of Ecology, 1994). All jurisdictions must classify and designate natural resource lands (e.g., agricultural and forest land) and critical areas (e.g., wetlands, fish and wildlife habitat, aquifer recharge areas). These jurisdictions must also adopt development regulations such as zoning ordinances to protect these critical areas.

In addition to the requirements, Washington's fastest growing cities and counties must adopt development regulations to conserve natural resource lands. These jurisdictions must establish Urban Growth Areas that can accommodate the increase in population expected to occur over the next 20 years. Comprehensive plans and development regulations consistent with these plans must also be adopted.

As a federal agency, BPA is exempt from obtaining permits to impact critical areas. Designated critical areas, however, would be identified and mitigation for these impacts would be developed to be consistent with the applicable county's critical area ordinance.

1.1.3 Shoreline Management Act (SMA)

The goal of Washington's Shoreline Management Act of 1971 (SMA, 173-16 WAC) is "to prevent the inherent harm in an uncoordinated and piecemeal development of the state's shorelines" (Washington Department of Ecology, 2001). Cities and counties are the primary regulators but the state has authority to review local programs and permit decisions. The State's authority is housed in the Department of Ecology. Under the SMA, each city and county adopts a shoreline master program that is based on state guidelines but tailored to the specific geographic, economic, and environmental needs of the community. Master programs provide policies and regulations addressing shoreline use and protection as well as a permit system for administering the program.

The project would cross one river, two creeks, and one lake that are designated as shorelines of the state: the Columbia River in Kittitas, Grant, and Benton Counties; Naneum Creek in Kittitas County; and Nunnally Lake and Lower Crab Creek in Grant County.

Final structure locations will not be determined until the detailed design stage of project development. During design, designated shorelines would be identified and mitigation for these crossings would be developed. Where possible, BPA would locate structures outside of the shoreline jurisdictional area. BPA would take the following measures, when practicable, to assure consistency with each counties' Shoreline Master Programs.

- Location of structures within the identified shoreline would be avoided if possible. If locations within the shoreline area could not be avoided, BPA would consult with the appropriate state and local agencies to determine the best placement of the transmission structure.
- Transmission line structures would be located in water bodies only if there were no reasonable alternative. (Placing structures in water bodies is not anticipated).
- Disturbed land would be restored as closely as possible to pre-project contours and replanted with an appropriate native seed mix. However, there may be locations where site topography would require near-bank disruption. A restoration and monitoring plan would be prepared before disturbing shoreline areas.
- Appropriate erosion control measures would be implemented.

1.1.4 Hydraulic Project Approval (HPA)

The goal of the Hydraulic Project Approval (Chapter 75.20 RCW, Chapter 220-110 WAC) is to protect fish in waters of the state. The WDFW must approve any form of work that uses, diverts, obstructs, or changes the natural flow or bed of any fresh water or saltwater of the state. Access roads crossing streams would be the only direct impact to fish, since BPA would try to avoid placing structures in streams, wetlands or floodplains.

BPA would obtain a hydraulic project approval. Waters of the state where fish would be impacted would be identified and mitigation for these impacts would be developed to be consistent with the hydraulic project approval requirements.

1.1.5 Forest Practices Act

The Washington Forest Practices Act and Forest Practices Rules and Regulations are the state's principal means of regulating activities on nonfederal forestlands. While not applicable to federal agencies, state and local agencies must demonstrate compliance in the management of their land, including decisions to sell or lease that land. Because the project would cross land owned by DNR, that agency would need to demonstrate compliance with the state Forest Practices Act.

The Forest Practices Rules and Regulations are administered and enforced by DNR. The rules and regulations set standards to address several issues, including reforestation, clearcut size, watershed analysis procedures, road design, riparian area buffers, wetland protection, and protection of threatened and endangered species. The Forest Practices Rules and Regulations apply to all forestlands in the project area.

Conversion of forestland is a Class IV forest practice (RCW 79.09.050). Forest practices under Class IV are not exempt from SEPA requirements. Applications for Class IV forest practices must be submitted to and approved by DNR prior to conducting the activity (RCW 79.09.050). Failure to state that any land covered by the application will be converted to another use would result in a six-year moratorium on development of the land (RCW 76.09.060).

The Forest Practices Act also sets forth rules for road construction and maintenance (WAC 222-24), and the Washington Forest Practices Board (WFPB) Manual contains guidelines for forest roads, including best management practices (BMPs), road maintenance and abandonment plans, and recommended tools.

1.1.6 Noxious Weed Control

County Noxious Weed Control Boards coordinate weed detection and control activities that emphasize the prevention of invasion by noxious weeds, eradication when possible, and containment of established species. County weed boards work locally to control weeds on state-owned and private lands. To accomplish this, counties adopt a County Weed List each year, which is divided into Classes A-C (similar to the state list) and based on the degree of threat they pose to that county. Counties also maintain Education Lists that include weeds not included in Class A-C, but for which the Weed Board will assist landowners with control efforts.

Federal law refers to weeds as "undesirable species" that may include a broader range of species than state-listed weed species (Federal Noxious Weed Act, 1986, P.L. 93-629, Section 15). On federal lands, land management agencies designate personnel to address the problems presented by weed species. In the proposed study area, personnel from county weed boards and federal land management agencies serve on joint task forces to address weed control in a concerted way, in an effort to coordinate efforts and share information.

BPA conducts weed surveys before construction to determine whether any weed mitigation needs to be conducted prior to construction and also to identify preventative measures that can be taken to minimize the risk of spreading or introducing weeds as a result of construction activities. BPA also conducts weed surveys after construction to assess whether any further weed mitigation measures are necessary.

1.2 Counties

Alternatives would be located in Kittitas, Grant, Benton, and Yakima counties in central Washington State. There are no incorporated cities or towns crossed by the alternatives. Table 5.5-7, *Zoning Designations Crossed by the Alternatives in Each County*, identifies zoning designations by county.

Table 5.5-7
Zoning Designations Crossed by the Alternatives in Each County

	Counties			
	Kittitas	**Grant**	**Benton**	**Yakima**
Zoning Designations	Forest and Range	Rural Light Industrial	Unclassified	Agricultural
	Agricultural-20	Rural Remote	GMA Agricultural	
		Rural Residential 3		
		Open Space Conservation		
		Agricultural		
		Public Open Space		

BPA would work with county planners to minimize conflicts between proposed activities and county land use plans by striving, as much as possible, to meet or exceed the substantive standards and policies of the county zoning ordinances and comprehensive plans.

1.2.1 Kittitas County

Zoning Ordinance

According to the Kittitas County Zoning Ordinance, an electrical transmission line is considered a "special utility" if it exceeds 115 kV. The proposal is a 500-kV transmission line and would, therefore, be considered a special utility. Special utilities are allowed as conditional uses in all zoning districts and typically require the approval of a Zoning Conditional Use Permit by the Kittitas County Board of Adjustment. Section 17.61.030 of the zoning ordinance identifies seven (A-G) approval criteria that must be addressed by an applicant for a Conditional Use Permit application. A proposed 500-kV transmission line, or special utility, would be consistent with the zoning ordinance as long as an applicant could show that the proposal meets the applicable review criteria.

Comprehensive Plan

None of the review criteria identified in Section 17.61.030 of the zoning ordinance specifically require an applicant to address how the proposal is consistent with the Kittitas County Comprehensive Plan. However, since the Kittitas County Comprehensive Plan responds to and implements the planning goals of the Washington State GMA, and guides land-use decisions throughout the county, it would be expected that a Zoning Conditional Use Permit would not be approved if it were determined that the proposed use was inconsistent with this plan.

All of the alternatives (Segments A, B, and C) in Kittitas County are located on lands identified in the comprehensive plan as rural multiple use and the Yakima Training Center. Lands mapped as rural multiple use are combined with a number of other lands (rural residential, non-designated agricultural, forest multiple use, and public recreation lands) and identified as Rural Lands in Chapter 8 of the comprehensive plan. In addition, Chapter 6 of the plan relates to utilities in general without distinguishing between utilities and special utilities. Each chapter outlines a number of goals, policies, and objectives relevant to rural lands and utilities. Project consistency with the applicable goals, policies and objectives is addressed below. There are no goals, policies, or objectives related to the management or development of the YTC in the Kittitas County Comprehensive Plan.

The applicable goals, policies, and objectives identified in Chapter 6, Utilities, and Chapter 8, Rural Lands, are as follows:

> *GPO 6.7* *Decisions made by Kittitas County regarding utility facilities will be made in a manner consistent with and complementary to regional demands and resources.*
>
> *GPO 6.18* *Decisions made regarding utility facilities should be consistent with and complementary to regional demand and resources and should reinforce an interconnected regional distribution network.*
>
> *GPO 6.21* *Avoid, where possible, routing major electric transmission lines above 55 kV through urban areas.*
>
> *GPO 6.32* *Electric and natural gas transmission and distribution facilities may be sited within and through areas of Kittitas County both inside and outside of municipal boundaries, UGAs, UGNs, Master Planned Resorts, and Fully Contained Communities, including to and through rural areas of Kittitas County.*
>
> *GPO 8.2B* (This GPO is a repeat of GPO 6.32 from Chapter 6.)

All of the alternatives would be consistent with the Kittitas County Comprehensive Plan. The new transmission line would become part of BPA's regional power grid serving the entire Northwest region. It would not cross through urban areas of Kittitas County. Although the alternatives would convert some rural lands to a utility facility, according to the comprehensive plan GPO 6.32 and 8.2B electrical transmission facilities may be sited through the rural areas of Kittitas County. In addition, implementation of **Best Management Practices (BMPs)** and mitigation measures to protect the natural and built environment, adjacent land uses, and any cultural resources identified would help ensure consistency with the County comprehensive plan.

1.2.2 Grant County

Zoning Ordinance

According to the Grant County Zoning Ordinance, an electrical transmission line is considered a "minor utility" if it is less than 115 kV and it is considered a "major utility" if it exceeds 115 kV. According to the ordinance, major utility developments are designed to serve a broader community or regional area. The new 500-kV transmission line would become part of the Pacific Northwest power grid, thus meeting the intent of major utility developments in Grant County.

According to Tables 4 and 5 in Chapter 24.03 of the Grant County Zoning Ordinance, a major utility is allowed as a conditional use in two of the six identified zoning designations through which Alternatives 1, 2, and 1A pass, Rural Light Industrial and Agricultural. As a result, approval of a Type III Conditional Use Permit from the Grant County Board of Adjustment would typically be necessary in order to establish the use. Section 25.08.060 of the zoning ordinance identifies ten approval criteria that must be addressed in a Conditional Use Permit application. A proposed 500-kV transmission line, or special utility, would be consistent with the zoning ordinance as long as an applicant could show that the proposal meets the applicable review criteria.

The same tables indicate that a major utility is a prohibited use in the remaining four zones, Rural Residential 3, Rural Remote, Open Space Conservation, and Public Open Space. Minor utilities are, however, allowed in these zones as discretionary uses. The existing transmission lines, which a portion of three alternatives parallel, were constructed prior to the most recent adoption of the Grant County Zoning Ordinance in October 2000. The prior zoning ordinance did not distinguish between major and minor transmission lines. As a result, any new transmission lines in excess of 115 kV through these zones would be considered an "illegal use" as defined by the zoning ordinance (E. Harrell, pers. comm., 2001).

Comprehensive Plan

The Grant County Zoning Ordinance implements the goals and policies of the Grant County Comprehensive Plan by transferring into regulations and ordinances all or any part of the general objectives and intent of the comprehensive plan. Thus, if a proposed use were inconsistent with the intent of the zoning ordinance it would also be inconsistent with the comprehensive plan. As discussed above, the proposed 500-kV transmission line would be inconsistent with the zoning ordinance if located in four of the six zoning designations through which the alternatives would cross. As a result, the transmission line would also be inconsistent with the comprehensive plan in those locations.

In the remaining two zones a Type III Conditional Use Permit would typically be required to build a new transmission line. The two zones, Rural Light Industrial and Agricultural, are part of the land use categories Rural Lands, more specifically rural activity centers, and Resource Lands, respectively. One of the criteria for approval of a Conditional Use Permit states that the proposed use must be consistent with the purposes and regulations of the Grant County Comprehensive Plan. Typically, to satisfy this criterion, and ultimately gain approval of the conditional use permit, consistency with the goals and policies of the Land Use Element, including the Rural Lands sub-element and the Resource Lands sub-element, (Chapter 5) as well as the Utilities Element (Chapter 10) would need to be shown.

The applicable goals and policies identified in Chapter 5, Land Use Element, and Chapter 10, Utilities Element, are as follows:

> *Goal RU-3: Promote the continuation and enhancement of the existing rural activity centers in order to preserve their multi-use function to the rural community of Grant County.*
>
> *Goal RE-2: Mitigate conflicts between agricultural and non-agricultural land uses in designated agricultural resource lands.*
>
> *Goal U-1: Necessary energy and communication facilities and services should be available to support current and future developments.*
>
> *Goal U-2: Negative impacts associated with the siting, development, and operation of utility services and facilities on adjacent properties, significant cultural resources, and the natural environment should be minimized.*

BPA has determined that the proposed 500-kV transmission line is a necessary addition to the Northwest power grid to ensure enough power is available to support existing and future developments in the region. The project, including structures and possible access roads, would convert some rural and resource lands to a utility facility. However, the facility would not preclude or severely inhibit agricultural or other land uses from occurring on the lands adjacent to the towers or the right-of-way. In addition, negative impacts associated with siting the transmission line will be minimized through the use of BMPs and mitigation measures (See Chapter 4, *Environmental Consequences*) to protect the natural and developed environment, adjacent land uses, and any cultural resources identified. Thus, the project would be consistent with the Grant County Comprehensive Plan in those areas were the proposed use would typically require a Type III Conditional Use permit.

1.2.3 Benton County

<u>Zoning Ordinance</u>

The all of the alternatives would cross one of two different zoning districts in Benton County, Unclassified and GMA Agricultural. The Benton County Zoning Ordinance, Title 11, does not specifically address utility transmission lines but historically they are considered permitted uses in all zoning designations regardless of the voltage. This is not expected to change for the proposed new transmission line (T. Marden, pers. comm. 2001).

The new Wautoma Substation would be constructed on land zoned GMA Agricultural. According to the Benton County Zoning Ordinance Section 11.18.050 states that *"Public or quasi-public buildings and yards and utility buildings, such as: pumping stations, fire stations, substations and…"* are allowable uses in this zoning district; no land use reviews would be required to locate the new substation.

Comprehensive Plan

All alternatives in Benton County are located on lands identified in the Benton County Comprehensive Plan as either the Hanford Reservation or GMA Agricultural and zoned according to the Benton County Zoning Ordinance as Unclassified and GMA Agricultural.

Although the project would convert some agricultural land to a utility use, transmission lines and a utility substation are allowable uses in the GMA Agricultural and the Unclassified zoning districts. As allowable uses, they do not require the approval of a Benton County land use review and, therefore, would be consistent with the intent of the zoning ordinance.

Since the zoning ordinance implements and must be consistent with the Benton County Comprehensive Plan, a proposed use that is consistent with the zoning ordinance would also be consistent with the comprehensive plan. Thus, the proposed transmission line and substation facilities would be consistent with the Benton County Comprehensive Plan. To further ensure consistency with the comprehensive plan, BMPs and mitigation measures to protect the natural and developed environment, adjacent land uses, and any cultural resources identified would be implemented. (See Chapter 4, *Environmental Consequences*.)

1.2.4 Yakima County

Zoning Ordinance

After exiting the Yakima Training Center, Alternative 3 (Segment C), the only alternative located in Yakima County, would cross a portion of land that has a County zoning district designation of Agricultural. According to Section 15.08.630 of the Yakima County Zoning Ordinance, Title 15, a 500-kV transmission line would be considered a "utility service" since it is not a local transmission or collection line.

In the Agricultural zone, a utility service would typically require a Type II Administrative Review if the SEPA threshold for transmission lines is exceeded. According WAC 197-11-800 Section 24.c, a transmission line with an associated voltage of more than 55-kV is not exempt from the Washington State SEPA regulations. As a result, in the Agricultural zone of Yakima County a proposed 500-kV line would typically require the approval of a Type II Administrative Review from the Yakima County Planning Director in order for the use to be established. Section 15.12.040 of the zoning ordinance identifies the conditions of approval for Type II applications. A proposed 500-kV transmission line, or utility service, would be consistent with the zoning ordinance as long as an applicant could show that the proposal meets the applicable review criteria.

Comprehensive Plan

One of the criteria for approval of a Type II Administrative Review in Yakima County states that the proposed use must *"achieve and further the intent, goals, objectives, and policies of the comprehensive plan and this title" (Yakima County, 2000, Zoning Ord.)*. Thus, to establish a transmission line in the Agricultural zoning district, an application would need to show how the proposal is consistent with the Yakima County Comprehensive Plan; Plan 2015.

Alternative 3 (Segment C) in Yakima County is located on lands identified in the comprehensive plan as Agricultural Resource Areas, which is a sub-element of the Economic Resource Lands. The intent of the Agricultural Resource Areas is to *"…preserve, stabilize, and enhance the primary agricultural land base which is being used for, or offers the greatest potential for, continued production of agricultural products and harvesting" (Yakima County, 1998, Plan 2015)*. To do this a number of goals and policies have been identified in the comprehensive plan relating to the Agricultural Resource Areas. The comprehensive plan also includes a number of goals and policies related to utilities. While the plan does identify several goals and policies only a few are applicable to the proposed transmission line. The applicable goals and policies of the Land Use and Utilities sections of Plan 2015, Volume 1 are as follows:

> *Goal LU-ER-AG 1: Maintain and enhance productive agricultural lands and discourage uses that are incompatible with farming activities.*
>
> *Goal UT 17: Promote the delivery of electrical services, on demand, within the County consistent with utility's public service obligations.*
>
> *Policy UT 17.2: When new, expanded or upgraded transmission is required, use of existing corridors should be evaluated first. Yakima County should facilitate appropriate corridor sharing among different utility types and owners.*

There are no existing transmission line corridors for the new line to parallel. As a result, a new corridor would be required through the Agricultural Resource Area. A new transmission corridor, including structures and access roads, would convert some agricultural lands to a utility facility. However, the facility would not preclude or severely inhibit agricultural practices from occurring on the lands adjacent to the structures or the right-of-way. In addition, BMPs and mitigation measures to protect the natural and developed environment, adjacent land uses, and any cultural resources identified would be implemented. Thus, the project would be consistent with the Yakima County comprehensive plan. (See Chapter 4, *Environmental Consequences*.)

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SCHULTZ - HANFORD AREA
TRANSMISSION LINE PROJECT

APPENDIX I

ELECTRICAL EFFECTS

August 6, 2001

Prepared by

T. Dan Bracken, Inc.

for

Parsons Brinckerhoff

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ELECTRICAL EFFECTS FROM THE PROPOSED SCHULTZ – HANFORD AREA TRANSMISSION PROJECT

1.0 Introduction

The Bonneville Power Administration (BPA) is proposing to build a 500-kilovolt (kV) transmission line from the Schultz Substation near Ellensburg, Washington, to either the existing BPA 500-kV Hanford Substation located on the Hanford Site or to a new 500-kV Wautoma Substation located west of the Hanford Site. The proposed line and the associated remodeled and new substations are known as the Schultz – Hanford Area Transmission Project. Alternative routes include construction on new right-of-way on a new corridor, on existing right-of-way parallel to several existing lines, and on new right-of-way parallel to existing 230-kV and/or 115-kV lines. In addition, the existing Sickler-Schultz 500-kV line would be realigned on new right-of-way north of the Schultz substation. The purpose of this report is to describe and quantify the electrical effects of the proposed Schultz – Hanford/Wautoma 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 Schultz - Hanford/Wautoma 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, undated). 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 Schultz - Hanford/Wautoma 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 and power flow directions for the proposed and existing lines were provided by BPA and are based on the projected summer peak power loads in 2006. In the case of corridors with more than one line, calculations were performed for similar (maximum) current conditions on both lines.

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 reported in statistical terms to account for this variability. 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 ft. or 14 m for 500-kV lines). 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 Schultz – Hanford/Wautoma transmission line, such conditions are expected to occur about 7 percent of the time during a year, based on hourly records at the Yakima Air Terminal from 1996 to 1999. Corona activity also increases with altitude. For purposes of evaluating corona effects from the proposed line, an altitude of 2000 ft. (610 m) was assumed for Configurations A-1 to A-4 and 1200 ft. (366 m) for Configurations D-1 to D-4.

2.0 Physical Description

2.1 Proposed Line

The Schultz – Hanford/Wautoma 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 1436 A. The estimated currents in each phase are based on the projected summer peak load in 2006, as determined in case studies prepared by BPA. BPA 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 54 ft. (116.5 m) at 122°F (50°C). 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 Schultz – Hanford/Wautoma 500-kV line could parallel existing BPA 500-kV, 230-kV, and 115-kV lines along different segments of the alternative routes. In addition, the realigned Sickler-Schultz 500-kV line could parallel and existing 345-kV line. Eight possible configurations were identified, including the new right-of-way with no parallel line (Table 2). 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.

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 Schultz - Hanford/Wautoma 500-kV transmission-line configurations. The peak value on the right-of-way and the value at the edge of the right-of-way are given for the eight 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 both existing and proposed Configurations D-1 and D-3 with parallel lines.

The calculated peak electric field expected on the right-of-way of the proposed line on new right-of-way (Configuration A-1) is 8.9 kV/m. When the proposed line parallels other lines the peak field under the proposed line is 8.9 kV/m or less.

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, 230-kV, and 115-kV lines are 9.7, 3.3, and 1.7 kV/m, respectively.

The largest values expected at the edge of the right-of-way nearest the proposed line would be 2.0 kV/m. On the edge of the right-of-way away from the proposed line, the field would vary with the line configuration present. The largest fields at the edges of the existing rights-of-way are 5.2 and 2.0 kV/m for the 500- and 230-kV lines, respectively.

3.4 Environmental Electric Fields

The electric fields associated with the Schultz - Hanford/Wautoma 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 workdays 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 Schultz - Hanford/Wautoma 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 configurations. Field values on the right-of-way and at the edge of the right-of-way are given for projected maximum currents during summer peak load in 2006, for minimum and average conductor clearances. 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. Average fields over a year would be considerably reduced from the peak values, as a result of increased clearances above the minimum height and reduced currents from the maximum summer load value.

Figure 3 shows lateral profiles of the magnetic field under maximum current and minimum clearance conditions for selected configurations of the proposed 500-kV transmission line. A field profile for average height under Configuration A-1 is included in Figure 3a. Maximum field levels for the proposed and existing configurations of Configurations D-1 and D-3 are shown in Figures 3b and 3c.

For the proposed 500-kV line on new right-of-way with no parallel lines (Configuration A-1), the maximum calculated 60-Hz magnetic field expected at 3.28 ft. (1 m) above ground is 244 mG. This field is calculated for the maximum current of 1436 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 137 mG. (See Figure 3a.) Maximum fields under the proposed line in the configurations with parallel lines would be less than these values.

At the edge of the right-of-way of the proposed line, the calculated magnetic field for maximum current conditions is 55 mG for minimum conductor height and 46 mG for average conductor height. Fields at the edge of the right-of-way of the proposed line in the configurations with parallel lines would be less than those for Configuration A-1. The field at the edge of the right-of-way adjacent to a parallel line would depend on that line.

The magnetic field falls off rapidly as distance from the line increases. The calculated magnetic field for maximum current would be less than 10 mG at about 185 ft. (72 m) from the centerline. At a distance of 200 ft. (61 m) from the centerline of the proposed line, the field would be 8 mG for maximum current conditions.

The calculated fields for the seven other configurations that were analyzed are given in Table 4. For the existing lines, the peak magnetic fields on the rights-of-way are 302 mG and 170 mG, for the 500-kV and 230-kV lines, respectively. Fields at the edges of the existing rights-of-way range from 158 mG for the Vantage-Schultz 500-kV line to 7 mG for the North Bonneville-Midway 230-kV line, which has a very wide right-of-way. The maximum and edge of right-of-way field levels for the realigned Sickler-Schultz 500-kV line (Configurations A-2 and A-3) would be 262 mG and 60 mG, respectively.

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 Schultz - Hanford/Wautoma 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). Approximately 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 present only 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 Schultz - Hanford Area Transmission Project.

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 under the proposed Schultz - Hanford/Wautoma 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 (IEEE, 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 54 ft. (16.5 m) over road crossings along the route, resulting in a maximum field of 3.9 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 3.9 kV/m (at 3.28-foot height) would be 3.5 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 3.3 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 185 ft. (56.4 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 <u>might</u> 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, 1995).

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 BPA maximum allowable electric field limit would be met for all configurations of the proposed line. 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).

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 7 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 selected configurations. 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 Schultz - Wautoma 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 500-kV lines in the corridor just east of Schultz substation.

For configurations with parallel 230-kV lines (Configurations D-1 to D-4), the AN level at the edge of the right-of-way adjacent to the proposed line would be 50 dBA. For the Configuration A-4, which entails replacement of an existing 500-kV line with the proposed line, the AN level at the edge of the right-of-way would decrease by about 8 dBA. The AN at the edge of the right-of-way of the realigned Sickler-Schultz 500-kV line would be 59 dBA. The proposed Schultz-Wautoma line would increase the level at the edge of the existing 230-kV lines by 8-to-12 dBA. This increase would be perceived as a doubling of the noise level.

During fair-weather conditions, which occur about 92 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 not to 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 at the edge of the right-of-way for the proposed line would meet Washington Administrative Code limits for transmission lines. Noise levels near the existing Vantage-Schultz and Sickler-Schultz 500-kV lines exceed the limit and presumably are allowed because of the ages of the lines.

The computed annual L_{dn} level for transmission lines operating in areas with about 7 percent foul weather is about $L_{dn} = L_{50} - 4$ dB (Bracken, 1987). Therefore, assuming such conditions in the Schultz - Hanford area, the estimated L_{dn} at the edge of the right-of-way would be approximately 46 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 existing 230-kV right-of-way, increases in line noise levels during foul weather at the edge of the right-of-way adjacent to the existing lines would be perceived as a doubling of the noise level. 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.

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 (FCC, 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" (FCC, 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 eight 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 new right-of-way is 46 dBµV/m for 540-kV line operation; at 100 ft. (30 m) from the outside conductor, the level is 40 dBµV/m or less. 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 Sickler-Schultz line (47 dBµV/m at 100 ft. [30 m]). 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 in all configurations.

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 26 dBµV/m or less. This is comparable with TVI levels from other existing BPA 500-kV lines, and lower than that from the existing Sickler-Schultz 500-kV line (33 dBµV/m at 100 ft. [30 m]).

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. The proposed 500-kV line is designed to have lower corona levels than is present on the older 500-kV lines in the area. Therefore corona on the conductors would be less visible on this line than on others and 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 3.9 kV/m.

Under maximum current conditions, magnetic-field levels would be as follows:

- the maximum magnetic fields under the proposed line would be 244 mG;
- at the edge of the right-of-way nearest to the proposed 500-kV line, the magnetic field would be 55 to 66 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, 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.

List of References Cited

ACGIH (American Conference of Governmental Industrial Hygienists). 2000. 2000 TLVs and BEIs: Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices. American Conference of Governmental Industrial Hygienists, Cincinnati. 192 pages.

Ahlbom, A.; Albert, E.N.; Fraser-Smith, A.C.; Grodzinsky, A.J.; Marron, M.T.; Martin, A.O.; Persinger, M.A.; Shelanski, M.L.; and Wolpow, E.R. 1 July 1987. Biological Effects of Power Line Fields. New York State Power Lines Project Scientific Advisory Panel Final Report.

Baishiki, R.S.; Johnson, G.B.; Zaffanella, L.E.; Bracken, T.D.; Sussman, S.S.; Rauch, G.B.; and Silva, J.M. 1990. Studies of Power System Magnetic Fields: Characterization of Sources in Residential Environments, Measurement of Exposure, Influence On Computer Screens. (36-104) CIGRE, Paris, France. 10 pages.

Banfai, B.; Karady, G.G.; Kim, C.J.; and Maracas, K.B. 2000. Magnetic field effects on CRT computer monitors. IEEE Trans. on Power Delivery 15, 307-312.

Bassen, H.; Casamento, J.; and Crowl, B. 1991. Reduction of electric and magnetic field emissions from electric blankets (Meeting abstract). *In*: Bioelectromagnetics Society, 13th Annual Meeting, 23-27 June, Salt Lake City. Bioelectromagnetics Society, New York, 20.

BNRC (Montana Board of Natural Resources and Conservation). May 6, 1983. In the matter of the Bonneville Power Administration proposed construction of 500-kV transmission line, Case No. 883-2.

Bowman, J.D.; Garabrant, D.H.; Sobel, E.; and Peters, J.M. June 1988. Exposures to Extremely Low Frequency (ELF) Electromagnetic Fields in Occupations With Elevated Leukemia Rates. Applied Industrial Hygienics, 3(6, June):189-194.

Bracken, T.D. 1987. Audible Noise from High Voltage Transmission Facilities. A Briefing Paper Prepared for State of Florida Department of Environmental Regulation. (DER Contract No. SP122) State of Florida Department of Environmental Regulation.

Bracken, T.D. 1990. The EMDEX Project: Technology Transfer and Occupational Measurements, Volumes 1-3 Interim Report. EPRI Report EN-7048. (EPRI EN-7048) Electric Power Research Institute, Palo Alto, CA.

Chartier, V.L. April 1983. Empirical Expressions for Calculating High Voltage Transmission Corona Phenomena, First Annual Seminar Technical Career Program for Professional Engineers. Bonneville Power Administration, Portland, Oregon. April 1983, 75-82.

Chartier, V.L. and Stearns, R.D. January 1981. Formulas for Predicting Audible Noise from Overhead High Voltage AC and DC Lines. IEEE Transactions on Power Apparatus and Systems, PAS-100(No. 1, January 1981):121-129.

Dabkowski, J. and Taflove, A. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part II: Field Test Verification. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):788-794.

Deadman, J.E.; Camus, M.; Armstrong, B.G.; Heroux, P.; Cyr, D.; Plante, M.; and Thériault, G. August 1988. Occupational and Residential 60-Hz Electromagnetic Fields and High Frequency Electric Transients: Exposure Assessment Using a New Dosimeter. American Industrial Hygiene Association Journal, 49(8, August): 409-419.

Deno, D.W. and Zaffanella, L. 1982. Field effects of overhead transmission lines and stations. Chap. 8. *In*: Transmission Line Reference Book: 345 KV and Above. Second ed. (Ed: LaForest, J.J.). Electric Power Research Institute, Palo Alto, CA, 329-419.

EPA (Environmental Protection Agency). July 1973. Public Health and Welfare Criteria for Noise. (No. 500/9-73-002, July 27, 1973.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1974. Information On Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety. (No. PB-239 429.) U.S. Environmental Protection Agency, Washington, D.C.

EPA. 1978. Protective Noise Levels. Condensed Version of EPA Levels Document. (No. PB82-138827) U.S Environmental Protection Agency, Washington, DC.

FCC (Federal Communications Commission). 1988. Federal Communications Commission Rules and Regulations. 10-1-88 ed. Vol. II part 15, 47 CFR, Ch. 1.

Florida Department of Environmental Regulation. March 1989. Electric and Magnetic Fields. Chapter 17-274. Department of Environmental Regulation Rules, March 1989.

Florig, H.K. and Hoburg, J.F. 1988. Electric and Magnetic Field Exposure Associated With Electric Blankets. Project Resume. Contractor's Review. U.S. Department of Energy/Electric Power Research Institute.

Florig, H.K.; Hoburg, J.F.; and Morgan, M.G. April 1987. Electric Field Exposure from Electric Blankets. IEEE Transactions on Power Delivery, PWRD-2(2, April):527-536.

Gauger, J. September 1985. Household Appliance Magnetic Field Survey. IEEE Transactions on Power Apparatus and Systems, 104(9, September):2436-2445.

Glasgow, A.R. and Carstensen, E.L. February 1981. The Shock Record for 500 and 750 KV Transmission Lines in North America. IEEE Transactions on Power Apparatus and Systems, 100(2, February):559-562.

Harvey, S.M. 1983. Analysis of operator exposure to electric fields from video display units. Chap. 2. In Video Display Units--Characterization of Electric and Magnetic Fields. (Ontario Hydro Research Division Report # 83-503-K) (Ed: Walsh, M.L.). Ontario Hydro, Toronto, 31-56.

Heroux, P. 1987. 60-Hz Electric and Magnetic Fields Generated By a Distribution Network. Bioelectromagnetics, 8(2):135-148.

ICNIRP (International Committee on Non-ionizing Radiation Protection). April 1998. Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (Up to 300 GHz). Health Physics, 74(4, April):1-32.

IEEE (Institute of Electrical and Electronics Engineers, Inc.). 1978. Electric and Magnetic Field Coupling from High Voltage AC Power Transmission Lines -- Classification of Short-Term Effects On People. IEEE Transactions on Power Apparatus and Systems, PAS-97:2243-2252.

IEEE. 1987. IEEE Standard Procedures for Measurement of Power Frequency Electric and Magnetic Fields from AC Power Lines. ANSI/IEEE Std. 644-1987, New York, NY.

IEEE. 1990. National Electrical Safety Code. 1990 ed. Institute of Electrical and Electronics Engineers, Inc., New York, NY. 432 pages.

IEEE Committee Report. March/April 1971. Radio Noise Design Guide for High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, PAS-90(No. 2, March/April):833-842.

IEEE Committee Report. October 1982. A Comparison of Methods for Calculating Audible Noise of High Voltage Transmission Lines. IEEE Transactions on Power Apparatus and Systems, 101(10, October):4090-4099.

ITT Research Institute. 1984. Representative Electromagnetic Field Intensities Near the Clam Lake (WI) and Republic (MI) ELF Facilities. Report Prepared for Naval Electronics Systems Command, PME 110 E Washington, D.C. 20360. (Under contract N00039-84-C0070.) ITT Research Institute, Chicago, IL. 60 pages.

Jaffa, K.C. and Stewart, J.B. March 1981. Magnetic Field Induction from Overhead Transmission and Distribution Power Lines On Buried Irrigation Pipelines. IEEE Transactions on Power Apparatus and Systems, PAS-100(3, March):990-1000.

Jamison, V. September 1986. Standard Setting in the United States: The View from Montana. Proceedings of the International Utility Symposium, Toronto, Ontario, Canada, September 17-19, 1986.

Kaune, W.T.; Stevens, R.G.; Callahan, N.J.; Severson, R.K.; and Thomas, D.B. 1987. Residential Magnetic and Electric Fields Measured Over 24-H Periods. (Final Report, Power Lines Project 21082-18) (Prepared by Battelle, Pacific Northwest Laboratories.) Health Research, Inc., Albany, NY. 109 pages.

Keesey, J.C. and Letcher, F.S. 1969. Minimum Thresholds for Physiological Responses to Flow of Alternating Electric Current Through the Human Body At Power-Transmission Frequencies. (Report No. 1) Naval Medical Research Institute, Project MR 005.08-0030B, Bethesda, MD. 25 pages.

Loftness, M.O.; Chartier, V.L.; and Reiner, G.L. 1981. EMI Correction Techniques for Transmission Line Corona. (August 18-20, 1981, pp. 351-361.) Proceedings of the 1981 IEEE International Symposium on Electromagnetic Compatibility, Boulder, CO.

Maddock, B.J. September 1992. Guidelines and Standards for Exposure to Electric and Magnetic Fields At Power Frequencies. (Panel 2-05, CIGRE meeting August 30-September 5, 1992) CIGRE, Paris.

MEQB (Minnesota Environmental Quality Board). 1977. Public Health and Safety Effects of High Voltage Overhead Transmission Lines - An Analysis for the Minnesota Environmental Quality

Board By Banks, R.S., Kanniainen, C. M. And Clark, R. D. (Report no. HRP-0024077) MEQB, St. Paul, MN.

NJDEP (New Jersey Commission on Radiation Protection). 1981. News Release: Guidelines for High Voltage Transmission Lines Adopted. New Jersey State Department of Environment Protection, Trenton, NJ.

NYPSC (New York State Public Service Commission). 1978a. New York Public Service Commission, Order Granting in Part and Denying in Part Petitions for Rehearing and Clarifying Opinion No. 78-13, Issued October 13, 1978.

NYPSC. 1978b. Opinion No. 78-13: Cases 16529 and 26559 -- Common Record Hearings On Health and Safety of Extra High Voltage Transmission Lines. Opinion and other determining health and safety issues, imposing conditions, and authorizing, in case 26529, Operation pursuant to those conditions.

Olsen, R.G.; Schennum, S.D.; and Chartier, V.L. April 1992. Comparison of Several Methods for Calculating Power Line Electromagnetic Interference Levels and Calibration With Long Term Data. IEEE Transactions on Power Delivery, 7(April, 1992):903-913.

Oregon, State of. 1980. Oregon Administrative Rules Chapter 345, Division 80. Energy Facility Siting Council standards relating to public health and safety, 934-80-055.

Perry, D. 1982. Sound Level Limits from BPA Facilities. BPA memorandum, May 26, 1982; Department of Environmental Quality, Noise Control Regulations, Chapter 340, Oregon Administrative Rules, Division 35, March 1, 1978.

Reilly, J.P. 1979. Electric Field Induction on Long Objects -- A Methodology for Transmission Line Impact Studies. IEEE Transactions on Power Apparatus and Systems, PAS-98(6, Nov/Dec):1841-1852.

WDOE (Washington Department of Ecology). 1981. Letter from D.E. Saunders to J.H. Brunke, BPA, dated 9/3/81 regarding EDNA classification for substations and transmission line. State of Washington Department of Ecology, Olympia, WA.

Savitz, D.A. 1987. Case-Control Study of Childhood Cancer and Residential Exposure to Electric and Magnetic Fields. Final report to the New York State Department of Health Power Lines Project.

Sheppard, A.R. and Eisenbud, M. 1977. Biological Effects of Electric and Magnetic Fields of Extremely Low Frequency. New York University Press, New York.

Silva, M.; Hummon, N.; Rutter, D.; and Hooper, C. 1989. Power Frequency Magnetic Fields in the Home. IEEE Transactions on Power Delivery, 4:465-478.

Stopps, G.J. and Janischewskyj, W. 1979. Epidemiological Study of Workers Maintaining HV Equipment and Transmission Lines in Ontario. (Canadian Electrical Association Research Report) Canadian Electrical Association, Montreal. 82 pages.

Taflove, A. and Dabkowski, J. May/June 1979. Prediction Method for Buried Pipeline Voltages Due to 60 Hz AC Inductive Coupling. Part I: Analysis. IEEE Transactions on Power Apparatus and Systems, PAS-98(3, May/June):780-787.

TDHS Report. March 1989. EMF Rule Becomes Law; Hillsborough County Commission Challenges. Transmission/Distribution Health & Safety Report, 7(9, 31 March):1-3.

TDHS Report. August 1990. Updates: New York. Transmission/Distribution Health & Safety Report, 8(7, 31 August):4.

USDOE (U.S. Department of Energy), Bonneville Power Administration. March 1977. A Practical Handbook for the Location, Prevention and Correction of Television Interference from Overhead Power Lines. Portland, OR.

USDOE, Bonneville Power Administration. May 1980. A Practical Handbook for the Correction of Radio Interference from Overhead Powerlines and Facilities. (May 1980.) Portland, OR.

USDOE, Bonneville Power Administration. 1995. Living and Working Around High-Voltage Power Lines. (DOE/BP-799). Portland, OR. 9 pages.

USDOE, Bonneville Power Administration. 1996. Electrical and Biological Effects of Transmission Lines: A Review. (DOE/BP 2938 December 1996 1M) Portland, OR.

USDOE, Bonneville Power Administration. undated. "Corona and Field Effects" Computer Program (Public Domain Software). Bonneville Power Administration, P.O. Box 491-ELE, Vancouver, WA 98666.

Washington, State of. 1975. Washington Administrative Code, Chapter 173-60 WAC Maximum Environmental Noise Levels. Department of Ecology, Olympia, WA.

Zaffanella, L.E. 1993. Survey of Residential Magnetic Field Sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02) Electric Power Research Institute, Palo Alto, CA.

Zaffanella, L.E. and Kalton, G.W. 1998. Survey of personal magnetic field exposure, Phase II: 1000-perosn survey. Interim Report. EMF RAPID Program Engineering Project #6. Enertech Consultants, Lee, MA.

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 Schultz-Hanford Area Project configurations (4 pages).

	New Configurations			
Segment-Configuration	**A-1**	**A-2**	**A-3**	
Line Description	**Schultz-Hanford 500-kV Only**	**Sickler-Schultz 500-kV Only**	**Sickler-Schultz 500-kV**	**Rocky Reach-Maple Valley 345-kV**
Voltage, kV Maximum/Average[1]	550/540	550/540	550/540	362/358
Peak current, A Existing/Proposed[2]	— /1436	— /-1478	— /-1478	-459/-470
Electric phasing	BAC	BAC	BAC	ABC
Clearance, ft. minimum/Average[1]	33/47	33/47	33/47	31/45
Centerline distance-direction from Schultz – Hanford 500-kV Line, ft.	—	N/A	N/A	150-S[3]
Centerline distance to edge of ROW, ft.	75	75	75	75
Tower configuration	Delta	Delta	Delta	Flat
Phase spacing, ft.	40 H, 28.7 V	40H, 27.5V	40H, 27.5V	36H
Conductor: #/diameter, in.; spacing, in.	3/1.302; 17.04	2/1.602; 18	2/1.602; 18	1/1.602

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford line.
3 Distance from centerline of realigned Sickler-Schultz 500-kV line.

Table 1, continued

	Existing Configurations						
Segment-Configuration	**A-4**						
Line Description	**Grand Coulee-Schultz 500-kV DC (DC)**		**Columbia-Ellensburg 115-kV**	**Covington-Columbia #3 & Olympia-Grand Coulee DC**		**Sickler-Schultz 500-kV[4]**	**Vantage-Schultz 500-kV[3]**
	#2	**#1**		**230-kV**	**287-kV**		
Voltage, kV Maximum/Average[1]	550/540	550/540	121/117	242/235	301/292	550/540	550/540
Peak current, A Existing/Proposed[2]	-1470/-1653	-1470/-1653	-477/-453	-316/-341	-494/-486	-1338/—	1355/738
Electric phasing	BAC	BCA	CBA	BCA	BAC	BAC	ABC
Clearance, ft. minimum/Average[1]	33/47	33/47	25/35	30/42	30/42	33/47	33/47
Centerline distance-direction from Schultz–Hanford 500-kV line, ft.	500-N		375-N	250-N		125-N	0[3]
Centerline distance to edge of ROW, ft.	62.5	—	—	—	—	—	75
Tower configuration	Vertical	Vertical	Flat	Vertical	Vertical	Delta	Flat
Phase spacing, ft.	36.5, 56.5, 36.5H; 36V	36.5, 56.5, 36.5H; 36V	12H	31, 47, 31H; 21V	31, 47, 31H; 21V	40H, 27.5V	49H
Conductor: #/Diameter, in. ; spacing, in.	3/1.602; 17.04	3/1.602; 17.04	1/1.108	1/1.382	1/1.382	2/1.602; 18	1/2.50

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford line.
4 Proposed Schultz-Hanford/Wautoma 500-kV line will replace existing Vantage-Schultz 500-kV and existing Vantage-Schultz 500-kV will replace Sickler-Schultz 500-kV. Sickler-Schultz 500-kV will be realigned north of Schultz substation (Configurations A-2 and A-3).

Table 1, continued

	Existing Configurations				
Segment-Configuration	**D-1**	**D-2**			
Line Description	**Vantage-Midway 230-kV**	**N. Bonneville-Midway 230-kV**	**Midway-Moxee 115-kV**	**Midway-Grandview 115-kV**	**Big Eddy-Midway 230-kV**
Voltage, kV Maximum/Average[1]	242/235	242/235	121/117	121/117	242/235
Peak current, A Existing/Proposed[2]	609/593	537/518	153/154	308/293	779/730
Electric phasing	ABC	ABC	ABC	ABC	ABC
Clearance, ft. minimum/Average[1]	30/42	30/42	25/35	25/35	30/42
Centerline distance-direction from Schultz–Wautoma 500-kV line, ft.	125-E	375-E	287.5-E	237.5-E	137.5-E
Centerline distance to edge of ROW, ft.	50	187.5	—	—	62.5
Tower configuration	Flat	Flat	Flat	Flat	Flat
Phase spacing, ft.	27H	27H	12H	12H	27H
Conductor: #/Diameter, in.; spacing, in.	1/1.0	1/1.108	1/0.655	1/0.563	1/1.382

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford line.

Table 1, continued:

	Existing Configurations			
Segment-Configuration	**D-3**			**D-4**
Line Description	**N. Bonneville-Midway 230-kV**	**Midway-Grandview 115-kV**	**Big Eddy-Midway 230-kV**	**Big Eddy-Midway 230-kV**
Voltage, kV Maximum/Average[1]	242/235	121/117	242/235	242/235
Peak current, A Existing/Proposed[2]	537/518	308/293	779/730	779/730
Electric Phasing	ABC	ABC	ABC	ABC
Clearance, ft. minimum/Average[1]	30/42	25/35	30/42	30/42
Centerline distance-direction from Schultz–Wautoma 500-kV line, ft.	325-E	237.5-E	137.5-E	137.5-E
Centerline distance to edge of ROW, ft.	187.5	—	62.5	62.5
Tower configuration	Flat	Flat	Flat	Flat
Phase spacing, ft.	27H	12H	27H	27H
Conductor: #/diameter, in. ; spacing, in.	1/1.108	1/0.563	1/1.382	1/1.382

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford line.

Table 2: Possible segment configurations for Schultz - Hanford Area Project

Segment-Configuration	Description of other lines in corridor with Schultz–Hanford/Wautoma 500-kV line	Possible segments with same configuration	Miles
A-1	Schultz–Hanford/Wautoma 500-kV line only	A, B, C, E, F	22.4, 10.3, 30.6, 23.8, 31.9
A-2	Realigned Sickler-Schultz 500-kV only. (No Schultz-Hanford/Wautoma 500-kV)	A	1.0
A-3	Realigned Sickler-Schultz 500-kV Rocky Reach-Maple Valley 345-kV (No Schultz-Hanford/Wautoma 500-kV)	A	1.15
A-4	Grand Coulee-Schultz #2 and #1 DC 500-kV Columbia-Ellensburg 115-kV Covington-Columbia #3 230-kV/ Olympia-Grand Coulee 287-kV DC Vantage-Schultz 500-kV	A	1.88
D-1	Vantage-Midway 230-kV	D	19.4
D-2	N. Bonneville-Midway 230-kV Midway-Moxee 115-kV Midway-Grandview 115-kV Big Eddy-Midway 230-kV	D	4.51
D-3	N. Bonneville-Midway 230-kV Midway-Grandview 115-kV Big Eddy-Midway 230-kV	D	1.19
D-4	Big Eddy-Midway 230-kV	D	2.2

Table 3: Calculated electric fields for configurations of the proposed Schultz–Hanford/Wautoma 500-kV line operated at maximum voltage. Configurations are described in Tables 1 and 2. (6 pages)

a) Configuration A-1: Schultz – Hanford 500-kV line only

Configuration	**Proposed A-1**		**Existing**	
ROW width, ft.	150		—	
Line	Schultz–Hanford/Wautoma 500-kV		—	
Clearance	min.	avg.	—	—
Peak field, kV/m	8.9	4.9	—	—
Edge of ROW, kV/m	2.0	2.0	—	—

b) Configuration A-2: Realigned Sickler-Schultz - 500-kV line only

Configuration	**Proposed A-2**		**Existing**	
ROW width, ft. (m)	150 (46)		—	
Line	Sickler-Schultz 500-kV		—	
Clearance	min.	avg.	—	—
Peak field, kV/m	8.4	4.6	—	—
Edge of ROW, kV/m	1.8	1.8	—	—

c) Configuration A-3: Realigned Sickler-Schultz 500-kV and Rocky Reach-Maple Valley 345-kV lines

Configuration	**Proposed A-3**				**Existing A-3**	
ROW width, ft.	300				150	
Line	Sickler-Schultz 500-kV		Rocky Reach-Maple Valley 345-kV		Rocky Reach-Maple Valley 345-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	8.5	4.7	5.4	3.1	5.2	2.9
Edge of ROW, kV/m	1.9	1.9	2.1	1.9	2.0	1.8

Table 3, continued

d) Configuration A-4: Schultz-Hanford/Wautoma 500-kV line and six existing lines east of Schultz Substation

Configuration	**Proposed A-4**									
ROW width, ft.	637.5									
Line	Grand Coulee-Schultz DC 500-kV		Columbia-Ellensburg 115-kV		Covington-Columbia #3/ Olympia-Grand Coulee 230-/287-kV DC		Vantage-Schultz 500-kV		Schultz-Hanford/ Wautoma 500-kV	
Clearance	min	avg.	min	Avg.	min.	avg.	min	avg.	min	avg.
Peak field, kV/m	9.7	5.9	1.7	1.0	2.9/3.2	1.8/1.8	8.6	4.6	8.8	4.9
Edge of Row, kV/m	2.1	2.1	—	—	—	—	—	—	2.0	2.0

Configuration	**Existing A-4**									
ROW width, ft.	637.5									
Line	Grand Coulee-Schultz 500-kV DC		Columbia-Ellensburg 115-kV		Covington-Columbia #3/ Olympia-Grand Coulee 230-/287-kV DC		Sickler-Schultz 500-kV		Vantage-Schultz 500-kV	
Clearance	min	avg.	min	avg.	min	avg.	min.	Avg.	min	avg.
Peak field, kV/m	9.7	5.9	1.7	1.0	2.9/3.2	1.8/1.8	8.5	4.5	8.4	5.1
Edge of Row, kV/m	2.1	2.1	—	—	—	—	—	—	5.2	4.0

Table 3, continued

e) Configuration D-1: Schultz-Wautoma 500-kV and Vantage-Midway 230-kV lines

Configuration	**Proposed D-1**				**Existing D-1**	
ROW width, ft.	250				100	
Line	Vantage-Midway 230-kV		Schultz-Wautoma 500-kV		Vantage-Midway 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	3.3	2.0	8.9	5.0	3.1	1.8
Edge of ROW, kV/m	2.2	1.7	2.0	2.0	2.0	1.5

Table 3, continued

f) Configuration D-2: Schultz-Wautoma 500-kV and four existing parallel lines south of Midway Substation

Segment-Configuration	**Proposed D-2**									
ROW width, ft.	575									
Line	N. Bonneville-Midway 230-kV		Midway-Moxee 115-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV		Schultz-Wautoma 500-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	3.2	1.9	0.9	0.4	0.9	0.4	3.2	1.9	8.9	5.0
Edge of ROW, kV/m	0.1	0.1	—	—	—	—	—	—	2.0	2.0

Segment-Configuration	**Existing D-2**							
ROW width, ft.	487.5							
Line	N. Bonneville-Midway 230-kV		Midway-Moxee 115-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV	
Clearance	min.	avg.	min.	avg.	Min.	avg.	min.	avg.
Peak field, kV/m	3.2	1.9	0.8	0.4	1.0	0.4	3.3	1.9
Edge of ROW, kV/m	0.1	0.1	—	—	—	—	1.4	1.2

Table 3, continued

g) Configuration D-3: Schultz-Wautoma 500-kV and three existing parallel lines south of Midway Substation

Segment-Configuration	**Proposed D-3**							
ROW width, ft.	525							
Line Description	N. Bonneville-Midway 230-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV		Schultz-Wautoma 500-kV	
Clearance	min.	avg.	Min.	avg.	min.	avg.	min.	Avg.
Peak field, kV/m	3.2	1.9	0.9	0.4	3.2	1.8	8.9	5.0
Edge of ROW, kV/m	0.1	0.1	—	—	—	—	2.0	2.0

Segment-Configuration	**Existing D-3**					
ROW width, ft.	437.5					
Line Description	N. Bonneville-Midway 230-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	3.2	1.9	1.0	0.4	3.3	1.9
Edge of ROW, kV/m	0.1	0.1	—	—	1.4	1.2

Table 3, continued

h) Configuration D-4: Schultz-Wautoma 500-kV and Midway-Big Eddy 230-kV lines.

Segment-Configuration	**Proposed D-4**				**Existing D-4**	
ROW width, ft.	275				125	
Line	Midway-Big Eddy 230-kV		Schultz-Wautoma 500-kV		Midway-Big Eddy 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	3.4	2.0	8.9	4.9	3.2	1.9
Edge of ROW, kV/m	1.5	1.3	2.0	2.0	1.3	1.2

Table 4: Calculated magnetic fields for configurations of the proposed Schultz–Hanford/Wautoma 500-kV line operated at maximum current. Configurations are described in Tables 1 and 2. (4 pages)

a) Configuration A-1: Schultz–Hanford 500-kV line only

Configuration	**Proposed A-1**		**Existing**	
ROW width, ft.	150		—	
Line	Schultz–Hanford/Wautoma 500-kV		—	
Clearance	Min.	avg.	—	—
Peak field, mG	244	137	—	—
Edge of ROW, mG	55	46	—	—

b) Configuration A-2: Realigned Sickler-Schultz - 500-kV line only

Configuration	**Proposed A-2**		**Existing**	
ROW width, ft.	150		—	
Line	Sickler-Schultz 500-kV		—	
Clearance	min.	avg.	—	—
Peak field, mG	262	145	—	—
Edge of ROW, mG	57	48	—	—

c) Configuration A-3: Realigned Sickler-Schultz 500-kV and Rocky Reach-Maple Valley 345-kV lines

Configuration	**Proposed A-3**				**Existing A-3**	
ROW width, ft.	300				150	
Line	Sickler-Schultz 500-kV		Rocky Reach-Maple Valley 345-kV		Rocky Reach-Maple Valley 345-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	257	141	111	69	101	62
Edge of ROW, mG	60	50	40	33	35	28

Table 4, continued

d) Configuration A-4: Schultz-Hanford/Wautoma 500-kV line and six existing lines east of Schultz Substation

Configuration	**Proposed A-4**									
ROW width, ft.	637.5									
Line	Grand Coulee-Schultz DC 500-kV		Columbia-Ellensburg 115-kV		Covington-Columbia #3/ Olympia-Grand Coulee 230-/287-kV DC		Vantage-Schultz 500-kV		Schultz-Hanford/ Wautoma 500-kV	
Clearance	min	avg.	min	avg.	min.	avg.	min	Avg.	min	avg.
Peak field, mG	233	150	112	87	68	42	122	69	239	134
Edge of Row, mG	138	109	—	—	—	—	—	—	60	51

Configuration	**Existing A-4**									
ROW width, ft.	637.5									
Line	Grand Coulee-Schultz 500-kV DC		Columbia-Ellensburg 115-kV		Covington-Columbia #3/ Olympia-Grand Coulee 230-/287-kV DC		Sickler-Schultz 500-kV		Vantage-Schultz 500-kV	
Clearance	min.	avg.	min	avg.	min	avg.	min.	avg.	Min.	avg.
Peak field, mG	206	132	108	85	90	69	253	190	302	203
Edge of Row, mG	121	94	—	—	—	—	—	—	158	119

Table 4, continued

e) Configuration D-1: Schultz-Wautoma 500-kV and Vantage-Midway 230-kV lines

Configuration	**Proposed D-1**				**Existing D-1**	
ROW width, ft.	250				100	
Line	Vantage-Midway 230-kV		Schultz-Wautoma 500-kV		Vantage-Midway 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	139	89	239	132	133	84
Edge of ROW, mG	72	55	59	49	67	49

Table 4, continued

f) Configuration D-2: Schultz-Wautoma 500-kV and four existing parallel lines south of Midway Substation

Segment-Configuration	**Proposed D-2**									
ROW width, ft.	637.5									
Line	N. Bonneville-Midway 230-kV		Midway-Moxee 115-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV		Schultz-Wautoma 500-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	109	66	37	20	40	20	158	98	237	130
Edge of ROW, mG	7	7	—	—	—	—	—	—	60	50

Segment-Configuration	**Existing D-2**							
ROW width, ft.	487.5							
Line	N. Bonneville-Midway 230-kV		Midway-Moxee 115-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV	
Clearance	min.	avg.	min.	Avg.	min.	avg.	Min.	avg.
Peak field, mG	112	68	38	21	40	18	165	101
Edge of ROW, mG	7	7	—	—	—	—	62	50

Table 4, continued

g) Configuration D-3: Schultz-Wautoma 500-kV and three existing parallel lines south of Midway Substation

Segment-Configuration	**Proposed D-3**							
ROW width, ft.	587.5							
Line Description	N. Bonneville-Midway 230-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV		Schultz-Wautoma 500-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.	Min.	avg.
Peak field, mG	108	66	58	35	157	97	237	130
Edge of ROW, mG	7	7	—	—	—	—	60	50

Segment-Configuration	**Existing D-3**					
ROW width, ft.	437.5					
Line Description	N. Bonneville-Midway 230-kV		Midway-Grandview 115-kV		Big Eddy-Midway 230-kV	
Clearance	min.	avg.	Min.	avg.	min.	avg.
Peak field, mG	111	67	58	33	165	101
Edge of ROW, mG	7	7	—	—	62	50

Table 4, continued

h) Configuration D-4: Schultz-Wautoma 500-kV and Midway-Big Eddy 230-kV lines.

Segment-Configuration	**Proposed D-4**				**Existing D-4**	
ROW width, ft.	275				125	
Line	Midway-Big Eddy 230-kV		Schultz-Wautoma 500-kV		Midway-Big Eddy 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	167	106	238	131	170	107
Edge of ROW, mG	60	50	59	49	59	47

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.
70	Gas lawnmower at 100 ft.
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 Schultz–Hanford/Wautoma 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 Schultz-Hanford Area 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**
A-1	150 (46)	50	54	—	—	—
A-2	150 (46)	59	63	—	—	—
A-3	300 (91)	59, 57	63, 61	150 (46)	54	57
A-4	637.5 (194)	57, 54	60, 57	637.5 (194)	65, 57	69, 61
D-1	250 (76)	50, 48	53, 52	100 (30)	44	47
D-2	637.5 (194)	50, 42	53, 46	487.5 (149)	39, 37	42, 41
D-3	587.5 (179)	50, 42	53, 46	437.5 (133)	39, 37	43, 41
D-4	275 (84)	50, 46	53, 49	125 (38)	37	40

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 Schultz–Hanford/Wautoma 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 Schultz-Hanford Area ROW is given first.

	Fair-weather RI	
	Proposed	**Existing**
Configuration[1]	**L_{50}, dBmV/m**	**L_{50}, dBmV/m**
A-1	40	—
A-2	47	—
A-3	47, 39	39
A-4	40, 38	47, 38
D-1	39, 31	31
D-2	39, 28	22, 28
D-3	39, 28	22, 28
D-4	39, 30	22

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 Schultz–Hanford/Wautoma 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 Schultz-Hanford Area ROW is given first.

	Foul-weather TVI	
	Proposed	Existing
Configuration[1]	Maximum (foul), dBmV/m	Maximum (foul), dBmV/m
A-1	26	-
A-2	33	-
A-3	33, 26	26
A-4	26, 19	33, 19
D-1	25, 17	18
D-2	25, 15	9, 15
D-3	25, 15	9, 15
D-4	25, 11	9

1 Configurations are described in detail in Tables 1 and 2.

Figure 1: Configurations for proposed Schultz-Hanford Area Project 500-kV line: a) Proposed line with no parallel lines (Configuration A-1); b) Realigned Sickler-Schultz 500-kV with no parallel lines (Configuration A-2); c) Realigned Sickler-Schultz 500-kV line with parallel 345-kV line (Configuration A-3); d) Schultz-Hanford/Wautoma 500-kV line with six parallel lines east of Schultz Substation(Configuration A-4); e) Proposed Schultz – Wautoma 500-kV line with parallel Vantage – Midway 230-kV line (Configuration D-1); f) Proposed Schultz-Wautoma 500-kV line with four parallel existing lines south of Midway Substation (Configuration D-2); g) Proposed Schultz-Wautoma 500-kV line with three parallel existing lines south of Midway Substation (Configuration D-3); and h) Proposed Schultz-Wautoma 500-kV line with parallel Midway-Big Eddy 230-kV line (Configuration D-4). (8 pages)

a) Proposed line with no parallel lines (Configuration A-1) (not to scale)

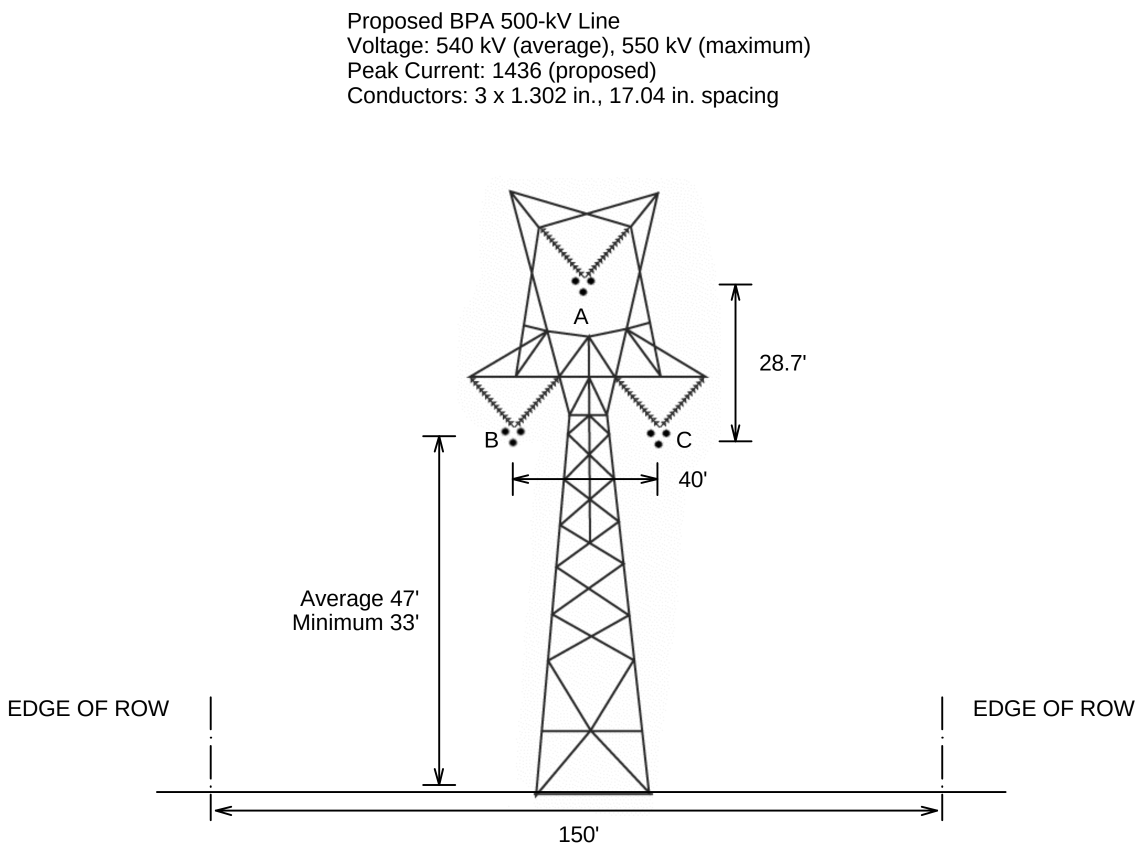


Figure 1, continued

b) Realigned Sickler-Schultz 500-kV line with no parallel lines (Configuration A-2) (not to scale)

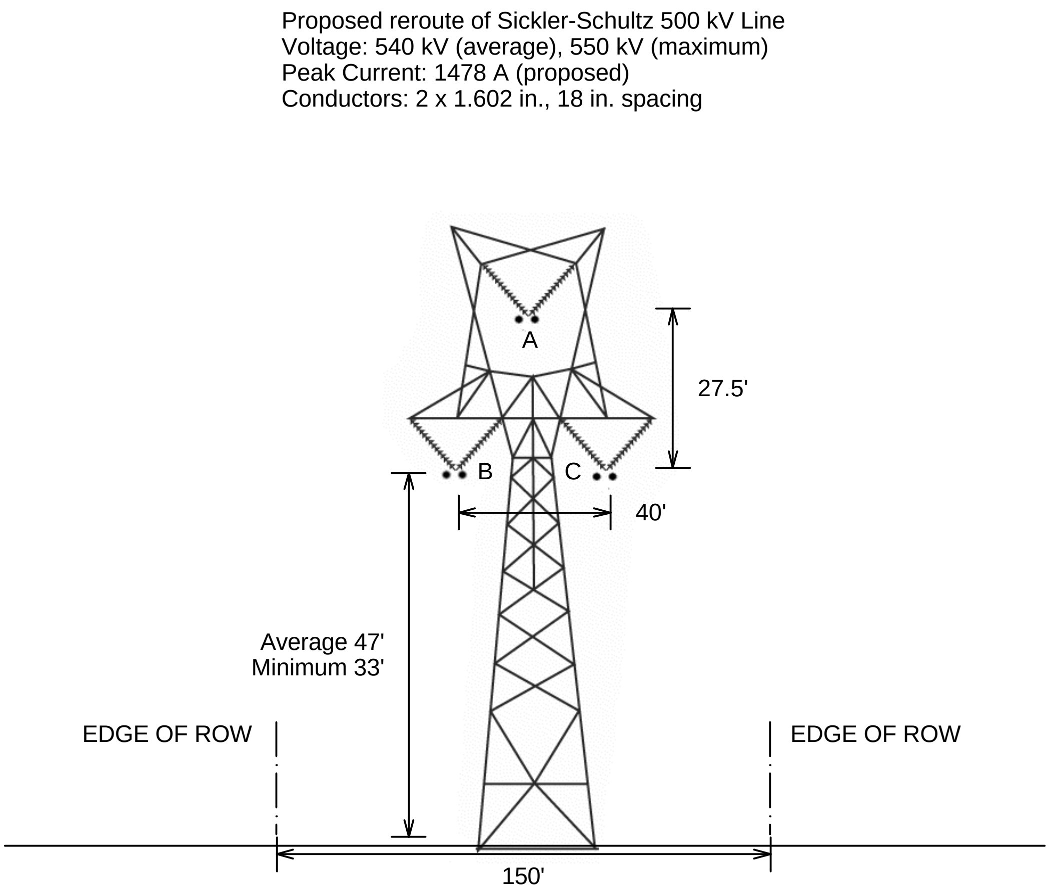


Figure 1, continued

c) Realigned Sickler-Schultz 500-kV line with parallel Rocky Reach-Maple Valley 345-kV line (Configuration A-3) (not to scale)

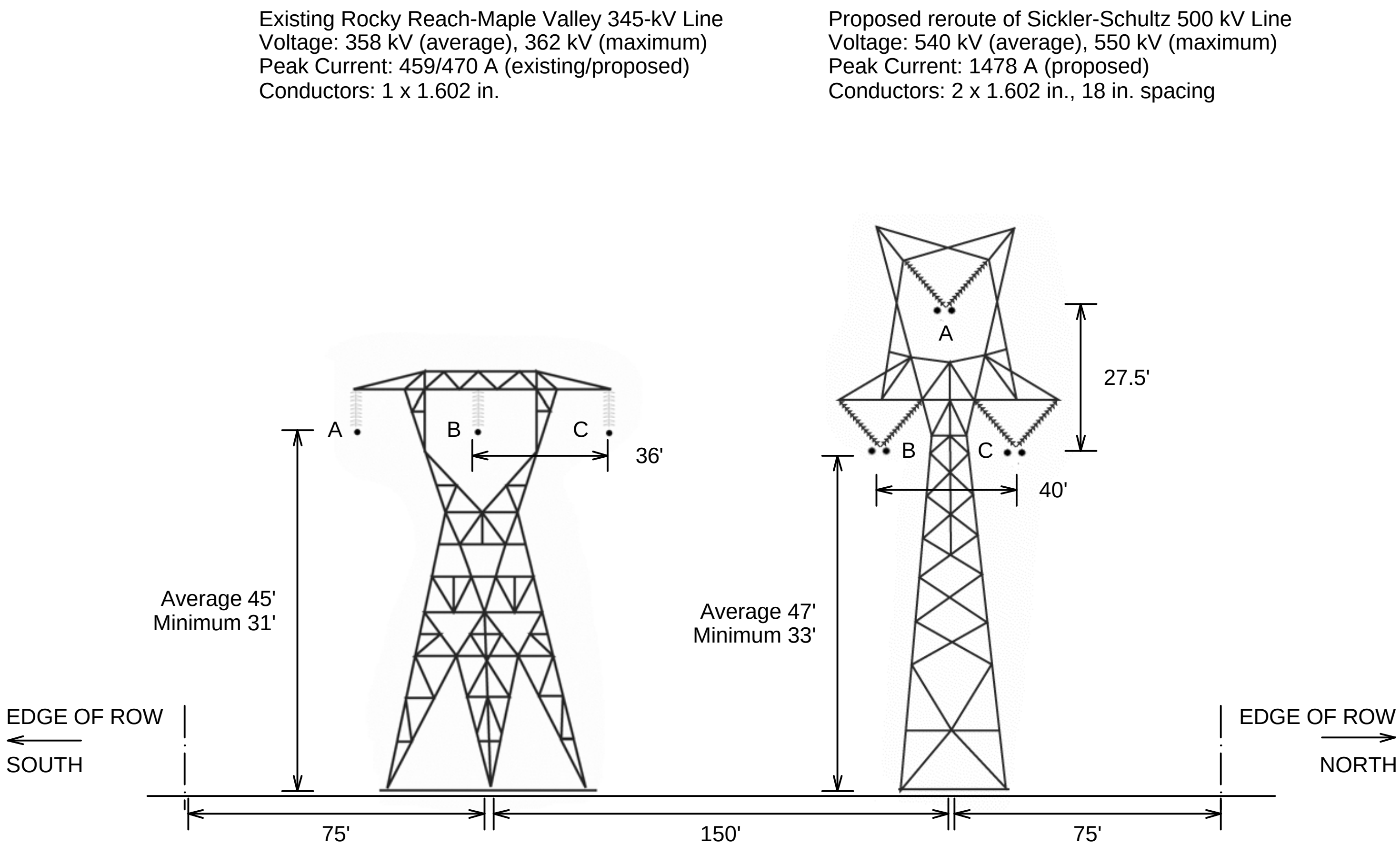


Figure 1, continued

d) Schultz-Hanford/Wautoma 500-kV line with six parallel lines east of Schultz Substation(Configuration A-4) (not to scale)

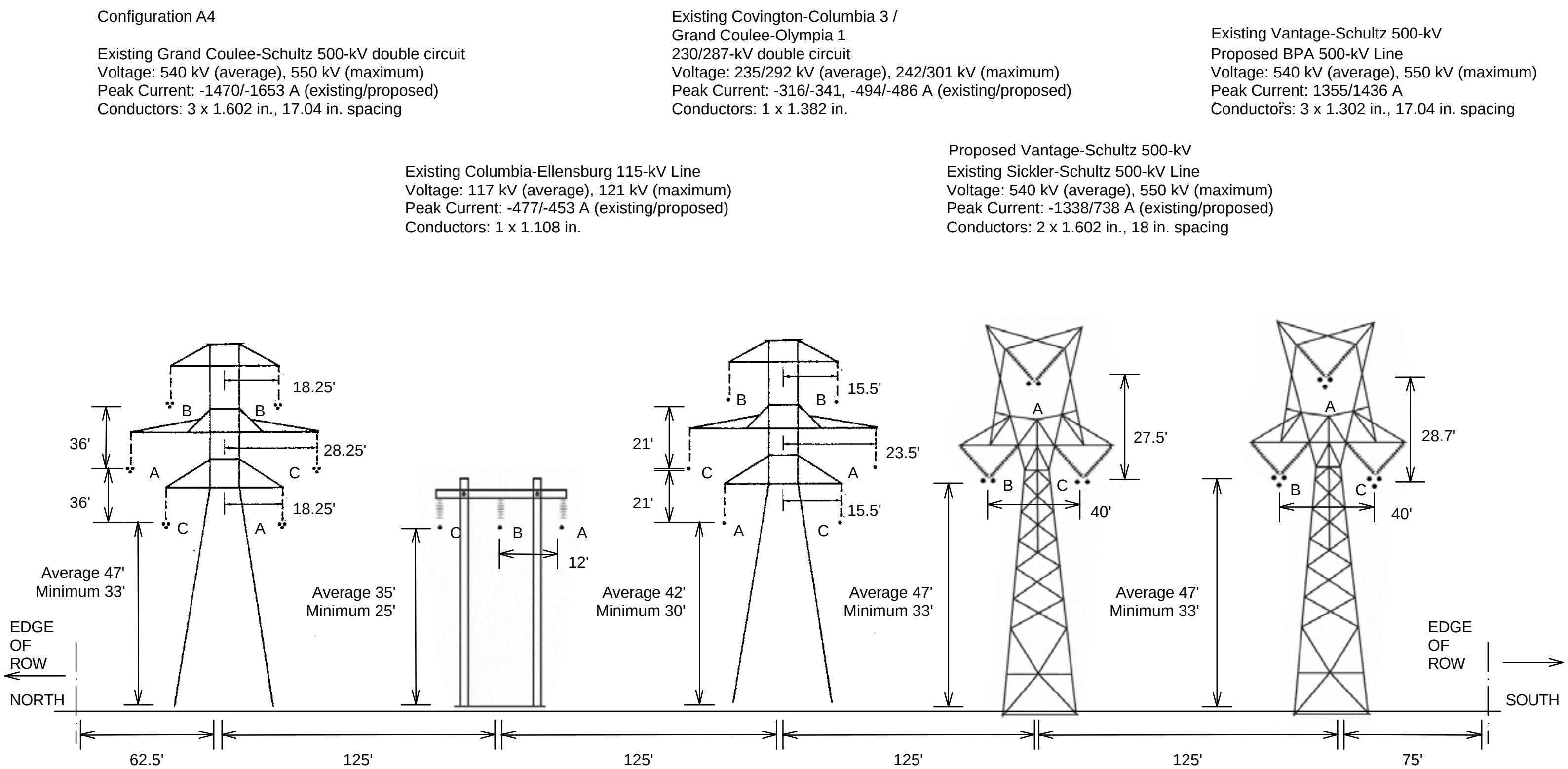


Figure 1, continued

e) Proposed Schultz – Wautoma 500-kV line with parallel Vantage – Midway 230-kV line (Configuration D-1). (Not to scale)

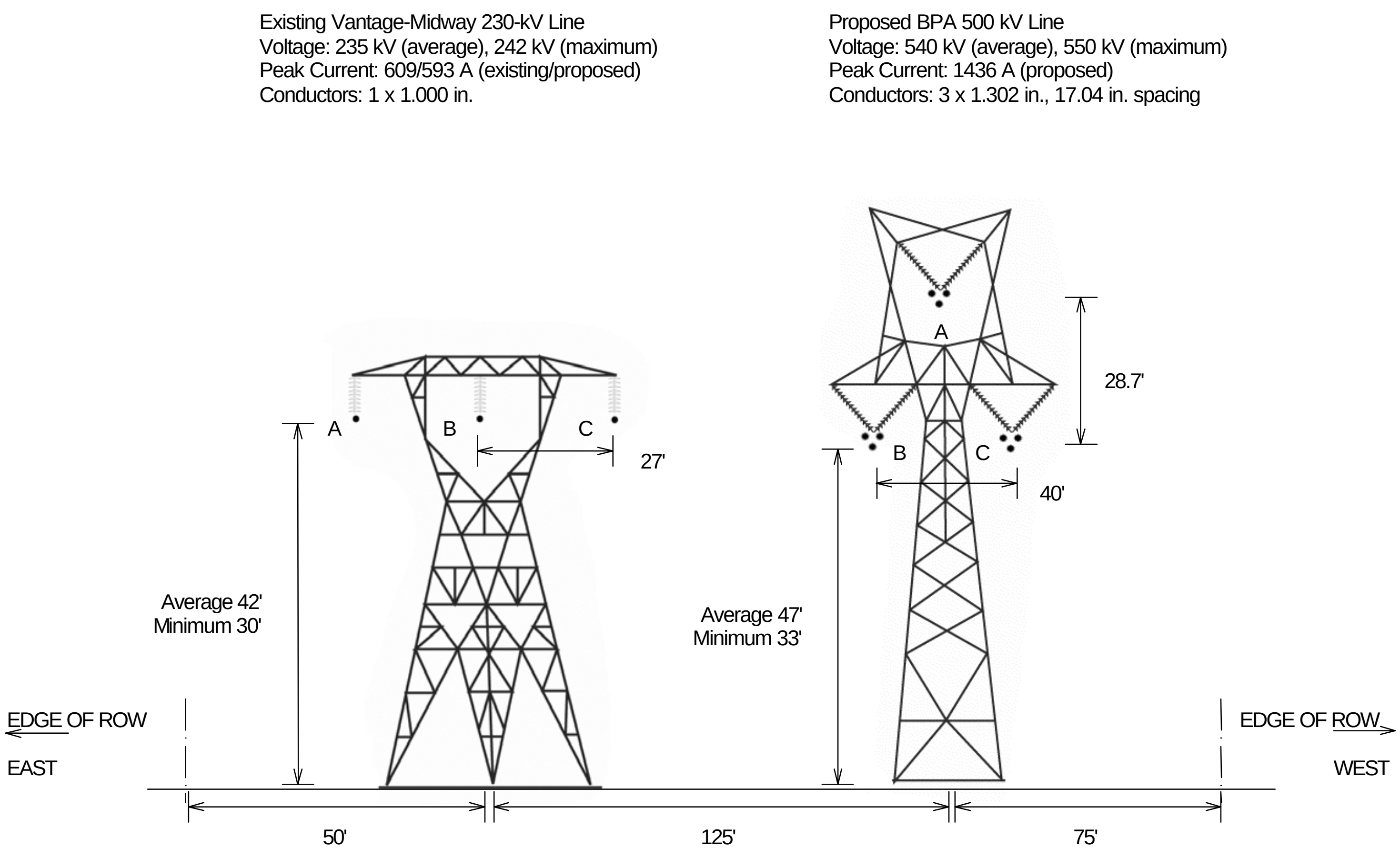


Figure 1, continued

f) Proposed Schultz-Wautoma 500-kV line with four parallel existing lines south of Midway Substation (Configuration D-2) (not to scale)

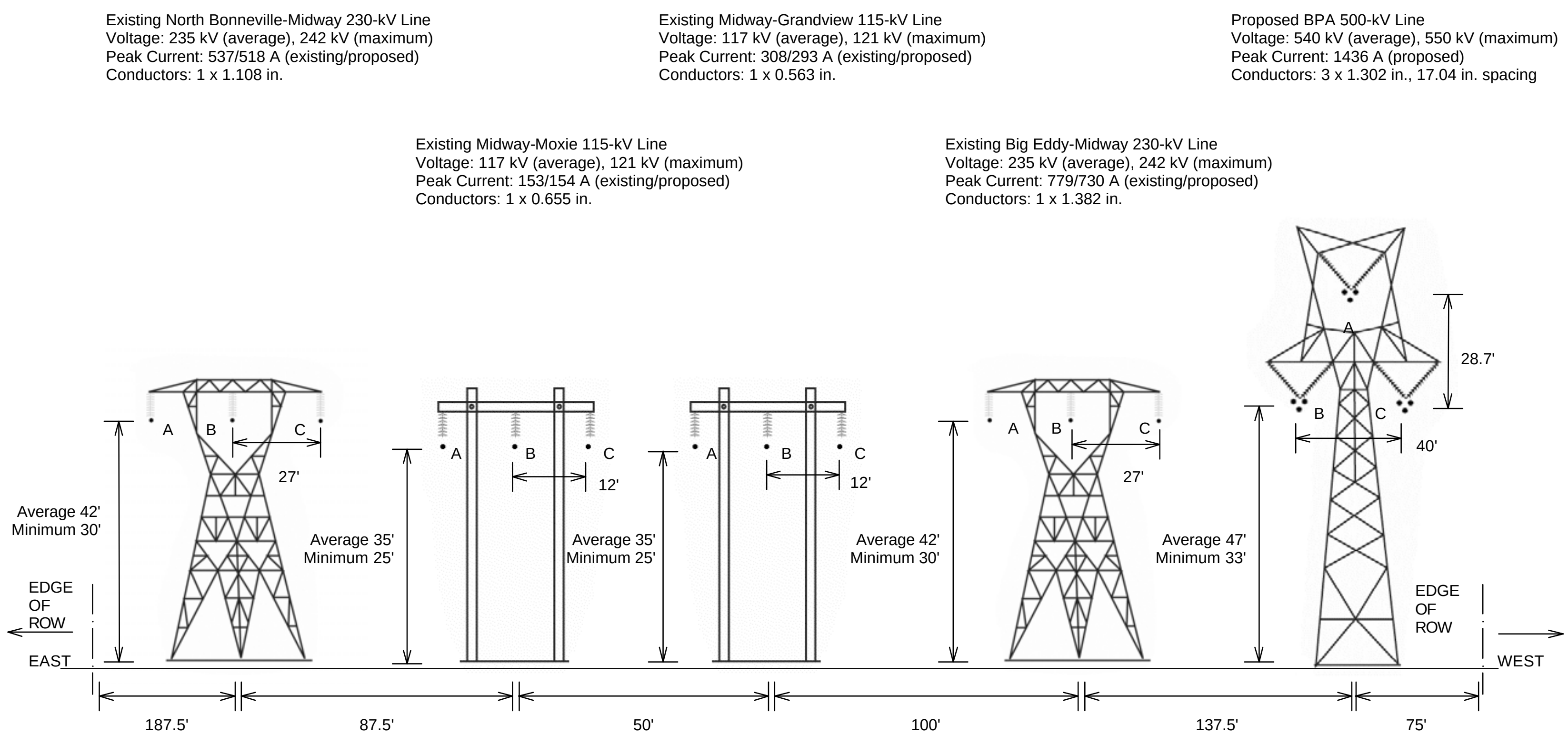


Figure 1, continued

g) Proposed Schultz-Wautoma 500-kV line with three parallel existing lines south of Midway Substation (Configuration D-3) (not to scale)

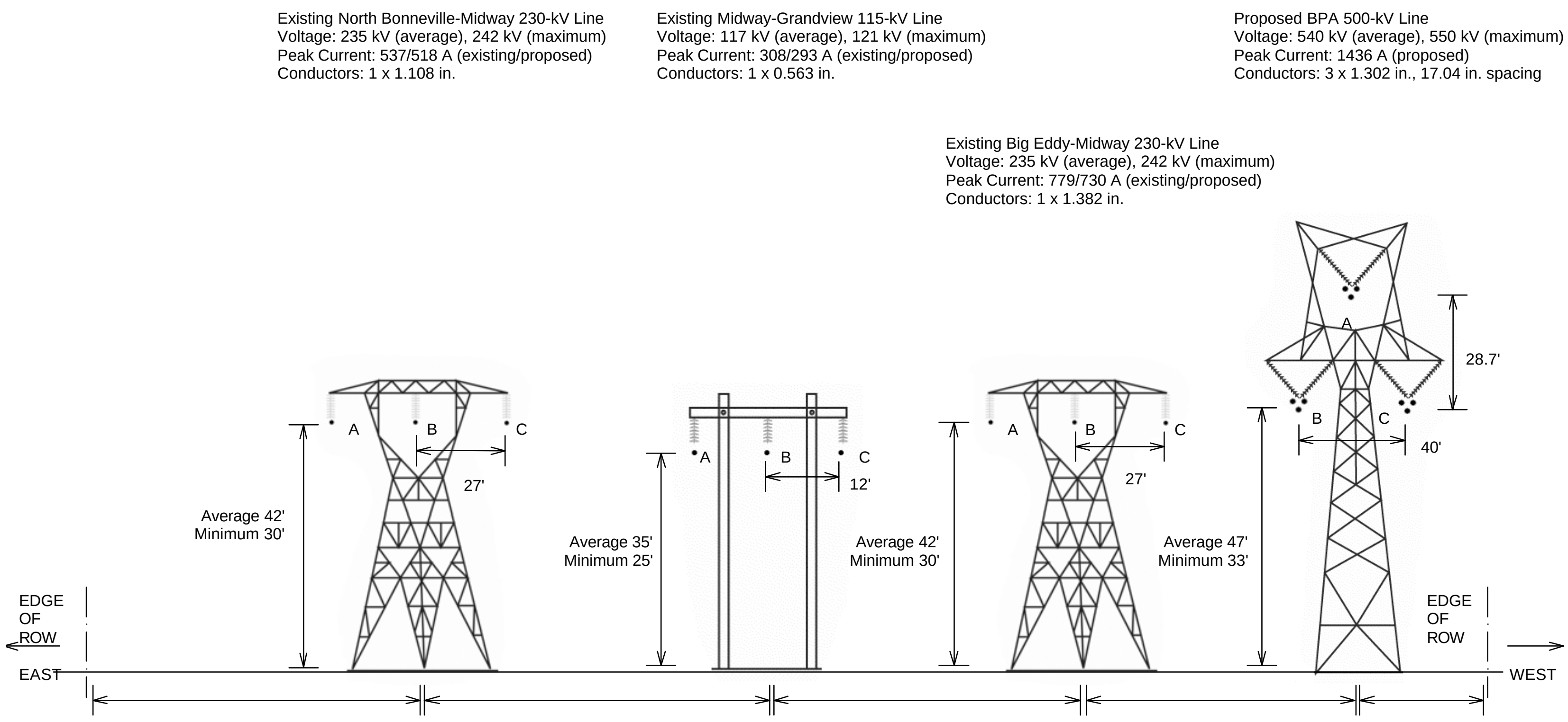


Figure 1, continued

h) Proposed Schultz-Wautoma 500-kV line with parallel Midway-Big Eddy 230-kV line (Configuration D-4) (not to scale)

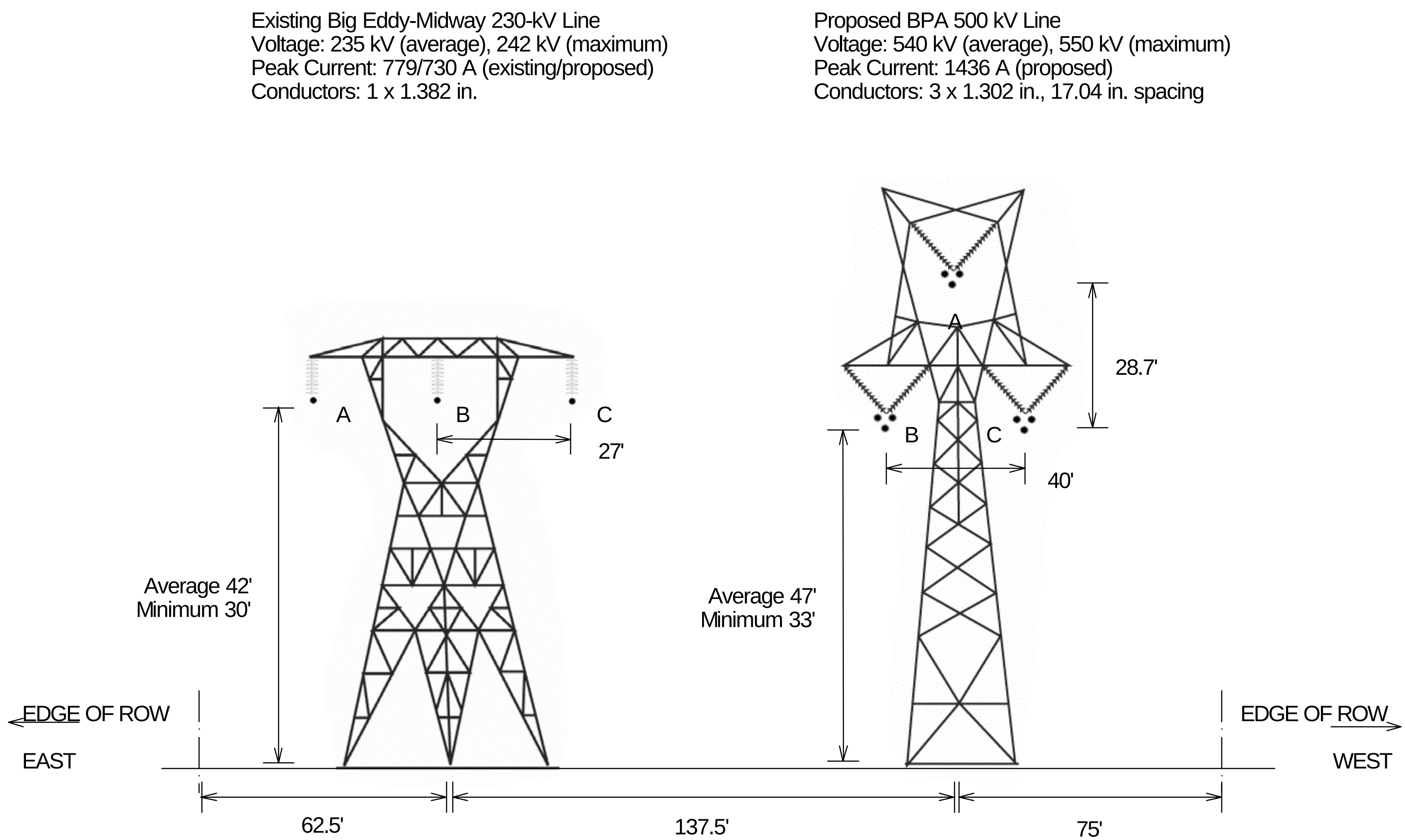


Figure 2: Electric-field profiles for selected configurations of proposed Schultz–Hanford/Wautoma 500-kV line: a) Proposed line with no parallel line (Configuration A-1); b) proposed line with parallel 230-kV line (Configuration D-1); c) proposed line with parallel 115-kV and 230-kV lines (Configuration D-3). Fields for maximum voltage and minimum clearances are shown. (2 pages)

a) Proposed line with no parallel line (Configuration A-1).

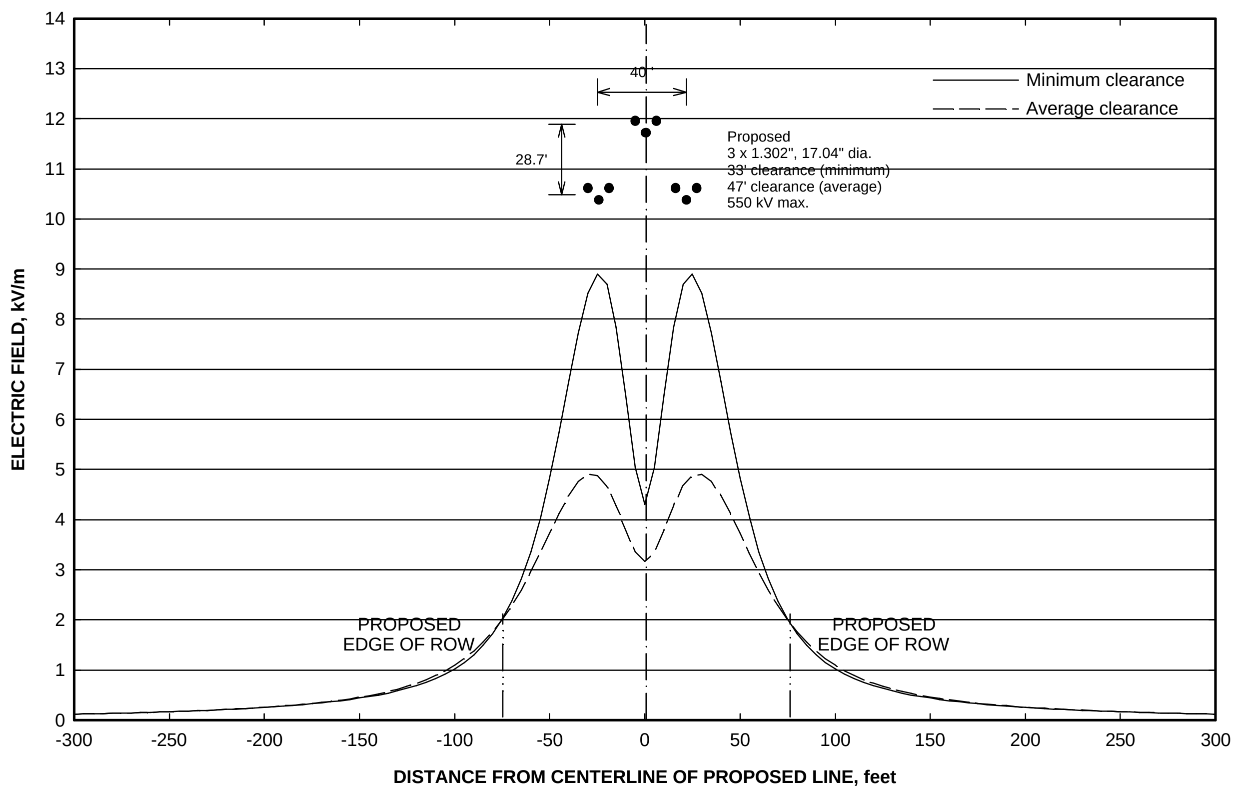
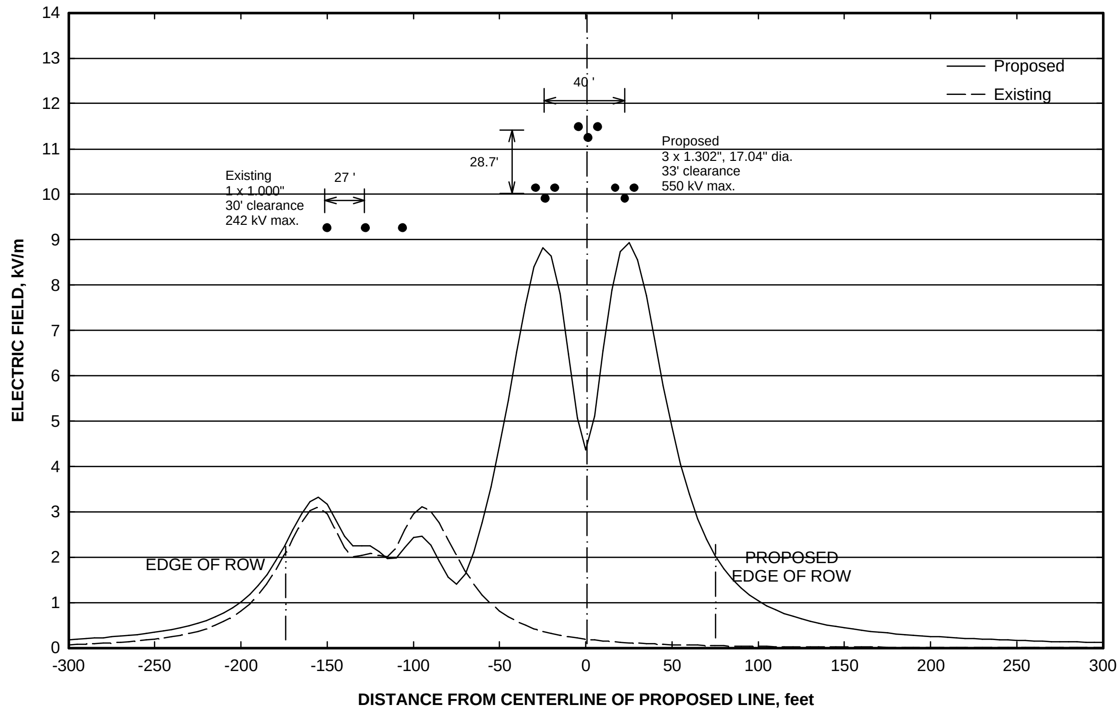


Figure 2, continued

b) Proposed line with parallel 230-kV line (Configuration D-1)



c) Proposed line with parallel 115-kV and 230-kV lines (Configuration D-3)

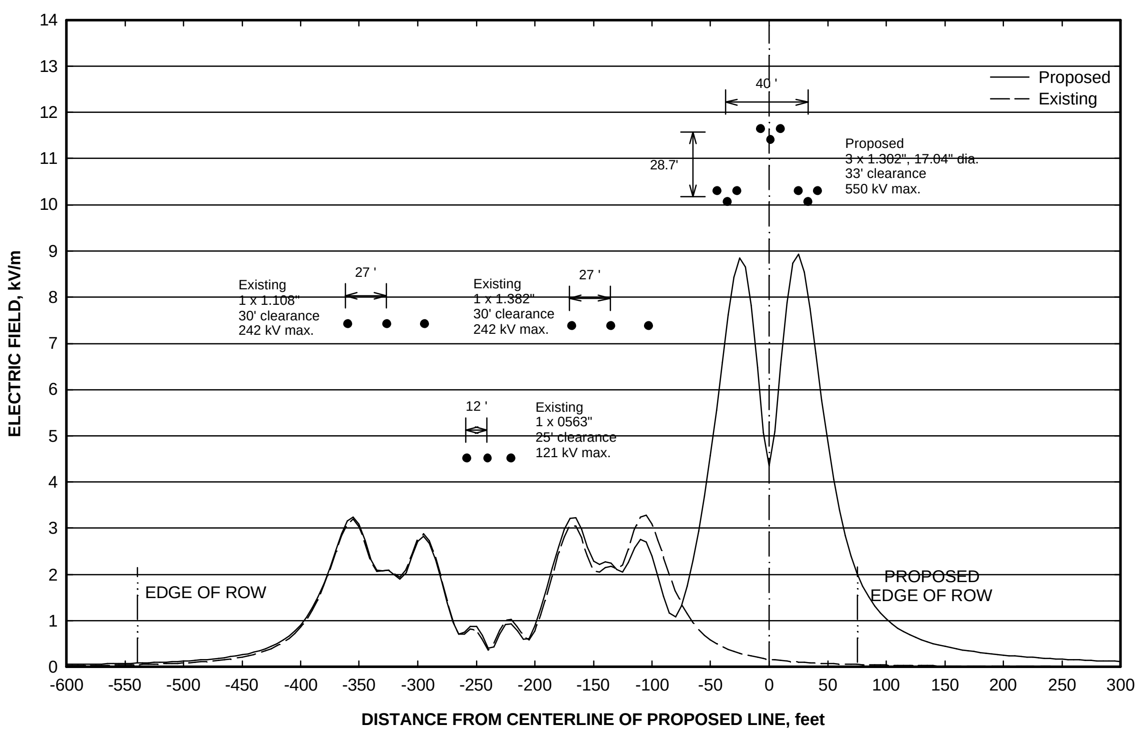


Figure 3: Magnetic-field profiles for selected configurations of the proposed Schultz–Hanford/Wautoma 500-kV line under maximum current conditions: a) proposed line with no parallel line (Configuration A-1); b) proposed line with parallel 230-kV line (Configuration D-1); and c) proposed line with parallel 115-kV and 230-kV lines (Configuration D-3). (2 pages)

a) Proposed line with no parallel line (Configuration A-1)

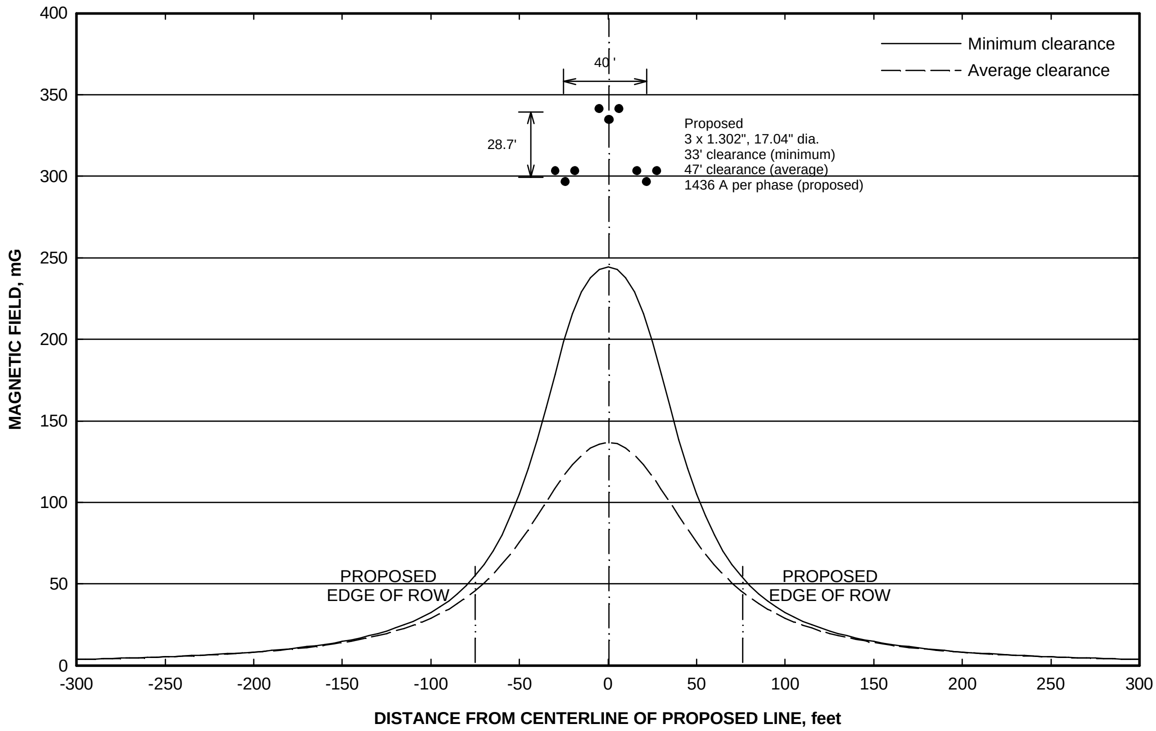
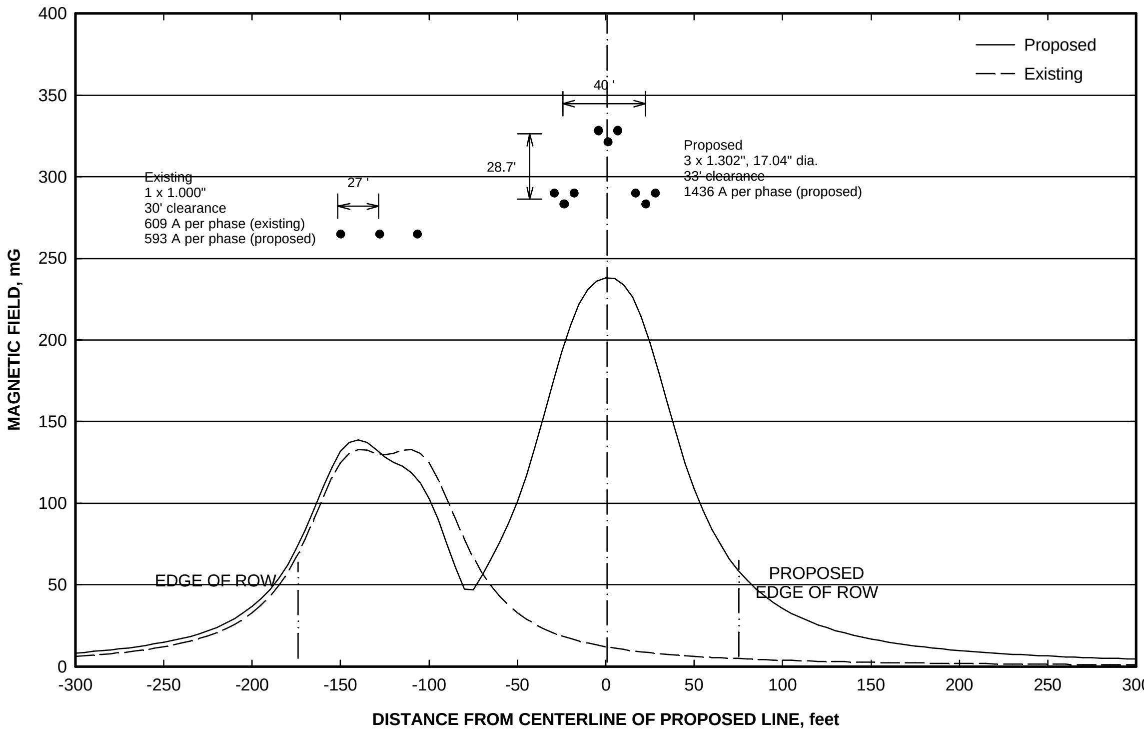


Figure 3, continued

b) Proposed line with parallel 230-kV line (Configuration D-1).



c) Proposed line with parallel 115-kV and 230 kV lines (Configuration D-3)

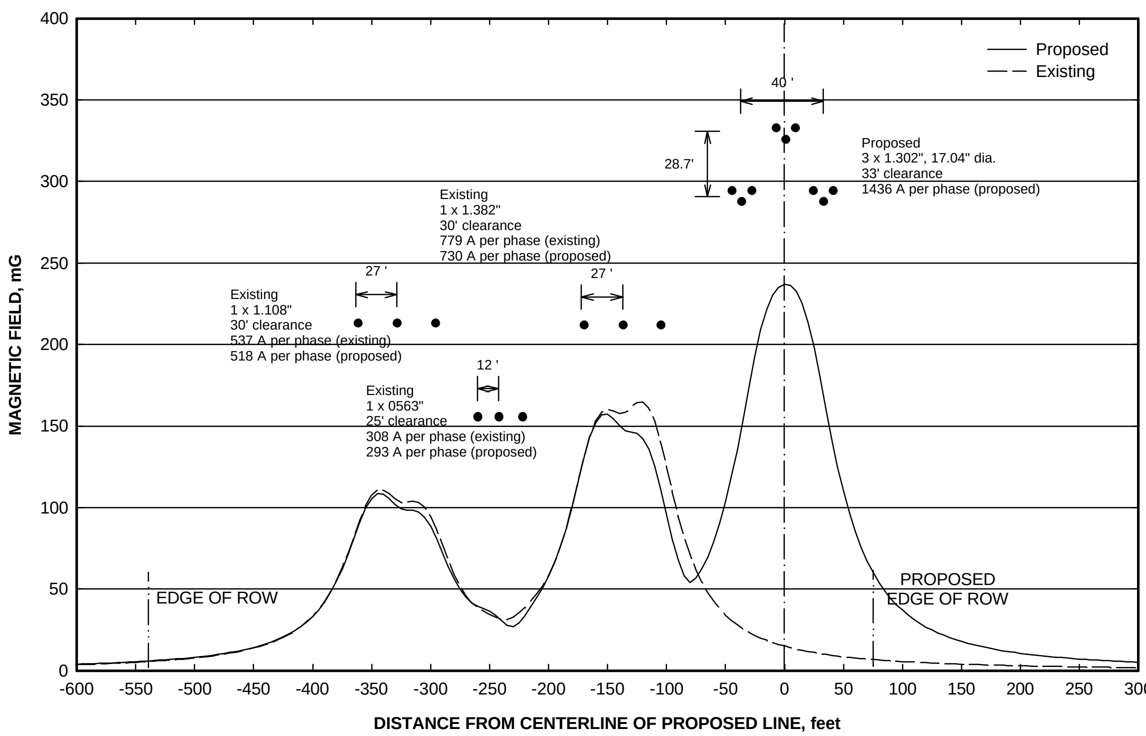


Figure 4: Predicted foul-weather L_{50} audible noise levels from selected configurations of proposed Schultz–Hanford/Wautoma 500-kV line a) proposed line with no parallel line (Configuration A-1); b) proposed line with parallel 230-kV line (Configuration D-1); and c) proposed line with parallel 115-kV and 230-kV lines (Configuration D-3). (2 pages)

a) Proposed line with no parallel line (Configuration A-1).

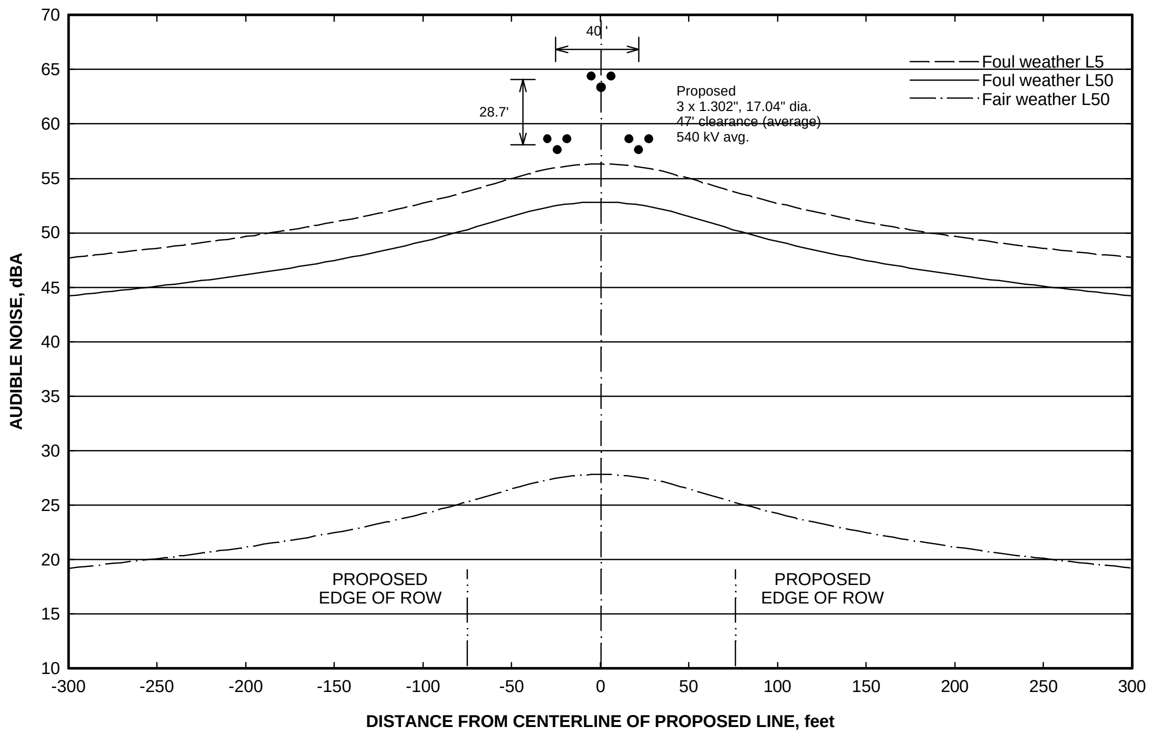
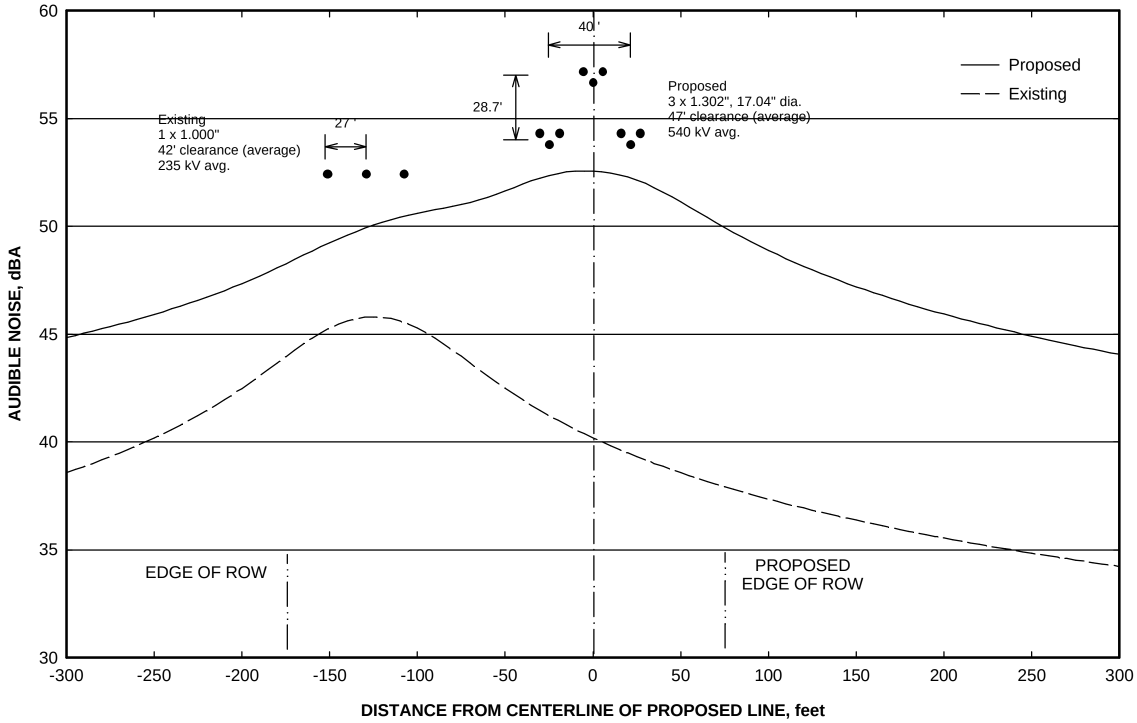
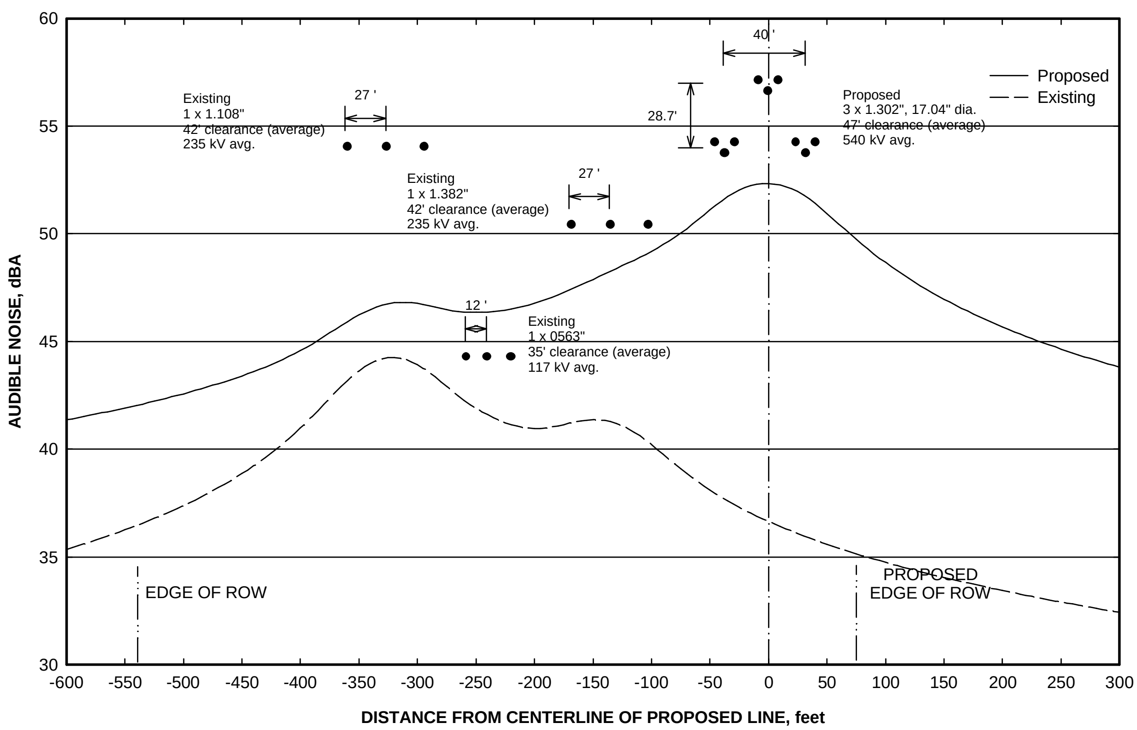


Figure 4, continued

b) Proposed line with parallel 230-kV line (Configuration D-1).



c) Proposed line with parallel 115-kV and 230-kV lines (Configuration D-3).



SCHULTZ - HANFORD AREA TRANSMISSION LINE PROJECT

ADDENDUM to

APPENDIX I

ELECTRICAL EFFECTS

August 28, 2001

Prepared by
T. Dan Bracken, Inc.

For

Parsons Brinckerhoff

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ADDENDUM

In the course of evaluating routing options for the proposed Schultz-Hanford Area Transmission Line Project, additional corridor options were identified. These new corridor options entail different configurations than those analyzed in the original Electrical Effects and Health Assessment appendices prepared for the project. 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 calculation methods and impacts related to fields and corona-generated audible noise and electromagnetic interference are discussed in the Electrical Effects appendix.

A.1 New configurations

The new corridor options for the Schultz - Hanford 500-kV line are as follows: 1) a section of Alternative G where the proposed Schultz – Hanford/Wautoma 500-kV line would parallel the existing Pacificorp 230-kV Wanapum – Pomona Heights line just west of the Columbia River crossing into Vantage Substation; and 2) a section of Alternative D1 where the proposed line would be placed on a double-circuit tower with the existing BPA Vantage – Midway 230-kV line. 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 two new configurations are summarized in Table A3 and plotted in Figure A2. The levels in Configuration G are very similar to those in the other configurations (D1 to D4) where the proposed 500-kV line parallels existing 230-kV lines. The calculated maximum electric fields under the proposed double-circuit line in Configuration D-1A are slightly higher than those for other configurations of the proposed 500-kV line and exceed 9 kV/m, the BPA limit for electric fields. The maximum field could be reduced below 9 kV/m by an increase in the minimum conductor height of 0.3 feet. The electric fields at the edge of the right-of-way would be lower for the double-circuit configuration (D-1A) than for the single-circuit delta configuration used elsewhere.

A.3 Magnetic-field levels

Calculated magnetic-field levels for the two new configurations are summarized in Table A4 and plotted in Figure A3. The levels for Configuration G are consistent with those for other configurations that include a single-circuit tower for the proposed 500-kV line. The maximum magnetic field under Configuration G would be 248 mG. Magnetic fields under the proposed double-circuit line of Configuration D-1A are somewhat lower with a maximum field on the right-of-way of 187 mG.

A.4 Audible noise levels

Corona-generated audible noise levels from the new configurations are shown in Table A5. The foul weather L_{50} and L_5 levels predicted for these configurations will be comparable with those for the previously considered configurations. The foul weather L_{50} level at the edge of the right-of-way will not exceed the 50-dBA limit established by BPA.

A.5 Electromagnetic interference

Corona-generated electromagnetic interference levels for the new configurations are shown in Tables A6 and A7 for radio interference (1 MHz) and television interference (75 MHz), respectively. The levels are comparable with those predicted for the other proposed configurations and are within acceptable levels.

A.6 Conclusions

The predicted levels for electric fields, magnetic fields, and corona effects from the new configurations are very similar to those calculated for the original configurations. Therefore, they do not change the basic conclusions of either the Electrical Effects or Health Assessment appendices prepared previously.

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.

Table A1: Physical and electrical characteristics of additional Schultz-Hanford Area Project configurations.

Segment-Configuration	Proposed A-1	Existing G	Proposed D-1A	
Line Description	Schultz-Hanford/ Wautoma 500-kV	Wanapum – Pomona Heights 230-kV	Schultz – Hanford/Wautoma & Existing BPA Vantage – Midway 230-kV	
			500-kV	230-kV
Voltage, kV Maximum/Average[1]	550/540	242/235	550/540	242/235
Peak current, A Existing/Proposed[2]	— /1436	-640/-640	— /1436	609/593
Electric phasing	BAC	ABC	ABC	CBA
Clearance, ft. Minimum/Average[1]	33/47	30/42	33/47	33/47
Centerline distance/direction from Schultz – Hanford/ Wautoma 500-kV Line, ft.	—	137.5/S	—	
Centerline distance to edge of ROW, ft.	75	62.5	75	
Tower configuration	Delta	Flat	Double-circuit Vertical	
Phase spacing, ft.	40 H, 28.7 V	17.5H	36.5 H, 56.5 H, 36.5 H, 36 V	
Conductor: #/diameter, in.; spacing, in.	3/1.302; 17.04	1/1.38	3/1.302; 17.04	3/1.302; 17.04

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford line.
H = horizontal V = vertical

Table A2: Possible additional segment configurations for Schultz - Hanford Area Project

Segment-Configuration	Description of other lines in corridor with Schultz–Hanford/Wautoma 500-kV line	Miles
G	Pacificorp Wanapum – Pomona Heights 230-kV	6
D-1A	Vantage – Midway 230-kV	8

Table A3: Calculated electric fields for configurations of the proposed Schultz – Hanford/Wautoma 500-kV line operated at maximum voltage. Configurations are described in Tables A1 and A2.

a) Configuration G: Schultz – Hanford/Wautoma 500-kV line and Pacificorp Wanapum – Pomona Heights 230-kV line

Configuration	**Proposed G**				**Existing G**	
ROW width, ft.	275				125	
Line	Schultz – Hanford/ Wautoma 500-kV		Pacificorp Wanapum – Pomona Heights 230-kV		Pacificorp Wanapum – Pomona Heights 230-kV	
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	8.9	4.9	2.7	1.5	2.7	1.5
Edge of ROW, kV/m	2.0	2.0	1.0	0.9	0.8	0.8

b) Configuration D-1A: Schultz – Hanford/Wautoma 500-kV and Vantage – Midway 230-kV lines

Configuration	**Proposed D-1A**				**Existing D-1A**	
ROW width, ft.	125				100	
Line	Vantage – Midway & Schultz – Hanford/Wautoma				Vantage – Midway 230-kV	
	230-kV		500-kV			
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, kV/m	5.1*	3.4*	9.1	5.0	3.1	1.8
Edge of ROW, kV/m	1.4	1.0	1.2	1.3	2.0	1.5

* At centerline.

Table A4: Calculated magnetic fields for configurations of the proposed Schultz–Hanford/Wautoma 500-kV line operated at maximum current. Configurations are described in Tables A1 and A2.

a) Configuration G: Schultz – Hanford/Wautoma 500-kV and Pacificorp Wanapum – Pomona Heights 230-kV line

Configuration	**Proposed G**				**Existing G**	
ROW width, ft.	275				125	
Line	Schultz – Hanford/ Wautoma 500-kV		Pacificorp Wanapum – Pomona Heights 230-kV		Pacificorp Wanapum – Pomona Heights 230-kV	
Clearance	min.	avg.	Min.	avg.	min.	avg.
Peak field, mG	248	140	130	75	125	70
Edge of ROW, mG	53	44	26	20	29	24

b) Configuration D-1A: Schultz – Hanford/Wautoma 500-kV and Vantage – Midway 230-kV line

Configuration	**Proposed D-1A**				**Existing D-1A**	
ROW width, ft.	125				100	
Line	Vantage – Midway & Schultz – Hanford/Wautoma				Vantage – Midway 230-kV	
	230-kV		500-kV			
Clearance	min.	avg.	min.	avg.	min.	avg.
Peak field, mG	167	95	187	103	133	84
Edge of ROW, mG	44	36	64	51	67	49

Table A5: Predicted foul-weather audible noise (AN) levels at edge of right-of-way (ROW) for proposed Schultz – Hanford/Wautoma 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 Schultz-Hanford Area Transmission 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
G	275 (84)	48, 45	52, 49	125	39	42
D-1A	125 (38)	49, 48	53, 52	100 (30)	43	46

1 Configurations are described in Tables A1 and A2.

Table A6: Predicted fair-weather radio interference (RI) levels at 100 feet (30.5 m) from the outside conductor of the proposed Schultz – Hanford/Wautoma 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 Schultz – Hanford Area Transmission Line Project ROW is given first.

	Fair-weather RI	
	Proposed	**Existing**
Configuration[1]	**L_{50}, dBmV/m**	**L_{50}, dBmV/m**
G	38, 29	26
D-1A	41, 38	30

1 Configurations are described in Tables A1 and A2.

Table A7: Predicted maximum foul-weather television interference (TVI) levels predicted at 100 feet (30.5 m) from the outside conductor of the proposed Schultz – Hanford/Wautoma 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 Schultz – Hanford Area Transmission Line Project ROW is given first.

	Foul-weather TVI	
	Proposed	**Existing**
Configuration[1]	**Maximum (foul), dBmV/m**	**Maximum (foul), dBmV/m**
G	24, 12	13
D-1A	24, 19	17

1 Configurations are described in detail in Tables A1 and A2.

Figure A1: Additional configurations for proposed Schultz-Hanford Area Transmission Line Project 500-kV line: a) Proposed line with parallel Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G); and b) Proposed line on double-circuit tower with existing BPA 230-kV line (Configuration D-1A). (2 pages)

a) Proposed 500-kV line parallel to Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G) (not to scale)

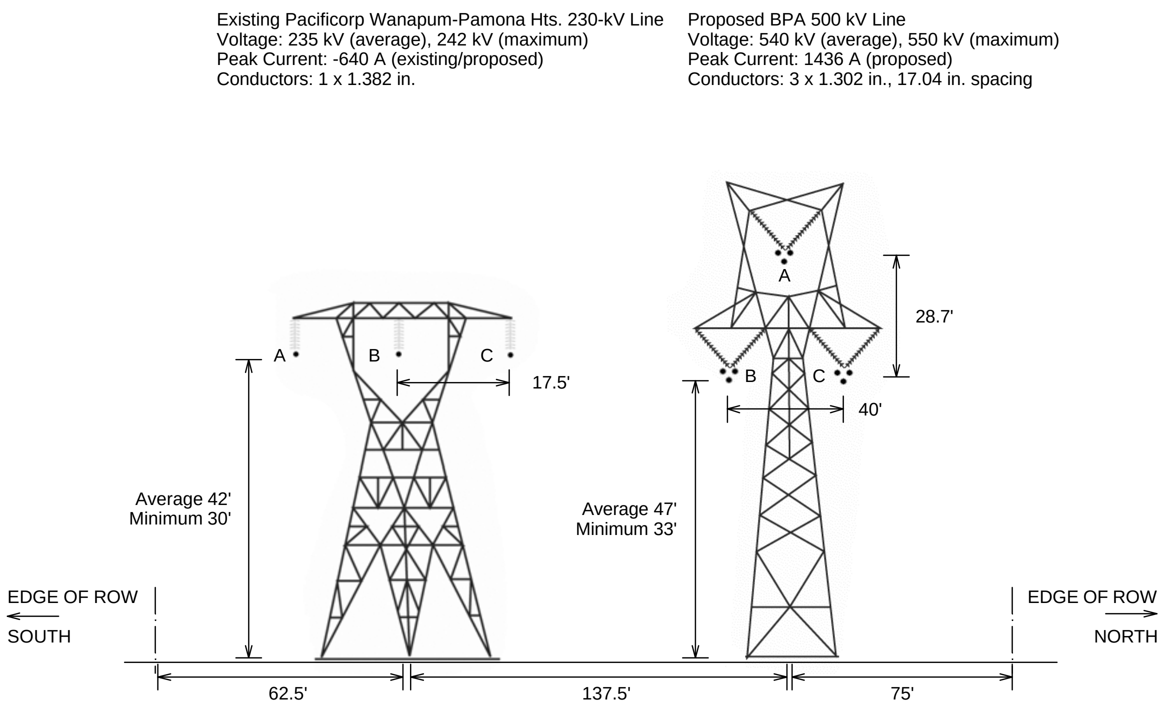


Figure A1, continued

b) Proposed 500-kV line on double-circuit tower with existing BPA Vantage – Midway 230-kV line (Configuration D-1A) (Not to scale)

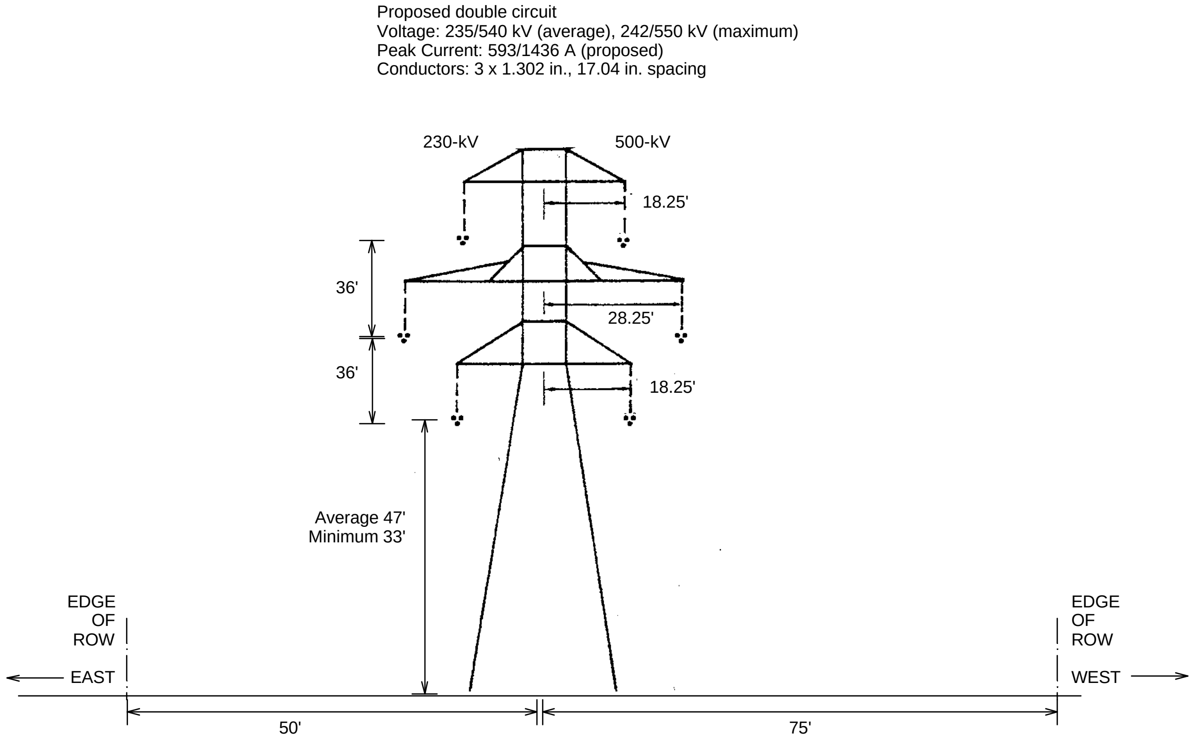


Figure A2: Electric-field profiles for additional configurations of proposed Schultz – Hanford/Wautoma 500-kV line: a) Proposed 500-kV line parallel to Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G); and b) proposed 500-kV line on double-circuit tower with existing BPA Vantage – Midway 230-kV line (Configuration D-1A). Fields for maximum voltage and minimum clearances are shown. (2 pages)

a) Proposed 500-kV line parallel to Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G).

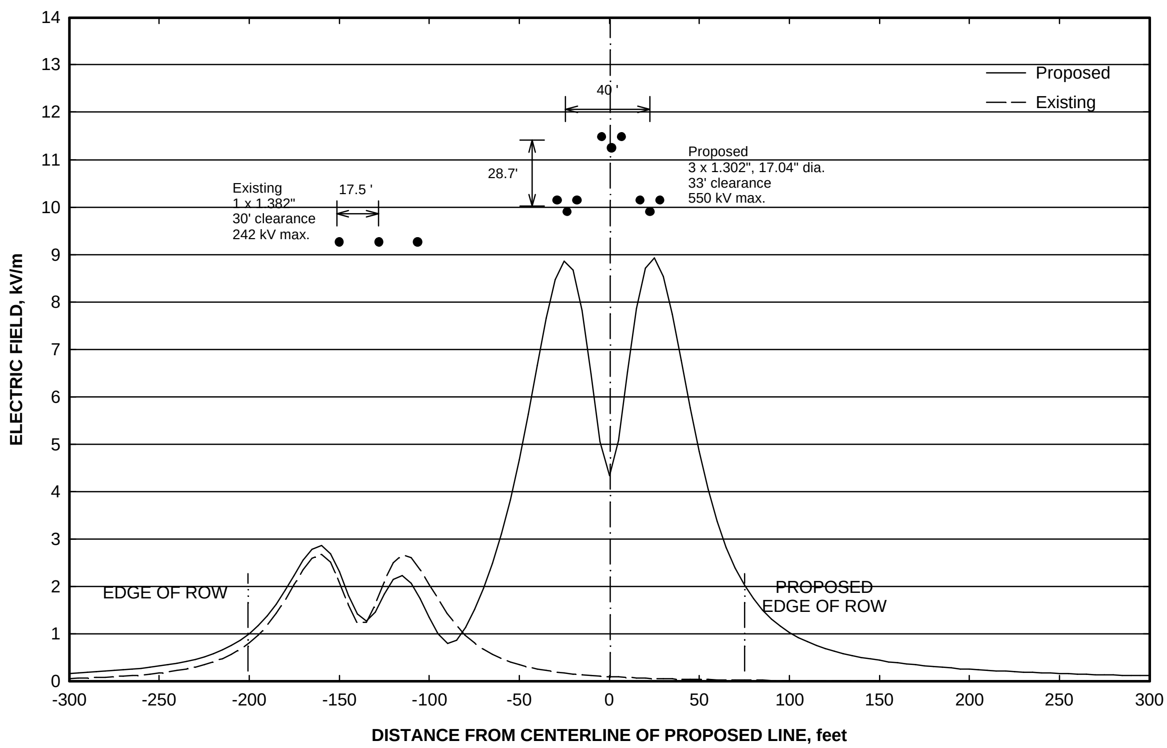


Figure A2, continued

b) Proposed 500-kV line on double-circuit tower with existing BPA Vantage – Midway 230-kV line (Configuration D-1A)

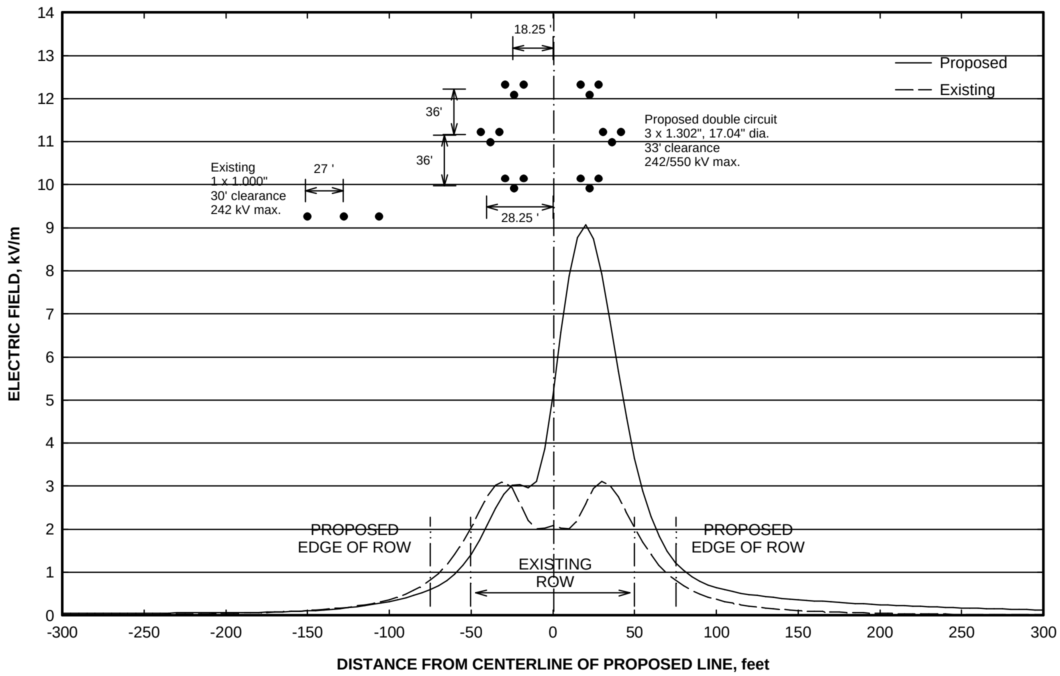


Figure A3: Magnetic-field profiles for additional configurations of the proposed Schultz–Hanford/Wautoma 500-kV line under maximum current conditions:
a) Proposed 500-kV line parallel to Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G); and b) proposed 500-kV line on double-circuit tower with BPA Vantage – Midway 230-kV line (Configuration D-1A). (2 pages)

a) Proposed 500-kV line parallel to Pacificorp Wanapum – Pomona Heights 230-kV line (Configuration G).

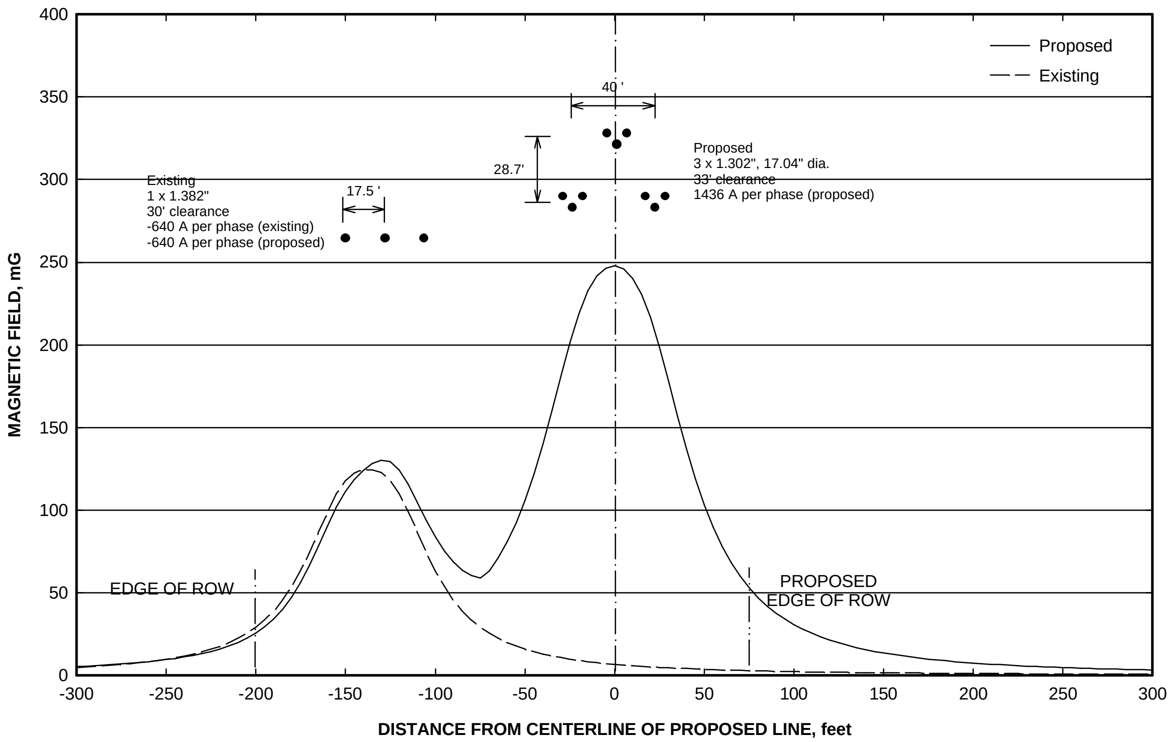
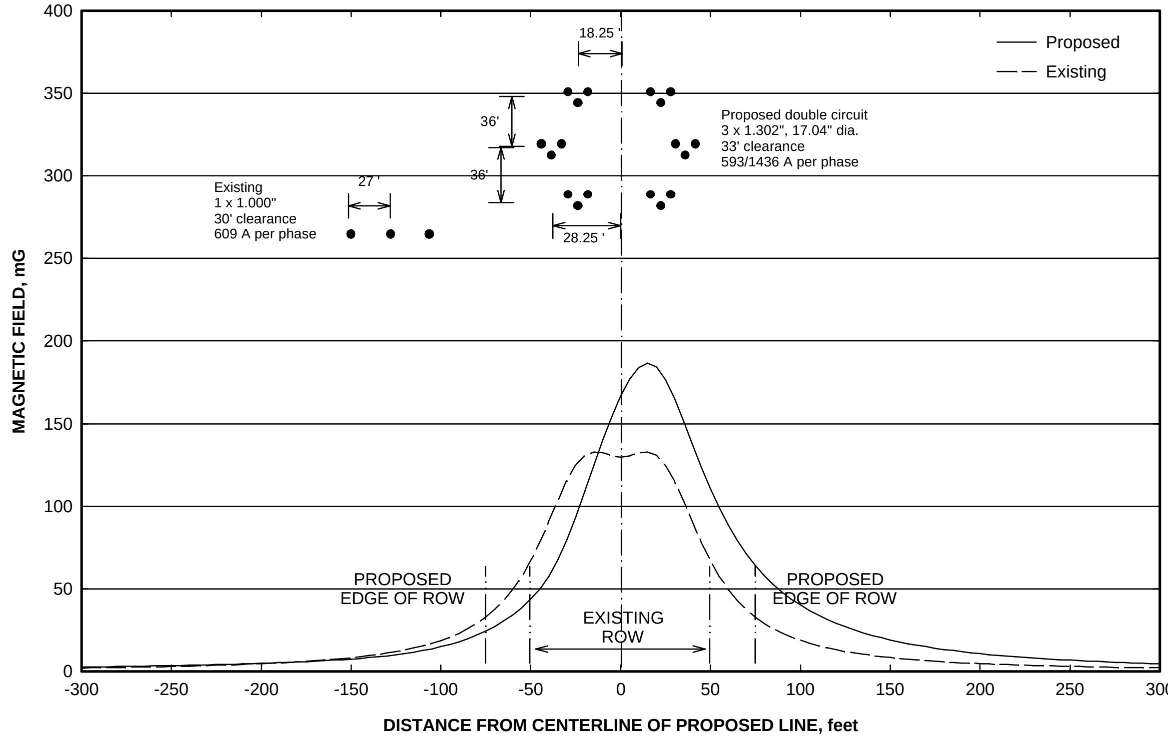


Figure A3, continued

b) Proposed 500-kV line on double-circuit tower with BPA Vantage – Midway 230-kV line (Configuration D-1A)



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SCHULTZ - HANFORD AREA TRANSMISSION-LINE PROJECT

ADDENDUM #2 to

APPENDIX I

ELECTRICAL EFFECTS

July 2002

Prepared by
T. Dan Bracken, Inc.

For

Parsons Brinckerhoff

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ADDENDUM #2

In the course of evaluating routing locations for the proposed Schultz-Hanford Area Transmission-line Project, five additional corridor layouts were identified: three in Segment A and two in Segment D. They entail different configurations than those analyzed in the original Electrical Effects and Health Assessment appendices prepared for the project. 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 five new configurations. The predicted levels from the proposed lines are compared with those from the no-action alternative in the same area. A previous Addendum described two additional configurations in Segments G and D.

Two of the new corridor configurations in Segment A (designated Configurations A-1A and A-1B) would be located in the area of Kittitas County where the proposed line would cross Coleman Road and Cookes Creek. The other three new corridor configurations incorporate structures with the conductors in a flat configuration instead of the delta (triangular) configuration that was originally considered. The flat configuration would be introduced in Segments A and B_{south} where the line crosses the Yakima Training Center (A-1C), in Segment D just south of the Vantage Substation (D-1B), and in a short section of Segment D just south of the Midway Substation (D-2A).

The calculation methods and impacts related to electric and magnetic fields and corona-generated audible noise and electromagnetic interference are discussed in the Electrical Effects appendix. An elevation of 2380 feet (ft.) (726 meters [m]) was assumed in the calculations for the Configurations A-1A and A1- B; 2000 ft. (610 m) was assumed for Configuration A-1C; and 1200 ft. (366 m) was assumed for Configurations
D1-B and D-2A.

Since the initial Electrical Effects appendix was completed, the Bonneville Power Administration has adopted a slightly modified structure design for single-circuit delta-configuration 500-kV lines. 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 both the proposed Schultz – Hanford/Wautoma and the rerouted Vantage – Schultz 500-kV lines in Configurations A-1A and A-1B. (See Table A2-1 and Figure A2-1.)

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 and Addendum #1 are still valid.

The new flat configuration incorporates a horizontal spacing of 35 ft. (10.7 m) between conductor bundles and would require a 180-ft. (55-m) right-of-way (ROW). The minimum clearance is 36 ft. (11 m); the average clearance is about 46 ft. (14 m).

A2.1 New configurations

The new corridor configurations for the Schultz – Hanford/Wautoma 500-kV line would replace those short sections of Segments A, B, and D previously included in the analyses of Configurations A-1, D-1, and D-2. The new configurations are as follows:

- Configuration A-1A would be a 5.7-mile section of Segment A where the route crosses Coleman Road and Cookes Creek. In this section the proposed Schultz – Hanford/Wautoma 500-kV line would parallel the existing Vantage – Schultz 500-kV line with a 200-foot spacing;
- Configuration A-1B would be a 1.4-mile section of Segment A in the area where the route crosses Coleman Road and Cookes Creek. In this section the proposed line would parallel a rerouted Vantage – Schultz 500-kV line with a separation of 200 feet on new right-of-way.
- Configuration A-1C would be a 14.8-mile section of Segments A and B_{south} where these routes cross the north end of the Yakima Training Center. In this section the proposed Schultz – Hanford/Wautoma 500-kV line would be constructed in a flat configuration without any parallel lines. It would require an additional 30 ft. (9 m) of ROW beyond that required for Configuration A-1.
- Configuration D-1B would be a 4.7-mile section of Segment D just south of the Vantage Substation where the proposed line crosses Saddle Mountain. In this section the proposed Schultz – Hanford/Wautoma 500-kV line would be constructed in a flat configuration parallel to the existing Vantage – Midway 230-kV line. It would require an additional 15 ft. (4.6 m) of ROW beyond that for Configuration D-1 for a total of 165 ft. (50.3 m) of new ROW.
- Configuration D-2A would be a 1.7-mile section of Segment D just south of the Midway Substation where the proposed line crosses the Hanford Monument. In this section the proposed Schultz – Hanford/Wautoma 500-kV line would be constructed in a flat configuration parallel to the existing North Bonneville – Midway 230-kV, Midway – Moxee 115-kV, Midway – Grandview 115-kV, and Big Eddy – Midway 230-kV lines. It would require an additional 15 ft. (4.6 m) of new ROW beyond that for Configuration D-2, for a total of 165 ft. (50.3 m) of new ROW.

Figure A2-1 shows these configurations; their physical and electrical characteristics are given in Tables A2-1 and A2-2.

A2.2 Electric-field levels

Calculated electric fields for the five new configurations are summarized in Table A2-3 and plotted in Figure A2-2. The peak electric-field levels for the new configuration would be comparable with each other and with levels for other 500-kV line configurations in the project. Peak values for the five configurations are between 8.6 and 8.7 kV/m for minimum clearance conditions. The electric fields at the edges of the right-of-way for the new configurations would be lower near the proposed and rerouted 500-kV lines (about 2.5 kV/m) than near the existing Vantage – Schultz 500-kV line in Configuration A1-A (about 5.3 kV/m).

The new flat configuration would result in comparable peak and edge-of-ROW fields to those from the delta configuration that it would replace. However, it would require a wider ROW.

A2.3 Magnetic-field levels

Calculated magnetic-field levels for the five new configurations are summarized in Table A2-4 and plotted in Figure A2-3. The peak and edge-of-right-of-way field levels for the new configurations are similar to each other and to levels in other configurations for the proposed 500-kV line. The maximum magnetic field under the new configurations would be about 257 mG (Configurations D1-B and D2-A). The edge-of-right-of-way fields adjacent to the 500-kV lines in the new configurations would be about 70 mG. At the edge of the ROW away from the 500-kV lines, the magnetic fields would be lower. These magnetic-field levels would be lower than those that would be under and adjacent to the existing Vantage – Schultz 500-kV line under the no-action alternative.

A2.4 Audible-noise levels

Corona-generated audible-noise (AN) levels from the new configurations are shown in Table A2-5. The foul weather L_{50} and L_5 levels predicted for the edge of right-of-way nearest the proposed line will be comparable with those for the previously considered configurations. AN levels at both edges of the right-of-way of Configuration A-1A would be dominated by noise from the existing Vantage – Schultz 500-kV line. The AN from the existing line exceeds that observed for other configurations in the project; the foul-weather L_{50} at the edge of the right-of-way is about 65 dBA. The proposed line would only add about 1 dBA to the existing levels at both edges of the Configuration A-1A right-of-way. The foul weather L_{50} levels at the edges of the ROW of the other new configurations would be much lower and would not exceed the 50-dBA limit established by BPA.

A2.5 Electromagnetic interference

Corona-generated electromagnetic interference levels for the new configurations are shown in Tables A2-6 for radio interference (1 MHz) and in Table A2-7 for television interference (75 MHz). The levels would be at 100 ft. from the outside conductors for all new configurations except Configuration A1-A. For Configuration A1-A, electromagnetic interference levels are determined by levels from the existing Vantage – Schultz 500-kV line. The levels near the other new configurations are similar to those from other configurations in the project.

A2.6 Conclusions

The predicted levels for electric fields, magnetic fields, and corona effects from the new configurations are very similar to those calculated for the original configurations. Therefore, they do not change the basic conclusions of either the Electrical Effects or Health Assessment appendices that were prepared previously. The levels of corona-related effects for Configuration A-1A are strongly influenced by levels from the existing Vantage – Schultz 500-kV line. The older single-conductor design for this line results in significantly more corona activity than the three-conductor bundle design proposed for the new and rerouted lines.

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 A2-1: Physical and electrical characteristics of new Schultz - Hanford Area Transmission-line Project configurations.

Configuration	A-1A, A-1B	A-1A	A-1B	A-1C, D-1B, D-2A	D-1B
Line Description	**Proposed Schultz – Hanford/ Wautoma 500-kV**	**Existing Vantage – Schultz 500-kV**	**Rerouted Vantage – Schultz 500-kV**	**Proposed Schultz – Hanford/ Wautoma 500-kV**	**Existing Vantage – Midway 230-kV**
Voltage, kV Maximum/Average[1]	550/540	550/540	550/540	550/540	242/235
Peak current, A No-action/Proposed[2]	-/1436	1355/738	1355/738	-/1436	609/593
Electric phasing	BAC	BAC	BAC	BAC	ABC
Clearance, ft. Minimum/Average[1]	35/45	33/47	35/45	36/46	30/42
Centerline distance/direction from Schultz – Hanford/Wautoma 500-kV Line, ft.	-	200W	200W	-	125E
Centerline distance to edge of ROW, ft.	75	75	75	90	50
Tower configuration	Delta	Flat	Delta	Flat	Flat
Phase spacing, ft.[3]	48H, 34.5V	49	48H, 34.5V	35H	27H
Conductor: #/ diameter, in.; spacing, in.	3/ 1.300; 17.04	1/ 2.50	3/ 1.300; 17.04	3/1.300; 17.04	1/1.0

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford/Wautoma line.
3 H = horizontal feet; V = vertical feet

Table A2-1, continued

Configuration	**D-2A**			
Line Description	**Existing N. Bonneville – Midway 230-kV**	**Existing Midway – Moxee 115-kV**	**Existing Midway – Grandview 115-kV**	**Existing Big Eddy – Midway 230-kV**
Voltage, kV Maximum/Average[1]	242/235	121/117	121/117	242/235
Peak current, A No-action/Proposed[2]	537/518	153/154	308/293	779/730
Electric phasing	ABC	ABC	ABC	ABC
Clearance, ft. Minimum/Average[1]	30/42	25/35	25/35	30/42
Centerline distance/direction from Schultz – Hanford/ Wautoma 500-kV Line, ft.	375E	287.5E	237.5E	137.5E
Centerline distance to edge of ROW, ft.	187.5	-	-	62.5
Tower configuration	Flat	Flat	Flat	Flat
Phase spacing, ft.[3]	27H	12H	12H	27H
Conductor: #/ diameter, in.; spacing, in.	1/1.108	1/0.655	1/0.563	1/1.138

1 Average voltage and average clearance used for corona calculations.
2 Minus sign indicates current flow in opposite direction to flow in parallel proposed Schultz – Hanford/Wautoma line.
3 H = horizontal feet; V = vertical feet

Table A2-2: New configurations for Schultz - Hanford Area Project

Segment-Configuration	Description of other lines in corridor with Schultz – Hanford/Wautoma 500-kV line	Miles
A-1A	**Existing Vantage – Schultz 500-kV line**	5.7
A-1B	**Rerouted Vantage – Schultz 500-kV line**	1.4
A-1C	**None**	14.8
D-1B	**Existing Vantage - Midway 230-kV line**	4.7
D-2A	**Existing N. Bonneville – Midway 230-kV line** **Existing Midway - Moxee 115-kV line** **Existing Midway - Grandview 115-kV line** **Existing Big Eddy - Midway 230-kV line**	1.7

Table A2-3: Calculated peak and edge-of-right-of-way electric fields for new configurations of the proposed Schultz – Hanford/Wautoma 500-kV line operated at maximum voltage. Configurations are described in Tables A2-1 and A2-2.

a) Peak electric field on right-of-way, kV/m

Location	Proposed Corridor		No-action Alternative Corridor	
Line Clearance	**Minimum**	**Average**	**Minimum**	**Average**
A-1A	8.7	5.8	8.5	5.1
A-1B	8.6	5.8	-	-
A-1C	8.7	5.2	-	-
D-1B	8.7	5.2	3.1	1.8
D-2A	8.7	5.2	3.3	1.9

b) Edge-of-right-of-way electric field, kV/m

Location	Proposed Line[1]		No-action Alternative Corridor[1]	
Line Clearance	**Minimum**	**Average**	**Minimum**	**Average**
A-1A	2.5, 5.3	2.5, 4.1	5.2	4.1
A-1B	2.5, 2.5	2.4, 2.4	-	-
A-1C	2.6	2.5	-	-
D-1B	2.6, 2.0	2.5, 1.5	2.0	1.5
D-2A	2.6, 0.1	2.5, 0.1	1.4, 0.1	1.2, 0.1

1 Electric field at edge of right-of-way adjacent to proposed line is given first.

Table A2-4: Calculated peak and edge-of-right-of-way magnetic fields for new configurations of the proposed Schultz – Hanford/Wautoma 500-kV line operated at maximum current. Configurations are described in Tables A2-1 and A2-2.

a) Peak magnetic field on right-of-way, mG

Location	Proposed Corridor		No-action Alternative Corridor	
Line Clearance	**Minimum**	**Average**	**Minimum**	**Average**
A-1A	229	155	288	185
A-1B	234	159	-	-
A-1C	251	164	-	-
D-1B	257	169	133	84
D-2A	257	170	165	101

b) Edge-of-right-of-way magnetic field, mG

Location	Proposed Corridor[1]		No-action Alternative Corridor[1]	
Line Clearance	**Minimum**	**Average**	**Minimum**	**Average**
A-1A	71, 88	62, 66	158	117
A-1B	68, 38	59, 33	-	-
A-1C	70	60	-	-
D-1B	68, 65	58, 47	67	49
D-2A	67, 5	57, 5	62, 7	50, 7

[1] Magnetic field at edge of right-of-way adjacent to proposed line is given first.

Table A2-5: Predicted foul-weather audible-noise (AN) levels at edge of right-of-way (ROW) by configuration of the proposed Schultz – Hanford/Wautoma 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 Schultz-Hanford Area Transmission-line Project ROW is given first.

	Foul-weather AN					
	Proposed			No-action Alternative		
Configuration[1]	ROW ft. (m)	L_{50}, dBA	L_5, dBA	ROW ft. (m)	L_{50}, dBA	L_5, dBA
A-1A	350 (107)	59, 65	62, 68	150 (46)	65	68
A-1B	350 (84)	50, 50	54, 54	-	-	–
A-1C	180 (55)	49	53	-	-	-
D-1B	265 (81)	49, 48	52, 52	100 (30)	44	47
D-2A	652.5 (199)	49, 42	52, 45	487.5 (149)	39, 37	42, 41

[1] Configurations are described in Tables A2-1 and A2-2.

Table A2-6: Predicted fair-weather radio interference (RI) levels at 100 feet (30.5 m) from the outside conductor by configuration of the proposed Schultz – Hanford/ Wautoma 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 Schultz – Hanford Area Line Transmission-line Project ROW is given first.

	Fair-weather RI	
	Proposed	**No-action Alternative**
Configuration[1]	**L_{50}, dBμV/m**	**L_{50}, dBμV/m**
A-1A	38, 48	48
A-1B	38, 38	-
A-1C	38	-
D-1B	37, 31	31
D-2A	37, 28	22, 28

1 Configurations are described in Tables A2-1 and A2-2.

Table A2-7: Predicted maximum foul-weather television interference (TVI) levels predicted at 100 feet (30.5 m) from the outside conductor by configuration of the proposed Schultz – Hanford/Wautoma 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 Schultz – Hanford Area Transmission-line Project ROW is given first.

	Foul-weather TVI	
	Proposed	**No-action Alternative**
Configuration[1]	**Maximum (foul), dBμV/m**	**Maximum (foul), dBμV/m**
A-1A	25, 35	35
A-1B	25, 25	-
A-1C	23	-
D-1B	22, 19	18
D-2A	22, 16	9, 15

1 Configurations are described in Tables A2-1 and A2-2.

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Figure A2-1: New configurations for proposed Schultz - Hanford Area Transmission-line Project 500-kV line: a) Configuration A-1A; b) Configuration A-1B; c) Configuration A-1C; d) Configuration D-1B; and e) Configuration D-2A.
(5 pages)

a) Configuration A-1A - Proposed 500-kV line parallel to existing Vantage – Schultz 500-kV line (not to scale)

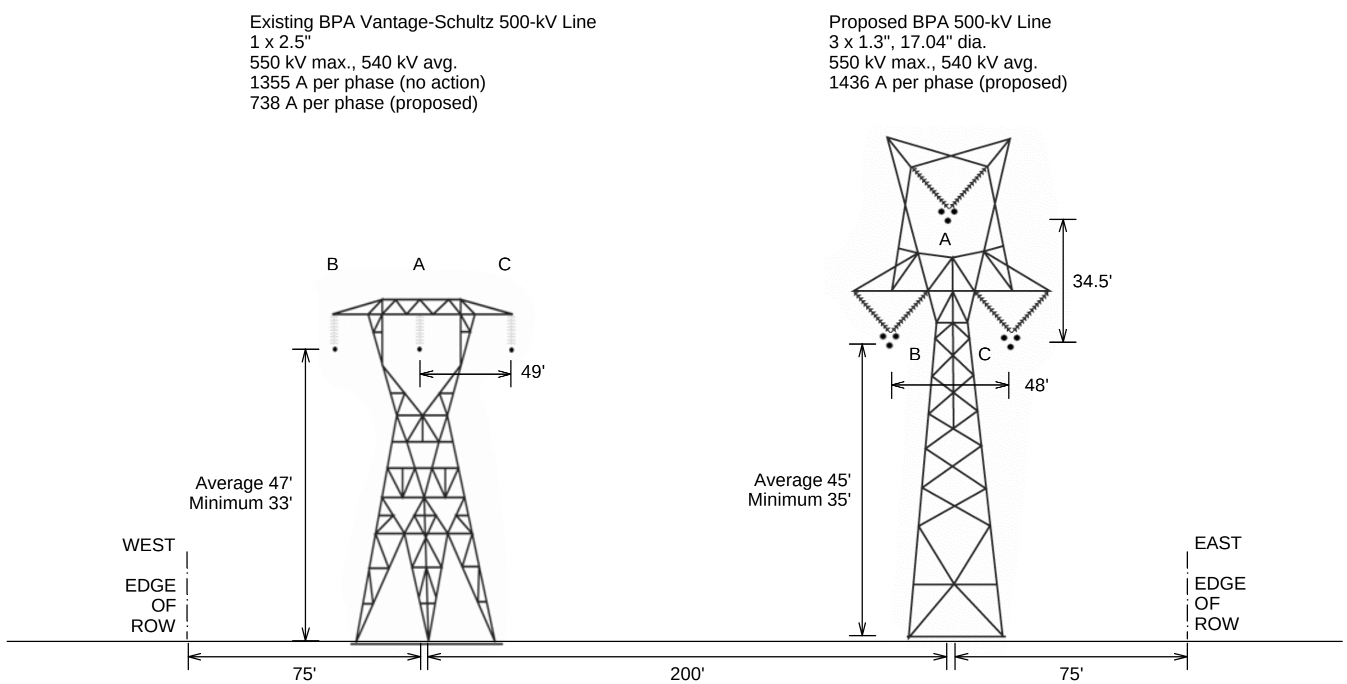

Figure A2-1, continued

b) Configuration A-1B - Proposed 500-kV line parallel to rerouted Vantage – Schultz 500-kV line (not to scale)

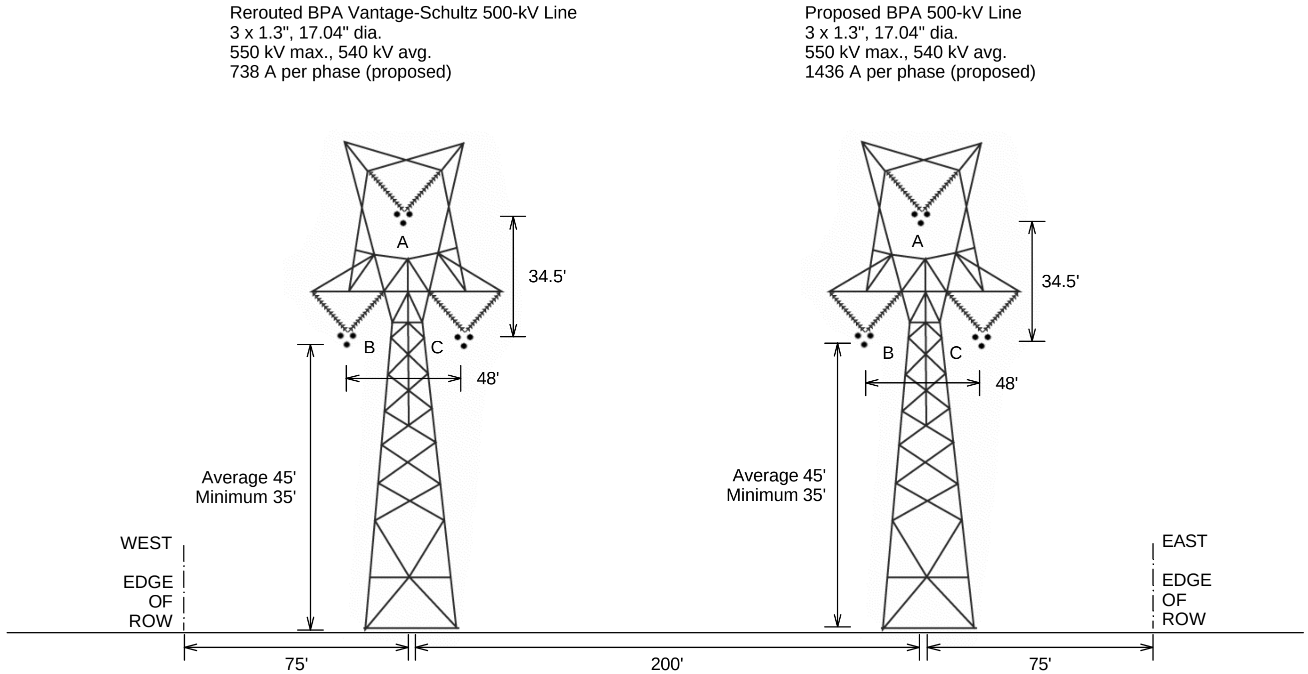

Figure A2-1, continued

c) Configuration A-1C - Proposed 500-kV line on flat structures (not to scale)

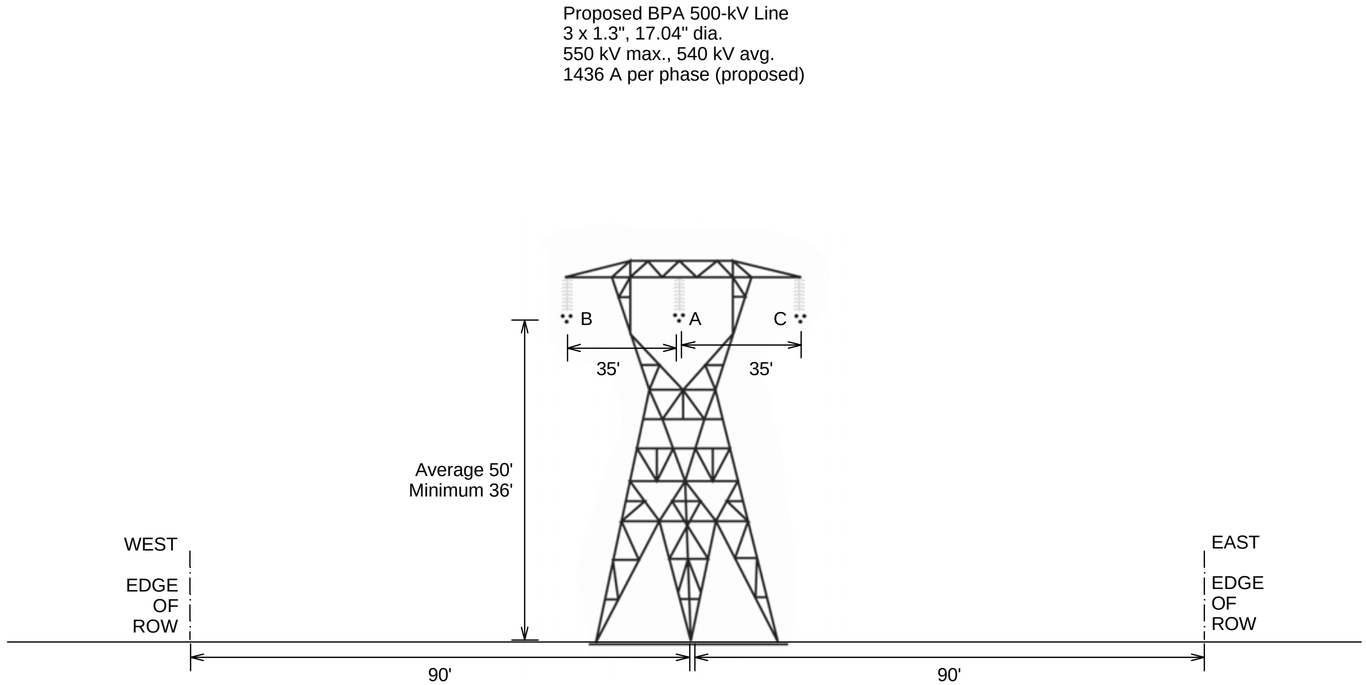

Figure A2-1, continued

d) Configuration D-1B - Proposed 500-kV line on flat structures parallel to Vantage – Midway 230-kV line (not to scale)

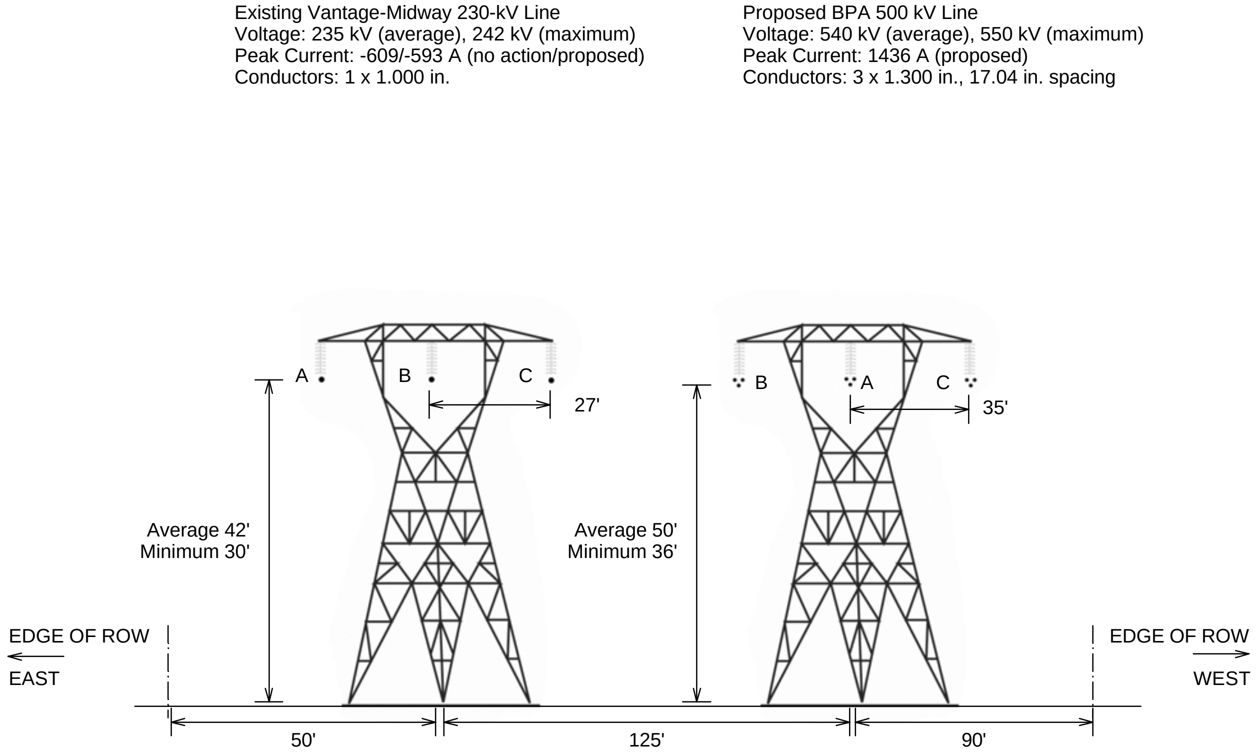

Figure A2-1, continued

e) Configuration D-2A - Proposed 500-kV line on flat structures parallel to two 230-kV lines and two 115-kV lines (not to scale)

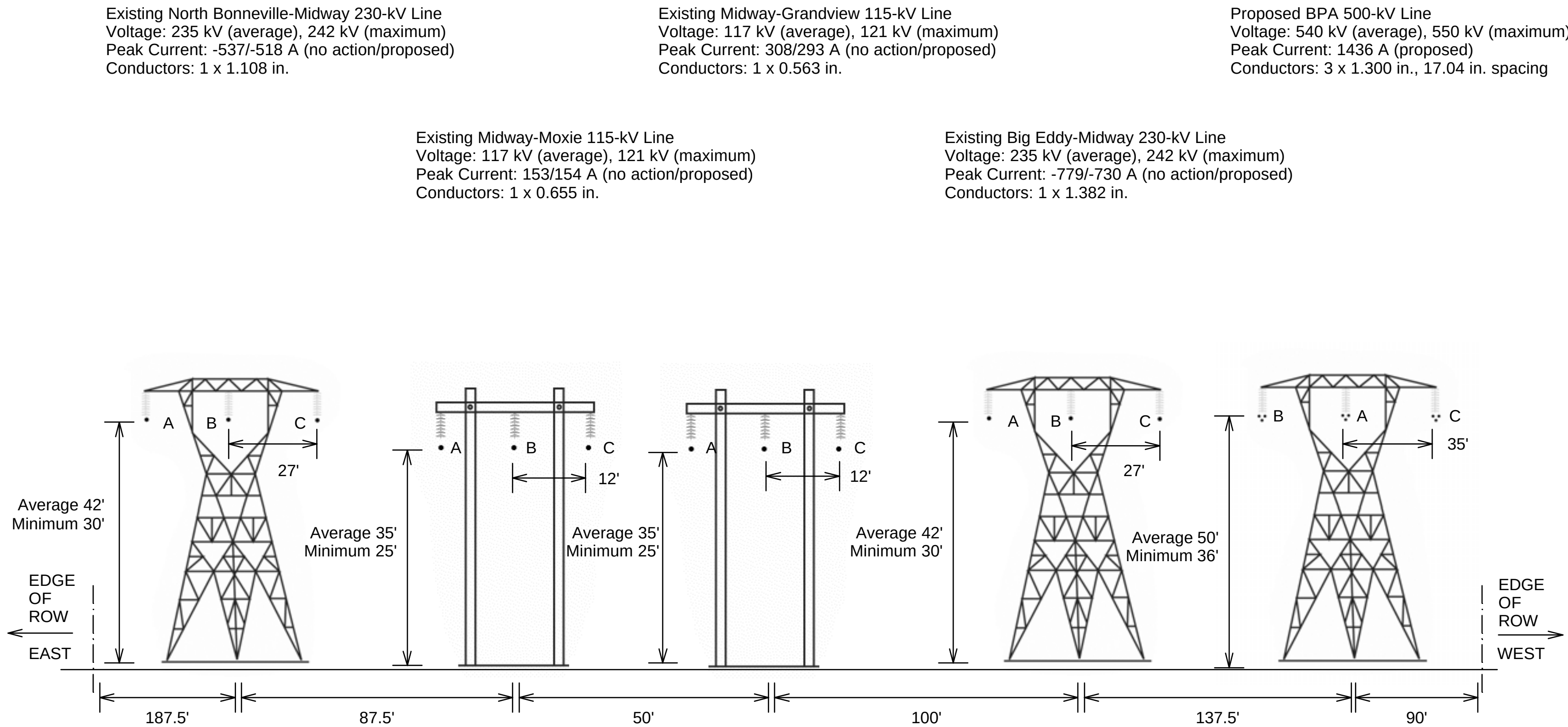

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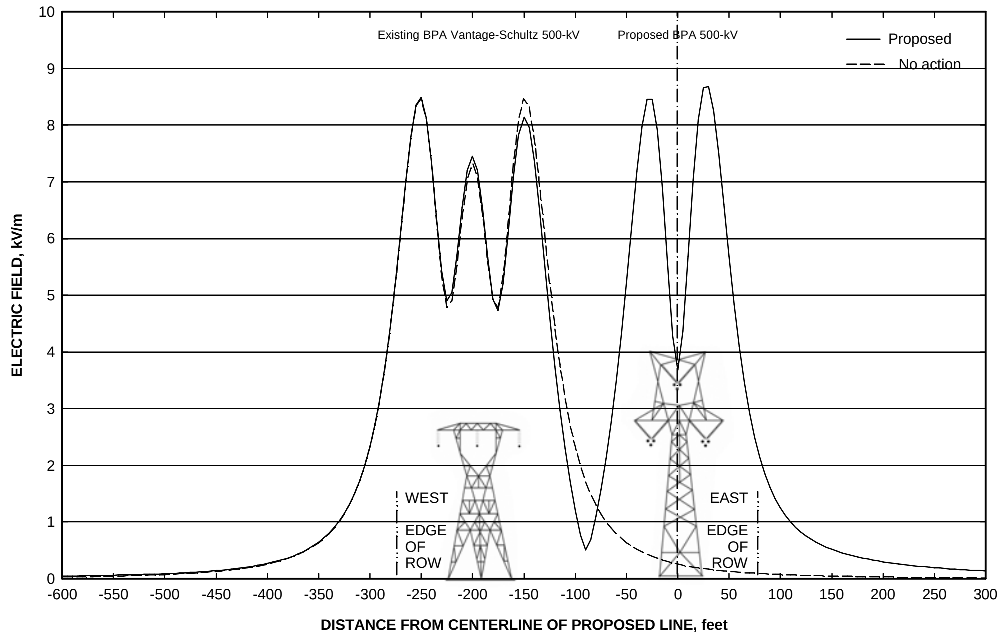
Figure A2-2: Electric-field profiles for new configurations of proposed Schultz – Hanford/ Wautoma 500-kV line for maximum voltage and minimum clearance: a) Configuration A-1A; b) Configuration A-1B; c) Configuration A-1C; d) Configuration D-1B; and e) Configuration D-2A. (3 pages)

a) Configuration A-1A - Proposed 500-kV line parallel to existing Vantage – Schultz 500-kV line



b) Configuration A-1B - Proposed 500-kV line parallel to rerouted Vantage – Schultz 500-kV line

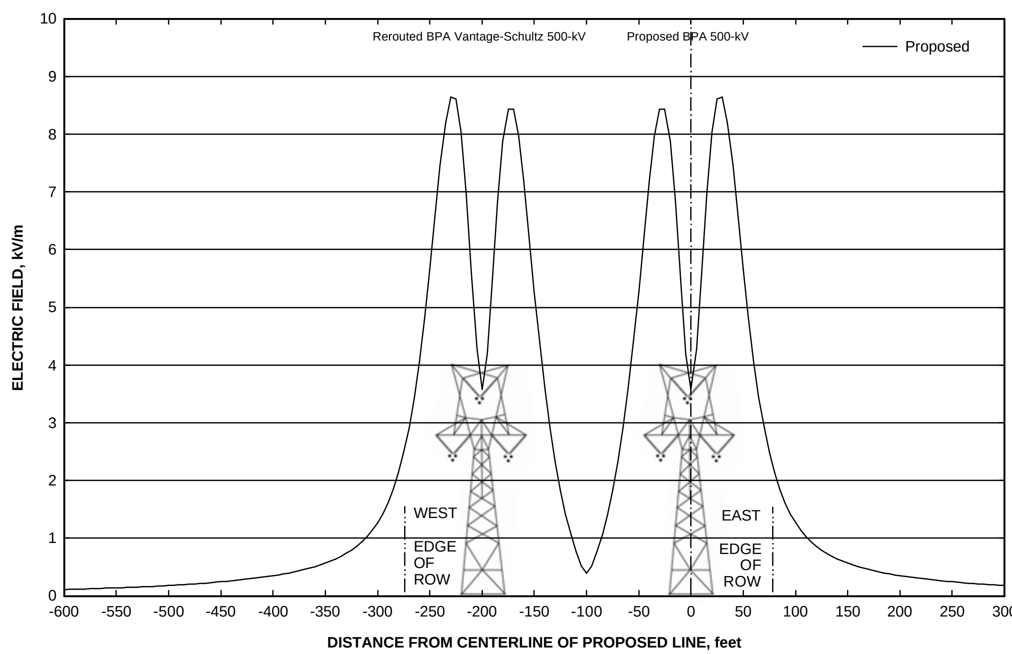
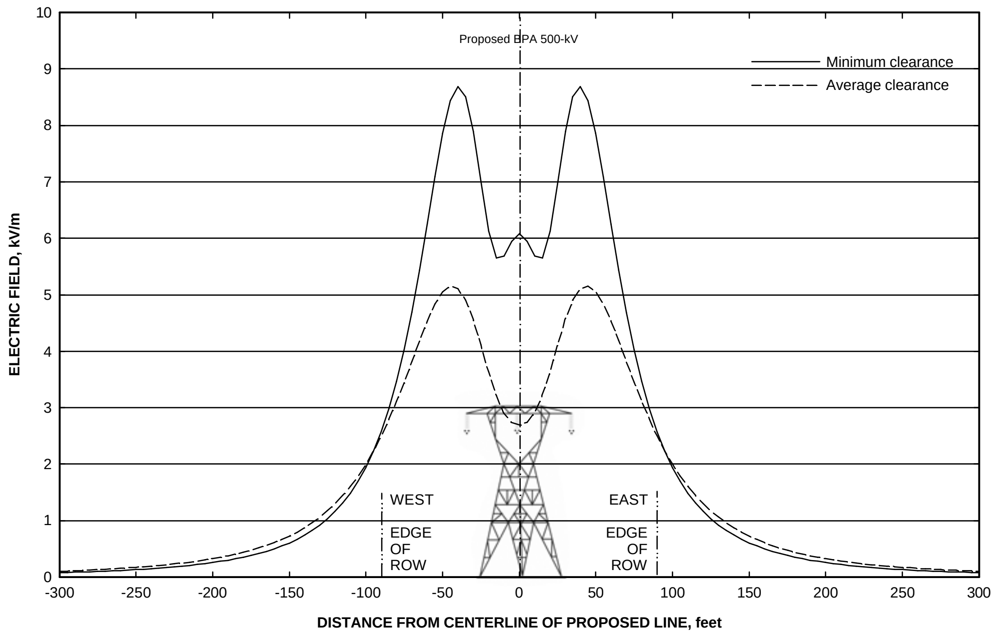


Figure A2-2, continued

c) Configuration A-1C - Proposed 500-kV line on flat configuration with no parallel lines



d) Configuration D-1B - Proposed 500-kV line with flat configuration parallel to existing Vantage – Midway 230-kV line

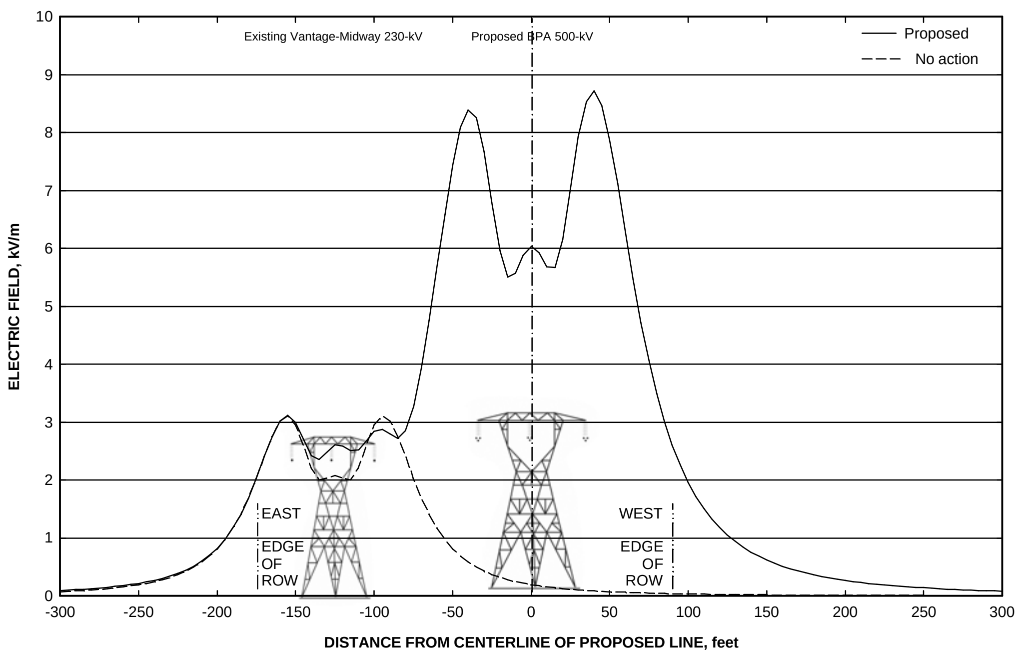


Figure A2-2, continued

e) Configuration D-2A - Proposed 500-kV line with flat configuration parallel to two 230-kV lines and two 15-kV lines

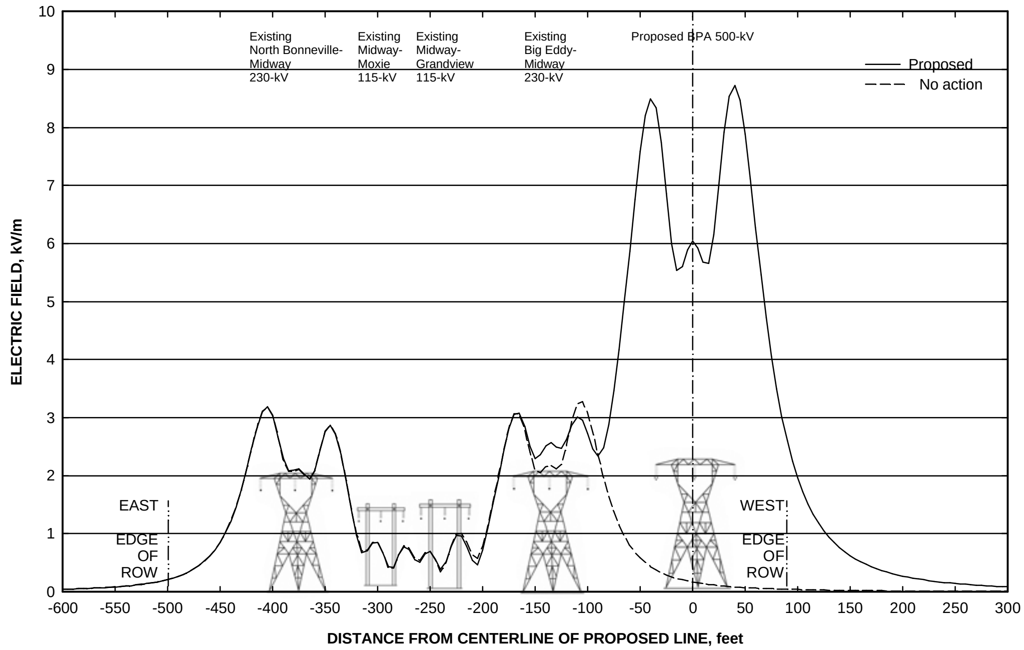
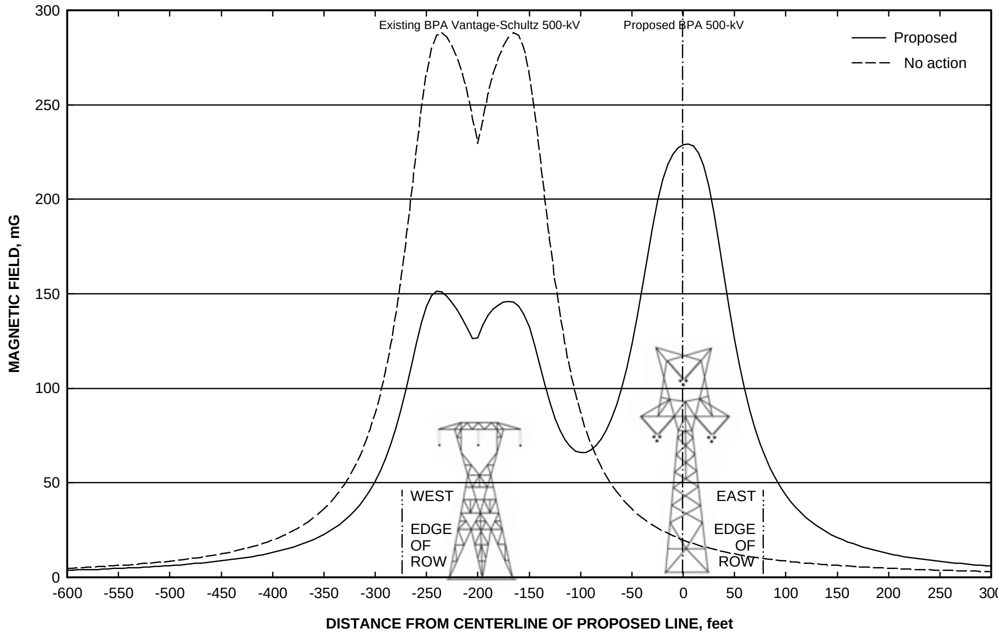


Figure A2-3: Magnetic-field profiles for new configurations of the proposed Schultz – Hanford/Wautoma 500-kV line for maximum currents and minimum clearances: **a) Configuration A-1A; b) Configuration A-1B;** c**) Configuration A-1C; d) Configuration D-1B; and e) Configuration D-2A.** (3 pages**)**

a) Configuration A-1A - Proposed 500-kV line parallel to existing Vantage – Schultz 500-kV line



b) Configuration A-1B - Proposed 500-kV line parallel to rerouted Vantage – Schultz 500-kV line

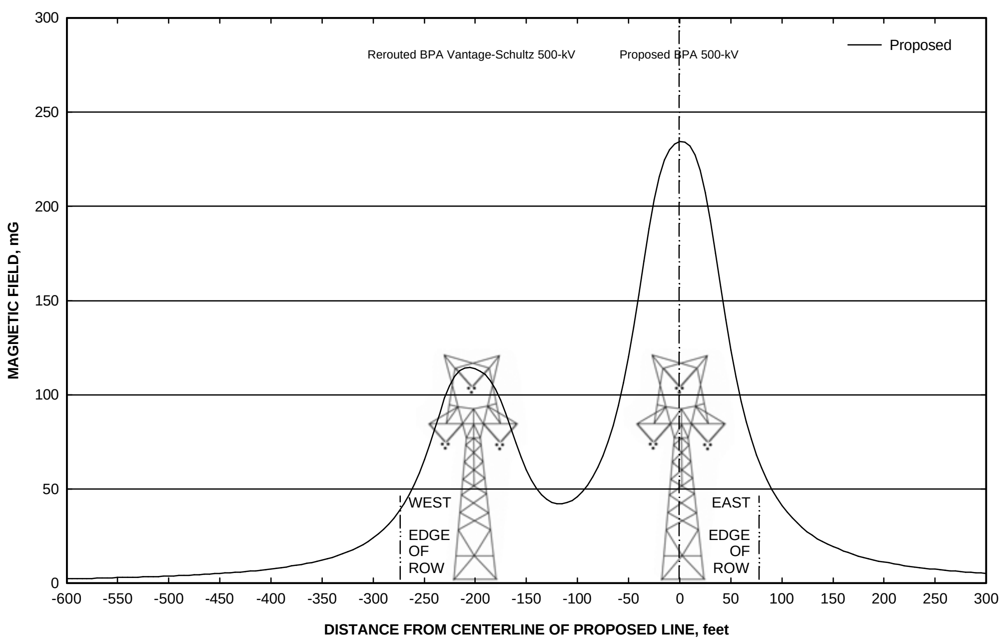
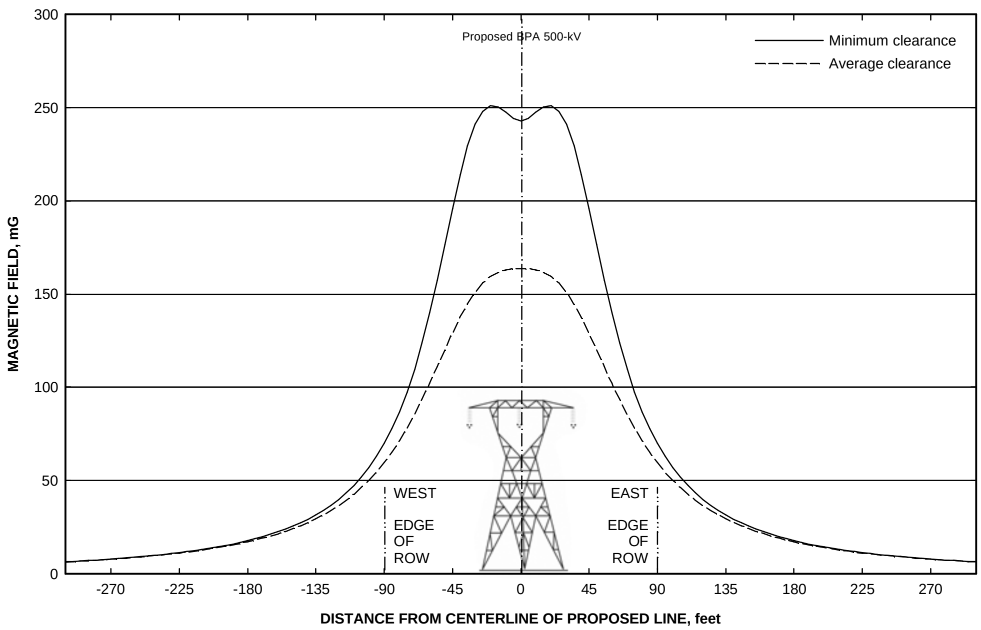


Figure A2-3, continued

c) Configuration A-1C - Proposed 500-kV line on flat configuration with no parallel lines



d) Configuration D-1B - Proposed 500-kV line with flat configuration parallel to existing Vantage – Midway 230-kV line

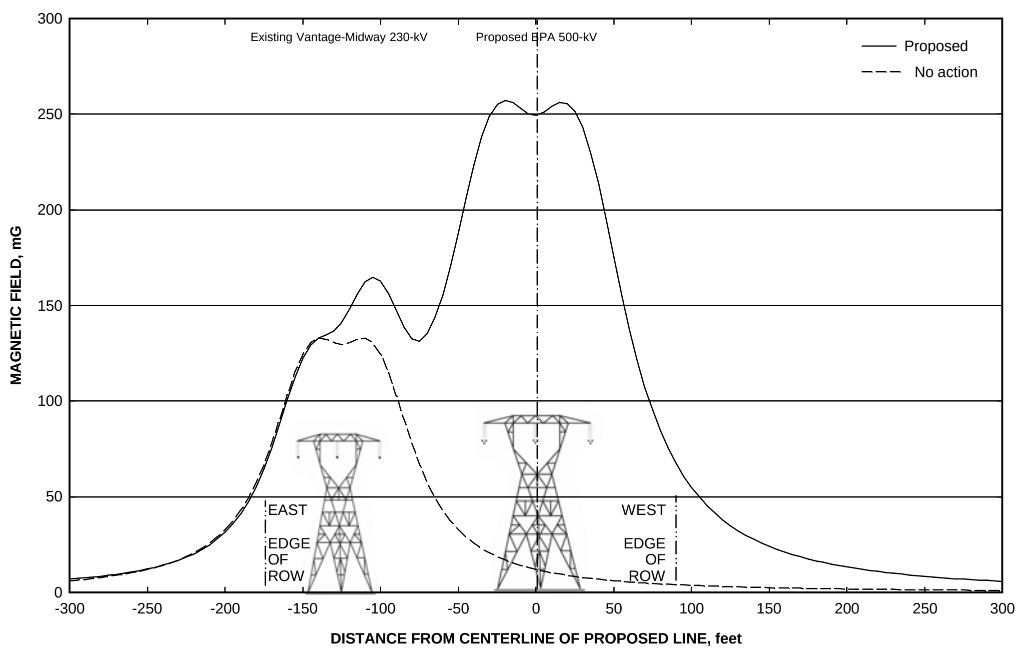
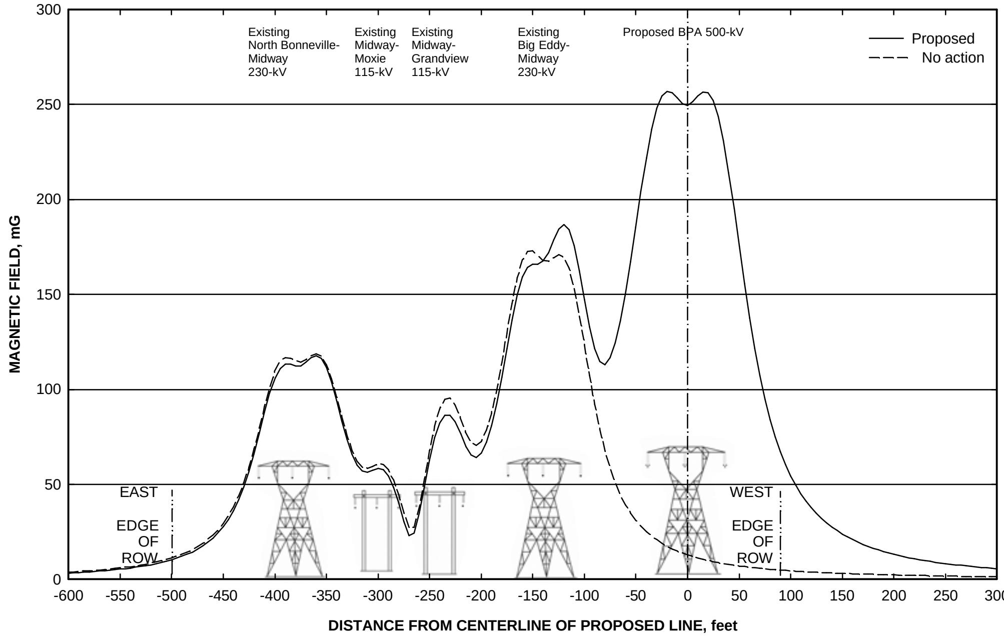


Figure A2-3, continued

e) Configuration D-2A - Proposed 500-kV line with flat configuration parallel to two 230-kV lines and two 15-kV lines



SCHULTZ - HANFORD AREA TRANSMISSION-LINE PROJECT

APPENDIX J:

ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

July 3, 2001

Prepared by

Exponent

and

T. Dan Bracken, Inc.

for

Parsons Brinckerhoff

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APPENDIX J: ASSESSMENT OF RESEARCH REGARDING EMF AND HEALTH AND ENVIRONMENTAL EFFECTS

1.0 Introduction

Over the last 20 years, research has been conducted in the United States and around the world to examine whether exposures to electric and magnetic fields (EMF) at 50/60 hertz (Hz) from electric power lines are a cause of cancer, or adversely affect human health. The research included epidemiology studies that suggested a link with childhood for some types of exposures, as well as other epidemiology studies that did not; it also included lifetime animal studies, which showed no evidence of adverse health effects. Comprehensive reviews of the research conducted by governmental scientific agencies in the U.S. and in the United Kingdom (UK) had examined the research, and did not find a basis for imposing additional restrictions (NIEHS, 1999; IEE, 2000).

The Bonneville Power Authority (BPA) requested that Exponent review the research on EMF and health and focus on exposures that might occur from the Schultz – Hanford Area Project. In December 2000, Exponent prepared a report to the BPA that summarized our assessment of the research regarding EMF and health (to be published as an appendix to the Kangley-Echo Lake Transmission Project environmental impact statement, summer 2001). This report was prepared after the National Institute of Environmental Health Sciences (NIEHS) had just completed the Congressionally funded research program known as RAPID (Research and Public Information Dissemination Program), and after publication of the NIEHS Working Group Report (NIEHS, 1998). Consequently, our report to the BPA presented the conclusions of these scientific panels, and reviewed the major research studies published after the NIEHS report was completed.

This update concentrates on recent major research studies to explain how they contribute to the assessment of effects of EMF on health. The focus is on both epidemiologic and laboratory research, because these research approaches provide different and complementary information for determining whether an environmental exposure can affect human health.

2.0 Health

2.1 The NIEHS Report and Research Program

In 1998, the NIEHS completed a comprehensive review of the scientific research on health effects of EMF. The NIEHS had been managing a research program that Congress funded in 1996, in response to questions 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 (the "Working Group") to review and evaluate the RAPID Program research and other research. Their report, *Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields,* was completed in July 1998 (NIEHS, 1998).

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 this 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]

2.2 Update of Research Related to Cancer

The California Department of Health Services conducted a workshop in 1999 to discuss epidemiologic research on EMF and health. The reports presented at this workshop recently became available (published in January 2001) as a supplement to the journal, *Bioelectromagnetics*. Many of the papers were technical discussions of methodology issues in epidemiologic studies of EMF, including discussions of how better to understand the conflicting results reported in previous studies (Neutra and Del Pizzo, 2001). For example, one study evaluates the extent to which systematic errors (known in epidemiology as selection bias or information bias) occurred in EMF studies and if so, whether they can be measured (Wartenberg, 2001a). Other researchers discuss epidemiologic approaches to study how possible confounding factors, such as the age and type of home and traffic density, might affect the interpretation of studies of EMF and childhood cancer (Langholz, 2001; Reynolds et al., 2001).

For this update, we review papers from this workshop that provide new information or statistical analyses. Several of the studies are "meta-analyses," an approach that incorporates statistical methods to analyze differences and aggregate the results of smaller studies. The section below includes a review of meta-analyses of the studies of childhood leukemia through 1999, and a meta-analysis of studies of breast cancer in adults (Erren et al., 2001).

2.2.1 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 is 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

[1] See, for instance, the articles cited in the **List of References** under Balcer- Kubiczek, Boorman, Loberg, and Ryan.

vicinity of a power line results from the flow of current; higher currents result in higher levels of magnetic fields.

Epidemiologic studies report results in the form of statistical associations. 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 context, including (for example) the nature of what is being studied, the source of the data, how the data were collected, and the size of the study. The larger studies and more powerful 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; UKCCS, 1999). Despite the larger sample size, these studies usually had a limited number of cases exposed over 2 or 3 milligauss (mG).

The following discussion briefly describes major studies.

- A study from British Columbia, Canada, included 462 children who had been diagnosed with leukemia and an equal number of children without leukemia for comparison (McBride et al., 1999). Magnetic-field exposure was assessed for each of the children in several ways: personal monitors were worn in a backpack for 48 hours, a monitor took measurements in the bedroom for 24 hours, the wiring outside the house was rated by potential exposure level, and measurements were taken around the outside perimeter of the homes. Regardless of the method used to estimate magnetic-field exposure, the magnetic-field exposure of children who had leukemia was not greater than that of the children in the comparison group.

- 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 with any of the three methods of estimating exposure from wire configuration codes. (Wire codes are a method of estimating relative exposure intensity based on the configuration of the power lines.) 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 broad margin of error and major methodological problems in the study preclude any clear interpretation of the findings.

- The United Kingdom Childhood Cancer Study, the largest study to date, included a total of 1073 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.

- The UKCCS investigators had obtained magnetic-field measurements on only a portion of the cases in their study (UKCCS, 1999). To obtain additional information, they used a method to assess exposure to magnetic fields without entering homes; they were thus able to analyze 50% more subjects (UKCCS, 2000). For all these children, they measured distances to power lines and substations. This information was used to calculate the magnetic field from these external field sources, based on power-line characteristics related to production of magnetic fields. The results of the second UKCCS study showed no evidence for an association with leukemia for magnetic fields calculated to be between 1 mG and 2 mG, 2 mG and 4 mG, or 4 mG or greater at the residence, in contrast to the weak association reported for measured fields of 4 mG or greater in the first report (UKCCS, 1999).

Recently, researchers reanalyzed the data from previous epidemiology studies of magnetic fields and childhood leukemia (Ahlbom et al., 2000; Greenland et al., 2000). 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. A pooled analysis is preferable to other types of meta-analyses in which the results from several studies are combined from grouped data obtained from the published studies. These analyses 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. 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).

The authors are appropriately cautious in the interpretation of their analyses, and they clearly identify the limitations in their evaluation of the original studies. Magnetic fields above 0.3 µT in residences are estimated to be rather rare, about 3% in the U.S. (Zaffanella, 1993). Limitations include sparse data (few cases) to adequately characterize a relationship between magnetic fields and leukemia, uncertainties related to pooling different magnetic-field measures without evidence that all of the measures are comparable, and the incomplete and limited data on important confounders (other risk factors for disease that may distort the analysis) such as housing type and traffic density.

A meta-analysis of the data from epidemiologic studies of childhood leukemia studies was presented at the California Workshop and recently published (Wartenberg, 2001b). This meta-analysis did not have the advantage of obtaining and pooling the data on all of the individuals in the studies, unlike those published before it (Ahlbom et al., 2000; Greenland et al., 2000). Rather than individual data, Wartenberg (2001b) used an approach that extracted the published results, reported as grouped data from several published studies. He used 19 studies overall, after excluding 7 studies that had insufficient data on individuals or deficiencies in the exposure assessment data. He reported a weak association for a) "proximity to electrical facilities" based on wire codes or distance, and b) magnetic-field level over 2 mG, based on either calculations from wiring and loading characteristics (if available) or on spot magnetic-field measurements. The results show more cases than controls exposed to measured or calculated fields above 2 mG. The author concludes that the analysis supports an association, although the size of the effect is small to moderate, but also notes "limitations due to design, confounding, and other biases may suggest alternative interpretations" (Wartenberg, 2001b:S-100).

The results of this meta-analysis are not directly comparable to previous ones regarding fields of 3 or 4 mG because the analysis was not based on individual data. The comparison of grouped data used different cut points for the analysis and different criteria for the comparison group. None of these three analyses (Ahlbom et al., 2000; Greenland et al., 2000; Wartenberg, 2001b) includes the results of the UK analysis of over 3000 cases based on calculated fields, which found no association between EMF and childhood cancer, regardless of the exposure level.

2.2.2 Epidemiology Studies of Adults

Studies of adults with certain types of cancer, such as brain cancer, breast cancer, or leukemia, have reported associations with exposure to magnetic fields at residences, but results have not been consistent across studies. Contradictory results among studies argue against a conclusion that the association reflects a cause-and-effect relationship. Studies that include more people, obtain more detailed and individual exposure assessments, or include people who have higher exposures are weighed more heavily by scientists in their assessments of risk.

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 (Wrensch 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.

A number of recent studies of breast cancer had focused on electric blankets as a source of high exposure. Electric blankets are assumed to be one of the strongest sources of EMF exposure in the home. Three studies of electric blanket use found no evidence that long-term use increased the risk of breast cancer. 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:

- 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 female nurses, data were obtained on known risk factors for breast cancer as well as electric blanket use (Laden et al., 2000). For a large subset of this group, the questions about exposure were asked before the disease occurred, a step taken to eliminate bias in recalling exposure.

Erren (2001) reported the results of a meta-analysis of the studies of breast cancer, in which the results of 24 different studies in women were statistically aggregated. When the results of all 24 studies were pooled, including studies of workplace exposures, the estimate indicated an association between EMF and a small excess breast cancer risk. The pooled results for exposure to EMF in the vicinity of electrical facilities did not show an association with breast cancer, nor did the results for exposure to EMF from appliance use. However, the meta-analysis also showed a lack of consistency among the results of the individual studies, a broad variation in the designs, and a wide range of methods used to assess exposure. No adjustments were made to the data to give increased weight to studies based on more comprehensive exposure assessments. The author also noted that the weak statistical association might be an artifact rather than an indication of cause-and-effect (Erren, 2001).

2.2.3 Laboratory Studies of EMF

Laboratory studies complement epidemiologic studies of people because the heredity, diet, and other health-related exposures of animals can be better controlled or eliminated. 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 as follows: 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 responses 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., 2000b). 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).

2.2.4 Summary Regarding Cancer

The latest epidemiologic studies of childhood cancer, considered in the context of the other data, provide no persuasive and consistent evidence that leukemia in children is causally associated with magnetic fields measured at the home, calculated based on distance and current loading, or with wire codes. Recent meta-analyses reported no association between childhood cancer and magnetic fields below 2 or 3 mG. Although some association was reported for fields above this level, fields at most residences are likely to be below 3 or 4 mG. The authors of each of these analyses 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. Large, well-conducted animal studies provide no convincing evidence that exposure increases the risk of cancer. Animal studies, and studies of initiation and promotion, provide no basis to conclude that EMF increases leukemia, lymphoma, breast, brain or any other type of cancer.

2.3 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 typically weaker magnetic fields such as power lines (Bracken et al., 1995; Belanger et al., 1998).

A recent epidemiology study examined miscarriages[2] 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 (Lee et al., 2000). The researchers assessed exposure prior to

[2] The medical term for miscarriage is spontaneous abortion.

the birth (a prospective study) and 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.

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 conclusions of the NIEHS.

2.4 Recent Reviews by Scientific Advisory Groups

Reviews of the scientific research regarding EMF and health by the Health Council of the Netherlands were published in 2000 and updated in May 2001. The Institute of Electrical Engineers of the UK published a review in 2000. The National Radiological Protection Board of Great Britain (NRPB) Advisory Group on Non-Ionising Radiation published the most recent review in 2001. This review includes research published in 2000, and includes the most comprehensive discussion of the individual research studies.

2.4.1 National Radiological Protection Board of Great Britain (NRPB) Advisory Group on Non-Ionising Radiation

The conclusions from the report prepared by the NRPB's Advisory Group on Non-Ionising Radiation (AGNIR) on extremely low frequency (ELF) EMF and the risk of cancer are consistent with previous reviews. The eight members from universities, medical schools, and cancer research institutes reviewed the reports of experimental and epidemiological studies, including reports in the literature in 2000. Their general conclusions are as follows:

> Laboratory experiments have provided no good evidence that extremely low frequency electromagnetic fields are capable of producing cancer, nor do human epidemiological studies suggest that they cause cancer in general. There is, however, some epidemiological evidence that prolonged exposure to higher levels of power frequency magnetic fields is associated with a small risk of leukaemia in children. In practice, such levels of exposure are seldom encountered by the general public in the UK [or in the US] (NRBP, 2001: 164).

The group further recognizes that the scientific evidence suggesting that exposure to power-frequency electromagnetic fields poses an increased risk of cancer is very weak. Virtually all of the cellular, animal and human laboratory evidence provides no support for an increased risk of cancer incidence following such exposure to power frequencies, although sporadic positive findings have been reported. In addition, the epidemiological evidence is, at best, weak.

These conclusions of the Advisory Group are consistent with previous reviews by the NIEHS (1999) and the Health Council of the Netherlands (HCN, 2000). The NRPB response to the Advisory Group report states "the review of experimental studies by [the Advisory Group] AGNIR gives no clear support for a causal relationship between exposure to ELF-EMFs and cancer" (NRPB, 2001:1).

2.4.2 Health Council of the Netherlands

The Health Council of the Netherlands has prepared an update of its 1992 Advisory Report on exposure to electromagnetic fields (0 Hz to 10 MHz) (HCN, 2000). Eight members of the Expert Committee prepared the report. The Expert Committee based its analysis on the review and summaries of the studies provided in the NIEHS (1998) and concurred with the views of the director of the NIEHS (1999). For the update, the Committee evaluated a number of publications that appeared after these reports, e.g., McBride (1999) and Green et al. (1999a), and wrote:

> The committee thinks that the quality of the relevant epidemiological research has improved considerably since the publication of the advisory report in 1992. Even so, this research has not resulted in unequivocal, scientifically reliable conclusions (p. 15).

The Council emphasizes that the associations with EMF reported in epidemiologic studies are strictly statistical and do not demonstrate a cause-and-effect relationship. In their view, experimental research does not demonstrate a causal link or a mechanism to explain EMF as a cause of disease in humans. They concluded that there is no reason to recommend measures to limit residence near overhead power lines (HCN, 2000).

2.4.3 Institution of Electrical Engineers (IEE) of Great Britain

One of the recent reviews was that of the Institution of Electrical Engineers (IEE) of Great Britain (IEE, 2000). In 1992, the IEE set up a Working Party 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).

3.0 Ecological Research

Scientists have studied the effects of high-voltage transmission lines on many plant and animal species in the natural environment. In this section, we briefly review the research on the effects of EMF on ecological systems to assess the likelihood of adverse impacts. In addition to the comprehensive review of research on this topic by wildlife biologists at the BPA (Lee et al., 1996), we searched the published scientific literature for more recent studies published between 1995 and February 2001.

3.1 Fauna

The habitat on the transmission right-of-way and surrounding area shields most wildlife from electric fields. Vegetation in the form of grasses, shrubs, and small trees largely shields small ground-dwelling species such as mice, rabbits, foxes and snakes from electric fields. Species that live underground, such as moles, woodchucks, and worms, are further shielded from electric fields by the soil. Hence, large species such as deer and domestic livestock (e.g., sheep and cattle) have greater potential exposures to electric fields since they can stand taller than surrounding vegetation. However, the duration of exposure for deer and other large animals is likely to be limited to foraging bouts or the time it takes them to cross under the line. Furthermore, all species would be exposed to higher magnetic fields under a transmission-line than elsewhere, as the vegetation and soil do not provide shielding from this aspect of the transmission-line electrical environment.

Field studies have been performed in which the behavior of large mammals in the vicinity of high-voltage transmission lines was monitored. No effects of electric or magnetic fields were evident in two studies from the northern United States on big game species, such as deer and elk, exposed to a 500-kV transmission line (Goodwin 1975; Picton et al., 1985). In such studies, a possible confounding factor is audible noise. Audible noise associated with high-voltage power transmission lines (with voltages greater than 110-kV) is due to corona. Audible noise generated by transmission lines reaches its highest levels in inclement weather (rain or snow).

Much larger populations of animals that might spend time near a transmission line are livestock that graze under or near transmission lines. To provide a more sensitive and reliable test for adverse effects than informal observation, scientists have studied animals continuously exposed to fields from the lines in relatively controlled conditions. For example, grazing animals such as cows and sheep have been exposed to high-voltage transmission lines and their reproductive performance examined (Lee et al., 1996). In some studies, the effects of exposure over one or more successive breedings were examined (Angell et al., 1990). Compared to unexposed animals in a similar environment, it was found that the exposure did not affect reproductive functions or pregnancy of cows (Algers and Hennichs, 1985; Algers and Hultgren, 1987).

A group of investigators from Oregon State University, Portland State University, and other academic centers evaluated the effects of long-term exposure to EMF from a 500-kV transmission line operated by BPA on various cellular aspects of immune response, including the production of proteins by leukocytes (IL-1 and IL-2) of sheep. In previous unpublished reports, the researchers found differences in IL-1 activity between exposed and control groups. However, in their most recent replication, the authors found no evidence of differences in these measures of immune function. The sheep were exposed to 27 months of continuous exposure to EMF, a period of exposure much greater than the short, intermittent exposures of sheep grazing under transmission lines. Mean exposures of magnetic and electric fields were 3.5-3.8 µT (35-38 mG) and 5.2-5.8 kV/m, respectively (Hefeneider et al., 2001).

Scientists from Illinois Institute of Technology (IIT) monitored the possible effects of electric and magnetic fields on fauna and flora in Michigan and Wisconsin from 1969 – 1997 to evaluate the effects of an above-ground, military communications antenna operating at 76 Hz. The antenna produces EMF similar in physical characteristics to those produced by high-voltage transmission lines but of much lower intensity. This study included embryonic development, fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior, and showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997).

The hormone melatonin, secreted at night by the pineal gland, plays a role in animals that are seasonal breeders. Studies in laboratory mice and rats have suggested that exposure to electric and/or magnetic fields might affect levels of the hormone melatonin, but results have not been consistent (Wilson et al., 1981; Holmberg, 1995; Kroeker et al., 1996; Vollrath et al., 1997; Huuskonen et al., 2001). However, when researchers examined sheep and cattle exposed to EMF from transmission lines exceeding 500-kV, they found no effect on the levels of the hormone melatonin in blood, weight gain, onset of puberty, or behavior in sheep and cattle (Stormshak et al., 1992; Lee et al., 1993; Lee et al., 1995; Burchard et al., 1998).

Another part of the IIT study examined the effect of the antenna system fields on the growth, development, and homing behavior of birds. Studies of embryonic development (Beaver et al., 1993), fertility, postnatal growth, maturation, aerobic metabolism, and homing behavior showed no adverse impacts of ELF electric and magnetic fields on the animals (NRC, 1997). Fernie and colleagues studied the effects of continuous EMF exposure of raptors to an electric field of 10 kV/m in a controlled, laboratory setting. The exposure was designed to mimic exposure to a 765-kV transmission line.

Continuous EMF exposure was found to reduce hatching success, yet increase egg size, fledging success, and embryonic development (Fernie et al., 2000). In a study of the effects on body mass and food intake of reproducing falcons, the authors found that EMF lengthened the photoperiod as a result of altered melatonin levels in the male species, yet concluded that "EMF effects on adult birds may only occur after continuous, extended exposure" (p. 620), which is not likely to occur from resting on power lines (Fernie and Bird, 1999).

Several avian species are reported to use the earth's magnetic field as one of the cues for navigation. It has been proposed that deposits of magnetite in specialized cells in the head are the mechanism by which the birds can detect variations in the inclination and intensity of a dc magnetic field (Kirschvink and Gould, 1981; Walcott et al., 1988). In early studies of transmission lines, it was reported that the migratory patterns of birds appeared to be altered near transmission lines (Southern, 1975; Larkin and Sutherland, 1977). However, these studies were of crude design, and Lee et al. (1996) concluded that, "During migration, birds must routinely fly over probably hundreds (or thousands) of electrical transmission and distribution lines. We are not aware of any evidence to suggest that such lines are disrupting migratory flights" (p. 4-59). No further studies on this topic were identified in the literature.

Bees, like birds, are able to detect the earth's dc magnetic fields. They are known to use magnetite particles, which are contained in an abdominal organ, as a compass (Kirschvink and Gould, 1981). In the laboratory, they are able to discriminate between a localized magnetic anomaly and a uniform background dc magnetic field (Walker et al., 1982; Kirschvink et al., 1992).

Greenberg et al. (1981) studied honeybee colonies placed near 765-kV transmission lines. They found that hives exposed to electric fields of 7 kV/m had decreased hive weight, abnormal amounts of propolis (a resinous material) at hive entrances, increased mortality and irritability, loss of the queen in some hives, and a decrease in the hive's overall survival compared to hives that were not exposed. Exposure to electric fields of 7-12 kV/m may induce a current or heat the interior of the hive; however, placing the hive farther from the line, shielding the hive, or using hives without metallic parts eliminates this problem. ITT studied the effects of EMF on bees exposed to the 76-Hz antenna system at lower intensities and concluded that these behavioral effects of "ELF-EMF impacts are absent or at most minimal" (NRC, 1997:102).

Reptiles and amphibians contribute to the overall functioning of the forest ecosystems. However, little research has been performed on the effects of EMF on reptiles and amphibians in their natural habitat.

3.2 Flora

Numerous studies have been carried out to assess the effect of exposure of plants to transmission-line electric and magnetic fields. These studies have involved both forest species and agriculture crops. Researchers have found no adverse effects on plant responses, including seed germination, seedling emergence, seedling growth, leaf area per plant, flowering, seed production, germination of the seeds, longevity, and biomass production (Lee et al., 1996).

The only confirmed adverse effect of transmission lines on plants was reported for transmission lines with voltages above 1200-kV. For example, Douglas Fir trees planted within 15 m of the conductors were shorter than trees planted away from the line. Shorter trees are believed to result from corona-induced damage to the branch tips. Trees between 15 and 30 m away from the line suffered needle burns, but those 30 m and beyond were not affected (Rogers et al., 1984). These effects would not occur at the lower field intensities expected beyond the right-of-way of the proposed 500-kV transmission line.

3.3 Summary

The habitat on the transmission-line rights-of-way and surrounding areas shield smaller animals from electric fields produced by high-voltage transmission lines; thus, vegetation easily shields small animals from electric fields. The greatest potential for larger animals to be exposed to EMF occurs when they are passing beneath the lines. Studies of animal reproductive performance, behavior, melatonin production, immune function, and navigation have found minimal or no effects of EMF. Past studies have found little effect of EMF on plants; no recent studies of plants growing near transmission lines have been performed. In summary, the literature published to date has shown little evidence of adverse effects of EMF from high-voltage transmission lines on wildlife and plants. At the field intensities associated with the proposed 500-kV, no adverse effects on wildlife or plants are expected.

LIST OF REFERENCES

Ahlbom, A.; Day, N.; Feychting, M.; Roman, E.; Skinner, J.; Dockerty, J.; Linet, M.; Michealis, J.; Olsen, J.H.; Tynes, T.; Verasalo, P.K. 2000. A pooled analysis of magnetic fields and childhood leukaemia. British Journal of Cancer, 83(5): 692-698.

Algers, B.; and Hennichs, K. 1985. The effect of exposure to 400-kV transmission lines on the fertility of cows: a retrospective cohort study. Preventive Veterinary Medicine 3: 351-361.

Algers, B.; and Hultgren, J. 1987. Effects of long-term exposure to a 400-kV, 50-Hz transmission line on estrous and fertility in cows. Preventive Veterinary Medicine 5: 21-36.

Angell, R.F.; Schott, M.R.; Raleigh, R.J.; Bracken, T.D. 1990. Effects of a high-voltage direct-current transmission line on beef cattle production. Bioelectromagnetics. 11(4):273-82.

Balcer-Kubiczek, E.K.; Harrison, G.H.; Davis, C.C.; Haas, M.L.; Koffman, B.H. 2000. Expression analysis of human HL60 exposed to 60 Hz square or sine-wave magnetic fields. Radiation Research, 153(5): 670-678.

Beaver, D.L.; Hill, R.W.; Lederle, P.E. 1993. Assessment of the effects of extremely low frequency electromagnetic radiation on growth and maturation in nestling tree swallows and deer mice. Electricity and Magnetism in Biology and Medicine. M. Blank, ed., San Francisco Press, Inc., pp. 925-926.

Belanger, K.; Leaderer, B.; Hellenbrand, K.; Holford, T.R.; McSharry, J.; Power, M.E.; Bracken, M.B. 1998. Spontaneous abortion and exposure to electric blankets and heated water beds. Epidemiology, 9:36-42.

Boorman, G.A.; Anderson, L.E.; Morris, J.E.; Sasser, L.B.; Mann, P.C.; Grumbein, S.L.; Hailey, J.R.; McNally, A.; Sills, R.C.; Haseman, J.K. 1999. Effects of 26-week magnetic field exposure in a DMBA initiation-promotion mammary glands model in Sprague-Dawley rats. Carcinogenesis, 20: 899-904.

Boorman, G.A.; McCormick, D.J.; Ward, J.M.; Haseman, J.K.; Sills, R.C. 2000a. Magnetic fields and mammary cancer in rodents: A critical review and evaluation of published literature. Radiation Research, 153(5), Part 2; 617.

Boorman, G.A.; Rafferty, C.N.; Ward, J.M.; Sills, R.C. 2000b. Leukemia and lymphoma incidence in rodents exposed to low-frequency magnetic fields. Radiation Research, 153(5), Part 2; 627.

Bracken, M.B.; Belanger, K.; Hellenbrand, K.; Dlugosz, L.; Holford, T.R.; McSharry, J.E.; Addesso, K.; Leaderer, B. 1995. Exposure to electromagnetic fields during pregnancy with emphasis on electrically heated beds: association with birth weight and intrauterine growth retardation. Epidemiology, 6(3): 263-270.

Burchard, J.F.; Nguyen, D.H.; Block, E. 1998. Effects of electric and magnetic fields on nocturnal melatonin concentrations in dairy cows. J Dairy Sci. 81(3):722-7.

Erren, T.C. 2001. A meta-analysis of epidemiological studies of electric magnetic fields and breast cancer in women and men. Bioelectromagnetics Supplement, 5: S105-S119.

Fernie, K.J.; and Bird, D.M. 1999. Effects of electromagnetic fields on body mass and food-intake of American kestrels. The Condor. 101:616-621.

Fernie, K.J.; Bird, D.M.; Dawson, R.D.; Lague, P.C. 2000. Effects of electromagnetic fields on the reproductive success of American kestrels. Physiol Biochem Zool. 73(1):60-5.

Gammon, M.D.; Schoenberg, J.B.; Britton, J.A.; Kelsey, J.L.; Stanford, J.L.; Malone, K.E.; Coates, R.J.; Brogan, D.J.; Potischman, N.; Swanson, C.A.; Brinton, L.A. 1998. Electric blanket use and breast cancer risk among younger women. American Journal of Epidemiology, 148: 556-63.

Goodwin Jr., J.G. 1975. Big game movement near a 500-kV transmission line in northern Idaho. Bonneville Power Administration, Engineering and Construction Division, Portland, OR, June 27.

Green, L.M.; Miller, A.B.; Villeneuve, P.J.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Donnelly, K.E. 1999a. A case control study of childhood leukemia in southern Ontario, Canada, and exposure to magnetic fields in residences. International Journal of Cancer, 82:161-170.

Green, L.M.; Miller, A.B.; Agnew, D.A.; Greenberg, M.L.; Li, J.H.; Villeneuve, P.J.; Tibshirani, R. 1999b. Childhood leukemia and personal monitoring of residential exposures to electric and magnetic fields in Ontario, Canada. Cancer Causes and Control, 10: 233-243.

Greenberg, B.; Bindokas, V.P.; Frazier, M.J.; Gauger, J.R. 1981. Response of honey bees, *apis mellifera L*., to high-voltage transmission lines. Environmental Entomology, 10: 600-610.

Greenland, S.; Sheppard, A.; Kelsh, M.; Kuane, W.; Poole, C.; Kelsh, M.A. 2000. Childhood leukemia and power frequency magnetic fields: analysis from pooled data of thirteen epidemiologic studies. Epidemiology, 11: 624-634.

HCN (Health Council of the Netherlands). 2000. Report on Exposure to Electromagnetic Fields (0 Hz – 10 MHz). No. 2000/06E.

Hefeneider, S.H.; McCoy, S.L.; Hausman, F.A.; Christensen, H.L.; Takahashi, D.; Perrin, N.; Bracken, T.D.; Shin, K.Y.; Hall, A.S. 2001. Long-term effects of 60-Hz electric vs. magnetic fields on IL-1 and IL-2 activity in sheep. Bioelectromagnetics, 22(3):170-177.

Holmberg, B. 1995. Magnetic fields and cancer: animal and cellular evidence--an overview. Environ Health Perspect. 103 Suppl 2:63-7.

Huuskonen, H.; Saastamoinen, V.; Komulainen, H.; Laitinen, J.; Juutilainen, J. 2001. Effects of low-frequency magnetic fields on implantation in rats. Reprod Toxicol, 15(1):49-59.

IEE (Institution of Electrical Engineers), Biological Effects Working Party. May 2000. The possible harmful biological effects of low level electromagnetic fields of frequencies up to 300 GHz. IEE Position Statement.

Kirschvink, J.L.; and Gould, J.L. 1981. Biogenic magnetite as a basis for magnetic field detection in animals. Biosystems, 13(3):181-201.

Kirschvink, J.L.; Diaz Ricci, J.; Nesson, M.H.; Kirschvink, S.J. 1992. Magnetite-based magnetoreceptors in animals: structural, behavioral, and biophysical studies. Electric Power Research Institute (EPRI), Report No. TR-102008, Palo Alto, CA. September.

Kroeker, G.; Parkinson, D.; Vriend, J.; Peeling, J. 1996. Neurochemical effects of static magnetic field exposure. Surg Neurol, 45(1):62-6.

Laden, F.; Neas, L.M.; Tolbert, P.E.; Holmes, M.D.; Hankinson, S.E.; Spiegelman, D.; Speizer, F.E.; Hunter, D.J. 2000. Electric blanket use and breast cancer in the nurses' health study. American Journal of Epidemiology, 152(1): 41-49.

Langholz, B. 2001. Factors that explain the power line configuration wiring code - childhood leukemia association: what would they look like? Bioelectromagnetics Supplements, 5: S19-S31.

Larkin, R.P., and Sutherland, P.J. 1977. Migrating birds respond to Project Seafarer's electromagnetic field. Science, 195(4280): 777-9 1977, Feb 25.

Lee, G.M.; Neutra, R.R.; Hristova, L.; Yost, M.; Hiatt, R.A. 2000. The use of electric bed heaters and the risk of clinically recognized spontaneous abortion. Epidemiology, 11: 406-415.

Lee, J., Bao, J.Z., Lu, S.T., Seaman, R.L. 1995. An ultra-wide-band exposure system for studying biological effects (meeting abstract). Bioelectromagnetics Society, 17th Annual Meeting, Boston, MA, p. 160, June 18-22.

Lee, J., Stormshak, F., Thompson, J., Thinesen, P., Painter, L., Olenchek, B., Hess, D., Forbes, R. 1993. Endocrine responses of Ewe lambs exposed to 60-hz electric and magnetic fields from 500-kV transmission line. Electricity and Magnetism in Biology and Medicine. M. Blank, ed., San Francisco Press, Inc., pp. 401-404.

Lee, J.M. BPA Biological Studies Task Team. 1996. Electrical and biological effects of transmission lines: a review. Bonneville Power Administration, Portland, Oregon, December.

Linet, M.S.; Hatch E.H.; Kleinerman, R.A.; Robinson, L.L.; Kaune, W.T.; Friedman, D.R.; Seversch, R.K.; Haines, C.M.; Hartsock, C.T.; Niwa, S.; Wacholder, S.; Tarone, R.E. 1997. Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. New England Journal of Medicine, 337: 1-7.

Loberg, L.I.; Engdahl, W.R.; Gauger, J.R.; McCormick, D.L. 2000. Expression of cancer-related genes in human cells exposed to 60 Hz magnetic fields. Radiation Research, 153(5): 679-684.

McBride, M.L., and Gallagher, R.P. 1999. Power-frequency electric and magnetic fields and risk of childhood leukemia in Canada. American Journal of Epidemiology, 149:831-842.

McCormick, D.L.; Boorman, G.A.; Findlay, J.C.; Hailey, J.R.; Johnson, T.R.; Gauger, J.R.; Pletcher, J.M.; Sill, R.C.; Haseman, J.K. 1999. Chronic toxicity/oncogenicity evaluation of 60 Hz (power frequency) magnetic fields in B6C3F mice. Toxicologic Pathology, 27:279-285.

Neutra, R.R., and Del Pizzo, V. 2001. A richer conceptualization of "exposure" for epidemiological studies of the "EMF mixture". Bioelectromagnetics Supplements, 5: S48-S57.

NIEHS (National Institute of Environmental Health Sciences). 1998. Assessment of Health Effects from Exposure to Power-Line Frequency Electric and Magnetic Fields: Working Group Report. NIH Publication No. 98-3981. Research Triangle Park, NC: National Institute of Environmental Health Sciences of the U.S. National Institutes of Health.

NIEHS (National Institute of Environmental Health). 1999. Health effects from exposure to power line frequency electric and magnetic fields. NIH; National Institute of Health; NIH No. 99-4493; Research Triangle Park, NC.

NRBP (National Radiological Protection Board). 2001. Response statement of the NRPB: ELF electromagnetic fields and the risk of cancer. National Radiological Protection Board, Chilton, Dicot, Oxon, Volume 12, No.1, ISNB 0-859951-456-0.

NRC (National Research Council). 1997. An evaluation of the U.S. Navy's extremely low frequency communications system ecological monitoring program. National Academy Press, Washington, D.C.

Picton, H.D., Canfield, J.E., Nelson, G.P. 1985. The impact of a 500-kV transmission line upon the North Boulder Winter Elk Range. US Forest Service Contract 53-0398-30E-3.

Radiation Research. 2000. (Special Edition Updating RAPID results.) 153(5): 637-641. *See entries under Balcer-Kubiczek, Boorman, Loberg, and Ryan.*

Reynolds, P.; Elkin, E.; Scalf, R.; Von Behren, J.; Neutra, R.R. 2001. A Case-Control Pilot Study of Traffic Exposures and Early Childhood Leukemia Using a Geographic Information System. Bioelectromagnetics Supplement, 5:S58-S68.

Rogers, L.E., Beedlow, P.A., Carlile, D.W., Ganok, K.A., Lee, J.M. 1984. Environmental studies of a 1100-kV prototype transmission line: an annual report for the 1984 study period. Prepared by Battelle Pacific Northwest Laboratories for Bonneville Power Administration, Portland, Oregon.

Ryan, B.M.; Symanski, R.R.; Pomeranz, L.E.; Johnson, T.R.; Gauger, J.R.; McCormick, D.L. 1999. Multi-generation reproduction toxicity assessment of 60-Hz magnetic fields using a continuous breeding protocol in rats. Teratology, 59(3): 156-62.

Ryan, B.M.; Polen, M.; Gauger, J.R.; Mallett, E.; Kerns, M.B.; Bryan, T.L.; McCormick, D.L. 2000. Evaluation of the developmental toxicity in Sprague-Dawley rats. Radiation Research, 153(5): 637-641.

Southern, W.E. 1975. Orientation of gull chicks exposed to project Sanguine's electromagnetic field. Science, 189: 143-144.

Stormshak, F., Bracken, T.D., Carey, M., Chartier, V., Dickson, L., Forbes, R., Hall, A., Havens, P., Hess, D., Krippaehne, S., Lee, J., Ogden, B., Olenchek, B., Painter, L., Rowe, K., Stearns, R., Thinesen, P., Thompson, J. 1992. Joint HVAC transmission EMF environmental study: final report on experiment 1. Bonneville Power Administration, Contract # DE-B179-90BPO4293, Portland, OR, May.

UKCCS (United Kingdom Childhood Cancer Study Investigators). 1999. Exposure to power frequency magnetic fields and the risk of childhood cancer. The Lancet, 353(9194): 1925-31.

UKCCS (United Kingdom Childhood Cancer Study Investigators). 2000. Childhood cancer and residential proximity to power lines. British Journal of Cancer, 83:1573-80.

Vollrath, L.; Spessert, R.; Kratzsch, T.; Keiner, M.; Hollmann H. 1997. No short-term effects of high-frequency electromagnetic fields on the mammalian pineal gland. Bioelectromagnetics, 18(5):376-87.

Walcott, C.; Gould, J.L.; Lednor, A.J. 1988. Homing of magnetized and demagnetized pigeons. J Exp Biol, 134:27-41.

Walker, C.E.; Seitelman, D.L.; McElhaney, J.H.; Mullen, S.P.; Hagadorn, B.; Seto, Y.J. 1982. Effects of high-intensity 60-Hz fields on bone growth. Journal of Bioelectricity, 1(3):339-349.

Wartenberg, D. 2001a. The potential impact of bias in studies of residential exposure to magnetic fields and childhood leukemia. Bioelectromagnetics Supplements, 5: S32-S47.

Wartenberg, D. 2001b. Residential EMF exposure and childhood leukemia: Meta-analysis and population attributable risk. Bioelectromagnetics Supplements, 5: S86-S104.

Wilson, B.W.; Anderson, L.E.; Hilton, D.I.; Phillips, RD. 1981. Chronic exposure to 60-Hz electric fields: effects on pineal function in the rat. Bioelectromagnetics, 2(4):371-80.

Wrensch, M.; Yost, M.; Miike, R.; Lee, G.; Touchstone, J. 1999. Adult glioma in relation to residential power frequency electromagnetic field exposures in the San Francisco Bay Area. Epidemiology, 10: 523-527.

Zaffanella, L.E. 1993. Survey of residential magnetic field sources. Vol. 1: Goals, results, and conclusions. (EPRI TR-102759-V1, Project 3335-02). Electric Power Research Institute, Palo Alto, CA.

Zheng, T.Z.; Holford, T.R.; Mayne, S.T.; Owens, P.H.; Zhang, B.; Boyle, P.; Carter, D.; Ward, Y.W.; Zahm, S.H. 2000. Exposure to electromagnetic fields from use of electric blankets and other in-home electrical appliances and breast cancer risk. American Journal of Epidemiology, 151(11): 1103-11.

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.

William H. Bailey, Ph.D., is a Principal Scientist and manages the Health practice scientists in Exponent's New York office. Before joining Exponent, Dr. Bailey was President of Bailey Research Associates, Inc., the oldest research and consulting firm with specialized expertise in electro-magnetic fields and health. Dr. Bailey specializes in applying state-of-the-art assessment methods to environmental health and impact issues. His 30 years of training and experience include laboratory and epidemiologic research, health risk assessment, and comprehensive exposure analysis. Dr. Bailey is particularly well known for his research on potential health effects of electromagnetic fields and is active in setting IEEE standards for human exposure to electromagnetic fields. He uses advanced analytical and statistical methods in the design and analysis of both experimental studies and epidemiology and survey research studies. In addition, Dr. Bailey's postgraduate training in the social, economic, and behavioral sciences is helpful in assessing the important effects of social, economic, and community factors on health risks and vulnerability to environmental impacts in health and environmental justice research. He is a member of a working group that advises a committee of the World Health Organization on risk assessment, perception, and communication. Dr. Bailey is also a visiting scientist at the Cornell University Medical College. He was formerly Head of the Laboratory of Neuropharmacology and Environmental Toxicology at the New York State Institute for Basic Research, Staten Island, New York, and an Assistant Professor and NIH postdoctoral fellow in Neurochemistry at The Rockefeller University in New York.

Maria DeJoseph is an Epidemiologist in Exponent's Health Group and is based in New York, New York. Ms. DeJoseph has a background in epidemiology and biological sciences. She served as the primary investigator for a case-control epidemiologic study of her design to investigate a mediastinitis outbreak in cardiothoracic surgery patients. Ms. De Joseph also has recruited and interviewed subjects, and analyzed hormone levels for an epidemiologic breast cancer study. She has conducted phytochemical analyses of medicinal plants including the isolation and fractionation of tropical plants used medicinally by indigenous peoples and primates of Central and South America. Ms. DeJoseph has served as an ethnobotanical and zoopharmacological field researcher in Mexico, Costa Rica and Venezuela. She has used a variety of methods to identify chemical and prospective pharmaceutical compounds, including HPLC, column chromatography, anti-microbial assays, gas chromatography mass spectrometry (GC-MS), and nuclear magnetic resonance spectroscopy (NMR). Before joining exponent, Ms. DeJoseph was a Research Assistant in the Medical School, Division of Epidemiology at Stanford University.

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CONDEMNATION

If landowners refuse BPA's offers to buy land rights (fee or right-of-way easements), BPA would acquire the landrights through condemnation. After a transmission line route has been selected and surveyed, it is usually not possible to use alternative routes to avoid areas where owners are not willing to sell right of way easements for the transmission line or access road right-of-ways, or fee for substations. In some cases, feasible alternative means of access may be found.

If, after good faith negotiations, BPA and a landowner are not able to agree on terms of a purchase, BPA would ask the U. S. Department of Justice to begin condemnation proceedings in U. S. District Court on BPA's behalf. In such cases, the U. S. Attorney files a "declaration of taking" in the court having jurisdiction of the area where the land is located. The declaration of taking describes the location of the fee parcel, or the easement and the uses that the United States will be entitled to make of the property covered by the easement. The Court notifies the landowner and all other parties who have a legal interest in the property that the action has been filed.

The United States owns the easement as soon as the declaration of taking is filed. However, the Government does not have the right to use the property until the Court issues an order delivering possession of the easement to the United States. A judge typically does not sign such an order until the landowner has been notified of the filing and has had a chance to respond. Possession is usually given to an agency promptly after that, but a judge will consider the landowner's response and may schedule a hearing, if requested, before deciding when to deliver possession of property to the agency.

At the time when the declaration of taking is filed, funds are deposited in the registry of the court, in the amount that BPA estimates to be the value of the landrights. This estimate is based on BPA's appraisal. The amount of the deposit is subsequently adjusted, if necessary, to reflect estimated market value at the time when the declaration of taking is filed. While the case is in progress, the landowner can petition the Court to withdraw and use the money that has been deposited by BPA.

The condemnation proceedings determine the value of the landrights taken by the United States. Both sides have an opportunity to present evidence of value, and the Court determines the amount of the ultimate award. If the amount is more than the funds deposited by BPA, the remainder is deposited, with interest from the date when the declaration of taking was filed.

It is sometimes possible for a landowner or his attorney to negotiate a settlement through discussions conducted through the U. S. Attorney after the condemnation proceedings have begun but before a trial. If this occurs, a trial can be avoided.

Each side pays its own litigation costs, unless the award is closer to the landowner's opinion of the value of the landrights than to the Government's. If the amount of the award is closer to the landowner's opinion of value, the Court can have the Government reimburse the landowner for certain costs that he reasonably incurred in the case.

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Compatibility Detemination

Use: Schultz-Hanford Area Transmission Line Project ana associated minor modification of existing right-of-way

Refuge Name: Columbia National Wildlife Refuge (NWR)

County: Adams, Washington; Grant, Washington

Establishing and Acquisition Authorities:

Public Land Order 243, September 6, 1944

Migratory Bird Conservation Act, as amended [16 USC 715- 715r]

Migratory Bird Hunting and Conservation Stamp Act of 1934 [16 USC 718- 718h; 48 Stat. 451]

Fish and Wildlife Act of 1956, as amended [16 USC 742a- 742j; 70 Stat. 1119])

Refuge Purpose(s}:

For withdrawn lands -"... as a refuge and breeding ground for migratory birds and other wildlife ..." Public Land Order 243, dated Sept. 6,1944.

"...for use as an inviolate sanctuary, or for any other management purpose, for migratory birds." 16 U.S.C. § 715d (Migratory Bird Conservation Act)

National Wildlife Refuge System Mission:

The mission of the National Wildlife Refuge System is "...to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" (National Wildlife Refuge System Administration Act of 1966, as amended [16 U.S.C. 668dd-668ee]).

Description of Use(s}:

The proposed Bonneville Power Administration (BPA) project would add 150' width to an existing 100' wide and half mile long right-of-way (ROW) and construct a new transmission line in Central Washington to increase transmission system capacity north of Hanford. Construction would include placement of two flat 500-kilovolt single-circuit steel towers on U.S. Fish and Wildlife Service (USFWS) land, adjacent to towers on an existing parallel line (also on USFWS land.) The additional ROW would exclude the construction or placement of any buildings, and is considered a minor expansion because the existing roads and juxtaposed corridor will be used for access, and new towers will be lined up with existing towers. Sandy and rocky substrates in the ROW should restrict impacts mostly to the "footprints" of the two towers.

A description of the entire project under consideration for this determination can be found in the following document and is incorporated by reference: *Schultz-Hanford Area Transmission Line Project, Final Environmental Impact Statement, DOE/EIS-0325, January 2003* (FEIS). This Compatibility Determination is an appendix to the FElS.

Construction and ROW for the power line would occur on the west side of an isolated parcel of

USPWS land near the confluence of Crab Creek and the Columbia River near Schwana in Grant County, Washington. The location is in Section 2, T15N, R23E (see maps attached.)

Construction is projected for 2004. Annual maintenance visits would likely occur during the spring when noxious weed control might be needed.

The construction portion of this project would include the use of ground vehicles and equipment to erect power line footings and legs. Helicopters would be used to move and place towers that were pre-constructed off-site. An existing operation and maintenance road would be improved to allow vehicle access.

This power line location was selected as the least environment-damaging route among six considered. It is adjacent to another power line which uses the same access roads and right-of-way. Bonneville Power Administration is responsible for providing uninterrupted power to meet demand across the region, and this line would eliminate a bottleneck and increase reliability during high demand periods.

Availability of Resources:

Compensation was received from BP A for the entire planning process to help determine compatibility. Annual inspection and treatment of invasive species in the right-of-way is addressed as a stipulation necessary to ensure compatibility.

Weed control would utilize a refuge truck and A TV spray equipment, using one or two staff days and herbicide. Monitoring would be accomplished during these annual visits. BP A funds would be transferred to the USPWS, Columbia NWR for these weed-related compliance activities, including preparation of a Pesticide Use Proposal required by USPWS if herbicides are needed. Ultimately, after native plant species are re-established, minimal refuge resources would be required and could be completed within existing operating budgets.

Anticipated Impacts of the Use(s):

Cumulative and long-term impacts would be negligible due to measures adopted as stipulations necessary to ensure compatibility. Short-term and long-term impacts are listed below. BP A has completed cultural resources review, and tower sites and access roads are located outside cultural resource boundaries (4.10.3 FElS.) A description of the entire project under consideration can be found in the FElS.

- Short-term soil disturbance would occur during construction phase from use of vehicles and equipment where the towers will be installed.
- There would be noise associated with construction, including equipment and helicopter used to place tower on legs and to stretch conductor, that is short-term.
- Vegetation removal at tower sites, and trampling or crushing during construction phase next to tower sites and along spur access roads, would be a short-term impact.
- .Addition of towers and horizontally-oriented parallel conductor lines, high tension ground line, and fiber optic cable that add a potential bird-strike hazard would be a permanent, long-term impact.

Public Review and Comment:
The public review and comment period began September 26, 2002 and ended October 10, 2002. The following methods were used to solicit public review and comment:

1. Posted notice at Columbia NWR headquarters, Royal City PO, and Othello PO.
2. Public notice on September 26, 2002 in the following newspapers: Columbia Basin Herald, Othello Outlook, Royal Review.

There were no comments from the public.

Following the above public comment period, Columbia NWR adopted the BPA's FEIS. The FEIS documents public comments received by BP A and responses they provided. BP A's Record of Decision will be issued no sooner than 30 days following publication notice in the Federal Register for the FElS. Our Record of Decision will be issued after the BPA's Record of Decision has been signed.

Determination: (check one below)

___ Use is Not Compatible

_X_ Use is Compatible With Following Stipulations

Stipulations Necessary to Ensure Compatibility:
In accordance with 603 FW 2.11 (D) for minor modifications of existing rights-of-way, and to avoid resource impacts and ensure no net loss of habitat quantity and quality, BP A will implement the following: 1) Stipulations listed below, and referenced in Chapters 5.5.1.4 and 5.20.4 and Appendix L of the FElS dated January 2003, will be reflected unchanged in the BPA Record of Decision and will be reflected in our Record of Decision; 2) road access is closed (if necessary with construction of new gate and fence) to prevent unauthorized vehicle trespass to proposed and existing right-of-way; 3) helicopter installation of towers is used to avoid the need for heavy and wide-tracked ground equipment on sensitive soils and vegetation; 4) tower design is changed from delta to flat configuration, which places all transmission wires lower and on a single horizontal plane; 5) bird diverters are added to the overhead ground-wires and fiber optic cable to help deter bird strikes; 6) road width is reduced to approximately 101 which will protect native vegetation and reduce the area requiring annual weed control; 7) noxious weed control is included as a requirement of the right-of-way expansion and includes the existing right-of-way, which we will monitor; 8) vehicle inspection and weed removal will occur for all BP A employees, contractors, and their agents before entering refuge lands; 9) re-vegetation of construction site will occur using adapted native plant species; 10) a pre-construction meeting will occur between the BPA project inspector and contractor(s) and the Fish and Wildlife Service to ensure that these requirements are understood.

This Compatibility Determination will become effective on the date the U.S. Fish and Wildlife Service's Record of Decision is signed and made available to, the affected public.

Justification:
Changes following review of the Draft EIS eliminated incompatible portions of the original project, and are documented in letters appended to this Determination of Compatibility from BPA Project Manager Lou Driessen to CNWR Project Leader Bob Flores on 7/18/02 and 8/27/2002. These include stipulations 3-6 above. Although there will be minor short-term impacts, the measures implemented to ensure compatibility that include re-vegetation with native species, noxious weed control and access restrictions, should actually improve habitat quality above the current condition. This proposal supports the Refuge purposes, National Wildlife Refuge System mission, and mandate to ensure biological integrity, diversity, and environmental health.

Mandatory Re-Evaluation Date: (provide month and year for "allowed" uses only)

____________ Mandatory 15-year Re-Evaluation Date (for priority public uses)

December 2012 Mandatory 10-year Re-Evaluation Date (for all uses other than priority public uses)

NEPA Compliance for Refuge Use Decision: (check one below)

___ Categorical Exclusion without Environmental Action Statement

___ Categorical Exclusion and Environmental Action Statement

___ Environmental Assessment and Finding of No Significant Impact

_X_ Environmental Impact Statement and Record of Decision

References Cited:

Schultz-Hanford Area Transmission Line Project, Draft Environmental Impact Statement, DOE/EIS-0325, February 2002.

Schultz-Hanford Area Transmission Line Project, Final Environmental Impact Statement, DOE/EIS-0325, January 2003.

Letter of 7/18/02 from Lou Driessen, BP A Project Manager, to Bob Flores, Columbia NWR Project Leader (attached).

Letter of 8/27/02 from Lou Driessen, BPA Project Manager, to Bob Flores,) Columbia NWR Project Leader (attached).

Memo to USFWS Regional Director Anne Badgley from Columbia NWR Project Leader Robert Flores: NEP A compliance for Schultz-Hanford Area Transmission Line Project- Adoption of Final Environmental Impact Statement, December 2002.

Refuge Determination:

Prepared by: Randy Hill (Signature) 12/19/02 (Date)

Refuge Manager/
Project Leader
Approval: (Signature) 12/19/02 (Date)

Concurrence:

Acting Refuge Supervisor: (Signature) 12/23/02 (Date)

Regional Chief,
National Wildlife
Acting Refuge System: (Signature) 122302 (Date)