FERC/DEIS-0038

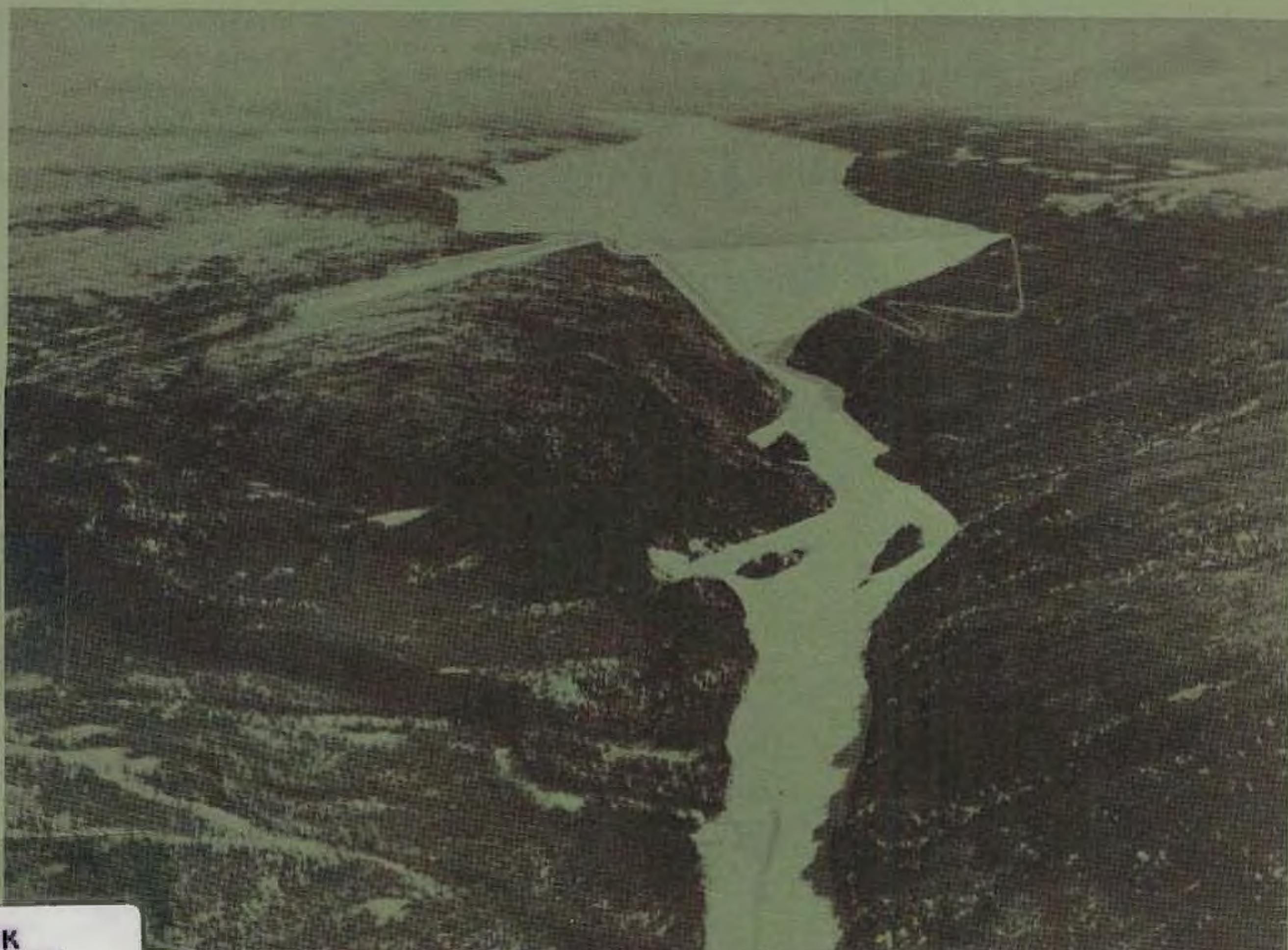
SUSITNA HYDROELECTRIC PROJECT

FERC No. 7114

ALASKA

Draft Environmental Impact Statement

Volume 3: Appendices E through G



OFFICE OF ELECTRIC POWER REGULATION
FEDERAL ENERGY REGULATORY COMMISSION

MAY 1984

FERC/DEIS-0038

FEDERAL ENERGY REGULATORY COMMISSION
OFFICE OF ELECTRIC POWER REGULATION

DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUSITNA HYDROELECTRIC PROJECT
FERC NO. 7114 - ALASKA

Volume 3.

Appendix E. Geology and Soils

Appendix F. Land Use and Ownership

Appendix G. Climate, Air Quality, Noise

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Additional copies of the Draft-EIS may be ordered from:

Division of Public Information
Federal Energy Regulatory Commission
825 North Capitol St., NE.
Washington, D.C. 20426

May 1984

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APPENDIX E

GEOLOGY AND SOILS

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APPENDIX E. GEOLOGY AND SOILS

E.1 AFFECTED ENVIRONMENT

E.1.1 Proposed Project

E.1.1.1 Upper and Middle Susitna River Basin

E.1.1.1.1 Topography

The upper and middle Susitna River Basin is located in Southcentral Alaska within the Pacific Mountain System physiographic division of Alaska (Cobb, 1974). The Susitna River headwaters in the Susitna Glacier [2,800 feet (ft), or 850 meters (m), MSL] on the southern slope of the Alaska Range. The arcuate Alaska Range, which borders the basin to the north, west and east, is approximately 600 miles (mi) [970 kilometers (km)] long and 50 to 80 mi (80 to 130 km) wide. Most peaks are between 5,000 and 8,200 ft (1,500 and 2,500 m) MSL north of the upper Susitna Basin and within Denali National Park. Elevations in the Alaska Range are greatest in Denali National Park and Preserve, increasing to a maximum of 20,320 ft (6,190 m) at Mount McKinley approximately 75 mi (120 km) northeast of the reservoir sites.

From the Susitna Glacier, the Susitna River flows to the south-southwest approximately 55 mi (88 km) through a broad, glaciated, intermontaine valley of knob and kettle and braided-channel topography. Just south of the Tyone River at approximately 2,200 ft (670 m) MSL, the river turns west and flows across the northwestern edge of the poorly drained, lake-speckled Copper River Lowland and the northern edge of the Talkeetna Mountains, a nearly circular mountain mass with most peaks between 6,000 and 8,300 ft (1,830 and 2,530 m) MSL.

Approximately 40 mi (64 km) west of Tyone River the Susitna flows through the broad V-shaped valley at the proposed Watana Dam site [elevation 1,600 ft (490 m) MSL] near the confluence of Deadman Creek. Approximately 30 mi (50 km) further downstream the Susitna River flows through the deep gorge of Devil Canyon and the proposed Devil Canyon dam site (elevation 1000 ft, or 300 m, MSL) a few miles upstream of Portage Creek. After passing through Devil Canyon, the Susitna River channel broadens and the river flows to the southwest along the western edge of the Talkeetna Mountains and the eastern border of Denali State Park. Within 10 mi (16 km) of the project dam sites, the topography is dominated by scoured bedrock knobs and ridges, and glacial sediment deposits. The Watana dam site is located in a relatively broad V-shaped valley that rises steplike from a steeper lower portion [1,600 ft (490 m) MSL] to flatter, more gentle slopes at higher elevations [2,200 ft (670 m) MSL]. Vertical rock outcrops limit access to the lower sections of the Watana dam site. At the Devil Canyon site, the Susitna River flows through a very narrow, 600-ft (185-m) deep gorge [1,000 ft (300 m) MSL] about 2 mi (3 km) in length. The valley is asymmetrical in shape, with the northern abutment sloping about 45° and the southern abutment steeper at about 60°. The southern abutment displays overhanging cliffs and detached rock blocks. The northern abutment is less rugged in the upper half but steeper in the lower portion (Acres American, undated).

The preferred access route to the damsite areas is illustrated in Figure E-1. This route originates at a railhead in Cantwell in the Broad Pass or Chulitna River valley and then follows the existing Denali Highway to a point 21 mi (34 km) east of the junction of the George Parks and Denali highways. A new road would be constructed from this point approximately 35 mi (56 km) due south across relatively flat terrain of the Brushkana and Deadman creek valleys to the Watana dam site. Access to the Devil Canyon development would be accomplished by a railroad extension from the existing Alaska Railroad at Gold Creek to a railhead facility adjacent to the Devil Canyon camp area. This railroad extension would follow relatively level terrain [1,600 to 1,800 ft (490 to 550 m) MSL] south of the Susitna River. To provide access to the Watana dam site and the existing highway system, a connecting road would be constructed north of the Susitna River from the Devil Canyon railhead to the Watana dam site. The 32-mi (51-km) road would rise gently to an elevation of almost 4,000 ft (1,220 m) MSL before dropping gently to the Watana dam site.

The proposed locations of the construction village and permanent town site and the construction camp for the Watana dam are on level terrain north of the Susitna River just upstream from the dam site between Tsusena and Deadman creeks at approximately 2,300 ft (700 m) MSL. The proposed sites of the Devil Canyon construction camp and village are on the southern side of the Susitna River on level terrain [elevation approximately 1,700 ft (520 m) MSL] upstream from the dam site.

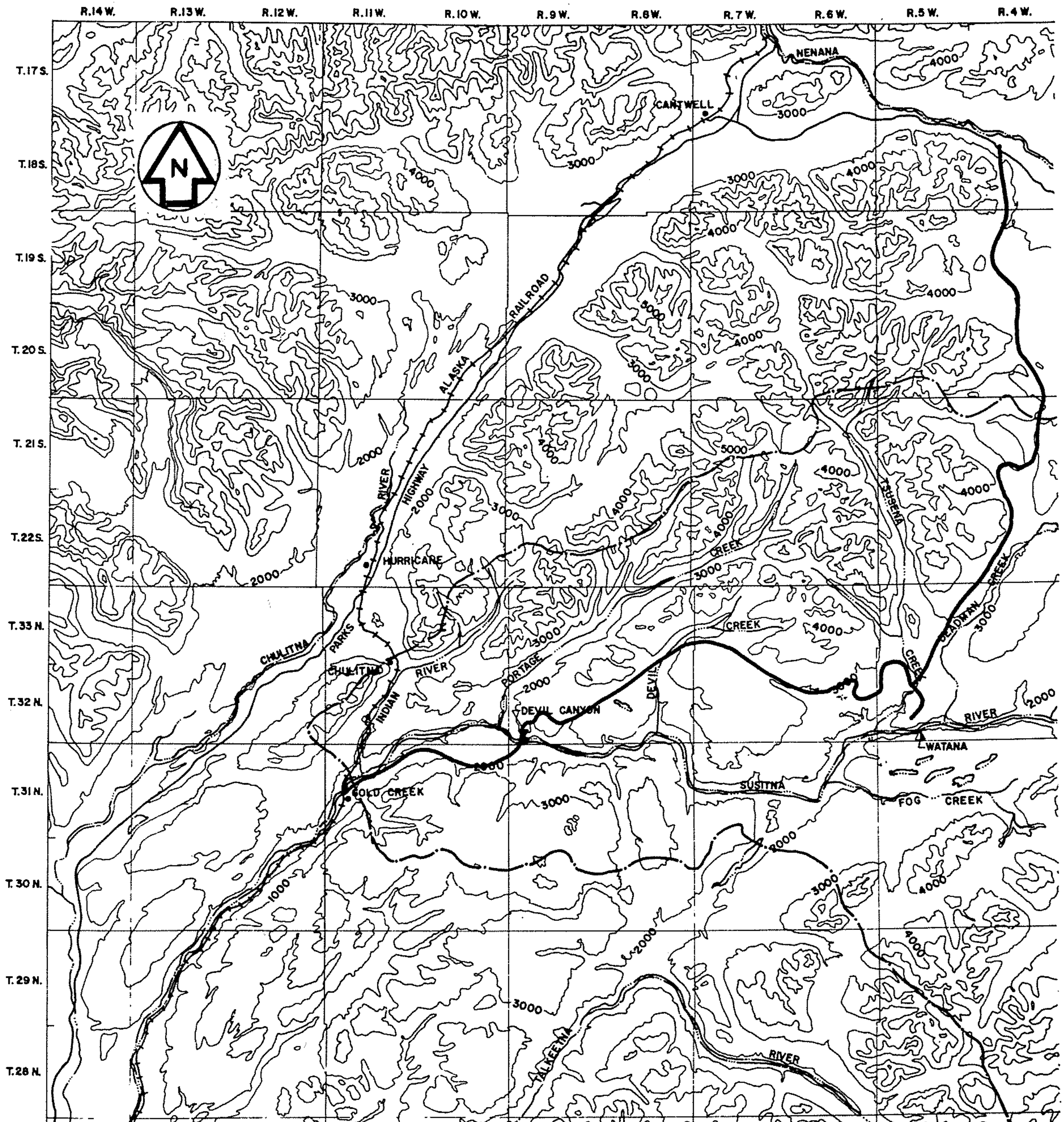

Figure E-1. Alternative Access Plan 18 (Proposed). [Source: Exhibit E, Vol. 9, Chap. 10, Fig. E-10.9]

All the proposed borrow pit and quarry areas for the Watana and Devil Canyon damsite construction activities are located on relatively flat terrain adjacent to the Susitna River or in broad valleys of tributaries to the Susitna (Figs. E-2, E-3). All but quarry site K and borrow site G are near the Watana dam site.

Quarry site A would be developed at the southern abutment of the Watana dam site at approximately 2,300 to 2,600 ft (700 to 790 m) MSL in an area that has been glacially scoured into east-west swales. Quarry L is located on a rock knob 400 ft (120 m) upstream of the proposed upstream coffer dam on the southern bank and is separated from the main valley by a relict channel. Quarry B is located about 2 mi (3 km) upstream from the dam site at 1,700 to 2,000 ft (520 to 600 m) MSL along the Susitna River and Deadman Creek (Exhibit E, Vol. 9, Chap. 10, pp. E-10-84 - E-10-99).*

Borrow site D lies in a broad plateau immediately northwest of the Watana dam site and extends eastward northeast of the dam site [2,150 ft (655 m) MSL] towards Deadman Creek [2,450 ft (745 m) MSL]. Benches and swales up to 50 ft (15 m) in height dominate the site topography. At borrow site H, the topography is generally rolling and much of the site is covered by swamps and marshes. The site slopes from 2,400 to 1,400 ft (730 to 430 m) MSL towards the Susitna River. Borrow site E is located on a large, flat, alluvial fan deposit 3 mi (5 km) downstream of the dam site on the northern bank of the confluence of Tsusena Creek and the Susitna River. Elevation across the site varies from 1,410 ft (430 m) MSL near the river level to 1,700 ft (520 m) against the valley walls to the north. Borrow sites I and J are located in the Susitna River valley fully within the confines of the proposed Devil Canyon and Watana reservoirs (Exhibit E, Vol. 9, Chap. 10, pp. E-10-89 - E-10-97).

Secondary borrow site C is located in a broad glacial valley 4.5 mi (7.2 km) upstream from Tsusena Butte. Secondary borrow site F occupies the middle stretch of Tsusena Creek to north of Clark Creek, where it abuts borrow site C (Exhibit E, Vol. 9, Chap. 10, pp. E-10-87 - E-10-94).

In the Devil Canyon area, borrow site G is located approximately 1,000 ft (300 m) upstream from the proposed dam site on a large, flat-lying fan or terrace extending from the southern bank of the Susitna River approximately 80 ft (24 m) above the river. Quarry site K is approximately 5,300 ft (1,600 m) south of the saddle dam site at 1,900 ft (580 m) MSL. The site is located on the east-west face of the exposed 200-ft (60-m) high rock cliff (Exhibit E, Vol. 9, Chap. 10, pp. E-10-100 - E-10-103).

E.1.1.1.2 Geology

BEDROCK GEOLOGY

The Devil Canyon and Watana dam sites lie in the Susitna River Basin within the Talkeetna Mountains of Southcentral Alaska. According to Csejtey et al. (1978), southern Alaska developed by the accretion of a number of continental blocks onto the North American plate during Mesozoic times. Each of these terrains had varying geologic histories and as a result the stratigraphy and structure of this region is highly complex.

The oldest rocks which outcrop in the region are metamorphosed upper Paleozoic clastic flows and tuffs locally interbedded with marble. This rock sequence trends northeastward along the eastern portion of the Susitna River Basin. Triassic and Jurassic metavolcanic and sedimentary rocks unconformably overlie the Paleozoic rock sequence and can be found to outcrop around Watana and Portage Creeks. The Paleozoic and Lower Mesozoic rocks are intruded by Jurassic plutonic rocks composed chiefly of granodiorite and quartz diorite. The Jurassic-age intrusive rocks form the batholithic complex of the Talkeetna Mountains (Acres American, undated).

A thick turbidite sequence of interbedded Cretaceous graywackes and argillite resulting from the uplift of the Talkeetna Mountains and the subsequent rapid erosion underlie a large part of the project area and form the bedrock at the Devil Canyon site. These rocks were subsequently deformed and intruded by a series of Tertiary-age plutonic rocks. The Watana site is underlain by one such plutonic body which comprises the southern limit of the diorite pluton which predominates along upper Tsusena Creek. The plutons were subsequently intruded and overlain by felsic and mafic volcanics, and mafic volcanics are found downstream from the Watana site (Fig. E-4) (Acres American, undated).

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*Throughout this document, references to specific "Exhibits" are to the exhibits submitted to FERC as part of Alaska Power Authority's Susitna Hydroelectric Project License Application. References to specific "Appendices" (App.) are to the appendices provided in Volumes 2 through 7 of this Draft Environmental Impact Statement.

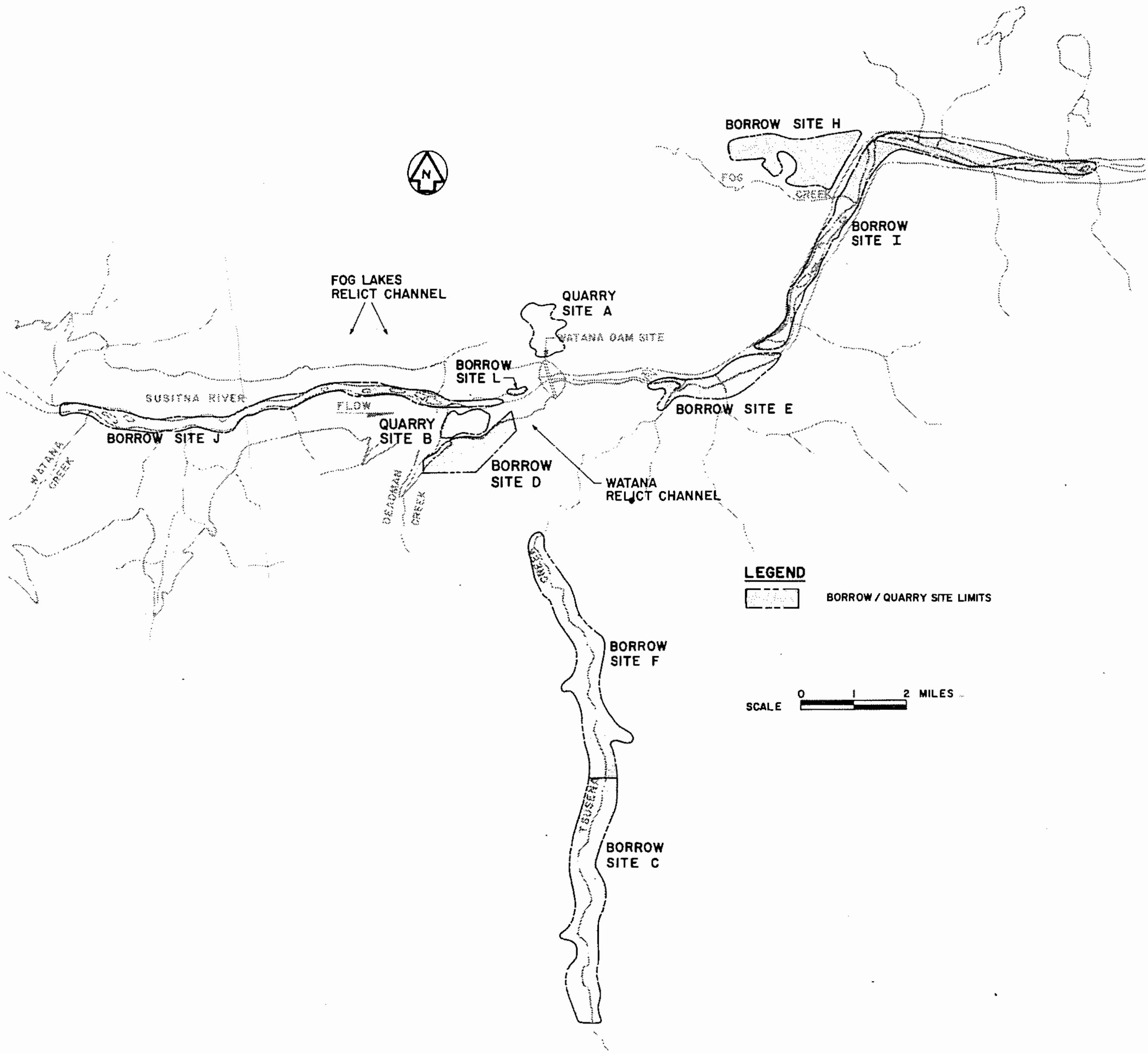

Figure E-2. Watana Borrow/Quarry Sites. [Source: Exhibit E, Vol. 9, Chap. 10, Fig. E.10.13]

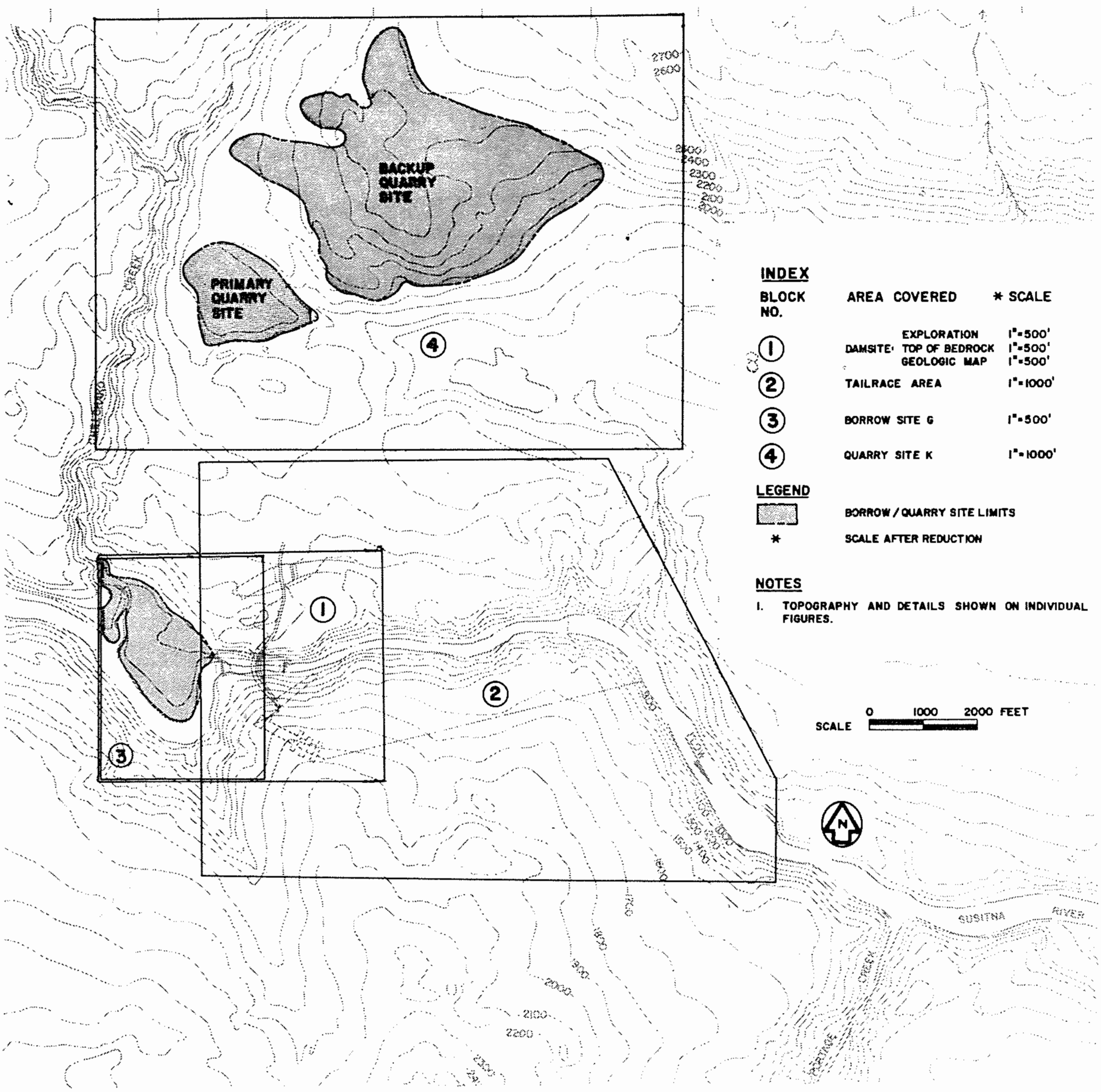

Figure E-3. Devil Canyon Borrow/Quarry Sites. [Source: Exhibit E, Vol. 9, Chap. 10, Fig. E.10.14]

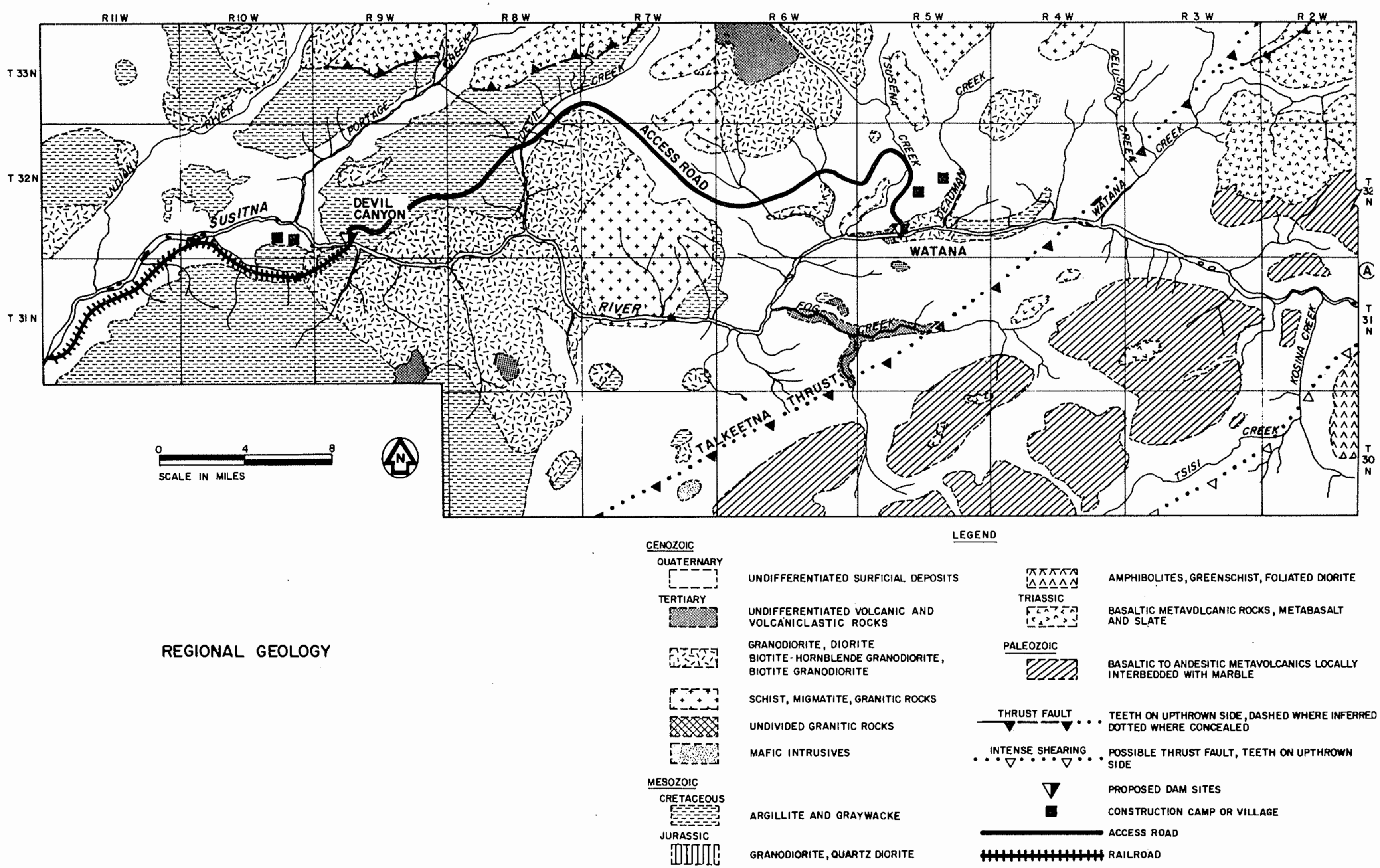

Figure E-4. Regional Geology Underlying Site Features. [Source: Exhibit E, Vol. 7, Chap. 6, Fig. E-6.1]

At the proposed Watana dam site the dioritic pluton is generally massive in texture and competent. Small discontinuous alteration zones, fraction zones, and shears, as well as two major and two minor joint sets, have been found at the site. The joints are generally steep and many follow the structural trend of the region.

The two most prominent areas of shearing and alteration have been named "The Fins" and "The Fingerbuster." The Fins, located upstream from the proposed site of the diversion tunnel on the northern bank of the Susitna, is an area approximately 400 ft (120 m) wide comprising by three major northwest-trending zones of shearing and alteration that have eroded into steep gullies. The Fingerbuster is located downstream from the proposed damsite. This feature is exposed in a 40-ft (12-m) wide, deep, talus-filled gully along the andesite porphyry/diorite contact. The rock contact is severely weathered, with closely spaced joints and slickenslides indicating vertical displacement (Exhibit E, Vol. 7, Chap. 6, pp. E-6-13 - E-6-16).

Two buried relict river channels that could potentially affect reservoir impoundment exist within the Watana project area. The Watana relict channel extends from a location approximately 2,000 ft (600 m) upstream from the dam site on Deadman Creek to Tsusena Creek and apparently follows the softer sheared and fractured rock of "The Fins" structure. The Watana relict channel is filled with approximately 450 ft (130 m) of overburden deposits including basal fill, alluvium, glacial fluvial silts, sands, and gravels as well as lacustrine clays (Acres American undated: Vol. 1, pp. 6-36 - 6-39).

The Fog Lakes buried channel extends between the Watana damsite and the higher ground 5 mi (8 km) to the southeast. The channel is filled by approximately 350 ft (100 m) of glacial deposits (Exhibit E, Vol. 7, Chap. 6, p. E-6-17).

The contacts between the interbedded graywackes and argillites at the Devil Canyon site are tight and both rocks are fresh and hard. The argillite/ graywacke has been severely deformed by folding and where exposed, foliation planes which parallel bedding planes appear slaty and phylitic. The northern canyon wall at the damsite appears to be controlled by the bedding planes. A few of the numerous felsic and mafic dikes in the area are closely fractured and eroded and have formed steep, talus-filled gullies, some of which exhibit shearing with the host rock (Exhibit E, Vol. 7, Chap. 6, p. E-6-18).

Four joint sets have been delineated in the Devil Canyon area. Loose rock blocks have been formed by the intersection of two of these joint sets, and one joint set opens on the southern bank, dipping towards the river creating a potential slippage plane (Exhibit E, Vol. 7, Chap. 6, p. E-6-19). Shear and fracture zones exist beneath the proposed saddle dam area. These zones generally have vertical to steep northeastly dips and are generally 1 ft (0.3 m) wide (Exhibit E, Vol. 7, Chap. 6, p. E-6-20). The bedrock units underlying other project features in the vicinity of the dam site are illustrated in Figure E-4.

Quarry sites A, L, and possibly B at the Watana dam site (Fig. E-2) will be considered as potential sources of rockfill for dam construction. Quarry site A would be developed in a large, exposed diorite and andesite porphyry rock knob approximately 1 square mile (mi^2) [2.6 square kilometers (km^2)] at the southern abutment of the Watana dam site. Quarry L would consist primarily of diorite, with occasional andesitic sills or dikes. Bedrock at quarry B, a secondary quarry site, is interfingered with poor-quality sedimentary volcanic and metamorphic rock and is covered with thick overburden in several areas (Exhibit E, Vol. 9, Chap. 10, pp. E-10-84 - E-10-99). At Devil Canyon quarry site K, the bedrock is a slightly metamorphosed, medium-grained biotite granodiorite that contains inclusions of argillite (Exhibit E, Vol. 9, Chap. 10, p. E-10-103).

SURFICIAL GEOLOGY

The following description of the surficial geology of the project area is based (unless otherwise specified) on the photointerpretation terrain evaluation conducted by Acres American Inc. (undated: Vol. 2, Appendix J).

During the Pleistocene, the entire Susitna project study area was repeatedly glaciated. The early Pleistocene glaciers completely covered south-central Alaska, covering many of the mountains in the project area as evidenced by their rounded summits. The last glaciation to completely cover the project area may be correlated with the Illinoian glaciation of the Continental United States (Pewe, 1975). Ice flowing from the Alaska Range, the Talkeetna Mountains, and several highland centers spread across the project lowlands, depositing a sheet of gray, gravelly, sandy, and silty basal till. The till varies in thickness from 100 ft (30 m) in river basins to a thin blanket over bedrock. This till is believed to overlie older, poorly exposed Quaternary sediments. Prominent lateral moraines of the major glacial advance occur on the flanks of the mountains bordering the central Watana Creek-Stephan Lake Lowland.

An extensive glaciolacustrine sequence overlies the basal till unit in the areas occupied by proglacial lakes formed when the glaciers from the Alaska Range blocked the existing drainage patterns. Talkeetna River Valley glaciers blocked low divides between Stephan Lake and the Talkeetna River, and the Copper River Basin was occupied by an extensive proglacial lake. Lacustrine deposits cover much of the Watana Creek-Stephan Lake Lowland and extend upstream along the Susitna River to the Susitna-Copper River Lowland. In the Watana Creek-Stephan Lake Lowland, the unit is generally less than 20 ft (6 m) thick and composed of medium to fine sand with a significant gravel content. The lake deposits of the Copper River Lowland are thought to be thicker and finer. In the Watana Creek-Stephan Lake area, several deltas and strandline features were formed at about the 3,000 ft (900 m) MSL.

Hummocky, coarse-grained deposits of ablation till overlie the lacustrine sediments between Tsusena and Deadman creeks and the basal till in the valleys north of Deadman Creek and in the Denali Highway area. In small, isolated proglacial lakes, lacustrine sediment deposits have also been found overlying the ablation till. Esker and kame deposits are also found along the Susitna River between the Oshetna and Tyone rivers.

Fluvial erosion and entrenching of the project area portion of the ancestral Susitna and its tributary streams occurred in the intervals between glacial advances. Remnants of older entrenching events are preserved in several abandoned and buried channel sections along the modern Susitna River, such as at the Vee Canyon dam site, at Deadman and Tsusena creeks north of the Watana dam site, above and south of the southern abutment at the Devil Canyon dam site, and near the river level just upstream of the Watana dam site and downstream of Watana Creek. Many of these relict channels are filled with fluvial, glacio-fluvial, lacustrine, and outwash materials.

Since the Pleistocene, downcutting by the Susitna River has excavated a V-shaped valley within the wide glaciated valley floor and has rejuvenated many tributary streams. Several terraces are found above the Susitna River and its major tributaries, most notably Tsusena Creek. Some occur high on the valley walls as eroded terrace remnants (upstream of Watana Creek), while others occur as very recent low, flat planar features. The terraces are frequently modified by the deposition of alluvial fan debris and/or soil solifluction lobes and sheets across their surfaces. Alluvial fans have also been deposited where steep small drainages emerge onto floors of wider glaciated valleys.

Numerous colluvial deposits have been formed as a result of the effects of frost cracking, cryoturbation, and gravity. Steep, rubbley, talus cones have accumulated below cliffs, and thin deposits of frost-churned soils cover bedrock on slightly less precipitous slopes. Solifluction has modified the surficial glacial till and/or lacustrine deposits on numerous slopes in high-land areas (as along Devil Creek) and on the broad lowlands.

Several types of mass movements such as solifluctions, bimodal flows, skin flows and small rotational slides have occurred throughout the project area. Most of the slope instability has been found within the basal till unit on steep slopes and above the actively eroding streams. Failure of this material appears to be strongly related to saturation of soil following the thaw of permafrost. The basal unit is frequently overlain by lacustrine material and the lacustrine material fails with the till. Most failures occur as small, shallow debris slides or debris flows; however, a few large slump failures occur (Exhibit E, Vol. 7, Chap. 6, p. E-6-34).

The steep valley walls at the Devil Canyon site are covered by a thin veneer of overburden. Glacial deposits cover flatter upland areas to depths of 5 to 35 ft (2 to 11 m), while talus deposits are found at the base of the valley walls. A topographic depression along the southern bank of the lakes in the area is filled with glacial deposits to a depth of 85 ft (26 m). Up to 100 ft (30 m) of course to massive alluvium is present in the river channel. Alluvial fan and point bar deposits at the Cheechako Creek confluence range from 100 ft (30 m) to more than 300 ft (90 m) in thickness (Exhibit E, Vol. 7, Chap. 6, p. E-6-18), upstream from Devil Canyon Creek, the river valley slopes are covered with increasing amounts of basal tills, coarse-grained floodplain deposits and alluvial fan deposits (Exhibit E, Vol. 7, Chap. 6, p. E-6-32).

At the Watana reservoir site, overburden depth ranges from 0 to 80 ft (0 to 24 m). Talus deposits occur at the lower slopes; deposits of glacial till, alluvium, and talus are found in the upper areas of the abutments near the top of the slopes. River alluvia consisting of sand, silt, coarse gravels, and boulders average 80 ft (24 m) in thickness beneath the proposed dam site (Exhibit E, Vol. 7, Chap. 6, p. E-6-13).

At the Watana damsite area, borrow sites D and H are considered as potential sources of semi-pervious to pervious material; sites C, E, and F for granular material; and sites I and J for pervious gravel (Fig. E-2). All but sites C and F are considered primary sites for development (Exhibit E, Vol. 9, Chap. 10, p. E-10-84). Borrow site D is covered with potentially large quantities of clay and silt. Borrow site H is covered by an organic layer and underlain by layers of silt, sand, and gravel. Borrow site E is underlain by a sequence of bouldery till and river and floodplain gravels and sands. Borrow sites I and J contain large volumes of river and floodplain gravel deposits (Exhibit E, Vol. 9, Chap. 10, pp. E-10-86 - E-10-98).

Secondary borrow site C overlies basal till, outwash, and alluvial deposits consisting of saturated gravels and sands. Secondary borrow site F overlies a series of gravel bars and terraces. Deposits at this site are expected to consist of clean sands and gravels (Exhibit E, Vol. 9, Chap. 10, pp. E-10-81 - E-10-95).

At Devil Canyon, borrow site G overlies Susitna River alluvial gravels and sands, ancient terraces, Cheechako Creek alluvium and talus (Exhibit E, Vol. 9, Chap. 10, p. E-10-101).

E.1.1.1.3 Soils and Permafrost

The prominant soils along the Susitna River Valley are generally well-drained Spodsols. Specifically, Humic Cryorthods (S010) are present in the river valley downstream of the Devil Canyon dam site and Pergelic Cryorthods - Histic Pergelic Cryaquepts (S015) are present upstream. Pergelic Cryorthods - Histic Pergelic Cryaquepts (S016) are present on the highlands north of the Susitna River valley. Descriptions of these soils and their limitations for use and development are presented in Tables E-1 and E-2. These soils have formed primarily on gravelly, glacial deposits or loamy colluvial sediments. These soils are typically unsuited for cultivation but may be used for grazing. High water tables, periodic flooding, steep slopes, poor stability, low permeabilities, and stoniness severely limit the potential use of these soils although well drained soils in this area may have only slight or moderate limitations for construction (Rieger et al., 1979).

Soils along the remaining sections of the river are classified as Inceptisols or incompletely formed, horizonless soils. In the highlands south of the Susitna River Valley, soils of the Pergelic Cryumbrepts - Rough Mountainland association (IU3) occur (see Table E-1). The Inceptisols in this area are not suitable for cultivation and have severe limitations for construction and roads due to flooding and high water tables (Rieger et al., 1979). Throughout the upper and middle reaches of the Susitna River, permafrost is generally shallow in most areas but is deep or absent in some of the very sandy or gravelly material.

In the Watana reservoir area, permafrost has been delineated primarily on the flatter slopes below an elevation of 2,300 ft (700 m) MSL and is nearly continuous in the basal tills and is sporatic to continuous in the lacustrine deposits (Exhibit E, Vol. 7, Chap. 6, p. E-6-34). Permafrost is also present primarily on the north-facing slopes and is evidenced by ground ice, patterned ground stone nets, and slumping of glacial till overlying permafrost. Frozen alluvium and interstitial ice crystals have been observed in outcrops and drill hole drive samples and may be 200 to 300 ft (60 to 90 m) thick. Temperature measurements of the permafrost indicate that the permafrost is warm (within one degree of freezing) (Exhibit E, Vol. 7, Chap. 6, p. E-6-16). In contrast to the north-facing slopes, the south-facing slopes are less steep and better drained which may be indicative of less continuous permafrost and/or slightly coarser surface materials (Exhibit E, Vol. 7, Chap. 6, p. E-6-35). The construction camp and village site overlie permafrost free ablation till and organic deposits (Acres American, undated: Appendix J). Intermittent permafrost has been found in the vicinity of the Watana relict channel, to depths of 240 ft (70 m) in the relict channel and to varying depths in borrow site D.

As overburden in and around the Devil Canyon dam site area is thin or absent, permafrost has not been noted. The potential for sporadic permafrost to be present in some areas of the southern abutment has been noted in aerial photographs (Exhibit E, Vol. 7, Chap. 6, p. E-6-21). Upstream from the southern abutment permafrost may be present in the basal till deposits (Exhibit E, Vol. 7, Chap. 6, p. E-6-33). Permafrost is expected to occur in the basal till and organic deposits which underlie the construction camp and village sites south of the dam site (Acres American, undated).

No determination has been made as to the presence of permafrost along the proposed access route; however, discontinuous permafrost may be expected within fine surficial deposits and on the northern slopes of the Susitna valley.

E.1.1.1.4 Mineral Resources

Within the upper Susitna River Basin, mining has been characterized since the 1930s by low-density claims and intermittent activity. Several inactive claims exist within the projected areas of the Watana and Devil Canyon reservoir impoundments; however, no mining activity has occurred in this area and no interest in further exploration of the mineral potentials within the project area has been expressed by outside parties (Exhibit E, Vol. 7, Chap. 6, p. E-6-5).

Active placer mining has been concentrated primarily in Gold, Chunilna (Clear) and Portage creeks, with some active claims being present around Stephen and Fog lakes, Jay Creek, and the Watana Hills east of Jay Creek. Gold, copper, and silver placer mining at Gold Creek was active from the early 1950s through the late 1970s. Gold placer claims have been worked on Chunilna Creek since the late 19th Century and at least six mining claims remain. Only one claim remains active on Portage Creek, where mining also dates back to the late 19th Century (Exhibit E, Vol. 7, Chap. 6, p. E-6-5).

Table E-1. Soil Associations within the Susitna Project Study Area - General Description, Offroad Trafficability Limitations (ORTL), Common Crop Suitability (CCS), Road Location Limitations (RLL), and Low Building Limitations (LBL)†[1]

EF1 - Typic Cryofluvents - Typic Cryaquepts, loamy, nearly level.

- Dominant soils of this association consist of well-drained, stratified, waterlaid sediment of variable thickness over a substratum of gravel, sand, and cobblestones. Water table is high in other soils, including the scattered muskegs. ORTL: Slight - Severe (wet; subject to flooding); CCS: Good - Poor (low soil temperature throughout growing season). RLL: Moderate (flooding); LBL: Severe (flooding).

E01 - Typic Cryorthents, loamy, nearly level to rolling.

- This association occupies broad terraces and moraines; most of the bedrock is under thick deposits of very gravelly and sandy glacial drift, capped with loess blown from barren areas of nearby floodplains. Well-drained, these soils are the most highly developed agricultural lands in Alaska. ORTL: Slight, CCS: Good - Poor (Short frost-free period); RLL, LBL: Moderate-Severe (steep slope, susceptability to frost action).

HY1 - Sphagnic Borofibrists, nearly level association.

- Broad depressions and basins in glaciated lowlands have deep, poorly drained peat soils. Organic matter is at least 5 feet thick over very gravelly drift. ORTL, RLL, LBL - Very Severe (wet, organic soils). CCS - Unsuited (wet, organic).

IA15 - Drystric Cryandepts, loamy, hilly to steep - Fluvaquentic Borohemists, nearly level association.

- On foot slopes and hills, these soils are well drained. Under a thick mat of decomposed organic matter the soils are predominantly fine grained, very strongly acid, thixotropic and extend to depths of 20 to 40 inches. Very poorly drained fibrous organic soils occur in depressions on high benches and in drainageways. ORTL: Severe to Very Severe (steep slopes, organic soil); CCS - Poor-Unsuited (steep slopes, low soil temperatures, organic soils wet); RLL and LBL - Severe to Very Severe (steep slopes, low load supporting capacity.

IQ2 - Histic Pergelic Cryaquepts - loamy, nearly level to rolling.

- The dominant soils in this association are poorly drained, developed in silty material of variable thickness over very gravelly glacial drift. Most soils have a shallow permafrost table, but in some of the very gravelly, well-drained soils, permafrost is deep or absent. ORTL: Severe - (wet); CCS: Poor; RLL, LBL: Very severe (wet, permafrost).

IQ3 - Histic Pergelic Cryaquepts - Typic Cryofluvents, loamy, nearly level.

- Soils of this association located in low areas and meander scars of floodplains are poorly drained silt loam or sandy loam; these are usually saturated above a shallow permafrost table. Soils on the natural levees along existing and former channels are well-drained, stratified silt loam and fine sand; permafrost may occur. ORTL: Severe (wet); CCS: Unsuitable (low temperature during season; wet) - Good (but subject to flooding); RLL, LBL: Moderate - Very Severe (wet, permafrost).

IQ25 - Pergelic Cryaquepts - Pergelic Cryochrepts, very gravelly, hilly to steep.

- Soils of this association occupying broad ridgetops, hillsides, and valley bottoms at high elevation are poorly drained, consisting of a few inches of organic matter, a thin layer of silt loam, under which is very gravelly silt loam; permafrost table is at a depth greater than 2 feet. In locations of hills and ridges above tree line these soils are well-drained. ORTL: Severe (wet, steep slopes); CCS: Unsuitable (wet; low soil temperature; short, frost-free period); RLL, LBL: Severe (steep slopes, wet).

IR1 - Typic Cryochrepts, loamy, nearly level to rolling.

- On terraces and outwash plains, these soils are well-drained, having a thin mat of course organic matter over gray silt loam. In slight depressions and former drainage ways, these are moderately well-drained soils, having a thin organic mat over silt loam, with a sand or gravelly substratum. ORTL: Slight; CCS: Good-Fair (short frost-free period); RLL, LBL: Moderate (low load supporting capacity, frost heaving).

Table E-1. (Continued)

IR10 - Typic Cryochrepts, very gravelly, nearly level to rolling - Aeric Cryaquepts, loamy, nearly level to rolling.

- Generally well- to moderately well-drained soils of terraces, outwash plains, and low moraines. Typically, these soils have a silt loam upper layer over gravelly soils. Pockets of poorly drained soils with a shallow permafrost table occupy irregular depressions. ORTL, RRL, LBL: Slight; CCS: Good - Poor (wet; low soil temperature throughout growing season; short, frost-free period).

IR13 - Typic Cryochrepts - Histic Pergelic Cryaquepts, very gravelly, hilly to steep associations.

- On steep, hillsides and footslopes, the soils are well-drained and are formed in very gravelly and stony colluvium and residual material. Soils are commonly 20 to 40 inches thick over bedrock on the steeper slopes. ORTL, RLL, LBL: Severe (steep slopes); CCS: Poor (steep slopes, droughty soils).

IR14 - Alfic Cryochrepts, loamy, hilly to steep - Histic Pergelic Cryaquepts, loamy, nearly level to rolling.

- On mid-slopes, these soils are well drained, of micaceous loess ranging to many feet thick over shattered bedrock of mica schist. Bottomland areas are poorly drained with a relatively thick surface of peatmoss. In these soils, permafrost ranges from 5 to 30 inches in depth. ORTL: Moderate - Severe (steep slope; wet); CCS: Poor (steep slopes; highly susceptible to erosion); RLL, LBL: Severe (steep slopes).

IU3 - Pergelic Cryumbrepts, very gravelly, hilly to steep - rough mountainous land.

- On high alpine slopes and ridges close to mountain peaks, these soils have a thin surface mat of organic material beneath which is an 8 to 12-inch-thick, dark brown horizon formed in very gravelly or stony loam. This association also includes areas of bare rock and stony rubble on mountain peaks. ORTL, RLL, LBL: Severe - Very Severe (steep slope); CCS: Unsuitable (short, frost-free period; shallow bedrock).

RM1 - Rough Mountainous Land.

- Rough, mountainous land composed of steep, rocky slopes; icefields; and glaciers. Soils on lower slopes are stony and shallow over bedrock. Unsuitable for agriculture. Roads feasible only in major valleys.

SO1 - Typic Cryorthods, loamy, nearly level to rolling - Sphagnic Borofibrists, nearly level.

- Low hills, terraces, and outwash plains have well-drained soils formed in silty loess or ash, over gravelly glacial till. Depressions have poorly drained, fibrous organic soils. ORTL: Slight - Very Severe; CCS: Good (on well-drained soils) - Unsuitable (wet organic soil); RLL, LBL: Moderate (frost action susceptability, low load supporting capacity) - Severe (wet, organic soils).

SO4 - Typic Cryorthods, very gravelly, nearly level to rolling - Sphagnic Borofibrists, nearly level.

- Soils of nearly level to undulating outwash plains are well-drained to excessively well-drained, formed in a mantel of silty loess over very gravelly glacial till. Soils of the association located in depressions are very poorly drained, organic soils. ORTL, RLL, LBL: Slight - Very Severe; CCS: Good - Unsuitable (wet, organic).

SO5 - Typic Cryorthods, very gravelly, hilly to steep - Sphagnic Borofibrists, nearly level.

- On the hills and plains, these soils, formed in a thin metal of silty loess over very gravelly and stony glacial drift, are well drained and strongly acid. In muskegs, most of these soils consist of fibrous peat. ORTL: Severe (steep slope); CCS: Unsuitable (steep slopes; stones and boulders; short, frost-free season); RLL, LBL: Severe - Very Severe (steep slopes, stony, wet, organic soils).

SO10 - Humic Cryorthods, very gravelly, hilly to steep.

- Generally, these are well-drained soils of foothills and deep mountain valleys, formed in very gravelly drift with a thin mantel of silty loess or mixture of loess and volcanic ash. These soils are characteristically free of permafrost except in the highest elevation. ORTL, RLL, LBL: Severe (steep slope); CCS: Poor - Unsuitable (low soil temperature throughout growing season; steep slopes).

Table E-1. (Continued)

S015 - Pergelic Cryorthods - Histic Pergelic Cryaquepts, very gravelly, nearly level to rolling.

- On low moraine hills, these soils are well drained, formed in 10 to 20 inches of loamy material over very gravelly glacial drifts. On foot slopes and valleys, these soils tend to be poorly drained, with shallow permafrost table. ORTL: Slight - Severe (wet); CCS: Unsuitable (short, frost-free period; wet; stones and boulders); RLL, LBL: Moderate (permafrost) - Severe (wet, steep slopes).

S016 - Pergelic Cryorthods very gravelly, hilly to steep - Histic Pergelic Cryaquepts, loamy, nearly level.

- On hilly moraines these soils are well-drained; beneath a thin surface of partially decomposed organic matter, the soils have spodic horizons developed in shallow silt loam over very gravelly or sandy loam. In valleys and long foot slopes, these are poorly drained soils, with a thick, peaty layer over a frost-churned loam or silt loam. Here, depth of permafrost is usually less than 20 inches below surface mat. ORTL: Severe (steep slope; wet); CCS: Unsuitable (short, frost-free period) - Poor (wet; low soil temperature); RLL, LBL: Severe - Very Severe (steep slopes, wet permafrost).

†[1] See Table E-2 for definitions for Offroad Trafficability Limitations (ORTL), Common Crop Suitability (CCS), Road Location Limitations (RLL), and Low Building Limitations (LBL).

Conversions: To convert feet to meters, multiply by 0.305; to convert inches to centimeters, multiply by 2.54.

Source: Rieger et al. (1979).

Table E-2. Definitions for Offroad Trafficability Limitations and Common Crop Suitability of Soil Associations

OFFROAD TRAFFICABILITY LIMITATIONS (ORTL)

Offroad Trafficability refers to cross-country movement of conventional wheeled and tracked vehicles, including construction equipment. Soil limitations for Offroad Trafficability (based on features of undisturbed soils) were rated Slight, Moderate, Severe, and Very Severe on the following bases:

- Slight

  Soil limitations, if any, do not restrict the movement of cross-country vehicles.

- Moderate

  Soil limitations need to be recognized but can generally be overcome with careful route planning. Some special equipment may be required.

- Severe

  Soil limitations are difficult to overcome, and special equipment and careful route planning are required. These soils should be avoided if possible.

- Very Severe

  Soil limitations are generally too difficult to overcome. Generally, these soils are unsuitable for conventional offroad vehicles.

COMMON CROP SUITABILITY (CCS)†[1]

Soils were rated as Unsuitable, Good, Fair, and Poor for the production of common crops on the following bases:

- Unsuitable

  Soil or climate limitations are generally too severe to be overcome. None of the common crops can be grown successfully in most years, or there is danger of excessive damage to soils by erosion if cultivation is attempted.

- Good

  Soil or climate limitations, if any, are easily overcome, and all of the common Alaskan crops can be grown under ordinary management practices. On soils of this group --

- Fair

  Soils or climate limitations need to be recognized but can be overcome. Common crops can be grown, but careful management and special practices may be required.

- Poor

  Soils or climate limitations are difficult to overcome and are severe enough to make the use questionable. The choice of crops is narrow, and special treatment or management practices are required. In some places, overcoming the limitations may not be feasible. On soils of this group --

ROAD LOCATION LIMITATIONS (RLL)

The soil limitations ratings are based on the properties of undisturbed soil to a depth of 5 feet. It is assumed that any surface layer of organic material will be removed in construction.

- Slight

  Soil limitations, if any, are easily overcome.

- Moderate

  Soil limitations can be overcome but result in difficult and costly modifications in road design and construction.

Table E-2. (Continued)

- Severe

  Soil limitations are difficult to overcome and may affect road alignment and location. Special design requirements may result in excessive construction costs.

- Very Severe

  Soil limitations are so difficult or expensive to overcome that soils should be avoided if possible.

LOW BUILDING LOCATION (LBL)

Ratings are in terms of soil limitations for both construction and maintenance of buildings with relatively light foundation loads such as residences, service buildings, picnic area shelters:

- Slight

  Soil limitations, if any, are easily overcome and do not require unusual planning or design or alterations of natural soil features.

- Moderate

  Soil limitations need to be recognized but can be overcome by careful planning or design. A few special precautions or alterations may be needed.

- Severe

  Soil limitations are difficult to overcome. Special precautions or alterations are required which may not be economically feasible.

- Very Severe

  Soil limitations are too severe to be overcome except at great cost. Soils are generally unsuitable for low buildings.

†[1] The principal crops grown in Alaska--barley, oats, grasses for hay and silage, and potatoes--were considered in preparing ratings. Although only these crops were used, it is assumed that the ratings are also valid for vegetables and other crops suited to Alaskan soils.

Conversion: To convert feet to meters, multiply by 0.305.

Source: Rieger et al. (1979).

Although extensive deposits of coal, the major mineral resource of the Matanuska-Susitna Borough, are located to the south and west of the project area, the middle and upper Susitna Basin has a zero potential for coal (Merritt et al., 1982b). The middle and upper Susitna Basin lies on the edge of the Copper River Plateau, however, which is an area of 1,063,400 acres (430,300 ha) of fuel-grade peat, the second largest area of peat reserves in the state (Rawlinson and Hardy, 1982).

E.1.1.1.5 Seismicity

According to Csejtey et al. (1978) the rocks of the Talkeetna Mountains region have undergone complex and intense thrusting, folding, faulting, shearing, and differential uplifting as a result of regional metamorphism and plutonism. Three major periods of deformation have been recognized--(1) a period of metamorphism, plutonism, and uplift lasting from the Late Early to the Late Jurrassic, (2) an intense alpine orogeny in the Middle to Late Cretaceous, and (3) a period of faulting and folding in the Middle Tertiary that extended possibly into the Quaternary. The major structural features of the Talkeetna Mountains trend northeast to southwest and were formed primarily during the Cretaceous alpine orogeny with the accretion of northwest drifting continental blocks into the North American plate.

SEISMIC FEATURES

Within the Susitna Basin and surrounding areas, several potential sources of seismic ground motion at the reservoir and dam sites have identified (Woodward-Clyde, 1982). These sources include the Castle Mountain fault, the Denali fault, the Benioff interplate region, and the Benioff intraplate region (Fig. E-5). The distances of the closest approach of these potential sources to the proposed dam sites are listed in Table E-3.

The Castle Mountain fault is a strike-slip fault that dips steeply to the north and trends east-northeast/west-southwest. The Delani fault is predominantly a right lateral strike-slip fault with an arcuate east-west trend. Both faults are regarded as major suture zones within the earth's crust, and displacement along portions of both faults has occurred since the end of the Mesozoic. Displacement has continued in the western segment of the Castle Mountain fault and the McKinley strand of the Denali fault since the Holocene. With respect to the two dam and reservoir sites, the effect of potential seismic ground motions from the Denali fault is considered to be significantly greater than from the Castle Mountain fault (Woodward-Clyde, 1982).

The Benioff zone is a zone of seismicity associated with the subduction of the Pacific plate under the North American plate along the Aleutian Trench in the Gulf of Alaska. The two subzones or regions of the Benioff zone are considered to be a source of seismicity for the sites (Woodward-Clyde, 1982). Although these sources are thought to contain faults with recent displacement* that could cause seismic ground motion at the Watana and Devil Canyon sites, generally it is expected that because of their distance from the sites, these faults do not have the potential for rupture through the sites (Woodward-Clyde, 1982).

On the basis of their potential effect on ground motion and surface rupture considerations and their proximity to the Watana and Devil Canyon sites, 13 features were investigated in detailed field studies (Fig. E-6). According to the 1982 Woodward-Clyde seismic report, none of these features was found to be seismically significant with respect to the sites.

The Watana site is located in the vicinity of 4 of the 13 features (Table E-4). Two of these features, the Talkeetna thrust fault and the Fins feature, are judged to be faults without recent displacement. The Susitna and the Watana river features are judged to be lineaments that are not related to youthful faulting. Of the nine features near the Devil Canyon site, only one feature, KD5-2, is a fault; the eight other features are identified as lineaments. No recent displacement is noted for any of these features (Woodward-Clyde, 1982).

Within the Susitna Basin, only the Castle Mountain and Denali faults are considered to have been subject to recent displacement, and the Benioff zone is also considered to be a potential seismic source. Because of their recent seismic activity, the maximum credible earthquake (MCE) was estimated for each of these three potential seismic sources by Woodward-Clyde Consultants (1982). In case a fault with recent displacement had been overlooked in the geologic investigations, estimations of a detection level earthquake for this fault were also made.

Estimations of MCEs for each seismic source were made using both the deterministic and probabilistic approach. For the deterministic approach it is assumed that the MCE will occur during the lifetime of the facility and at the closest approach of the seismic source to the

*Recent displacement as defined for this project is a fault that has had surface rupture during the past 100,000 years.

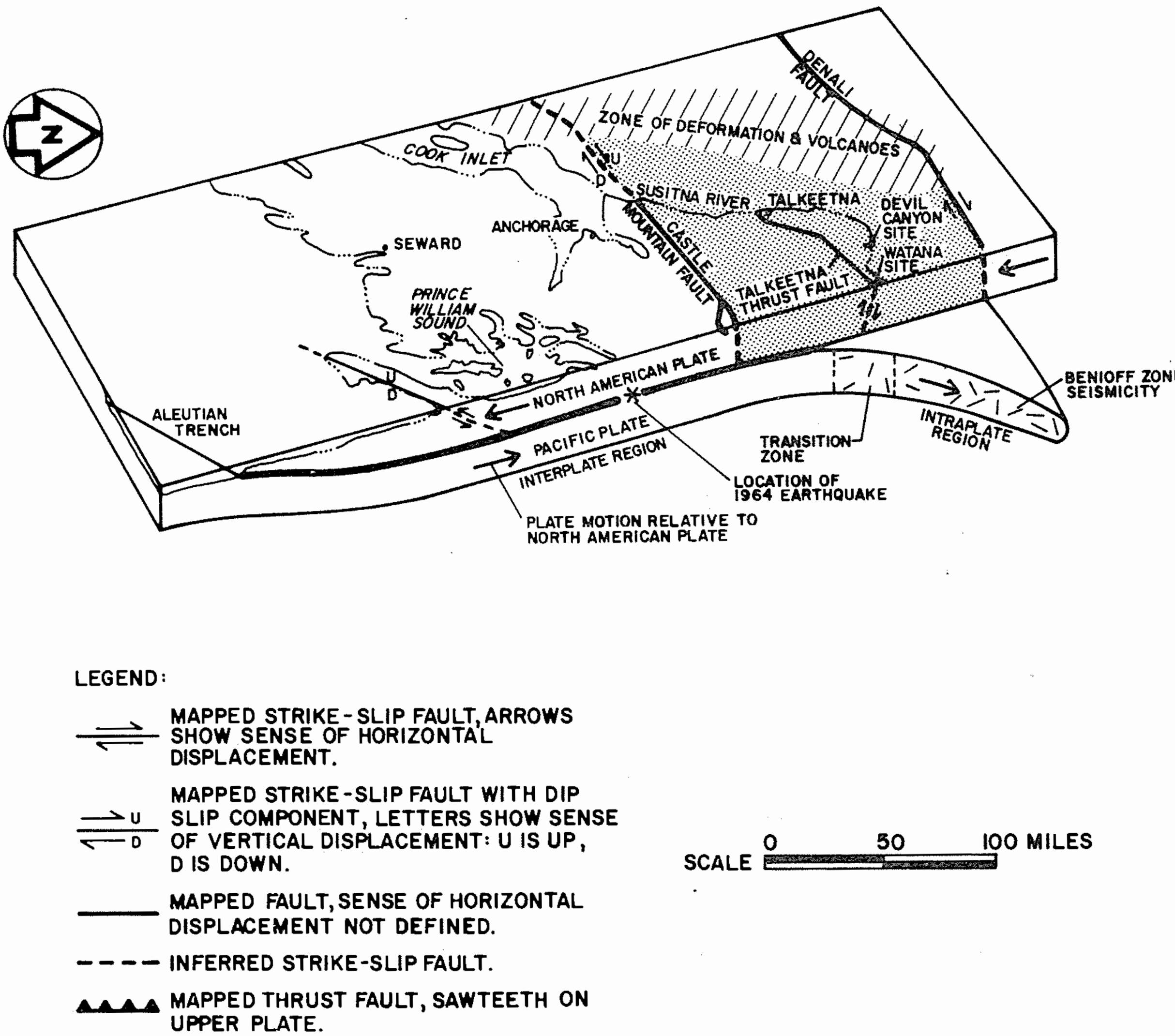

Figure E-5. Significant Seismic Faults and Features within the Susitna Basin. [Source: Woodward-Clyde Consultants, 1982]

Table E-3. Summary of Boundary Faults and Significant Features

Feature No.†[1]	Feature Name†[2]	Fault (F) or Lineament (L)	Length (miles)	Distance†[3] (miles) from Devil Canyon	Distance†[3] (miles) from Watana	Fault with Recent Displacement
BOUNDARY FAULTS						
AD5-1	Castle Mountain Fault	F	295	71	65	Yes
HB4-1	Denali Fault	F	1358	40	43	Yes
	Benioff Zone (Interplate)	F	434	56	40	Yes
	Benioff Zone (Intraplate)	F	46	38	31	Yes
WATANA SIGNIFICANT FEATURES						
KC4-1	Talkeetna Thrust	F	78	16	4	No
KD3-3	Susitna Feature	L	95	16	2	No
KD3-7	Watana River	L	31	22	0	No
KD4-27	Fins Feature	F	2	23	0	No
DEVIL CANYON SIGNIFICANT FEATURES						
KC5-5	-	L	12	4.5	19	No
KD5-2	-	F	0.8	3.5	24	No
KD5-3	-	L	51	3.6	14	No
KD5-9	-	L	2.5	1	24	No
KD5-12	-	L	14.5	1.5	17	No
KD5-42	-	L	3	0.5	22	No
KD5-43	-	L	1.5	0	24	No
KD5-44	-	L	21	0.3	23	No
KD5-45	-	L	19.5	0.8	35	No

†[1] Alpha-numeric code number is based on: (a) a first letter designation for the 1:250,000 quadrangle where the feature is located (A = Anchorage, H = Healy, K = Talkeetna Mountains); (b) the letter and number of the 1:63,380 quadrangle at the midpoint of the feature; and (c) a number designating the order of the feature's recognition.

†[2] Feature name is given if assigned.

†[3] Distance is the closest approach of the surface trace of the fault or lineament.

Conversion: To convert miles to kilometers, multiply by 1.61.

Modified from Woodward-Clyde Consultants (1982).

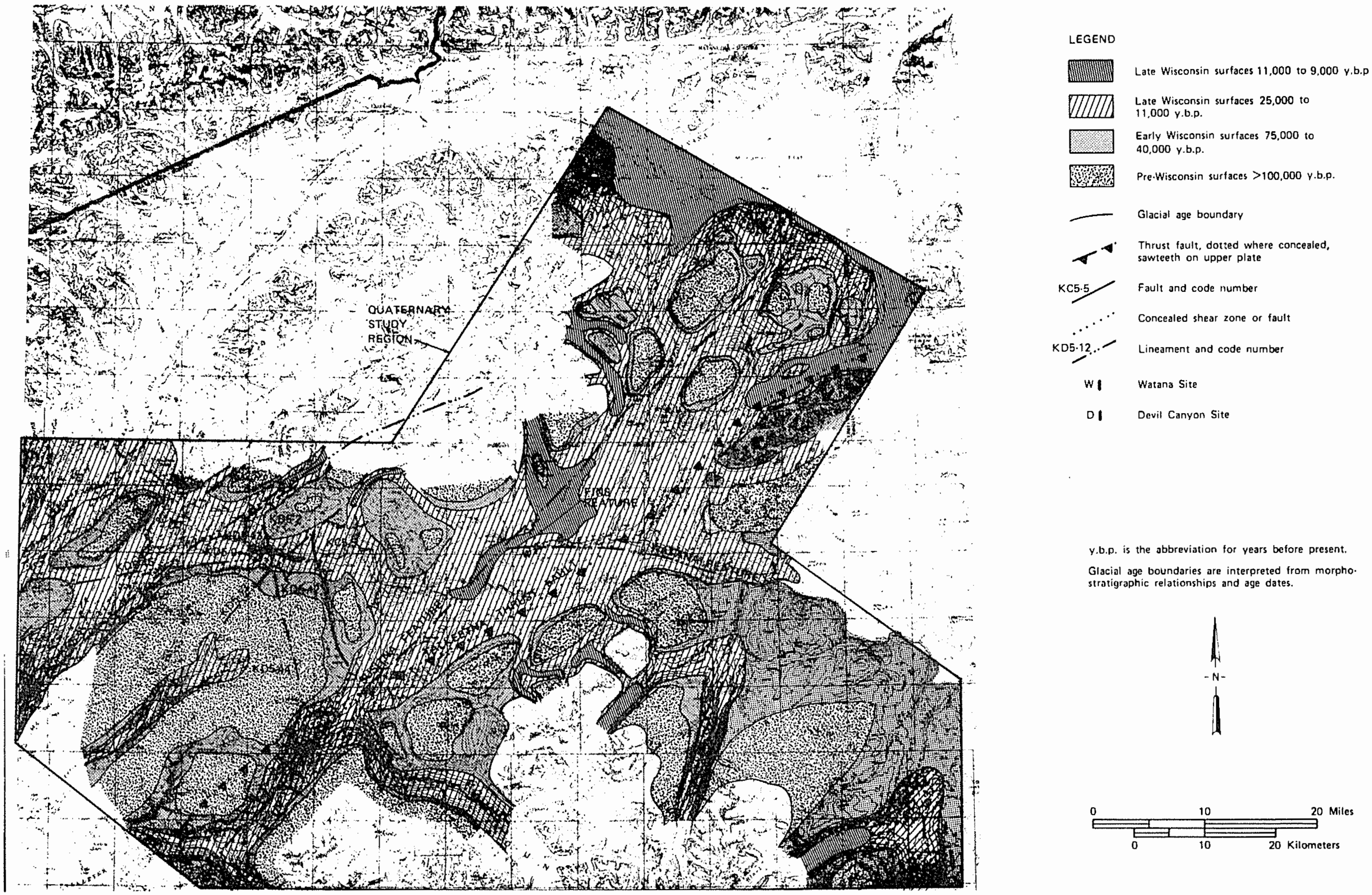

Figure E-6. Significant Features near the Watana (W) and Devil Canyon (D) Dam Sites. [Source: Adapted from Woodward-Clyde Consultants, 1982]

Table E-4. Summary of Earthquake Sources Considered in Ground-Motion Studies

Earthquake Source	Maximum Credible Earthquake (magnitude)†[1]	Closest Approach to Proposed Dam Sites (miles)		Mean Peak Ground Acceleration (g)	
		Devil Canyon	Watana	Devil Canyon	Watana
Castle Mountain Fault	7-1/2	71	65	-	-
Denali Fault	8	40	43	0.2	0.2
Benioff Zone (interplate)	8-1/2	57	40	0.3	0.35
Benioff Zone (intraplate)	7-1/2	38	31		
Detection-level Earthquake	6	<6	<6	0.5	0.5

†[1] Modified Mercalli Scale.

Conversion: To convert miles to kilometers, multiply by 1.61.

Source: Modified from Woodward-Clyde Consultants (1982).

site. The probabilistic approach models the occurrence of the seismic event using geological and seismological site region characteristics and is designed to provide a more realistic model of seismic ground motions. The MCEs for each seismic source are listed in Table E-4.

Information on the MCE magnitudes and the proximity of the fault from the proposed sites was also used to estimate levels of earthquake ground motions at the sites. These estimates were based on analyses of ground motions recorded during previous earthquakes appropriate for the conditions of the sites. Attenuation records for subduction-zone earthquakes in South America and Japan were used to evaluate the relationship of potential earthquakes occurring on the Benioff zones beneath the sites. Recordings from Californian and other western U.S. earthquakes were used to evaluate the relationship for shallow focus crustal earthquakes occurring on the Castle Mountain fault, the Denali fault, and for the detection-level earthquakes. The mean attenuation relationships for peak ground acceleration from the Benioff interplate region and the Denali fault (the most intense sources of ground shaking from MCEs of the four potential sources), as well as the detection-level earthquake are listed for each site in Table E-4.

As discussed, features in the vicinity of the proposed Watana and Devil Canyon sites have been judged either not to be faults or to be faults without recent displacement. As none of these features are considered to be seismic sources, no MCE has been assigned to the various features (Woodward-Clyde, 1982).

E.1.1.2 Lower Susitna River Basin

E.1.1.2.1 Topography

The lower Susitna River Basin is a part of the physiographic region known as the Cook Inlet-Susitna Lowland. This lowland is primarily a broad, relatively flat to gently rolling area. Elevations range from sea level at the tidal flats along Cook Inlet to 500 ft (150 m) MSL with local relief ranging from 50 to 250 ft (15 to 75 m). The lowland has two branching arms which extend into the surrounding rugged mountain ranges--the Matanuska Valley bordered by the Talkeetna Mountains to the north and the Chugach Mountains to the south, and the Susitna River Valley east of the Alaska Range. The Susitna Valley extends north from the center of the lowlands and occupies a floodplain which varies from 1 to 8 mi (1 to 13 km) in width. The Susitna River, a braided, glacier-fed stream, and two of its major tributaries, the Chulitna and Yentna rivers, originate in the Alaska Range. At Tyonek, the Cook Inlet Lowlands extend approximately 25 mi (40 km) from the shore to the tidal range.

The topography of the Susitna Valley is dominated by glacial features such as ground moraines to the west of the river as well as drumlin fields, eskers, and kettles. Broad terraces and outwash plains dominate the southern part of the lowlands and low moraines with irregular rolling to steep slopes are dominant in the eastern and northern parts of the lowlands. Fluvial processes continue to modify and incise the glacial deposits and stram and terrace deposits are prevalent along drainages west of Cook Inlet. Talus slopes, landslide scours, avalanche chutes and rock glaciers are present at the edges of the valley (Selkregg 1974; Schoephorster and Hinton, 1973; Merritt et al., 1982a).

Due to low slopes and the nature of the substrate, the lowland remains poorly drained. Ponds, lakes, and muskegs occur throughout most of the lowlands. Irregularly shaped, very poorly drained muskegs range in size from a few to several thousand acres. Low-lying tidal plains as much as 2 mi (3 km) wide border the Cook Inlet (Schoephorster and Hinton, 1973).

E.1.1.2.2 Geology

BEDROCK GEOLOGY

The subsurface geology of the Susitna Lowlands is relatively unexplored and, as a result, the structure and stratigraphy of this area are poorly understood (Merritt et al., 1982a).

Cook Inlet and much of the lower Susitna Basin occupies a structural trough underlain by rocks of Tertiary age and mantled by glacial deposits of Quaternary age. The stratigraphy of the Susitna Lowland is dominated by a thick, complex, weakly consolidated Tertiary coal-bearing sedimentary sequence of sandstone, siltstone, claystone, and conglomerates known as the Kenai Group. North of the Castle Mountain fault the Kenai Group is relatively thin [typically 2,000 ft (600 m) or less] and overlies granitic rocks; south of the fault, the Kenai Group ranges from 10,000 to 16,000 ft (3,000 to 5,000 m) in thickness and overlies older Tertiary sedimentary rocks and Mesozoic aged sedimentary, igneous and volcanic rocks. Rapid lateral and vertical changes in the lithology of the Kenai Group are common, and exposures of these rocks are generally confined to the foothills of the Alaska Range and to isolated, usually steep, incised, and largely inaccessible stream canyon walls within the lowlands (Merritt et al., 1982a,c).

Paleozoic clastic and carbonate rocks are exposed in the Alaska Range. Mesozoic and early Tertiary volcanic and clastic rocks, locally interbedded with limestone, make up the bulk of the bedded rocks in the Chugach Mountains. Large batholiths of Jurassic, Cretaceous, and Tertiary-age granodiorites, quartz monzonite and related rock types invade the older sedimentary and volcanic rocks in the Talkeetna Mountains and Alaska Range. Smaller plutons are present in the Chugach Mountains (Cobb, 1974).

SURFICIAL GEOLOGY

The majority of the Susitna Lowland is covered with thick deposits of undifferentiated Pleistocene fluvial, glacial, or glacifluvial unconsolidated sediments ranging from glacial till and outwash gravels to alluvium and beach deposits.

Most of the area has a mantle of silty wind-laid deposits that contain large quantites of volcanic ash. The loess ranges from a few inches to 6 ft (several centimeters to 2 m) in thickness. Deposits of gravel and sand on terraces and outwash plains are generally well sorted and nearly free of fine material. Morainal deposits generally consist of poorly sorted very gravelly and stony material. Stratified deposits of silt and fine sand that range from a few inches to 6 ft (several centimeters to 2 m) in thickness over gravel deposits are present on floodplains. The tidal plains are predominantly clayey, and laterally extensive proglacial lake deposits through much of the southern lowlands are silty and clayey. Most muskegs consist of coarse, extremely acid peat derived from sphagnum moss and sedges (Schoephorster and Hinton, 1973).

Widely scattered areas of slump and landslide material can be found throughout the lowland, especially near steep stream channels and mountain foothills (Merritt et al., 1982a,c).

E.1.1.2.3 Soils and Permafrost

Spodosolic soils occur throughout much of the Susitna Lowland in areas of low rolling moraines and nearly level to undulating outwash plains interspersed with many small poorly drained muskegs and lakes. These soils are primarily well drained and formed on a thin mantle of silty loess over thick deposits of very gravelly glacial drift. In low lying areas, sphagnum peat moss is common and on low terraces and floodplains bordering streams, soils range from very gravelly clay loam to stratified sand and silt loam. In general, the well-drained soils on the nearly level to rolling uplands are suitable for cultivation and have few use limitations (Rieger et al., 1979). Approximately 50% of the soils in this area are classified as arable (Selkregg, 1974).

Bottomland and terrace soils of the Susitna and Yentna rivers are generally well drained, stratified Entisols or young, poorly formed soils. Although these soils have severe limitations for use due to flooding, high water tables and stream bank erosion, terrace soils are suitable for cultivation and commercial timber development. Access to these soils is often difficult because many areas are isolated by muskegs and frequently flooded land (Rieger et al., 1979).

Histosols or deep, wet, peat soils are present on the southern bank of the Yentna River as well as at the mouth of the Susitna River. These soils have severe limitations for almost all uses as a result of their extremely acidic nature and high water tables (Rieger et al., 1979).

On the foot slopes and the glaciated and nonglaciated hills of the Cook Inlet, the dominant soils are Inceptisols or incompletely formed, horizonless soils. The soils are generally formed in the layer of volcanic ash overlying the gravelly glacial till. The well-drained soils are suitable for rangeland, and where slopes are gentle to moderate can be cultivated. Steep slopes and wetness are the major limitations to use of these soils (Rieger et al., 1979).

Although permafrost is not uncommon on the northern portion of the Susitna Lowland, the southern portions of the lowland near the Cook Inlet and along the Susitna River are generally free of permafrost. Flanking these areas is a zone underlain by isolated masses of permafrost. Discontinuous permafrost is present at the edge of the lowlands near the mountains (Merritt et al., 1982a).

E.1.1.2.4 Mineral Resources

The Kenai Group strata of the Cook Inlet Basin of Southcentral Alaska contain substantial reserves of subbituminous and lignite coals suitable for surface mining. These coals are extremely low in sulfur and favorably located with respect to potential markets. Total coal resources of the Cook Inlet Basin, including deep coal seams beneath Cook Inlet, may reach 1.5×10^{12} tons [1.4×10^{12} metric tons (MT)].

Because of geographic and geologic constraints, the areas of coal exposures are separated from one another and traditionally have been divided into four principal coal fields: Yentna, Beluga, Kenai, and Matanuska (Edgar et al., 1982).

The Yentna and Beluga fields contain a good grade of low-sulfur, lignite to subbituminous coal from the Tertiary Kenai Group. In the drainage areas of the Beluga and Chuitna rivers, conditions are favorable for surface mining as the coal seams are thick (more than 50 ft, or 15 m) near the surface and are relatively flat-lying (Edgar et al., 1982).

In the Kenai field, numerous thin, subbituminous to lignite coal beds [3 to 10 ft (0.8 to 3 m) thick] are interbedded with sandstones, siltstones, and claystones. Although overburden ratios are low and coal units are essentially flat, the thinness of the coal seams inhibits commercial development. Complex faulting and folding of the Matanuska coal field and comparatively small coal reserves has increased the expense and difficulty in mining the bituminous and anthracite coals in this field (Edgar et al., 1982).

The Cook Inlet Basin also contains portions of two major sedimentary petroleum provinces--the Mesozoic province and Cook Inlet Tertiary province. The Mesozoic province consists of a thick wedge of marine sedimentary rocks of Jurasic and Cretaceous age that extends from the Alaska Peninsula to the Matanuska Valley. These rocks contain many indications of petroleum, including source beds, oil and gas seeps, and shows in test wells. The Cook Inlet Tertiary province consists of a thick basin-like section of nonmarine conglomerate, sandstone shale, and coal between the Alaska Range and the Chugach Mountains. All of the presently producing oil and gas fields in the state are located in these rocks in the central part of the basin. Due to limited exploration, the total extent of these oil and gas resources is not yet known.

The Susitna Lowland also contains 1,825,350 acres [738,870 hectares (ha)] of fuel-grade peat, the second largest such reserve in the state (Rawlinson and Hardy, 1982).

Small amounts of gold, silver, and base metals have been produced from the upper Chulitna area near the Alaska Railroad. In the southern Alaska Range, metallic sulfide minerals are common in and near granitic plutons. There is large-scale production of gold from gold-bearing quartz veins in the southern border of the Talkeetna batholith in the Willow Creek area near Palmer. Placer gold deposits have also been mined in the vicinity of Yentna and Valdez creeks since the late 19th Century (Cobb, 1974).

Other mineral resources of the area include minor amounts of ceramic clay and agricultural lime from near Anchorage, a little gypsum from Sheep Mountain in the upper Matanuska Valley, soapstone (for carving) from near Palmer, and large amounts of construction materials along railroad and highway routes near Anchorage (Cobb, 1974).

E.1.1.2.5 Seismicity

Southcentral Alaska is part of a vast, continuous seismically active belt that circumscribes the entire Pacific Ocean basin. The Southcentral Region is one of the most seismically active areas in North America, experiencing thousands of shocks each year. The lower Susitna Basin falls within a region where damage due to seismic events is ranked as major.

E.1.1.3 Power Transmission Line Corridors

E.1.1.3.1 Topography

Willow-to-Anchorage Segment. The proposed Willow-to-Anchorage segment of the corridor extends from Anchorage across Knik Arm mud flats to Point Mackenzie. The corridor continues north following the Elmendorf Moraine across level terrain and extensive wetlands from Point Mackenzie to Willow via Red Shirt Lake. A detailed topographic description of the lower Susitna River Basin was presented above in Section E.1.1.2.1.

Healy-to-Willow Segment. The central section of the proposed transmission route as described by Commonwealth Associates (1982) would extend north from the swampy lowlands of the Willow substation [200 ft (60 m) MSL] cross low bedrock-cored hills into the floodplains and gravel terraces of the braided Talkeetna River [800 ft (240 m) MSL], proceed through the foothills of the Talkeetna Mountains [1,500 ft (460 m) MSL], and cross Chunilna Creek [950 ft (290 m) MSL]. The transmission line would turn northeast at Lane Creek and extend along the base of the Talkeetna Mountains above the Susitna River [3,300 ft (1,000 m) MSL] dropping steeply to Gold Creek valley [950 ft (290 m) MSL].

North of Gold Creek Valley, the proposed route would gradually rise from an elevation of 1,500 ft (460 m) MSL, follow the slope near the Talkeetna Mountains, then cross the floodplain and terraces of the Susitna River. On the northern side of the river, the proposed route would traverse the top of a low, mountainous area, then drop into the Indian River Valley. Between the Indian River and Chulitna Pass, the route again would follow along a slope near the base of another segment of the Talkeetna Mountains [2,100 ft (640 m) MSL]. The corridor then would rise to an elevation of 2,200 ft (670 m) MSL near the deeply incised canyon of Hurricane Gulch across talus slopes, alluvial fans, and morainal surfaces that parallel the Chulitna River Valley. This morainal surface, characterized by elongate, relatively flat-topped ridges, is continuous to the north almost to Cantwell.

North of Little Honolulu Creek [1,850 ft (560 m) MSL] the proposed route would follow the glacially scoured Broad Pass Valley occupied by the Chulitna River, cross the East and Middle Forks of the Chulitna River, and rise to an elevation of approximately 2,200 ft (670 m) MSL at Jack River. The line would cross the wide, braided floodplain and extensive terraces of the Jack River, climb to an elevation of 3,400 ft (1,040 m) MSL across the Reindeer Hills, and then drop to the floodplain of the Nenana River [2,050 ft (620 m) MSL]. From the Nenana River, the proposed route would follow along the talus slope of Panorama Mountains and the steep and rocky ridge to the north [2,000 to 2,400 ft (610 to 740 m) MSL]. After crossing the ridge, the route would extend northwest through more gentle slopes and cross Carlo Creek [2,200 ft (670 m) MSL] and a relatively flat glacial till plain south of the small floodplain of the Yanert Fork [1,700 ft (520 m) MSL].

From Yanert Fork the route would follow the base of Mount Fellows, rise to about 2,600 ft (790 m) MSL and turn northeast to cross Montana Creek. The route would continue at this elevation, crossing below two rock glaciers through a U-shaped glacial valley to Moody Creek. From here, the route would be on a relatively steep slope above Moody Creek that remains fairly level, then fluctuates and drops to about 1,700 ft (520 m) MSL at Copeland Creek. After leaving the Copeland Creek area the route would rise to 1,800 ft (550 m) MSL, traverse a large outwash terrace between Copeland Creek and Healy Creek, and descend to approximately 1,300 ft (400 m) MSL near the Healy substation.

Healy-to-Fairbanks Segment. The corridor would follow the nearly level floodplain of the Nenana River Valley northward from Healy [elevation 1,400 ft (430 m) MSL] through the northern foothills of the rugged Alaska Range. The foothills parallel the main range and slope northward across the level, coalesced outwash-fans of the Alaska Range and the flat Tanana-Kuskokwim lowlands [elevations ranging from 1,000 ft (300 m) MSL near the Alaska Range to 400 ft (120 m) MSL near the Tanana River]. After crossing the meandering and braided Tanana River east of Nenana, the corridor would parallel on existing transmission line route through the rounded ridges and gently sloping hills of the unglaciated Yukon-Tanana Upland region, following the flat, alluvium-floored Goldstream Creek Valley to Ester [elevations 350 to 600 ft (100 to 200 m) MSL] (Furbush and Schoephorster, 1977; Cobb, 1974).

E.1.1.3.2 Geology

BEDROCK GEOLOGY

Willow-to-Anchorage Segment. Bedrock along the Willow-to-Anchorage segment area is deeply buried by surficial sediments. A discussion of the bedrock geology present in the lower Susitna Basin is presented in Section E.1.1.2.2.

Healy-to-Willow Segment. The bedrock encountered along the central portion of the proposed route paralleling the Intertie is highly fractured and closely jointed, predominantly as a result of the structural complexity of the Alaska Range and of frost action. Specific lithologies change rapidly and can vary drastically within 10 ft (3 m) in any direction of the line. Analysis of the bedrock along the Intertie route was conducted by Commonwealth Associates (1982). Bedrock rock exposures become common north of Chunilna Creek between the Talkeetna foothills and mountains. Bedrock in this area is generally a hard, closely jointed, thinly bedded argillite with quartz veins. Approaching Gold Creek, bedrock is exposed at the surface, mantled by rubble formed by frost-shattering of bedrock. The bedrock consists of argillite interbedded with slate and graywacke, which is thinly bedded, very closely jointed, and contains quartz veins and minor slickenside surfaces. Between Gold Creek and Jack River, bedrock consisting of highly fractured argillite or shale is exposed primarily in creek gullies or river valleys. Coal outcrops at Coal Creek south of Jack River.

Metamorphosed sedimentary rocks, the core of the Reindeer Hills north of Jack River, as well as thinly bedded argillite, chert, minor conglomerates, and limestones, outcrop in stream gullies and occasionally at the surface of the hills. These rocks are typically highly fractured, moderately to severely weathered, and heavily slickensided. In the northern portion of the Reindeer Hills, bedrock composed of rhyolite and dacite is also found.

Steep talus slopes and exposed bedrock occur in the Panorama Mountains. Bedrock is highly fractured, very closely jointed, and very slickensided as a result of the proximity of the McKinley Strand of the Denali Fault. Few bedrock outcrops are noted between Carlo Creek and Yanert Fork except along stream valleys. North of Yanert Fork more bedrock is exposed along the base of Mount Fellows. This bedrock consists of well to moderately well consolidated sandstones, conglomerates, siltstones, and minor amounts of coal that have been intruded in places by moderately hard, moderately fractured, and heavily slickensided basalt and diabase dikes. Above the elevation of the Intertie route on Mount Fellows, volcanic-type bedrock is exposed.

At Montana and Moody Creek, granite and highly fractured and foliated micaceous quartzitic schist are exposed. The granitic bedrock has formed very open, blocky talus deposits, while talus formed from the schist contains many fines. Due to steep vertical joints in the schist, steep exposed rock faces have formed along the Moody Creek valley. More schistic bedrock is exposed along the southern side of Healy Creek.

Healy-to-Fairbanks Segment. The bedrock along this segment includes two pre-Cenozoic metamorphosed schist formations and poorly consolidated Tertiary continental formations. A major unconformity separates the schists and the continental formations. The Precambrain metasedimentary Birch Creek schist is present in the Nenana River gorge south of Healy and between Fairbanks and the Town of Nenana. The younger Totatlanika schist formation consists of rhyolite flows and tuffs and outcrops near Windy Creek east of Clear and in the Slate Creek drainage west of the Nenana River (R&M Consultants, 1981). sp.

Poorly consolidated, sandstone, claystone, subbituminous and lignite coal units outcrop between Healy and Lignite Creek. Individual coal beds up to 40 ft (12 m) thick represent a resource with significant development potential. Between Nenana and Healy the most widespread bedrock unit is the Nenana gravel, a poorly consolidated, easily eroded sedimentary conglomerate (R & M Consultants, 1981; Cobb, 1974).

SURFICIAL GEOLOGY

Willow-to-Anchorage Segment. From Point MacKenzie north toward Willow, the proposed transmission line route roughly follows the prominent Elmendorf Moraine, which formed during the Late Wisconsin glacial period at the point of farthest advance of the Matanuska and Knik Valley glaciers. Proglacial lacustrine deposits cover much of the Cook Inlet-Susitna Lowland area, and outwash deposits cover the western flank of the Elmendorf Moraine. Lacustrine deposits of the proglacial lake have not been mapped within the project corridor but are present near Talkeetna and interfinger with outwash and deltaic deposits west of the project area (R & M Consultants, 1981).

Large mudflats occupy much of the Cook Inlet and Knik Arm area, and thick organic deposits are present in poorly drained areas. Further descriptions of the surficial deposits in the Susitna Lowland are presented in Section E.1.1.2.2.

Healy-to-Willow Segment. The surficial geology along this portion of the proposed route, as in much of Alaska, is characterized by a great variety of terrain types occurring over a relatively short distance. The type of geologic materials present can change rapidly along a short distance both laterally and with depth, particularly where there is an irregular bedrock surface, as is common in glaciated terrain. If the route were to be changed even slightly, the material types encountered could be significantly different from those described by Commonwealth Associates (1982).

In the swampy lowlands immediately north of the Willow substation, surficial peat deposits overlying gravel are common. Further north, gravel and till deposits up to 30 ft (9 m) thick predominate. As the route proceeds through the foothills of the Talkeetna Mountains, gravel deposits thin and form a mantle over the foothills. Peat deposits occur in the lowlands between the hills. Within the Talkeetna Mountains between Chunilna Creek and Gold Creek, less than 10 ft (3 m) of gravel, talus, and peat are found in the valleys between the bedrock ridges.

North of Gold Creek, the route crosses the Susitna River floodplains and terraces. Till and gravel deposits greater than 30 ft (9 m) thick are present between Gold Creek and Chulitna Pass [1,400 ft (430 m) MSL]. Within the Chulitna River Valley talus slopes, alluvial fans, and morainal surface deposits are present. Irregular kettle-like gravel deposits overlie the bedrock north of Hurricane Gulch.

In the Broad Pass Valley, the route crosses alluvial fan, ground moraine, lake, slope wash, talus, floodplain, and swamp deposits. Very dense, clayey, silty, gravelly sand or sandy gravel, cobbley till is the predominant material type in this area, and till and gravel deposits are more than 30 ft (9 m) thick. Thick gravel deposits are also present in the floodplains of the Jack and Nenana rivers.

Talus and gravel deposits overlie bedrock in both the Reindeer Hills and Panorama Mountains. Northeast of Carlo Creek thin gravel deposits cover the bedrock, and the talus cones range from open, large, angular blocks to angular blocks in a fine-grained matrix.

North to Yanert Fork, the proposed route crosses a flat glacial till plain consisting of dense tills greater than 30 ft (9 m) thick and till-mantled hills of outwash gravel and occasional deposits of lake clay.

Two inactive rock glaciers are present on the slopes above the route between Montana and Moody Creek. Talus and alluvial fan deposits overlie bedrock in this region. From Copeland Creek to Healy the route transverses a large outwash terrace. Moderately to poorly consolidated gravels and sandstones of the Healy Creek formation extend under the outwash terrace. Morainal deposits trend along the southern edge of the outwash terrace. Gravel deposits in excess of 30 ft (9 m) thick are found within this segment of the route.

Healy-to-Fairbanks Segment. Extensive, well-sorted floodplain terrace and alluvial fan deposits, as well as colluvium and solifluction deposits, cover the Nenana River Valleys. The Tanana-Kuskokwim Lowlands north of the Alaska Range are almost exclusively covered by alluvial fan deposits. The Yukon-Tanana Uplands north of the Tanana River are covered by silty and sandy micaceous loess deposits derived chiefly from the outwash plains south of the Tanana River. The thickness of this mantle of loess ranges from 1 ft (0.3 m) on high ridges to 200 ft (60 m) on the low hills near the Tanana River. Much of the original loess has been eroded from steeper slopes and has accumulated on the lower slopes and in narrow upland valleys. Lenses of organic material occur throughout the redeposited silt.

E.1.1.3.3 Soils and Permafrost

Willow-to-Anchorage Segment. The soils along this portion of the proposed corridor are classified as Spodsols, specifically, Typic Cryorthods-Sphagnic Borofibrists [S01, S04 and S05 (see Table E-1)]. These soils usually have a thick surface mat of partially decomposed organic litter over a gray mineral horizon (Rieger et al., 1979). Although typically difficult to work and low in natural fertility, good agricultural soils have been identified in the corridor. Approximately 50% of the soils in this area may be classified as arable (Selkregg, 1974). From Point MacKenzie north to Willow, soils along the transmission corridor have formed on organic-covered outwash deposits, older till, outwash, ablation till, and fluvial delta and floodplain deposits that have a high erosion potential. The frost heave potential is considered extreme only for the fluvial delta deposits; the liquefaction potential for these soils is high, while slope stability is very low. All other soils have moderate to high slope stabilities and moderate to low liquefaction potentials (R & M Consultants, 1981). Permafrost is generally absent in this segment of the proposed Corridor.

Healy-to-Willow Segment. North of Willow to just north of Cantwell through the Susitna and Chulitna river valleys, soils are generally classified as well-drained Spodsols. Specifically, Typic Cryorthods-Sphagnic Borafibrists (S01) predominate between Willow and just south of Curry; Humic Cryorthods (S10) between Curry and Broad Pass, and Pergelic Cryorthods-Histic Pergelic Cryaquepts (S015) between Broad Pass and Cantwell (see Table E-1). These soils are generally formed on gravelly glacial deposits, terraces, and outwash plains covered by varying thicknesses of silty loess or volcanic ash. Except for well-drained soils to the south, these soils are typically unsuited for cultivation but may be used for grazing. High water tables, periodic flooding, steep slopes, poor stability, low permeabilities, and stoniness severely limit the potential use of these soils (Rieger et al., 1979).

In the Nenana River valley north to Healy, soils are primarily classified as Inceptisols or poorly formed, horizonless soils. To the south, these soils are formed in very gravelly colluvial material weathered from local bedrock. They range from well to poorly drained and are generally shallow and unsuited for cultivation. To the north, the soils have formed on loess-covered, gravelly and sandy alluvial deposits, are well to moderately well drained, and are potentially suited for cultivation (Rieger et al., 1979). Much of the central portion of the corridor is underlain by discontinuous permafrost (Selkregg, 1974). Permafrost is more common toward the northern section of the corridor at higher elevations and in poorly drained sediments.

Healy-to-Fairbanks Segment. The soils typically found within the Healy-to-Fairbanks segment of the proposed transmission corridor are classified as Inceptisols. Poorly drained [Histic Pergelic Cryaquepts-Typic Cryofluvents associations (IQ3) (see Table E-1)] underlain by permafrost are present on the lower parts of the Tanana-Nenana River floodplains. On the slightly higher natural levees, soils are well drained and suitable for forage crops and hardy vegetables. Permafrost is often deep or absent in these well-drained soils. Discontinuous permafrost underlies much of the corridor. Permafrost generally underlies most of the floodplains, alluvial fans, drainage ways of uplands, and the north-facing slopes, but is absent on steeply sloping south-facing hillsides (Rieger et al., 1963).

From north of the Alaska Range foothills to Fairbanks and in the Nenana River Valley north of Healy, the proposed transmission corridor crosses Typic Cryochrepts-Aeric Cryaquepts soil associations (1R10) formed on alluvial fan outwash and terrace and floodplain deposits. North of the Tanana River, Alfic Cryochrepts-Histic Pergelic Cryaquepts (IR14) soils associations have been formed on eolian loess deposits, as well as on colluvium and loess overlying bedrock. All but the soils formed on the outwash deposits have a high to moderate erosion potential. The frost heave potential is high for silty soils formed on eolian loess and silty alluvial fan deposits, but low for more coarse-grained soils (R & M Consultants, 1981).

E.1.1.3.4 Mineral Resources

Willow-to-Anchorage Segment. A detailed discussion of the mineral resources in the Lower Susitna Basin is presented in Section E.1.1.2.4.

Healy-to-Willow Segment. A detailed discussion of the mineral resources in the upper and middle Susitna Basin is presented in Section E.1.1.1.4.

Healy-to-Fairbanks Segment. The region through which the Healy-to-Fairbanks segment of the transmission line corridor would pass is identified as a metal province for gold, tine, tungsten, zinc, lead, antimony and silver (Selkregg, 1977). Several lode and placer deposits consisting of gold with subordinate silver and antimony ores have been located in quartz veins and mineralized zones in the Precambrian and Paleozoic schists and in the Tertiary Nenana gravel. This area has been a small but steady, producer of placer gold since 1904 (Cobb, 1974). The Fairbanks area is ranked as a mineralized area primarily for gold, silver, antimony and tungsten (Selkregg, 1977). Most of the lodes are concentrated within 25 mi (40 km) of Fairbanks, the gold loads being primarily near the granitic plutons at Pedro and Gilmore domes northeast of Fairbanks and at the Ester dome west of the city. The Fairbanks area is also the leading producer of placer gold in the state, producing over 7,650,000 ounces [240,000 kilograms (kg)] since 1902 (Cobb, 1974).

Extensive deposits of Tertiary coal are present in the Nenana Basin. The subbituminous coal beds have been folded and faulted into a series of smaller basins (Jarvis Creek, Healy Creek, Tatlanika, Hood River, Suntrana, Lignite Creek, Teklanika, etc.) and vary in thickness from a few inches to more than 60 ft (18 m) (Edgar et al., 1982). The only major current coal mine in Alaska, the Usibelli Coal Mine near Healy, produced approximately 800,000 tons (730,000 MT) of coal by surface mining (Alaska Dept. of Natural Resources, 1982). Total original resources in beds exceeding 2.5 ft (0.8 m) in thickness and beneath less than 1,000 ft (300 m) of overburden are estimated at 4.79 million tons (4.35 million MT) (Cobb, 1974).

E.1.1.3.5 Seismicity

SEISMIC FEATURES

Willow-to-Anchorage Segment. The Willow-to-Anchorage segment crosses the Castle Mountain fault system, which has a maximum credible earthquake of 7.4 magnitude, and overlies the Aleutian Trench-Arc Megathrust, which has a potential seismicity of magnitude 8.5 to 8.7 (R & M Consultants, 1981).

Healy-to-Willow Segment. The seismic features affecting the Healy-to-Willow area are similar to those discussed in Section E.1.1.1.5.

Healy-to-Fairbanks Segment. The Healy-to-Fairbanks area has a highly active seismic history that is not related to known surface faults. Two areas of known seismic activity occur within the vicinity of Clear-Anderson and Fairbanks-North Pole. The Denali fault (maximum credible earthquake of 8.5 magnitude) is a few miles south of Healy, perpendicular to the Healy-to-Fairbanks corridor. Another fault of uncertain activity has been located between Healy and Lignite (R & M Consultants, 1981).

Certain areas along the proposed transmission routes may be underlain by soils that are potentially susceptible to seismically induced ground failure, such as liquefaction and landsliding, during moderate to large earthquakes. Areas identified as having the potential for seismically induced landslides include (1) areas with previous landslides and slumps, (2) rivers and stream valleys with steep slopes and overhanging promontories, and (3) areas with ground fracturing on slopes above rivers and stream valleys. Areas identified as having a potential for seismically induced liquefaction include floodplain deposits along the margins of rivers and streams, as well as areas underlain by glacial deposits, particularly kettles and deposits with standing or near-surface water (Woodward-Clyde, 1982).

SEISMIC PROBABILITIES

According to a 1982 seismic report (Woodward-Clyde, 1982), seismically induced liquefaction and landslides are probable during moderate to large earthquakes. The probability of such events occurring within the region are discussed in Sections E.1.1.1.5 and E.1.1.2.5.

E.1.2 Susitna Development Alternatives

E.1.2.1 Alternative Dam Locations and Designs

E.1.2.1.1 Watana I-Devil Canyon

Descriptions of the topography, geology, soils, mineral resources, and seismicity of these two sites are presented in Section E.1.1.1.

E.1.2.1.2 Watana I-Modified High Devil Canyon

Descriptions of the topography, geology, soils, mineral resources and seismicity of the Watana I site are the same as those presented in Section E.1.1.1. The Modified High Devil Canyon alternative site is located about 4 mi (6 km) west of the confluence of Devil Creek and the Susitna River within the steep-sided Devil Canyon section of the Susitna River. A description of the regional topography in the vicinity of the alternative site is presented in Section E.1.1.1.1, and a description of the regional geology is presented in Appendix E.1.1.1.2. The High Devil Canyon is underlain by Cretaceous argillites and graywackes as well as Tertiary biotite granodiorites and volcanic rocks. The bedrock near the site is generally covered by solifluction floodplain and terrace deposits, as well as ablation and basal tills, alluvial fans, and colluvium (Acres American, undated).

Soils within the river valley are primarily classified as Spodsols, specifically Humic Cryorthods (S010) (see Table E.1) and have a thick surface mat of partially decomposed organic litter over a gray mineral horizon. These soils are typically difficult to work and generally have low natural fertility. North of the Susitna River Valley, Pergelic Cryorthods-Histic Pergelic Cryaquepts (S016) are present. At higher elevations south of the Susitna River Valley, Inceptisols or young, incompletely formed soils, specifically Pergelic Cryumbrepts-Rough Mountainous Land (IU3) are present (Rieger et al., 1979). Within this region, the soils are generally considered nonarable and suitable only for grazing. Slopes are generally steeper than 12%, and soils have a medium erosion potential (Selkregg, 1974). Permafrost in this area is discontinuous.

The mineral resources of the entire upper and middle Susitna Basin are described in Section E.1.1.1.4, and the potential for seismic activity within the Modified High Devil Canyon site is similar to that described in Section E.1.1.1.5.

E.1.2.1.3 Watana I-Reregulating Dam

The topography, geology, soils, mineral resources and seismicity that would be affected by the Watana I-Reregulating dam alternative are identical to those described in Section E.1.1.1.

E.1.2.2 Alternative Access Routes

The 18 alternative access routes conform to three general corridors: Corridor 1: From the Parks Highway to the Watana dam site via the north side of the Susitna River; Corridor 2: From the Parks Highway to the Watana dam site via the south side of the Susitna River; and Corridor 3: From the Denali Highway to the Watana dam site. Environmental descriptions of these three corridors are presented below.

E.1.2.2.1 Topography

Corridor 1 and 2 are located adjacent to the steep-sided Susitna River Valley on the relatively flat-topped hills that reach elevations of 2,000 to 3,000 ft (600 to 900 m) MSL south of the river (Corridor 2) and 3,000 to 4,000 ft (900 to 1,200 m) MSL north of the river (Corridor 1). Portage and Devil creeks, tributaries to the Susitna River, cut steep-sided valleys through the hills in Corridor 1. Prairie Creek cuts a wide, gently sloping valley through the eastern portion of Corridor 2. Numerous small, unconnected lakes are scattered throughout both corridors.

Corridor 3 is located in the broad, relatively flat valleys of Brushkana and Deadman creeks. Elevations vary from approximately 2,000 ft (600 m) MSL near the confluence of Deadman Creek and Susitna River to 5,500 ft (1,700 m) MSL at the crest of the isolated hills located within the valley, to 3,000 ft (900 m) MSL at the Denali Highway. Small, unconnected lakes are present throughout all low areas of this Corridor.

E.1.2.2.2 Geology

Corridors 1 and 2 are generally underlain by Tertiary biotite granodiorites and Cretaceous argillites and graywackes. The bedrock is covered by ablation and basal tills; solifluction, floodplain, and terrace deposits; as well as alluvial fans and colluvium. Corridor 3 is underlain by Tertiary schists, migmatites, and granites, as well as granodiorites. Surficial deposits include basal and ablation tills and organic, ablation, colluvium, lacustrian, and solifluction deposits (Acres American, undated).

E.1.2.2.3 Soils

Soils found throughout much of Corridors 1, 2, and 3 are generally classified as Spodsols. Specifically, Humic Cryorthods (S10) are present within the Susitna River Valley, and Pergelic Cryorthods-Histic Pergelic Cryaquepts (SO15, SO16) are present throughout much of the remaining area. Inceptisols, specifically Pergelic Cryumbrepts-Rough Mountainous Land (IU3), are present in the highlands south of the Susitna River in Corridor 2 and Rough Mountainous Lands (RM1) are present in the northernmost sections of Corridor 1. Descriptions of these soils and their limitions are presented in Table E-1.

E.1.2.2.4 Mineral Resources

The mineral resources of the upper and middle Susitna Basin are described in Section E.1.2.1.1.4.

E.1.2.2.5 Seismic Geology

The potential for seismic activity within the area covered by the three corridors is as described in Section E.1.1.1.5 for the upper and middle Susitna Basin.

E.1.2.3 Alternative Power Transmission Routes

E.1.2.3.1 Topography

Willow-to-Anchorage Segment. Within this segment, Corridor 1 and 2 (ADFC and AEFC) are located within the lower Susitna River Basin. A topographic description of this area is presented in Section E.1.1.2.1. Corridor 3 (ABC') extends from the Willow substation along the edge of the Talkeetna Mountains and the Little Susitna River floodplain across the flat Matanuska Valley to Palmer. South of Palmer, the corridor crosses the braided floodplains of the Matanuska and Knik rivers. At the base of the Chugach Mountains, the route extends southwest towards Anchorage, following the Elmendorf Moraine at the edge of the Knik Arm tidal flats and lowlands and the base of the Chugach Mountains.

Dams-to-Gold Creek Segment. The topography for this segment of the transmission corridors, except for corridor sections JHI and AHI, is as described in Section E.1.1.1.1. Corridor section JHI follows the Devil Creek Valley [2,000 ft (600 m) MSL] in a northerly direction through various creek valleys and water divides between rugged, rocky hills [elevations between 4,000 and 5,500 ft (1,200 and 1,700 m) MSL] towards the Jack River Valley. Following the floodplain of the Jack River, segment JHI joins the proposed Intertie just south of Summit Lake in Broad Pass. Corridor segment AHJ follows the Tsusena Creek Valley through similar topography towards the Jack River Valley.

Healy-to-Willow Segment. The topography of this segment of the transmission corridor is described in Section E.1.1.3.1.

Healy-to-Fairbanks Segment. Four corridors were proposed for the Healy-to-Fairbanks segment: Corridor 1 (ABC), Corridor 2 (ABDC), Corridor 3 (AEDC), and Corridor 4 (AEF). Both eastern corridors (1 and 2) follow the Nenana River Valley northward through the northern foothills of the Alaska Range before proceeding northward and northeastward across the coalesced outwash fans of the Alaska Range and the flat Tanana-Kuskokwim Lowlands. Corridor 1 parallels an existing transmission line route through the rounded ridges and gently sloping hills of the Yukon Tanana Upland region following the flat, alluvium-floored Goldstream Creek Valley to Ester. Corridor 2 bypasses the hilly topography of the upland region by crossing the braided Tanana River channel and proceeding north to Ester through a small series of drainage divides.

Corridors 3 and 4 both follow the Healy Creek and Wood River Valleys through the northern foothills of the Alaska Range. The corridor routes separate north of the Japan Hills in the Tanana-Kuskokwim Lowlands and proceed north across the level topography to Ester and Fairbanks.

E.1.2.3.2 Geology

Willow-to-Anchorage Segment. A description of the bedrock and surficial geology of the Cook Inlet and Lower Susitna Basin applicable to the Willow-to-Anchorage Segment is presented in Section E.1.1.2.2.

Dams-to-Gold Creek Segment. Tertiary biotite granodiorites schists, migmatites, and granites, as well as Cretaceous graywackes and argillites, underlie most of this segment. Extensive surficial deposits overlie much of the region. These deposits include floodplain, solifluction deposits, colluvium, basal and ablation till. Organic deposits are also present in poorly drained areas.

Healy-to-Willow Segment. The bedrock and surficial geology of this segment of the transmission corridor are described in Section E.1.1.3.2.

Healy-to-Fairbanks Segment. Mississippian Age, metamorphosed, volcanic and sedimentary rocks underlie the northern foothills of the Alaska Range in the vicinity of Corridors 3 and 4. Extensive, well-sorted floodplain, terrace, and alluvial fan deposits cover the Nenana River Valley and the Tanana-Kuskokwim Lowland. North of the Tanana River, thick, valley bottom, eolian silt and sand deposits are also present. Late Precambrian and early Paleozoic, highly metamorphosed, clastic rocks underlie the Yukon-Tanana Uplands (Selkregg, 1977).

E.1.2.3.3 Soils

Willow-to-Anchorage Segment. Spodsolic soils, specifically Typic Cryorthents-Sphagnic Borofibrists (SO1, SO4, SO5), occur throughout much of the Willow-to-Anchorage segment. These soils are listed in Table E-5 and a description and their limitations are outlined in Table E-1. Although typically difficult to work and low in natural fertility, good agricultural soils have been identified in the vicinity of Corridor 2 (ADFC). Approximately 50% of the soils in this area may be classified as arable (Selkregg, 1974). Entisols, or young, poorly formed soils, specifically Typic Cryofluvents-Typic Cryaquepts (EF1) and Typic Cryorthents (EO1) are present in the Matanuska and Knik River floodplains in the vicinity of Corridor 3 (ABC'). Permafrost is generally absent in this area.

Dams-to-Gold Creek Segment. The soils found in this are as described in Section E.1.1.1.3. Rough Mountainous Land (RM1) (see Table E-1) is present within the Corridors JHI and AHI. This area is generally underlain by discontinuous permafrost.

Healy-to-Willow Segment. The soils of the Healy-to-Willow Segment of the transmission corridor are described in Section E.1.1.3.3.

Healy-to-Fairbanks Segment. The soils within the Healy-to-Fairbanks transmission segment are classified as Inceptisols or incompletely formed, horizonless soils. Although generally absent along the northern flank of the Alaska Range, discontinuous permafrost underlies most of the Tanana-Kuskokwin Lowland. Moderately thick to thin permafrost is present north of the Tanana River (Selkregg, 1977).

E.1.2.3.4 Mineral Resources

Willow-to-Anchorage Segment. The mineral resources of the lower Susitna Basin are described in Section E.1.1.2.4.

Dams-to-Gold Creek and Healy-to-Willow Segments. The mineral resources of these areas are described in Section E.1.1.1.4.

Healy-to-Fairbanks Segment. The Healy-to-Fairbanks segment is identified as metal province for gold, tin, tungsten, zinc, lead, antimony, and silver. Several load and placer deposits have been located north of Healy and in the Fairbanks area. The Fairbanks area is ranked as a mineralized area primarily for gold, silver, antimony, and tungsten and is the leading placer-producing district in Alaska (Selkregg, 1977).

E.1.2.3.5 Seismic Geology

The potential for seismic activity within the Willow-to-Anchorage, Dams-to-Gold Creek, and Healy-to-Willow segments is similar to that described in Section E.1.1.1.5 for the upper and middle Susitna Basin. The Healy-to-Fairbanks segment lies at the northern edge of a vast, continuous, seismically active belt that circumscribes the Pacific Ocean. The potential for damage to structures during earthquakes in the Interior Region is considered major (Selkregg, 1977) (see Sec. E.1.1.3.5).

Table E-5. Soils Along the Proposed and Alternative Transmission Line Segments

	Corridor Segments				
Willow to Anchorage	AB	BC'	ADF	AEF	FC
	Willow to near Palmer -S04, Palmer E01	Palmer-E01; Knik Arm-EF, south of Eklutna to north of Anchorage S05; Anchorage-S04	Willow-S04; south of Willow to F-S01	Near lower Susitna River-S05; Remainder -S04	Near F-S04; Near C-S01

Dams to Gold Creek Segment	AB	BC	CD	BEC	AJ	JC	CF	AG	AH	H	HJ
	S015	B, westward -S015; near C-S010	S010	B-westward-S015; between B and C-IU3; near C-S010	A, westward-S015; remainder, except J-S016; near J-S010	S010	S010	Near A and along Denali Hwy.-S015; through mts. -S016	Near A-S015; mt. base-S016; mts.-RM1	Mts.-RM1; along hwy. -S015	Near J-S016; mid elevations -S017; mts.-RM1

Healy to Fairbanks Segment	AB	BC	BDC	AE	EDC	EF
	IR10	Near B,-IR10; flats south of Tanana River-IQ2; Tanana River-IQ3; Tanana River to Ester-IR14	Near B-IR10; remainder-IQ2	Near A-IR10; mt. base-IQ25; mt. area-RM1; near E-IR1	Near E-IR1; between E and open flats-IR10; open flats-IQ2; Tanana River-IQ3; Ester-IR14	Near E-IR1; south section of flats-IR10; flats-IQ2; Fairbanks-IQ3

†[1] See Table E-1 for explanation of soil units.

Source: Rieger et al. (1979).

E.1.2.4 Alternative Borrow Sites

Descriptions of the topography, geology, soils, and mineral resources of the primary and secondary borrow sites are presented in Section E.1.1.1.

E.1.3 Non-Susitna Generation Alternatives

E.1.3.1 Natural-Gas-Fired Generation Scenario

Under the natural-gas-fired generation scenario, eight 200-MW combined-cycle units would be located in the Cook Inlet region: three on the lower Beluga River, two on the Chuitna River, two on Cook Inlet near Kenai, and one southeast of Anchorage in Turnagain Arm. Descriptions of the topography, geology, soils, mineral resources, and seismic potential for these general regions are presented below.

E.1.3.1.1 Anchorage - Kenai Peninsula Region

TOPOGRAPHY

Glacial outwash plains of the Cook Inlet Lowlands extends along the eastern shore of the Kenai Peninsula from the Knik River to Katchemak Bay along the edge of the Kenai and Chugach mountain ranges. West of Turnagain Arm in the Anchorage area, this outwash plain is approximately 10 mi (16 km) wide; east of Turnagain Arm, the outwash plain reaches a maximum width of 45 mi (72 km) and is dotted by numerous lakes. Both Anchorage and Kenai lie on the northwestern shore of the Kenai Peninsula at the edge of these lowlands.

The Kenai Mountains to the west of Turnagain Arm and the Chugach Mountains to the east form the backbone of the Kenai Peninsula. The two ranges are extremely rugged, and peaks reach a maximum elevation of 6,600 ft (2,000 m) MSL. At elevations greater than 3,000 ft (900 m) MSL, glaciers and icefields cover much of the two ranges. Several glaciers extend down to sea level. East and south of Katchemak Bay, the coastline is rugged and steep.

GEOLOGY

The Kenai and Chugach Mountains are underlain by Mesozoic shales, graywackes, and volcanic rocks that are weakly metamorphosed but strongly deformed and faulted. Tertiary granitic intrusions occur throughout the clastic bedrocks. At the northeastern base of the two mountain ranges, highly modified glacial moraines and associated drift, as well as outwash and valley train deposits, are present.

The Cook Inlet Lowlands are underlain by a thick sequence of coal-bearing rocks of Tertiary Age that overlie thick sequences of Mesozoic rocks. The bedrock is covered by thick, unconsolidated, silt-rich glaciolacustrine, glacial, and glaciofluvial deposits. Well-sorted floodplain, terrace, and alluvial fan deposits are associated with major steam channels.

SOILS

The soils of the Cook Inlet Lowlands and the Kenai Peninsula are primarily Spodsols, specifically Typic Cryorthods-Sphagnic Borofibrists (S01, S04, S05). These soils usually have a thick surface mat of partially decomposed organic litter over a gray mineral horizon. Spodsols in this region are generally well-drained, strongly acid, loamy soils; 50% or more of these soils are arable.

In the Kenai-Chugach Mountain Ranges, bare rock (RM1) predominates, and soils are generally absent. Where present, soils are generally classified as Entisols, which are poorly formed, thin soils (Selkregg, 1974; Rieger et al., 1979).

The Kenai Peninsula is generally free of permafrost, although a few isolated patches may be present at higher elevations (Selkregg, 1974).

MINERAL RESOURCES

All of the Cook Inlet Lowlands on the Kenai Peninsula and in the Anchorage area are located within the Cook Inlet Tertiary Province, an area identified as having a high potential for gas and oil development (see Sec. 1.4.3 and Fig. 1-14), as well as containing known deposits of lignite to subbituminous coal. A discussion of the estimated coal resource of the Kenai coal field is presented in Section 1.4.4. Limestone of unknown quality and clay suitable for brick manufacture occur in the Cook Inlet Lowlands west of Anchorage. The central spine of the Kenai Peninsula is identified as a chromium and copper mineralized area and metal province. The occurrence of nickle and platinum in this area is also suspected. Numerous gold, silver, lead, zinc, copper, and chromium claims have been staked near the Anchorage and Homer areas on the peninsula (Selkregg, 1974).

SEISMIC POTENTIAL

All of the Kenai Peninsula and the Cook Inlet Lowlands are within a region where potential damage due to seismic events is ranked as major. The epicenter of the Alaskan earthquake of 1964 was located just east of Anchorage in the Chugach Mountains.

E.1.3.1.2 Chuitna and Lower Beluga Rivers

TOPOGRAPHY

The lower Beluga and Chuitna rivers project areas are located on the lowlands of the western portion of Cook Inlet. The Beluga area is adjacent to the braided river channel of the Lower Beluga River and the Cook Inlet tidal plains at elevations ranging from sea level to 200 ft (60 m) MSL. Because of low slopes and poor drainage, numerous ponds, lakes, and muskegs occur throughout much of the site area.

The proposed Chuitna project area is bounded by the deeply incised Chuitna River channel [600 ft (130 m) MSL] to the northeast and the broad, flat, marshy floodplain of Nickolai Creek [100 ft (30 m) MSL] to the southwest. A broad, rounded moraine dotted by numerous lakes, ponds, and muskegs rises to elevations of 1,100 ft (340 m) MSL between the two drainage system.

GEOLOGY

The Cook Inlet lowlands are generally underlain by the Kenai Group, a thick sequence of coal-bearing sedimentary rocks of Tertiary age. Thick deposits of undifferentiated Pleistocene fluvial, glacial, or glaciofluvial unconsolidated sediments, as well as loess and volcanic ash, are present throughout the Cook Inlet lowlands. Further description of the geology of this region is presented in Section E.1.1.2.2.

SOILS

In the lowlands of the lower Beluga River area, Histosols, specifically Sphagnic Borofibrists (HY1), are present in the marshy areas near the Cook Inlet tidal flats. Spodsolic soils, specifically Typic Cryorthods-Sphagnic Borofibrists (SO1), occur near the Beluga River. Inceptisols, specifically Drystric Cryandepts-Fluvaquentic Borohemists (1A15), predominate in the Chuitna area (Rieger et al., 1979). Further description of these soil types and their limitations to use are described in Table E-1. No permafrost is present in these areas.

MINERAL RESOURCES

The mineral resources of this region are described in Section E.1.1.2.4.

SEISMICITY

The seismic potential for these two locations is similar to that described in Section E.1.1.2.5 for the Cook Inlet region.

E.1.3.2 Coal-Fired Generation Scenario

Under the coal-fired generation scenario, three 200-MW coal units would be located at Willow and two 200-MW coal units would be located at Nenana. Descriptions of the topography, geology soils and mineral resources for these two areas are presented below. Additionally, ten 70-MW combustion turbines would be located around the Cook Inlet. General descriptions of the topography, geology, soils, and mineral resources of the Cook Inlet region are presented in Sections E.1.1.2 and E.1.3.1.

E.1.3.2.1 Willow

TOPOGRAPHY

Willow is situated in the flat alluvial plain of the lower Susitna River Basin (see Sec. E.1.1.2 for regional description) at an elevation of about 200 ft (60 m) MSL. Numerous lakes and poorly drained marshy areas are present in this area adjacent to the extensively braided Susitna River channel. To the east of Willow, the land rises gently to the base of the Talkeetna Mountains.

GEOLOGY

A detailed description of the geology of the lower Susitna River Basin is presented in Section E.1.1.2. The Willow area is generally underlain by sandy and gravelly alluvial materials that overlie weakly consolidated, Tertiary, coal-bearing sedimentary siltstones, claystones, and conglomerates of the Kenai Group.

SOILS

Soils in the Willow area closest to the Susitna floodplain are predominantly Entisols, specifically Typic Cryofluvents-Typic Cryaquepts (EF1) (see Table E-1). These soils are generally formed of well-drained, stratified, waterlaid sediment of variable thickness over a substratum of sand, gravel, and cobblestones. Flooded soils, sloughs, and scattered muskegs of fibrous peat also occur and severaly limit access development and intensive use of these soils (Rieger et al., 1979).

On the river terraces east of the Susitna River in the Willow area, Spodosolic soils, specifically Typic Cryorthods-Sphagnic Borofibrists (SO1) predominate. Where drainage is adequate, these soils are suitable for cultivation or forestry and have few limitations for roads, structures, or other intensive uses (Rieger et al., 1979). Permafrost is absent in the Willow vicinity.

MINERAL RESOURCES

The mineral resources of the lower Susitna Basin are described in Section E.1.1.2.

SEISMICITY

The potential for seismic activity in the Willow area is similar to that described for the lower Susitna Basin (Sec. E.1.1.2.5).

E.1.3.2.2 Nenana

TOPOGRAPHY

Most of the Nenana project area lies to the south of the Tanana River on nearly level floodplains at an elevation of approximately 400 ft (120 m) MSL between the unglaciated Yukon-Tanana Upland to the north and the outwash plains of the glaciated Alaska Range to the south. North of the Tanana River near the Nenana area, rounded hills and ridges rise to more than 1,600 ft (490 m) MSL. A description of the regional topography is presented in Section E.1.1.3.1.

GEOLOGY

A description of the regional geology of the Nenana area is presented in Section E.1.1.3.2. The area south of the Tanana River is underlain by gravelly alluvial deposits and Tertiary Nenana gravel, a poorly consolidated sedimentary conglomerate. North of the Tanana River, Precambrian metasedimentary Birch Creek schist underlies the rounded hills which are mantled by varying thicknesses of silty micaceous loess (Rieger et al., 1979; R&M Consultants, 1981).

SOILS

Within the floodplains of the Tanana River and its tributaries, wet Inceptisols, specifically Histic Perlagic Cryaquepts-Typic Cryofluvents (IQ3), are present. On the lower portions of the floodplain, these soils are poorly drained, are frequently flooded, and are underlain by shallow permafrost. Away from the floodplains, well-drained organic-rich Inceptisols, specifically Alfic Cryochrepts-Histic Pergelic Cryaquepts (IR14), occur. The well-drained and moderately well drained soils in this area are potentially suitable for cultivation or forestry and have few limitations for intensive use (see Table E-1). The poorly drained soils, flooded and shallow soils, and soils with permafrost in this area have severe limitations for construction and are generally not suitable for cultivation (Rieger et al., 1979). The total area suitable for agricultural purposes in this area is small (Furbush and Schoephorster, 1977).

MINERAL RESOURCES

The mineral resources of the region are described in Section E.1.1.3.4 for the Healy-to-Fairbanks segment of the proposed transmission corridor.

SEISMICITY

The potential for seismic activity within the vicinity of the Nenana Site is similar to that described for the Healy-to-Fairbanks transmission line segment (Sec. E.1.1.3.5).

E.1.3.3 Combined Hydro-Thermal Generation Scenario

E.1.3.3.1 Johnson

TOPOGRAPHY

The Johnson alternative site is located in the Tanana-Kuskokwin Lowland near the confluence of the Tanana River and the Johnson River. The headwaters of the Johnson River are in the glacier on the north slope of Mt. Hayes [9,860 ft (3,000 m) MSL] of the Alaska Range. Flowing north through a glaciated "U"-shaped valley, the Johnson River braids toward the broad Tanana Valley [elevation 2,000 ft (610 m) MSL]. The Tanana Valley is bordered by the Alaska Range to the south and the rounded, gentle ridges and slopes of the Yukon-Tanana Upland to the north.

GEOLOGY

Late Precambrian-early Paleozoic, highly metamorphic clastic rocks such as argillite, graywacke, phyllite, quartzite, and slate underlie the northern slopes of the Alaska Range in the vicinity of the Johnson site. Jurassic- to Tertiary-aged granitic intrusives have also been found in this area.

Thick alluvial deposits, predominately extensive well-sorted floodplain, terrace, and alluvial fan deposits, cover much of the Tanana River Valley and its tributaries. North of the Tanana River, bedrock is covered by thick eolian silt and sand deposits (Selkregg, 1977).

SEISMIC

Like all areas in Southcentral Alaska, the Johnson area is located in a region of extreme seismic activity. The major fault system in the area is the Denali Fault, located in the Alaska Range about 40 mi (60 km) southwest of the Johnson site. North of the Tanana River a series of northeast-southwest trending faults parallel the Shaw Creek Fault. The activity of these faults is not presently known, and the maximum probable earthquake to be expected at the Johnson site has not been evaluated.

SOILS

Soils formed in the Johnson area are typical of those formed in wet, cold climates. In the upland areas surrounding the Johnson River, soils are generally absent or poorly formed and are classified as Rough Mountainous lands (RM1). Within the Johnson and Tanana river valleys, soils are primarily Inceptisols or young, incompletely formed soils, specifically Typic Cryochepts-Histic Perlagic Cryaquepts (IR13) and Alfic Cryocrepts-Histic Perlagic Cryaquepts (IR14). Soils in this region are typically well drained and have a thin layer or organic matter incorporated into the upper few inches of soil. These soils are generally nonacid and have a silty loam, loamy or gravelly texture (Rieger et al., 1979).

Permafrost in this region is generally discontinuous and occurs primarily in areas of predominantly coarse-grained material. In areas of fine-grained deposits, permafrost may be moderately thick (Selkregg, 1977).

MINERAL RESOURCES

No metallic mineral resources have been identified in the Johnson site area. Coal is present west of the site in the Jarvis Creek coal field along the Delta River. Sand and gravel deposits are present near the site (Selkregg, 1977).

E.1.3.3.2 Keetna

TOPOGRAPHY

The Talkeetna site is located along the lower half of the Talkeetna River in the Copper River Plateau area northwest of the rugged Talkeetna Mountains. The headwaters of the Talkeetna River are in the glaciers of the Talkeetna Mountains [elevation 8,850 ft (2,700 m) MSL]; the river flows west to the broad, flat Susitna River Valley. Elevations at the alternative site are about 1,000 ft (300 m) MSL in the river valley, rising to 3,000 ft (900 m) MSL in the broad plateaus to the north.

GEOLOGY

Well-sorted terrace deposits are generally present along the Talkeetna River Valley margins, and floodplain deposits are limited in extent. Slightly to moderately modified moraine and associated drift deposits cover much of the site area. Jurassic and Cretaceous slates, shales, graywackes, and conglomerates that have been intruded by Jurassic to Tertiary granitics underlie the Talkeetna River Valley and surrounding hills (Selkregg, 1974). The Talkeetna Mountains are underlain by a large granitic batholith intruded into Mesozoic volcanic and older sedimentary rocks. To the north, near the site area, these older rocks are capped by flat-lying Tertiary basalt.

SEISMIC

The Keetna area is located in an extremely seismically active region. The principal fault system of concern in the area is the Denali Fault system, which is about 60 mi (100 km) north of the site. Numerous subparallel faults trending south-southwest to north-northeast are located approximately 30 mi (50 km) northwest of the area. Another active fault system, the Castle Mountain Fault, is approximately 50 mi (80 km) south of the Keetna site. No estimates have been made of maximum probable earthquakes to be expected at the Keetna site.

SOILS

Soils in the Talkeetna River area are typical of those found on uplands in areas of high precipitation [greater than 15 in (38 cm)] and are classified as Spodsols, specifically Humic Cryorthods (SO10). Permafrost in Talkeetna River Valley occurs as isolated masses, predominantly in the fine-grained deposits (Rieger et al., 1979).

MINERAL RESOURCES

Copper has been identified in a mineralized area southeast of the site area in the Talkeetna Mountains. Sand and gravel deposits have also been noted as potential resources for the immediate area (Selkregg, 1974).

E.1.3.3.3 Snow

TOPOGRAPHY

The Snow site is located in the Kenai Mountain Range in the Kenai Peninsula on the Snow River near the southern end inlet of Kenai Lake. The Kenai Range mountains are extremely rugged and reach a maximum elevation of 6,600 ft (2,000 m) MSL near the site. At elevations greater than 3,000 ft (900 m) MSL, glaciers and icefields cover much of the range. The Snow River occupies a deep gorge cut into the bedrock on the floor of a glacial valley.

GEOLOGY

Graywackes and slates are exposed in the Snow River Valley (Exhibit E, Vol. 9, Chap. 10, p. E-10-11). Deepwater sedimentary sequence of mildly metamorphic late Jurassic- to Cretaceous-age graywackes, siltstone, slat, sandstone, and conglomerate interbedded with volcanic basalts and detritus are reported for the area (Selkregg, 1974).

SEISMIC

Located within one of the most seismically active regions of the world, the Snow site is also located near several known fault systems: the Bruin Bay Fault system, the Castle Mountain Fault, and the Border Range Fault system. All three faults follow the regional, arcuate, sublinear structures trending parallel to the Gulf of Alaska. The Border Range Fault system, approximately 35 miles (55 km) northwest of the site, parallels the northwestern edge of the Kenai Mountains. The Castle Mountain Fault following the Matanuska River Valley lies at least 80 mi (130 km) north and northeast of the site. The Bruin Bay Fault system paralleling the northern coast of Cook Inlet lies at least 80 mi (130 km) northwest and west of the site. No estimations of the maximum probable earthquake to be expected at the Snow site have been made.

SOILS

Soils within the Snow River Valley are typical of soils forming on uplands in areas of high precipitation [greater than 15 in (38 cm)] and are classified as Spodsols, specifically Humic Cryorthods (SO10). Rough Mountainous lands (RM1) are present in the higher elevations adjacent to the river valley (Rieger et al., 1979). Generally the project area is free of permafrost, although isolated masses may be locally present at higher elevations.

MINERAL RESOURCES

The Snow site area lies within an area identified as a gold and copper (and to a lesser extent lead, zinc, silver, and tungsten) metal province. Numerous load and placer deposits, mines and prospects have been reported in the area, generally along the Snow River from Moose Pass, just northeast of the site area, to Seward. A mineralized area of chromium and copper ore is also present northwest of the area (Selkregg, 1974).

E.1.3.3.4 Browne

TOPOGRAPHY

The Browne site is located just north of Healy along the Nenana River at the edge of the northern foothills section of the Alaska Range to the south and the Tanana-Kuskokwin Lowland to the north.

The northern foothills are unglaciated, flat-topped, east-trending ridges 2,000 to 4,500 ft (600 to 1,500 m) MSL in elevation that are separated by rolling lowlands and glaciated valleys. The Nenana River flows north, cutting through these ridges before crossing coalesced outwash fans from the Alaskan Range in the Tanana-Kuskokwin Lowland. Badlands are commonly formed in areas of rapidly eroding soft Tertiary sediments in the Healy area. Elevations near the alternative site are approximately 2,000 ft (600 m) MSL along the Nenana River Valley and 1,000 ft MSL (300 m) in the lowlands to the north (Selkregg, 1977).

GEOLOGY

Extensive, well-sorted floodplain, terrace, and alluvial fan deposits, as well as moderately modified moraines and associated drift, are present within the Nenana River Valley. Middle Tertiary continental deposits of sandstone siltstone, conglomerate, claystone, and coal are found within the northern foothills of the Alaska Range. The northcentral flank of the Alaska Range is composed of Mississippian metamorphosed, volcanic and sedimentary rocks, as well as late Precambrian and early Paleozoic, highly metamorphosed clastic rocks such as argillite, graywacke, phyllite, and quartzite (Selkregg, 1977).

SEISMIC

The Browne site is in an extremely active seismic region. One of the major active fault systems in this region of Alaska, the Denali Fault and its associated branches, is located near to the site. Trending east-west, two major branches of this fault system pass to the south within 25 mi (40 km) and 45 mi (70 km) of the area. No estimations of maximum probable earthquakes to be expected at the Browne site have been made.

SOILS

Within the Nenana River Valley, soils are classified as Inceptisols or young, incompletely formed soils, specifically Typic Cryochrepts-Aeric Cryaquepts (IR10) (Rieger et al., 1979). Permafrost in this area is discontinuous (Selkregg, 1977).

MINERAL RESOURCES

Immediately to the east of the Nenana River, several load and placer deposits, prospects and mines have been identified within a region of possible antimony, gold, and silver resources. The Nenana coal field covers much of the Nenana River Valley and the area north and east of Healy. Subbituminous coal is currently mined at the Usibelli Mines. Clay and cement materials have also been identified as potential resources in the area (Selkregg, 1977).

E.1.3.3.5 Lake Chakachamna

TOPOGRAPHY

Lake Chakachamna is located in a deep, glaciated valley in the southernmost region of the Alaska Range just north of the Chigmit Mountains. The lake is surrounded on three sides by numerous glaciers and high rugged mountain peaks. The lake is bordered at its eastern outlet to Chakachatna River by morainal deposits associated with the Barrier Glacier. The Barrier Glacier originates in the snow fields high on the south slope of Mt. Spurr [11,070 ft (3,400 m) MSL], an active volcano (Bechtel, 1983). Elevations in the immediate area range from 1,200 ft (370 m) to sea level in the Cook Inlet lowlands 40 mi (64 km) to the east. The lowlands are broad, flat (less than 500 ft, or 150 m, above sea level) and poorly drained. They contain many thaw lakes and marshes.

The Chakachatna River flows through a narrow canyon within a broader valley bounded by Mt. Spurr on the north and the Chigmit Mountains on the south. The Chigmit Mountains to the south and the Tordrillo Mountains to the north have been repeatedly glaciated and contain many steep slopes and near vertical cliffs. The southern side of the Chakachatna River Valley consists of steep, glaciated, granitic bedrock slopes that rise continuously from the river to the adjacent mountain peaks. The north slope is covered by volcanic, glacial, and fluvial sediments (Bechtel, 1983). The McArthur River canyon is a narrow, steep-walled glaciated valley.

GEOLOGY

The late-Tertiary and/or early-Quaternary volcanic activity at Mt. Spurr caused a buildup of andesitic lava flows, pyroclastics and volcaniclastic sediments on top of a granitic mountain mass that is exposed along the southern valley of the Chakachatna River. The Quaternary Mt. Spurr volcanics are largely confined to a broad, wedge-shaped area bounded by Barrier Glacier, Brogan Glacier, and the Chakachatna River. Interspersed volcanic and glacial activity in this region occurred during the Pleistocene, with alternating periods of erosion and deposition; as a result, the Chakachatna Valley is covered by a complex of volcanic and glacial deposits. Glacial deposits include moraines, large areas of kame and kettle deposits, and glacier-marginal lake deposits (Bechtel, 1983).

The valley walls of the McArthur River canyon consist of granitic bedrock. A complex of cross-cutting joint sets and shear zones are exposed along the valley walls. The character of the valley slope varies with the joint orientation and character (Bechtel, 1983). The Cook Inlet lowlands are covered by alluvial and tidal sand, silt and gravel of Holocene age. The lowlands are underlain by a thick sequence of coal-bearing rocks of Tertiary age that rest on Mesozoic rocks about 30,000 ft (10,000 m) thick.

SEISMIC

Southern Alaska is one of the most seismically active regions of the world. Earthquakes in this region generally occur along the interplate boundary between the Pacific lithospheric plate and the North American plate from the Alaska panhandle to Prince William Sound and along the Kenai and Alaskan peninsulas to the Aleutian Islands. Movements of these plates has resulted in the development of complex faulting and folding of the regional geologic units. The Castle Mountain and Bruin Bay faults (major regional faults), as well as several other smaller faults, have been mapped near the Chakachamna Lake area. The Castle Mountain Fault passes within less than 1 mi (1.6 km) of the project facilities in the McArthur River area and within 11 mi (18 km) of Chakachamna Lake. A maximum magnitude earthquake of MS 7.5 has been estimated for this fault (Bechtel, 1983). Volcanic-induced earthquakes are also considered a potential seismic source for this region.

SOILS

Soils formed within the Lake Chakachamna area are typical of those found in wet, cold climates in mountainous and recently glaciated terrain. In the area, soils are generally absent (RM1). Inceptisols or young, incompletely formed soils resulting from the weathering or alteration of parent material, specifically Drystric Cryandepts (IA14, IA15) have developed within the Chakachatna River valley (see Table E-1). Most of the soils have developed on glacial deposits; the remainder have been formed on volcanic sediments (Rieger et al., 1979). Isolated masses of permafrost occur in this area.

MINERAL RESOURCES

The Chakachamna site is in an area identified as a metal province for molybdenum, copper, gold, silver, and, to a lesser extent, lead and zinc. No load or placer mines, deposits or claims have been recorded within 20 mi (30 km) of the site (Selkregg, 1974). The site is in an area of potential geothermal energy and is adjacent to the lignite and subbituminous Beluga Coal Fields. Producing oil and gas wells are common near Tyonek and the Cook Inlet south of the area (Selkregg, 1974).

E.1.3.3.6 Beluga River, Chuitna River, Nenana and Anchorage

Descriptions of the topography, geology, soils, and mineral resources of the lower Beluga River, the Chuitna River, and the Anchorage environs are presented in Section E.1.3.1. Descriptions of the topography, geology soils and mineral resources for the Nenana area are presented in Section E.1.3.2.

E.2 ENVIRONMENTAL IMPACT

E.2.1 Proposed Project

E.2.1.1 Watana Development

E.2.1.1.1 Construction

RESERVOIR SLOPE INSTABILITY

During reservoir filling, slope instability within the projected Watana impoundment area would be greatly influenced by changes in the groundwater regime and the thawing of permafrost sediments. As the reservoir level rises, the groundwater table in the confining slope would also rise, increasing the pore pressure and seepage acting on the slope and decreasing slope stability. Thaw of permafrost deposits in contact with the rising reservoir waters would decrease the stability of low-angle slopes, giving rise to solifluction, skin flow, and bimodal flow failures. Submergence of slopes in granular material might also lead to slumping or sliding beneath the reservoir level, causing increased suspended sediment concentrations in localized areas of the reservoir.

During the filling operation, the reservoir shoreline would be in contact with the steeper slopes of the Susitna River Valley for a distance of about 16 mi (26 km) upstream from the Watana dam site. The north-facing slopes of this valley between the dam site and Vee Canyon would have a high potential for slope failure during filling because of the presence of frozen basal fill, deep overburden and the steep slopes. Because of more variable geologic and topographic conditions on the south-facing slope, slope failure would be more localized along this slope.

Upstream of Vee Canyon, the impoundment would be contained within the Susitna floodplain, where less steep slopes underlain by permafrost would be encountered. Shallow rotational and flow slides might be expected in these areas as a result of permafrost thaw during the filling operation.

Slope failure during the construction period generally would be a gradual process confined to the reservoir shoreline. Slope failures might be expected to result for the most part in minor variations in the temporary shoreline configuration and might result in temporary increases in the suspended sediment concentrations in the portion of the reservoir adjacent to the slide. The actual magnitude of these failures would depend on the nature of the slope materials and their degree of saturation, due in part to climatic conditions and the rate of permafrost thaw.

Construction activities involving the movement of heavy equipment near the shoreline might also cause localized accelerated slope failure as a result of vehicle-induced vibration or overloading. Use of explosives in the development of the borrow sites might also trigger localized slumping in nearby saturated materials.

Because of the relatively slow and even rate of reservoir filling (three years to fill to normal pool level), the potential for slope instability during the filling of the reservoir would be reduced and probably limited to shallow surface flows and some localized sliding. Many of these slides or flows would occur underwater, and although they would contribute to localized suspended sediment concentrations in the reservoir, they would not disturb surrounding reservoir areas. Many of the failures that occurred above the reservoir level during filling might be submerged as the reservoir level reached normal pool level. Tree root systems that would not be removed during the clearing of vegetation from the reservoir would also act to stabilize the reservoir slopes to some degree. Although the rooting depth of most vegetation in the area is shallow, the matted tangle of roots would act to stabilize the surface soils until excess pore pressures in the slopes had dissipated. Areas affected by high excess pore pressures would be subject to rotational slope failuries, slumping, etc., regardless of the existence of this surface mat, however.

SEEPAGE

The permeabilities in the foundation rock at the proposed Watana dam site are not high [between 3.3×10^{-6} to 3.3×10^{-3} ft/s (1×10^{-6} to 1×10^{-3} m/s) (Exhibit E, Vol. 7, Chap. 6, p. E-6-16)]. Existing shear zones and joints in the vicinity of the site would be grouted to decrease seepage losses through and around the dam (see Sec. E.3). The greatest potential for seepage at the Watana dam site is expected to occur along the Watana relict channel, especially within the highly permeable units at depths of 208 to 231 ft (63 to 70 m) and 293 to 375 ft (89 to 114 m) (Acres American, undated). Seepage along this channel would result in loss of water from the reservoir, as well as piping and erosion of materials at the exit point of the relict channel at Tsusena Creek.

Because of the long seepage path [approximately 7,000 ft (2,100 m)] and the 6% hydraulic gradient (Acres American, undated), the possibility of seepage or piping through the buried relict channel is at present considered remote even without remedial measures. Further investigations, including additional borings and geophysical logging, would be conducted to assess the channel deposits. Present plans to mitigate any piping or seepage problem that develop include the construction of an underground adit with interceptor drain (Exhibit E, Suppl. Information, Sec. 6, Item 9). Additional remedial measures proposed by the Applicant to control seepage include the use of a relatively impervious material to blanket the upstream entrance of the relict channel, use of a filter-toe drain at the relict channel exit, and development of a cutoff wall by grouting of permeable layers within the channel (Exhibit E, Suppl. Information, Sec. 6, Item No. 12). All such measures should be effective in reducing the potential for piping and seepage in the relict channel. Should the decision be made to control rather than prevent underseepage, a natural springs environment would be created at the exit of the relict channel in Tsusena Creek. The rate of seepage flow through the relict channel would be influenced by the effectiveness of the measures used to control seepage.

Although saturation of the channel deposits and the thawing of permafrost within these deposits might increase the potential for liquefaction of the deposits, their history suggests that the deposits may be overconsolidated as a result of repeated glacial loading (Harza-Ebasco, 1983). As such, the potential for liquefaction of these deposits and the subsequent damage to the rim of the reservoir is believed to be small.

The low seepage gradient and the long seepage pathway [4 to 5 mi (6 to 8 km)] of the Fog Lake buried channel (Exhibit E, Vol. 7, Chap. 6, p. E-6-30) would reduce the potential for seepage in this channel. Further investigation of this channel is required to fully substantiate this conclusion, however.

As a result of increased hydrostatic head or pressure, the potential for seepage through either the relict channels or through joints or fractures in the bedrock would increase as the reservoir filled and would be maximum when maximum pool level was reached. Should increased seepage in the dam foundation develop during impoundment, underground grouting galleries would be constructed to facilitate remedial grouting activities (Exhibit E, Vol. 7, Chap. 6, p. E-6-40).

PERMAFROST THAW

In addition to effects of permafrost thawing on slope stability, major engineering problems arise where permafrost occurs in poorly drained, fine-grained sediments. Thawing of these ice-rich sediments produces excessive wetness and undesired plasticity and results in settling, caving, liquefaction, subsidence of ground surfaces, loss of bearing capacity, and sediment flows. Freezing of this active layer in winter results in frost heaving of the ground surface (Ferrians et al., 1969).

Because permafrost occurs throughout much of the Watana project area, the construction facilities, including the temporary construction camp and village, the air strip, and various site roads, would be expected to encounter permafrost. Construction of these facilities would disturb the thermal regime of the soils and could cause minor sediment flows or differential settling. Thawing of permafrost would result in settlement of surface facilities such as the construction village located in an area of deep frozen overburden north of the dam site. Since this area is relatively flat, flow slides would be considered unlikely.

To minimize the extent of permafrost thaw and thereby limit the extent of settlement of the construction facilities, the Applicant has proposed to use a large pad of granular material under the temporary construction camp and village facility to evenly distribute the load and to insulate the subsoil from the heated buildings. Rigid polystyrene insulation might also be used to increase the insulation base under the buildings. Additionally, pile supports would be used to support building foundations and thermopiles would be installed to remove excess heat in the soils surrounding and underlying all structures (Exhibit E, Suppl. Information, Sec. 6, p. 6-15-4). With proper use, these mitigation measures would be effective in minimizing permafrost thaw and subsequent impacts.

Thermal disturbance of permafrost soils under the site roads and air strip could be expected as a result of removal of the vegetation and the development and use of the facilities by heavy equipment. With such disturbances, the amplitude of seasonal fluctuation of temperatures might be two to three times greater than that of nearby undisturbed ground. Furthermore, the ground beneath the disturbed area would become more sensitive to the random year-to-year climatic variations. Troughs of thawed ground susceptible to frost heaving and solifluction would form beneath the road (or airstrip) surface; water from the thawing permafrost would flow along these troughs until it was trapped in a depression, creating quagmire conditions, or escaped through exterior drainageways. Without proper drainage, this surface runoff could cause additional permafrost deposits to melt. With thawing, settlement would occur; where water was trapped and refrozen, frost heaving would result. In subsequent years, freezing and thawing of the active layer under the roadway would be accelerated in areas where the melt water had drained away (Ferrians et al., 1969).

Where possible, the Applicant would attempt to locate all road and surface facilities on thaw stable soils. Where this is not feasible, roadways would be insulated through use of gravel pads or rigid synthetic insulation and thermopiles would be installed so as to control the degradation of the permafrost (Exhibit E, Suppl. Information, Sec. 6, Item 15). Previous experience in constructing roads and other facilities in areas of permafrost in Alaska indicate the feasibility of such activities (Ferrians et al., 1969).

RESERVOIR-INDUCED SEISMICITY

A reservoir-induced seismicity (RIS) event is defined as a naturally occurring seismic event triggered by the incremental increase in stress in the earth's crust associated with the impoundment of a reservoir. The epicenters of RIS events occur within the limited area affected by the reservoir's mass and pore pressures, which usually corresponds to the area underlying the surface of the reservoir.

In theory, reservoirs are considered capable of triggering an earlier occurrence of an earthquake expected for the region prior to reservoir construction, but are generally not thought to be capable of triggering an earthquake of a magnitude that would exceed that expected to occur naturally in the area. A discussion of the impacts related to such naturally occurring seismic events is presented in the next subsection.

When considered as one hydrologic entity, the combined Watana-Devil Canyon reservoir complex would be among the largest and deepest in the world. The size of reservoir, however, is not the primary determining factor in RIS, as many of the world's largest reservoirs have shown no change in seismicity, and a few relatively small reservoirs have produced earthquake activity far in excess of that expected for the seismic history for the region (Simpson and Negmatullaev, 1978).

Analysis of the global occurrence of RIS events (Woodward-Clyde, 1982) indicates that RIS is influenced by reservoir depth and volume, the tectonic stresses immediately beneath the reservoir, the rate of reservoir filling, as well as the existing pore pressures and permeabilities of the rock underlying the reservoir. In a comprehensive and thorough investigation comparing the proposed Susitna reservoir complex to similar reservoirs elsewhere, Woodward-Clyde Consultants (1982) concluded that the mean likelihood of an RIS earthquake within the 20-mi (32-km) belt on either side of the proposed reservoir is 0.46 (on a scale of 0 to 1) with a standard deviation of 0.22. The assumptions and conclusions made in the analyses of Woodward-Clyde Consultants are considered to be valid for this analysis.

Moderate to large RIS events generally have been found to occur only along faults with recent displacement reference. In the vicinity of the proposed reservoir complex, no such faults have been found to date. As a result, the likelihood of an RIS event of magnitude (M_s) >4 is considered low by Woodward-Clyde Consultants (1982). Because of the possibility that further field work may reveal the existence in this region of a fault with recent displacement, however, a RIS event of magnitude (M_s) 6, the magnitude of the detection level earthquake for the region (Woodward-Clyde, 1982) is considered possible for this reservoir system.

So as to analyze the effects of reservoir filling on the stress regime of the impoundment area, the Alaskan Power Authority intends to instrument the reservoir during the construction period for baseline purposes and would operate a sensitive microseismic network during and immediately after the reservoir filling period (Exhibit E, Suppl. Responses, Sec 6, Item 8). Because sudden changes in reservoir levels and rapid filling of reservoirs correlate positively with increased RIS activity (Simpson and Negmatullaev, 1978) the Applicant has proposed that the Watana reservoir would be filled slowly and evenly over a three-year period. This schedule should be effective in reducing the likelihood of inducing RIS events.

REGIONAL SEISMICITY

A discussion of the seismicity of the proposed Watana-Devil Canyon project area is presented in Section E.1.1.1.5. Earthquake activity in the project area would result primarily in increasing the magnitude of failure in the potentially unstable slopes within the reservoir area. Earthquakes could also trigger liquefaction of various unconsolidated deposits within the Watana reservoir area. The thick sequence of lacustrine materials overlying basal tills in the Watana Creek drainage (Acres American, undated) area would be especially susceptible to liquefaction during earthquakes. Liquefaction of the unconsolidated materials within the Watana relict channel (Acres American, undated) is considered unlikely, however, because of the assumed degree of consolidation of these sediments.

EROSION

To date, limited information describing the characteristics and the typical engineering properties of the soils and surficial sediments in the Watana project area is available. No detailed soil surveys have been conducted for this area by the Soil Conservation Service (Rieger et al., 1979), and preliminary investigations have been restricted primarily to a large-scale generalized terrain evaluation of the area based on low-altitude aerial photographs collaborated by only limited field checks (Acres American, undated: Appendix J). This lack of field information severely restricts the use of the terrain evaluation maps for site-specific analysis of potential erosion impacts resulting from construction activities in the Watana project area.

Despite this lack of substantiated site information, a few qualitative assessments of the potential for soil erosion impacts accompanying construction activities can be made. These assessments would be subject to change should field investigations necessitate alterations of the existing preliminary descriptions of soils within the project area.

A general description of the soils within the project area is presented in Section E.1.1.1.3. Most of these soils are thought to have severe limitations for construction activities as a result of high water tables, periodic flooding, steep slopes, and poor stability (Rieger et al., 1979). Based on the generalized studies conducted to date by the Applicant, however, the south-facing slopes of the Susitna Valley where most of the construction activity would be located are less steep and the soils are better drained than the north-facing slopes.

During the construction period, the development of borrow sites, site roads, the airstrip, the construction camp and village, and all dam-related features would result in the localized disturbance of soils and vegetation and subsequent increased erosion of surface soils. The potential for erosion would be greatest when rainfall was heavy or during spring snowmelt conditions. The subsequent runoff from these events could cause sheet, rill, or gully erosion. Construction of facilities on steep slopes could also result in slope and soil instabilities, increased erosion, and sedimentation.

The movement of heavy machinery during construction operations might substantially impact local areas of soil. Such movement might result in compaction of surface soil or removal of upper soil layers. Mechanical compaction generally reduces soil productivity by reducing rates of water infiltration and percolation, restricting root penetration, and increasing surface water runoff or ponding.

Excavation or backfill activities associated with numerous construction activities might also change soil characteristics by mixing the soil profile, bringing rock fragments or boulders to the surface, interrupting infiltration and drainage, as well as increasing erosion. Such disturbances might cause reductions in the soil fertility in the disturbed areas.

Such activities as road construction, excavation, and clearing could also result in alteration of local drainage patterns and surface water regimes. Blockage of drainage patterns could result in the water logging of soils, leading to the development of quagmires, the thawing of permafrost, and increased surface erosion of soils. Clearing of vegetation during construction could alter the thermal regimes of soils, causing deeper, earlier thaw of frozen soils in summer and earlier freeze of soils in winter.

Increased human use of the Watana project area, especially the use of off-road vehicles in the summer, would also occur during the construction period. Such activities would destroy surface vegetation and subsequently increase soil disturbance and erosion. These effects would be most severe in areas of permafrost and tundra vegetation.

To reduce the potentially adverse effects of these impacts, the Applicant has proposed to use a number of mitigative measures to reduce soil disturbances and soil erosion. The construction camp and village facilities would be located on gently sloping, generally well-drained, permafrost-free, ablation till deposits north of the dam site. During construction, these sites would be cleared of vegetation and would be vulnerable to erosion losses during periods of heavy precipitation and surface runoff. The Applicant has also attempted to reduce vegetation clearing requirements (and as a result reduce the area of disturbed soils) by minimizing the dimensions of the construction camp and village areas. Given the gentle 2% to 3% slopes and the well-drained condition of the soil, however, soil losses during such events would be expected to be minimal. Selected areas of natural vegetation would also be left undisturbed at the village site. These areas and all areas left in natural vegetation surrounding the cleared construction area would aid in filtering out or trapping the soil eroded from the construction area before it could reach any nearby waterways.

Erosion control for the construction camp and village site, as for all construction operations, would include the development of appropriate drainage systems, the placement of revetments to reduce flow velocities, and the use of desilting ponds. Protective barriers of brush or fill would be used along stream banks to control increased erosion resulting from construction activities (Exhibit E, Suppl. Information, Sec. 6, p. 6-15-5). These practices should be effective in keeping erosion losses from construction areas within acceptable levels.

Use of heavy construction vehicles in and around the camp and village sites during the clearing and construction operations would also result in soil compaction, resulting losses in soil fertility. Topsoil from the adjacent dam site borrow areas, however, would be used by the Applicant to reclaim all such disturbed areas surrounding the site. Revegetation of these disturbed areas would reduce the erosion losses in these areas (see Appendix J for discussion of the expected effectiveness of revegetation practices).

During the development of the project borrow areas, the upper 2 to 3 ft (0.6 to 0.9 m) of soil and organic matter would be stripped and stockpiled for later use in reclaiming disturbed project areas at the end of the construction period (Exhibit E, Vol. 7, Chap. 6, p. E-6-38). Borrow sites would be excavated only as necessary. Borrow sites D, F, and C and quarry site F would not be flooded by the reservoir and would either be regraded or reseeded after use or, if excavation is sufficiently deep, would be converted to ponds.

During the processing of excavated rock and gravel from the borrow sites and quarries for use in dam construction, concrete aggregate, support pads for buildings, and temporary service roads, large quantities of spoil materials would be produced. The Applicant proposes to dispose of these materials within the impoundment area. Exact locations of the soil disposal areas would be determined during the detailed engineering design phase (Exhibit E, Vol. 6A, Chap. 3, p. E-3-267). Prior to reservoir filling, temporary construction berms or temporary pits around the spoil piles would be used to control or contain the erosion of fines. Spoil piles would also be located in areas of the impoundment away from expected areas of turbulence or high-velocity currents so as to reduce the potential for entrainment of the fines during reservoir filling.

All temporary site roads would be graded, recontoured, and seeded following abandonment (Exhibit E, Vol. 7, Chap. 6, p. E-6-42). Where site roads cross areas of permafrost, gravel pads of sufficient thickness to insulate the roads would be used to control the degradation and subsequent failure of the permafrost (Exhibit E, Suppl. Information, Sec. 6, Item 15). Generally these measures should be adequate to control erosion due to borrow site and road development. Further mitigation measures that should be considered are discussed in Section 5.2.1.

Immediately prior to filling of the reservoir, the Applicant proposes to clear large trees and shrubs from the portion of the reservoir to be impounded during that construction year. When possible, clearing activities would be conducted during the winter so as to minimize soil losses during these activities. Low vegetation and organic debris covering the unconsolidated materials would not be intentionally removed during the clearing operation, thus providing a mat of stabilizing vegetation to inhibit soil erosion. Some damage might occur to this mat, however, due to heavy vehicle traffic during the clearing activity (Exhibit E, Vol. 6A, Chap. 3, p. E-3-160).

Because of the large area to be affected by vegetation clearing activities (see Appendix J), the erosion losses from this area may be expected to be subtantial (although unquantifiable), despite the measures to control erosion losses. Increased concentrations of suspended sediment are likely to be highest in surface runoff immediately following site clearing and prior to natural reestablishment of vegetation in the cleared area. As reservoir filling proceeded, however, the amount of the cleared land, and thus the total quantity of soils eroded, would be reduced.

GEOLOGICAL RESOURCES

At present, no mineral or fuel resources are known to exist within the Watana project area (see Sec. E.1.1.1.4). Development of the Watana dam and associated facilities would require the excavation and use of substantial rock and construction fill materials from the project area. None of these materials is considered unique to the area and is not required by competing developments. As such, no adverse impacts to the geological resources within the Watana project area are expected during the construction period. Reservoir impoundment would result in the flooding of 36,000 acres (15,000 ha) of soils. These soils are not suitable for agriculture.

E.2.1.1.2 Operation

RESERVOIR SLOPE INSTABILITY

With the filling of the impoundment area, slope instability would be influenced primarily by the large seasonal drawdown of the reservoir [estimated at 100 ft (30 m)], thawing of the permafrost soils, reestablishment of the groundwater regime, steepness of the reservoir slopes, and the nature of the slope materials. The primary impacts would be increased concentrations of suspended sediments in the areas adjacent to the slope failure, shoreline erosion, and disturbance of shoreline vegetation.

The 100-ft (30-m) drawdown zone along the reservoir edge should remain essentially unvegetated. Without vegetative cover, however, reservoir shoreline recession might be expected to continue until bedrock or gravel/cobble/boulder substrates were exposed. Slope instability in the drawdown zone would also be intensified by the yearly periodic freezing, thawing, saturation, and desiccation of the soils within this zone. After the reservoir was filled, the relative warmth of the reservoir water would cause permafrost thaw in adjacent hillsides, especially the southern shores of the Watana reservoir where the permafrost layer is 200 to 300 ft (60 to 90 m) thick.

Although the areal extents of slope instability along the Watana reservoir shoreline cannot be reliably quantified in advance, numerous areas of the reservoir would be expected to be vulnerable to slope failure. The 49-mi (78-km) reach along the southern shore of the impoundment area between the Watana dam site and the Oshetna River/Vee Canyon area has a high potential for flows and shallow rotational slides because of the presence of deep frozen basal till, relatively thick overburden, and steeper slopes. Similarly, a 10-mi (16-km) reach from the headwaters of the Watana reservoir to the Oshetna River/Goose Creek area which is underlain by thick frozen silt and clay deposits has a high potential for slope failure. More variable geologic and topographic conditions on the northern shore would give rise to the potential for a variety of slope conditions in this reach of the reservoir. A 10-mi (16-km) reach along the northern shore of the reservoir between Watana Creek and the dam site which is underlain by unconsolidated glacial outwash within the drawdown zone would be expected to experience slope instability problems. Upstream of Vee Canyon, the reservoir would be confined primarily to the floodplain of the Susitna River, and small rotational slides in areas underlain by permafrost would be expected. Shoreline erosion or beaching would occur primarily as a result of wave action and the sloughing or oversteepening of a backslope. Mass failures near the shoreline would probably result in the creation of new beaches along the disturbed section of reservoir shoreline.

Most of the slopes within the proposed impoundment area would be totally submerged. Approximately 16 mi (26 km) upstream of the dam site, the reservoir would inundate the steeper slopes of the Susitna River Valley, and the reservoir shoreline would be in contact with the low slopes of the surrounding upland terrain. In these areas where the reservoir shores are located above the break in slope, instability problems would be less than for areas where reservoir shores abut steeper slopes. Where permafrost underlies these gently sloping shorelines, however, flow slides could be expected to occur within these flat-lying slopes as a result of permafrost thaw.

Based on aerial photographic interpretation and limited field reconnaissance, the Applicant has calculated that approximately 15,000 acres (6,000 ha) of land adjacent to the reservoir shoreline might be affected to some degree by either beaching, flow, or block slides (Exhibit E, Suppl. Information, Sec. 6, Item 7). Of this total, approximately 270 acres (110 ha) of land outside the Watana project boundary might be affected by slope failure and erosion as a result of the reservoir impoundment (Exhibit E, Suppl. Information, Sec. 6, Item 10). The methodology involved in such calculations are thought by the Staff to be valid for this analysis. It is anticipated that these slope failures would be a long-term progressive activity resulting primarily from seasonal fluctuations in the reservoir level, the thawing of permafrost, and wave action at the shoreline. The length of time required for the restabilization of the slopes adjacent to the reservoir after inundation is unknown. Without altering the given characteristics of the dam and reservoir, there would be no way to avoid, minimize, rectify or reduce the impacts resulting from slope instability.

SEEPAGE

The potential for impacts resulting from seepage through and around the Watana dam is discussed in Section E.2.1.1.1. As discussed, seepage impacts would be maximum when the reservoir was at maximum pool level and would decrease somewhat with seasonal drawdown of the reservoir.

PERMAFROST THAW

The impacts resulting from permafrost thaw in the Watana project area during the construction phase are discussed in detail in Section E.2.1.1.1. Similar impacts might be expected during the operation phase. The permanent village would be located in an area relatively free of permafrost so as to prevent the development of long-term problems related to permafrost thaw. If the insulation base placed under the buildings of the temporary camp and village had been effective in preventing permafrost thaw, ground heaving should not occur when the heated buildings were removed at the end of the construction period.

RESERVOIR-INDUCED SEISMICITY

Reservoir-induced seismicity (RIS) is described in Section E.2.1.1.1. The impacts related to RIS events during the operation period would be similar to those described in the subsection on Seismic Impacts.

After impoundment of the reservoir was completed, variations in the reservoir level resulting from seasonal drawdowns might induce RIS events. Although small seasonal drawdowns would be expected at the Devil Canyon reservoir, large seasonal drawdowns [100 ft (30 m)] would be expected at Watana reservoir and might increase the probability of RIS events in the area. Because the rate of seasonal fluctuations in reservoir levels has not been specified to date by the Applicant, it is unclear whether the probability of RIS events resulting from seasonal fluctuations in the reservoir level during operation would be less than the probability of RIS events resulting from reservoir filling during the construction period. In other reservoirs around the world, however, the greatest earthquake activity has occurred soon after the filling of the reservoir and has then gradually decreased or disappeared with time (Simpson and Negmatullaev, 1978).

REGIONAL SEISMICITY

The seismically induced impacts expected for the Watana reservoir area during the operation period are similar to those discussed for the construction period.

EROSION

During the operation period, erosion would occur primarily along site roads, the airstrip, and in the vicinity of the permanent village. A detailed discussion of the nature of these impacts and measures to control erosional losses is presented in Section E.2.1.1.1. Many of the areas susceptible to erosion during the construction period (e.g., borrow sites, construction roads, dam facilities, etc.) would either be flooded by the impoundment or would be completed prior to the operation period and thus would not be susceptible to further erosion. Erosion losses during the operation period would be expected to be smaller than during the construction phase primarily because of the smaller area affected by surface facilities and their related activities. Increased use of off-road vehicles by the public during this period, however, could increase erosion and soil disturbances. Impacts related to shoreline erosion of the reservoir are discussed above in Section E.2.1.1.2.

GEOLOGICAL RESOURCES

For the reasons stated in Section E.2.1.1.1, the geological resources of the Watana project area would not be adversely impacted during the operation period.

E.2.1.2 Devil Canyon Development

E.2.1.2.1 Construction

RESERVOIR SLOPE INSTABILITY

The nature of slope instabilities that would be expected within the Devil Canyon reservoir during the filling of the reservoir are similar in nature to those discussed in Section E.2.1.1.1. During reservoir filling operations, similar areas would be expected to be susceptable to slope instability. The geological character of this reservoir area (e.g., the exposure of stable bedrock along the reservoir shores) would be fundamental in reducing slope instability impacts in this reservoir.

SEEPAGE

Bedrock permeabilities in the vicinity of the Devil Canyon dam site are generally low except in a number of shear and fracture zones. The permeabilities of these zones decreases with depth, and grouting would be used to further reduce the potential for seepage losses through these zones. Foundation preparation and grouting during the construction of the saddle dam across the buried channel south of the dam site would minimize seepage from the Devil Canyon reservoir via this pathway. Remedial grouting would be used to reduce any seepages that develop during reservoir impoundment.

PERMAFROST THAW

A general discussion of the effects of permafrost thaw resulting from construction activities is given in Section E.1.1.1.1. Based on terrain unit maps prepared for the Applicant (Acres American, Undated: Appendix J), permafrost might be present in the basal tills and organic deposits underlying the proposed temporary camp and village sites south of the Susitna River between the dam site and Portage Creek. Preliminary site investigations, however, suggest that no permafrost is present (Acres American, undated). Should permafrost be found in these vicinities, vegetation clearing would probably result in sufficient thawing of these thin sediments prior to construction, thereby reducing the impacts related to the thaw.

The Applicant proposes to locate all site roads so as to avoid, wherever possible, other isolated pockets of permafrost present in the Devil Canyon project area. Where permafrost was encountered, however, mitigation measures such as those described in Section E.2.1.1.1 would be used and should be effective in minimizing the degradation of the permafrost. Because of the lack of permafrost in much of the Devil Canyon project area, permafrost-related impacts should be minor.

RESERVOIR-INDUCED SEISMICITY

The reservoir-induced seismic impacts expected for the combined Watana-Devil Canyon reservoir complex during the construction period are described in Section E.1.1.1.1.

REGIONAL SEISMICITY

A discussion of the seismicity of the proposed Watana-Devil Canyon project area is presented in Section 3.1.1.2 and Section E.2.2.1. In the Devil Canyon reservoir area, earthquake activity would result primarily in increased reservoir slope instability. The potential for an earthquake-induced landslide would be most likely at the site of an old landslide on the south abutment at River Mile 175. Because the toe of the slide is located above the maximum pool elevation, it is unlikely that this slide would be reactivated by normal reservoir impoundment. Triggered by an earthquake, however, a mass slide in this area could result in the temporary blockage of river flow. The limited geologic/geotechnical information available for this slide area, however, precludes an analysis at this time of the potential severity of impacts resulting from such a slide (specifically the potential magnitude of the slide, the extent of upstream flooding that might be expected due to blockage of river flow, the probability of such a slide, etc.).

EROSION

During the construction period, the development of borrow areas, site roads, the construction camp and all dam-related features would result in localized disturbances and subsequent erosion of surface soils. The impacts expected for these activities within the Devil Canyon and the mitigation measures proposed to control erosion losses would be similar to those described in Section E.2.1.1.1.

Because of the steep, narrow configuration of Devil Canyon, the total area that would be cleared of vegetation prior to reservoir impoundment is only 15% of what would be cleared for the Watana reservoir. The thinness of the overburden in the Devil Canyon reservoir area would further reduce the potential magnitude of cumulative erosion losses within the impoundment zone. Effective use of the proposed mitigation measures should be sufficient to reduce or control erosion losses within the Devil Canyon project area. Additional mitigation measures that should be considered for this project are described in Section 5.3.

GEOLOGICAL RESOURCES

At present, no mineral or fuel resources are known to exist within the Watana project area (see Sec. E.1.1.1.4). Development of the Devil Canyon dam would require the excavation and use of substantial rock and construction fill materials from the area. Although clean sand and gravel deposits are scarce throughout the project area (Acres American, undated), sufficient materials would be available from the borrow and quarry pits. None of these materials would be required by competing developments. Thus, no adverse impacts to the geological resources within the Devil Canyon project area would be expected during the construction period.

Flooding of the impoundment area would result in the loss of approximately 6,000 acres (2,400 ha) of soils and rocks. None of the soils within the impoundment area are considered to be agriculturally suitable.

E.2.1.2.2 Operation

RESERVOIR SLOPE INSTABILITY

Confined entirely within the walls of the present Susitna River Valley, the Devil Canyon reservoir would be deep and narrow and would have a small seasonal drawdown [about 55 ft (17 m)]. In the area of Devil Canyon Creek and downstream, the reservoir shoreline would be in contact with steep bedrock cliffs, and slope instability would be primarily due to small rock falls resulting from the fluctuation of the reservoir and groundwater table accompanied by seasonal frost heaving. Upstream of Devil Canyon Creek, the potential for beaching and to a lesser extent rotational slides, bimodal flows, and solifluction would increase as the thickness of unconsolidated materials along the reservoir shoreline increased. An old landslide in the basal till on the south abutment at River Mile 175 might be reactivated as a result of permafrost thaw and changes in the groundwater regime accompanying the completion of the reservoir inundation. However, because the toe of this slide is located above the maximum pool elevation, it is unlikely that the slide would be reactivated by normal reservoir impoundment (see Sec. E.2.1.2.1). Failure of this slide might extend beyond the project boundaries (Exhibit E, Suppl. Information, Sec. 6, Item 10).

Based on aerial photography interpretation and limited field reconnaissance, the Applicant has calculated that approximately 2,500 acres (1,000 ha) of land adjacent to the reservoir shoreline might be affected to some degree by beaching and to a much lesser extent by flow or block slides (Exhibit E, Suppl. Information, Sec. 6, Item 7). The methodology used in calculating these areas is considered by the Staff to be valid for this analysis. These failures would be anticipated to be a long-term progressive activity within the reservoir project boundary area. The length of time that would be required for the slopes adjacent to the reservoir to restabilize after reservoir filling is unknown. The lower estimates of land disturbed by slope failure adjacent to the Devil Canyon reservoir relative to the Watana reservoir reflect the lack of sufficient depths and extent of unconsolidated materials and the presence of stable bedrock conditions along the Devil Canyon reservoir shoreline.

SEEPAGE

As discussed in Section E.2.1.1.1, seepage losses would be maximum when the maximum pool level for the reservoir was reached. Seepage losses at the Devil Canyon dam site would be expected to be controlled by grouting and by the generally low bedrock permeabilities (see Sec. E.2.1.2.1). As a result, seepage impacts would be expected to be minimal.

PERMAFROST THAW

The impacts related to permafrost thaw in the Devil Canyon project area during the construction period are discussed in Section E.2.1.2.1. Similar impacts might be expected during the operation phase. Because of the absence of permafrost, removal of the temporary camp and village structures would not disturb the thermal regime of the area.

RESERVOIR-INDUCED SEISMICITY

The reservoir-induced seismic impacts that would be expected for the combined Watana-Devil Canyon reservoir area during the operation period are described in Appendix E.2.1.2.2.

REGIONAL SEISMICITY

The seismically induced impacts that would be expected for the Devil Canyon reservoir area during the operation period are similar to those discussed for the Devil Canyon reservoir during the construction period (Sec. E.2.1.2.1.

EROSION

Subsequent to reservoir inundation, the primary erosional impacts within the Devil Canyon project area would be confined to limited beach erosion in the upper reaches of the reservoir area where overburden thicknesses increase and to erosion along any site roads that might remain around the dam facilities. During the operation phase, the Applicant would dismantle the construction camp and village facility and revegetate the site so as to reduce erosion losses from this area. All borrow sites would also be revegetated. These measures should be sufficient to control soil erosion losses within the project area.

GEOLOGICAL RESOURCES

For the same reasons discussed in Section E.2.1.2.1, no adverse impacts on the geological resources in the Devil Canyon project area would be expected during the operation period.

E.2.1.3 Access Routes

E.2.1.3.1 <u>Denali Highway to Watana</u>

CONSTRUCTION PERIOD

Construction of access roads in the Watana-Devil Canyon project area would be affected by and would in turn influence the potentials for frost heaving, permafrost thaw, slope instability, and liquefaction failures.

The presence of potentially unstable unconsolidated materials such as frozen basal till between the Denali Highway and the Watana dam site have been noted in the reconnaissance-level, aerial photography terrain evaluation mapping conducted by the Applicant (Acres American, undated: Appendix J) (see Sec. E.1.1.1.2). The potential for liquefaction and permafrost thaw related failure in these materials during the construction period might be high. The Applicant, however, has proposed to site, to the extent possible, the access road so as to avoid potentially unstable deposits found during more detailed geotechnical investigations conducted during access route development (Exhibit E, Suppl. Information, Sec. 6, Item 15).

Because of the lack of detailed information pertaining to the exact location and nature of the deposits within the access corridor and the uncertainty as to the exact location of the access road, evaluation of the extent of impacts related to access road construction is not possible at this time. It is known however, that approximately 630 acres (250 ha) of vegetation along the 44-mi (70-km) corridor from the Denali Highway to the Watana dam site would be cleared (Exhibit E, Vol. 6A, Chap. 3, p. E-3-245). These construction operations would result in increased surface erosion, soil compaction, possible changes in surface drainage patterns (resulting in waterlogging and possible liquefaction of soils) and potential impacts related to permafrost thaw. Development of the access route would also facilitate use of the corridor and surrounding areas by off-road vehicles.

In all areas, adequate drainage of the roadways would have to be ensured to prevent saturation of the underlying fill material and subsequent slumping or solifluction and to prevent roadside erosion. Inadequate drainage of roads crossing permafrost deposits could lead to permafrost thaw and eventual road collapse. Saturation of unconsolidated materials beneath the road bed would also increase the potential for liquefaction failure. A discussion of the impacts associated with the construction of roadways in areas underlain by permafrost is present in Section E.2.1.2.1. As the access route from the Denali Highway to Watana is underlain by discontinuous permafrost, many of these impacts might be expected. The Applicant proposes to reduce the impacts caused by permafrost thaw by using a thick pad of granular material or rigid synthetic insulation, as well as thermopiles to prevent thermal degradation of the underlying permafrost. The access route would also be located to avoid known deposits of permafrost wherever possible (Exhibit E, Suppl. Information, Sec. 6, Item 15).

As suggested by the Applicant, construction cuts in ice-rich soils might be stabilized by revegetation or by granular fill alone or in combination with synthetic insulation. Erosion could be controlled by providing adequate drainage and by placing revetments to reduce flow velocities. Placement of brush or fill along stream banks and use of desilting ponds could be used to mitigate downstream siltation impacts (Exhibit E, Suppl. Information, Sec. 6, Item 15).

To minimize the need for construction of individual access roads to borrow areas, the Applicant has proposed to site borrow areas required for access road construction immediately adjacent to the route. Use of these borrow sites would be minimized, however, through maximum use of side-borrow techniques in level terrain and balanced cut-and-fill techniques in sidehill cut areas. Use of these techniques would generally confine road construction activities to a strip approximately 20 ft (6 m) wide along each side of the road (Exhibit E, Vol. 6A, Chap. 3, p. E-3-264). The Applicant also has located the route along the lower slopes of the mountainous terrain within this corridor so as to follow well-drained terrain and gravelly soil types suitable to side-borrow and cut-and-fill construction techniques (Exhibit E, Vol. 6A, Chap. 3, p. E-3-261). Location of the route in this manner would be expected to reduce the volume requirements for borrow extraction for the road and minimize the areal extent of vegetation removal outside the proposed corridor as well.

The Applicant proposes to develop borrow areas only on a contingency to support road-construction where side-borrow material would not be available in sufficient quantities. In these borrow areas, overburden would be stockpiled temporarily during borrow site development in an area selected to minimize erosion and runoff (e.g., flat, well-drained, upland locations). Berms or drainage systems would be constructed as necessary around the stockpile to contain any eroded sediment. Following borrow pit use, overburden would be replaced in the borrow pit and would be revegetated (Exhibit E, Vol. 6A, Chap. 3, p. E-3-265).

The mitigation measures proposed by the Applicant should be sufficient to control or reduce the possible impacts resulting from construction of access roads in this area. Further information pertaining to the exact nature of the unconsolidated materials in the area would be required before final access road construction plans could be finalized, however, and before the potential magnitude of possible impacts could be determined.

No mineral or fuel resources would be impacted by the development of this access route. Road construction materials would be readily available from the borrow sites for access road development and would not impinge on local demand. No agriculturally suitable soils would be crossed by the access route.

OPERATION PERIOD

During the operation period, the access road between Denali Highway and the Watana dam site would continue to be affected by and in turn influence the potential for frost heaving, permafrost thaw, slope instability, and liquefaction failures. The nature of these impacts during the operation period should be similar to those described above for the construction period. During the operation period, impacts due to off-road vehicle use might increase, resulting in increased erosion and permafrost thaw in areas where vegetation damage is extensive. Access route borrow pits would be revegetated and erosion losses from these disturbed areas would be less than during the construction period.

E.2.1.3.2 <u>Watana to Devil Canyon</u>

CONSTRUCTION PERIOD

Construction of the Watana-to-Devil Canyon access route would result in the disturbance of approximately 400 acres (160 ha) of soil and vegetation along a 37-mi (59-km) corridor north of the Susitna River (Exhibit E, Vol. 6A, Chap. 3, p. E-3-243). Generally, the potential impacts related to the construction of this access route would be similar to those discussed above for the Denali Highway-to-Watana route. The presence of unstable unconsolidated geologic materials, such as frozen basal till, between the Watana and Devil Canyon dam sites, as determined in the reconnaissance-level terrain evaluation studies (Acres American, undated) indicates the high probability for liquefaction failures, landslides, and problems related to permafrost thaw during the construction period. These impacts could result in localized disturbances of soils and vegetation, and possibly increased sedimentation in nearby waterways. The mitigation measures proposed by the Applicant, such as siting of the access route to avoid areas of permafrost wherever possible and the use of insulation pads under the access roads (as described in Sec. E.2.1.3.1), should be effective in reducing the magnitude of these impacts. More detailed site information pertaining to the exact nature of the unconsolidated materials in the area and the exact location of the access route would be required before the potential magnitude of possible impacts could be determined however.

OPERATION PERIOD

The potential impacts related to the operation of the Watana-to-Devil Canyon access route would be expected to be similar in nature to those described in Section E.2.1.3.1.

E.2.1.3.3 <u>Rail Access to Devil Canyon</u>

CONSTRUCTION PERIOD

Construction of the 12-mi (19-km) railroad extension between Devil Canyon and Gold Creek on the southern side of the Susitna River would disturb approximately 72 acres (29 ha) of vegetation and soils (Exhibit E, Vol. 6A, Chap. 3, p. E-3-243). The potential impacts related to the construction of the rail access to Devil Canyon would be similar to those discussed in Section E.2.1.3.1. The presence of unstable unconsolidated geologic materials such as basal till, colluvium, and solifluction deposits, along this route, as determined in the reconnaissance-level terrain evaluation studies (Acres American, undated) indicates the high probability for liquefaction failures, landslides, and problems related to permafrost thaw during the construction period. These impacts should result in localized disturbances of soils and vegetation and possibly increased sedimentation in nearby waterways. The mitigation measures proposed by the Applicant, such as the location of the access route to avoid areas of permafrost wherever possible and use of insulation pads under the rail line should be effective in reducing the magnitude of these impacts. More detailed site information describing the exact nature of the unconsolidated materials in the area and the exact location of the rail link would be required before the potential magnitude of possible impacts due to construction activities could be determined.

In contrast to access road construction, which would require a clearing width of 120 ft (37 m), the rail access construction would require a clearing width of only 50 ft (15 m). On a per unit length basis, therefore, the soil disturbances and construction material requirements would be less for rail access than for road access.

Development of the railhead facility at Devil Canyon would require the disturbance of approximately 46 acres (19 ha) of vegetation and soil. The location of this facility on relatively flat terrain would reduce the possibility for excessive surface erosion during construction. Use of mitigation measures to control drainage and runoff as proposed by the Applicant for development of borrow sites and for all construction activities (see Sec. E.2.1.1.1) would be expected to provide adequate erosion control during the construction period. Other mitigative measures that could be used to minimize possible construction-related erosion impacts are discussed in Section E.3.

No mineral or fuel resources would be impacted by the development of the rail access to Devil Canyon. Necessary construction materials would be readily available in the area and would not impinge on local demands. No agriculturally suitable soils would be crossed by the rail access.

OPERATION PERIOD

During the operation period, the rail access to Devil Canyon would continue to be affected by and, in turn, influence the potential for frost heaving, permafrost thaw, slope instability, and liquefaction failures. The nature of these impacts for the rail line during the operation period should be similar to those described for the construction period.

Runoff from the concrete pad at the Devil Canyon railhead facility might increase the volume of local surface runoff to streams adjacent to the pad. Such runoff might increase erosion of soils adjacent to the pad unless adequate drainage systems were provided (see Sec. E.3).

In contrast to the access road corridors, off-road vehicle traffic would not be expected to increase as a result of the rail access development.

E.2.1.4 Power Transmission Facilities

E.2.1.4.1 Dams-to-Gold Creek Segment

CONSTRUCTION PERIOD

As previously discussed, the proposed transmission line segment between the dams and Gold Creek crosses potentially unstable, unconsolidated geologic materials such as frozen basal till, colluvium, and solifluction deposits. Determination of the location of these deposits has been made solely through the use of reconnaissance-level aerial photograph terrain evaluations supported by very limited field confirmation (Acres American, undated). Typical of such glaciated areas, however, the surficial deposits can change rapidly along a short distance both laterally and with depth. Because the exact locations of the transmission towers and associated access roads have not been identified to date, only general assumptions pertaining to the nature and magnitude of impacts related to the construction of the transmission corridor can be made at this time. The Applicant has proposed to make on-ground evaluation of site conditions during the detailed engineering design and construction planning phase so as to determine the appropriate management procedures for specific portions of the transmission corridor. These site assessments would be conducted in coordination with representatives of the U.S. Fish and Wildlife Service, the Alaska Department of Fish and Game, and the Alaska Plant Materials Center (Exhibit E, Vol. 6A, Chap. 3, p. E-3-273).

Development of the Dams-to-Gold Creek transmission line segment would require the selective clearing of trees and tall shrubs from approximately 1,500 acres (610 ha) of land. No clearing of low-lying vegetation or small shrubs from the right-of-way is proposed (Exhibit E, Vol. 6A, Chap. 3, p. E-3-244). Although heavy equipment movement within the right-of-way during the clearing process would disturb the surface soils and vegetation, resulting in the potential in increased erosion, the low-lying vegetation and organic mat covering the soil in the area should generally act to trap and stabilize any eroded sediment. In the few areas requiring extensive removal of trees and tall shrubs (see Appendix J) or where clearing occurred adjacent to drainage systems, sediment losses might be substantial. To prevent erosion of these sediments into waterways, the Applicant proposes to place brush along stream banks or to use desilting ponds to mitigate downstream siltation impacts (Exhibit E, Suppl. Information, Sec. 6, Item 15). These measures should be effective in providing adequate protection against erosion impacts. Other measures that could be used to control such erosion are discussed in Section E.3.

The plan to combine the Watana-to-Gold Creek access road and transmission line corridor would minimize the traffic-related vegetation removal and soil disturbance by reducing the distances required for transport of equipment from the nearest road to the transmission corridor (Exhibit E, Vol. 6A, Chap. 3, p. E-3-255). Use of the construction trails from the main access road to the right-of-way would be limited by the Applicant to flat-tread or balloon tire vehicles so that fill replacement or removal of organic layer would not be required (Exhibit E, Vol. 6A, Chap. 3, p. E-3-272). These measures should be effective in minimizing soil disturbances.

The construction of the transmission towers, control stations, and relay buildings would result in very localized disturbances of soils and vegetation. Wherever possible, the Applicant would construct all structures on thaw stable soils (Exhibit E, Suppl. Information, Sec. 5, Item 15). Where that was not possible, the Applicant would use numerous measures to mitigate the potential impacts due to thawing of ice-rich soils. These measures include the use of reinforcing support poles imbedded in the permafrost to depths greater than twice the thickness of the active layer in the permafrost, use of a concrete pad resting on an insulating gravel pad for guyed metal towers, and use of thermopiles to dissipate heat from the ground under and around the tower structure (Exhibit E, Suppl. Information, Sec. 6, Item 15). Use of these measures should increase the stability of all facilities and minimize the disturbance of the permafrost regime in the vicinity, thereby reducing the potential for localized settlement, slumping and solifluction of surface deposits.

The Applicant would evaluate the suitability of a particular terrain unit for transmission tower foundations through the use of onsite subsurface investigation, and sampling and laboratory testing at representative locations along the line length. A variety of tower and foundation designs would be available and would be selected so as to provide safe and economical tower foundation designs for each tower site (Exhibit B, p. B-2-120).

The primary impacts related to tower construction would be those associated with the development of access roads. The impacts that would be expected for the transmission line access routes between the dam sites and Gold Creek would be similar to those discussed in Sections E.2.1.3.1 and E.2.1.3.2.

No agriculturally suitable soils or known geologic resources would be impacted by the construction of the transmission line or access roads from Gold Creek to the two project dams.

OPERATION PERIOD

During the operation period, impacts related to the transmission lines would be those associated with maintenance of access roads between Gold Creek and the dam sites. The impacts would be similar to those discussed in Sections E.2.1.3.1 and E.2.1.3.2.

E.2.1.4.2 <u>Gold Creek-to-Fairbanks Segment</u>

CONSTRUCTION PERIOD

The general nature of impacts and the proposed measures to mitigate the impacts associated with transmission tower construction, right-of-way development, and transmission line access roads are discussed in Section E.2.1.4.1.

Landslide, solifluction, and colluvial deposits, as well as eolian loess, silty alluvial fan, floodplain, retransported till and organic deposits found along the transmission line corridor (see Sec. E.1.1.3) are known to have potentially undesirable soil foundation conditions. Generally, these conditions become increasingly more severe toward the northern segment of the proposed transmission line corridor. Permafrost deposits also become increasingly more continuous to the north and increase the potential for construction difficulties.

Between Gold Creek and Fairbanks, areas of fine-grained, poorly drained sediments were identified as areas of primary concern to construction projects associated with the Alaska Railroad (Ferrains et al., 1969) and would likewise affect transmission line construction. Surficial deposits between Broad Pass and Fairbanks (especially the Goldstream Valley) and the glaciolacustrine deposits near Moody in the Nenana River Valley are described as being of special concern because of their potential for impacts from permafrost thaw and liquefaction (e.g., settlement, caving, slumping, flow).

As discussed in Section E.2.1.4.1, the exact locations of the transmission towers and related facilities, as well as the locations of specific surficial deposits of concern, have not been clarified to date. As a result, only general estimates as to the nature and magnitude of impacts related to the construction of this transmission line segment can be made at this time.

Right-of-way development of the single-tower Gold Creek-to-Fairbanks line segment that would parallel the Intertie corridor for much of its length would result in the widening of the existing right-of-way by 190 ft (58 m). Soil and vegetation disturbances associated with this additional right-of-way development would be less than those associated with the development of a new 300-ft (90-m) transmission right-of-way. The existence of potential access roads for almost the entire length of this line would further minimize impacts related to access road construction.

Based on the few soil surveys compiled for this region (Furbush and Schoephorster, 1977; Rieger et al., 1963, 1979), agricultural soils along this segment of the transmission corridor appear to be very limited. No soils that are suitable for most field crops or that have few limitations restricting their use (Class I soils) are present along this corridor. In the northernmost portion of the corridor, limited areas of Class II soils (soils that have moderate limitations that reduce the choice of plants or that require moderate conservation practices) are crossed by the corridor. The impact to these soils from transmission line construction would be small because of the availability of existing access roads and the limited amount of space actually disturbed by the transmission tower. For similar reasons, development of the transmission line would not impact any geological resources within the proposed corridor. No known mineral or fuel resources are known to exist within the proposed right-of-way.

OPERATION PERIOD

During the operation period, impacts would be primarily attributable to the maintenance of access roads along the transmission line. These impacts would be similar in nature to those discussed in Section E.2.1.3.1.

E.2.1.4.3 <u>Gold Creek-to-Anchorage Segment</u>

CONSTRUCTION PERIOD

Along the Gold Creek-to-Anchorage segment of the transmission line route, permafrost is generally absent and soils are thaw stable. Numerous unconsolidated deposit that would be crossed by the transmission line corridor have highly undesirable foundation characteristics. Localized landslide deposits, marine tidal deposits found in the southern portion of the corridor, and fluvial deltaic and organic deposits found throughout the corridor are all subject to extreme to high liquefaction potential (Exhibit E, Suppl. Information, Sec. 6, Item 16). A description of the locations of these deposits is presented in Section E.1.1.3. However, because the exact location of the transmission towers and related facilities, as well as the location of specific surficial deposits of concern, have not been delineated to date, only general assumptions as to the nature and magnitude of impacts that would be expected as a result of transmission tower construction can be made.

The transmission corridor right-of-way would affect approximately 250 acres (100 ha) of the Point MacKenzie agricultural project and 535 acres (216 ha) of the Fish Creek agricultural project (Exhibit E, Suppl. Information, Sec. 6, Item 16). Additionally, the corridor would cross many areas of soil suited for agricultural production (Soil Conservation Service soil capability Classes II, III, and IV) south of Willow and east of the Susitna River (Schoephorster and Hinton, 1973; Schoephorster, 1968; Rieger et al., 1979). The impact to these soils would be primarily related to the development of any new access roads that might be required. Existing Intertie access roads would be used wherever possible. Only limited areas of soil would be disturbed by transmission tower construction. No geologic resources are known to exist within the proposed transmission corridor.

OPERATION PERIOD

During the operation period, transmission line impacts would be primarily attributable to maintenance of the transmission line access roads. These impacts would be similar in nature to those discussed in Section E.2.1.3.1

Chap. 3, p. E-3-244). Although heavy equipment movement within the right-of-way during the clearing process would disturb the surface soils and vegetation, resulting in the potential in increased erosion, the low-lying vegetation and organic mat covering the soil in the area should generally act to trap and stabilize any eroded sediment. In the few areas requiring extensive removal of trees and tall shrubs (see Appendix J) or where clearing occurred adjacent to drainage systems, sediment losses might be substantial. To prevent erosion of these sediments into waterways, the Applicant proposes to place brush along stream banks or to use desilting ponds to mitigate downstream siltation impacts (Exhibit E, Suppl. Information, Sec. 6, Item 15). These measures should be effective in providing adequate protection against erosion impacts. Other measures that could be used to control such erosion are discussed in Section E.3.

The plan to combine the Watana-to-Gold Creek access road and transmission line corridor would minimize the traffic-related vegetation removal and soil disturbance by reducing the distances required for transport of equipment from the nearest road to the transmission corridor (Exhibit E, Vol. 6A, Chap. 3, p. E-3-255). Use of the construction trails from the main access road to the right-of-way would be limited by the Applicant to flat-tread or balloon tire vehicles so that fill replacement or removal of organic layer would not be required (Exhibit E, Vol. 6A, Chap. 3, p. E-3-272). These measures should be effective in minimizing soil disturbances.

The construction of the transmission towers, control stations, and relay buildings would result in very localized disturbances of soils and vegetation. Wherever possible, the Applicant would construct all structures on thaw stable soils (Exhibit E, Suppl. Information, Sec. 5, Item 15). Where that was not possible, the Applicant would use numerous measures to mitigate the potential impacts due to thawing of ice-rich soils. These measures include the use of reinforcing support poles imbedded in the permafrost to depths greater than twice the thickness of the active layer in the permafrost, use of a concrete pad resting on an insulating gravel pad for guyed metal towers, and use of thermopiles to dissipate heat from the ground under and around the tower structure (Exhibit E, Suppl. Information, Sec. 6, Item 15). Use of these measures should increase the stability of all facilities and minimize the disturbance of the permafrost regime in the vicinity, thereby reducing the potential for localized settlement, slumping and solifluction of surface deposits.

The Applicant would evaluate the suitability of a particular terrain unit for transmission tower foundations through the use of onsite subsurface investigation, and sampling and laboratory testing at representative locations along the line length. A variety of tower and foundation designs would be available and would be selected so as to provide safe and economical tower foundation designs for each tower site (Exhibit B, p. B-2-120).

The primary impacts related to tower construction would be those associated with the development of access roads. The impacts that would be expected for the transmission line access routes between the dam sites and Gold Creek would be similar to those discussed in Sections E.2.1.3.1 and E.2.1.3.2.

No agriculturally suitable soils or known geologic resources would be impacted by the construction of the transmission line or access roads from Gold Creek to the two project dams.

OPERATION PERIOD

During the operation period, impacts related to the transmission lines would be those associated with maintenance of access roads between Gold Creek and the dam sites. The impacts would be similar to those discussed in Sections E.2.1.3.1 and E.2.1.3.2.

E.2.1.4.2 Gold Creek-to-Fairbanks Segment

CONSTRUCTION PERIOD

The general nature of impacts and the proposed measures to mitigate the impacts associated with transmission tower construction, right-of-way development, and transmission line access roads are discussed in Section E.2.1.4.1.

Landslide, solifluction, and colluvial deposits, as well as eolian loess, silty alluvial fan, floodplain, retransported till and organic deposits found along the transmission line corridor (see Sec. E.1.1.3) are known to have potentially undesirable soil foundation conditions. Generally, these conditions become increasingly more severe toward the northern segment of the proposed transmission line corridor. Permafrost deposits also become increasingly more continuous to the north and increase the potential for construction difficulties.

Between Gold Creek and Fairbanks, areas of fine-grained, poorly drained sediments were identified as areas of primary concern to construction projects associated with the Alaska Railroad (Ferrains et al., 1969) and would likewise affect transmission line construction. Surficial deposits between Broad Pass and Fairbanks (especially the Goldstream Valley) and the glaciolacustrine deposits near Moody in the Nenana River Valley are described as being of special concern because of their potential for impacts from permafrost thaw and liquefaction (e.g., settlement, caving, slumping, flow).

As discussed in Section E.2.1.4.1, the exact locations of the transmission towers and related facilities, as well as the locations of specific surficial deposits of concern, have not been clarified to date. As a result, only general estimates as to the nature and magnitude of impacts related to the construction of this transmission line segment can be made at this time.

Right-of-way development of the single-tower Gold Creek-to-Fairbanks line segment that would parallel the Intertie corridor for much of its length would result in the widening of the existing right-of-way by 190 ft (58 m). Soil and vegetation disturbances associated with this additional right-of-way development would be less than those associated with the development of a new 300-ft (90-m) transmission right-of-way. The existence of potential access roads for almost the entire length of this line would further minimize impacts related to access road construction.

Based on the few soil surveys compiled for this region (Furbush and Schoephorster, 1977; Rieger et al., 1963, 1979), agricultural soils along this segment of the transmission corridor appear to be very limited. No soils that are suitable for most field crops or that have few limitations restricting their use (Class I soils) are present along this corridor. In the northernmost portion of the corridor, limited areas of Class II soils (soils that have moderate limitations that reduce the choice of plants or that require moderate conservation practices) are crossed by the corridor. The impact to these soils from transmission line construction would be small because of the availability of existing access roads and the limited amount of space actually disturbed by the transmission tower. For similar reasons, development of the transmission line would not impact any geological resources within the proposed corridor. No known mineral or fuel resources are known to exist within the proposed right-of-way.

OPERATION PERIOD

During the operation period, impacts would be primarily attributable to the maintenance of access roads along the transmission line. These impacts would be similar in nature to those discussed in Section E.2.1.3.1.

E.2.1.4.3 Gold Creek-to-Anchorage Segment

CONSTRUCTION PERIOD

Along the Gold Creek-to-Anchorage segment of the transmission line route, permafrost is generally absent and soils are thaw stable. Numerous unconsolidated deposit that would be crossed by the transmission line corridor have highly undesirable foundation characteristics. Localized landslide deposits, marine tidal deposits found in the southern portion of the corridor, and fluvial deltaic and organic deposits found throughout the corridor are all subject to extreme to high liquefaction potential (Exhibit E, Suppl. Information, Sec. 6, Item 16). A description of the locations of these deposits is presented in Section E.1.1.3. However, because the exact location of the transmission towers and related facilities, as well as the location of specific surficial deposits of concern, have not been delineated to date, only general assumptions as to the nature and magnitude of impacts that would be expected as a result of transmission tower construction can be made.

The transmission corridor right-of-way would affect approximately 250 acres (100 ha) of the Point MacKenzie agricultural project and 535 acres (216 ha) of the Fish Creek agricultural project (Exhibit E, Suppl. Information, Sec. 6, Item 16). Additionally, the corridor would cross many areas of soil suited for agricultural production (Soil Conservation Service soil capability Classes II, III, and IV) south of Willow and east of the Susitna River (Schoephorster and Hinton, 1973; Schoephorster, 1968; Rieger et al., 1979). The impact to these soils would be primarily related to the development of any new access roads that might be required. Existing Intertie access roads would be used wherever possible. Only limited areas of soil would be disturbed by transmission tower construction. No geologic resources are known to exist within the proposed transmission corridor.

OPERATION PERIOD

During the operation period, transmission line impacts would be primarily attributable to maintenance of the transmission line access roads. These impacts would be similar in nature to those discussed in Section E.2.1.3.1

E.2.2 Susitna Development Alternatives

E.2.2.1 Alternative Dam Locations and Designs

E.2.2.1.1 Watana I-Devil Canyon

The impacts associated with the development of Devil Canyon site would be identical to those discussed in Section E.2.1.2. The impacts associated with the development of the Watana I alternative would be similar in nature, although not in magnitude, to those discussed in Section E.2.1.1. Because the Watana I reservoir elevation [2,100 ft (640 m) MSL] would be 100 ft (30 m) less than the proposed Watana project elevation [2,200 ft (670 m)] the total area affected by reservoir flooding would be less for the Watana I alternative. Fewer miles of beaches would be developed for the Watana I alternative, and as a result, the magnitude of reservoir slope failure might be less. However, because the reservoir height would be 100 ft (30 m) less for Watana I than for the proposed Watana reservoir, Watana I reservoir beaches would not be formed at the top of the surrounding slopes (as would be the case for the proposed project) but at the base or mid-slope. Such beach development under the Watana I alternative would accelerate reservoir slope failure and increase the magnitude of the impacts discussed in Section E.2.1.1.

Because of the reduced reservoir height for the Watana I alternative, seepage losses through the Watana relict channel and other joint features would be reduced as a result of reduced hydrostatic head pressure. The reduced dam height and size would also require considerably less construction material, thereby reducing borrow material requirements and borrow-site-related impacts.

E.2.2.1.2 Watana I-Modified High Devil Canyon

Impacts associated with the development of the Watana I alternative would be as presented in Section E.2.1.1. Impacts associated with the development of the Modified High Devil Canyon site would be similar in nature to those associated with the development of the Devil Canyon site (Sec. E.2.1.2). The Modified High Devil Canyon site would be located up river of the proposed Devil Canyon site and would crest at an elevation of 1,470 ft (441 m), so the reservoir would extend to just downstream of the Watana dam. The reservoir area for the Modified High Devil Canyon site would be smaller than for the proposed Devil Canyon site and consequently many impacts might be reduced. The total area of soils that would be disturbed by reservoir flooding would be less. Because the total length of beaches would be reduced for the Modified High Devil Canyon alternative, the magnitude of reservoir slope failure might also be reduced. However, because slope failure would be more likely to occur in the upstream portions of the Devil Canyon reservoir (the area that would be affected by the development of the Modified High Devil Canyon reservoir), the impacts related to reservoir slope could be similar for both alternatives.

E.2.2.1.3 Watana I-Reregulating Dam

Impacts associated with the development of the Watana I alternative are presented in Section E.2.2.1.1. Development of the Reregulating dam would result in the inundation of 15.8 river miles (25.4 km) and the creation of a reservoir covering 4,000 acres (1,600 ha).

The impacts associated with the development of the Reregulating dam alternative would be similar in nature to those discussed in Section E.2.1.2. Because the Reregulating dam alternative would inundate a smaller area than the proposed Devil Canyon reservoir, the magnitude of the impacts would be less. The disturbance and erosion of surface soils within the reservoir area would be less than for the proposed Devil Canyon alternative. In conjunction with the reduced reservoir size, the total length of beach development, and thus the total amount of beach erosion and slope failure, would also be smaller for the Reregulating dam alternative.

E.2.2.2 Alternative Access Routes

E.2.2.2.1 Northern Access Route

The general impacts that might be expected as a result of the construction and operation of a northern access route are similar to those described for the proposed access plan in Section E.2.1.3.2. The section of the alternative access route between Devil Creek and Tsusena Creek would be identical to the proposed access route. West of Devil Creek the route would follow the Portage Creek Valley, where extensive sidehill cutting would be required. Erosion losses might be high in this section.

E.2.2.2.2 Southern Access Route

The general impacts that might be expected as a result of the construction and operation of a southern access route are similar to those described for the proposed access plan in Section E.2.1.3.2. The mountainous topography of the area between the Devil Canyon and Watana dam sites would require a number of sidehill cuts and the construction of two major bridges

(Exhibit E, Vol. 2, pp. 13-2-64) for access between the two sites. Soils within these areas are classified as having severe to very severe limitations for road construction due to steep slopes. As a result, erosion losses in this area due to road construction could be high even with the use of mitigative measures.

E.2.2.3 Alternative Power Transmission Routes

E.2.2.3.1 Willow-to-Anchorage Segment

The general impacts and proposed measures to mitigate impacts associated with transmission tower construction, right-of-way development, and transmission line access roads are discussed in Section E.2.1.4. All corridors in this segment would cross areas of good agricultural soils. The exact extent of these areas is not known at this time, and the magnitude of the impacts due to transmission line and access route construction cannot be determined. Generally, however, only small areas of agricultural soil would be lost under each transmission tower structure. Use of existing roads where possible would minimize the loss of land. Construction activities associated with tower emplacement and road development might result in soil compaction, which might reduce soil fertility. Measures to mitigate the effect of soil compaction are discussed in Section E.3.

Within all three corridors, especially Corridors 2 (ADFC) and 3 (AEFC), areas of wet, organic soils with severe limitations to road and tower construction are present. It is assumed that these soils would be avoided by the Applicant wherever possible. Construction on these soils would jeopardize tower stability and access road use, as well as increase construction costs. No permafrost is present in this segment.

Because of the increased length of Corridor 1 (ABC') [73 mi (117 km)] relative to Corridors 2 [ADFC - 38 mi (61 km)] and 3 [AEFC - 39 mi (63 km)] the impacts associated with the development of Corridor 1 might be assumed to be greater than for Corridors 2 and 3. However, as segment BC' of Corridor 1 parallels a transmission line from Knik River to Anchorage and parallels the Glenn Highway from Knik River to Birchwood, as well as a railroad from Eagle to C', the actual amount of land disturbed in Corridor 1 for access roads and right-of-way might be similar or less than for Corridors 2 and 3.

E.2.2.3.2 Dams-to-Gold Creek Segment

All corridor segments in this area cross wet soils and several deep ravines, and all corridors except Corridor 13 (ABCF) and 15 (ABECF) encounter steep slopes. Shallow bedrock is encountered in all but Corridors 1 (ABCD), 2 (ABECD), 3 (AJCF), 13 (ABCF), 14 (AJCD), and 15 (ABECF). Where possible, ravines would be spanned. Elsewhere, construction of transmission towers and access roads on steep terrain or near ravines would accelerate soil erosion. Removal of vegetation from areas of shallow bedrock would result in accelerated erosion of soil from those areas. As the total amount of soil in these areas is limited, the total amount of soil losses would be small, although possibly significant for the vegetation in the area. Construction on areas of shallow bedrock as well as wet soils would require more elaborate and expensive tower installation procedures. The exact location of the transmission towers and associated access roads, as well as the location of specific surficial deposits or conditions of concern, are not yet specified, and only general assumptions can be made as to the relative magnitude of impacts related to construction in a particular corridor.

Corridors 1, 2, 3, 13, 14, and 15 are among the shortest of the corridors, ranging in length from 40 to 45 mi (64 to 72 km). These corridors are also located in an area of hilly topography, where erosion would be expected to be moderate. Corridors 4 (ABCJHI), 5 (ABECJHI), 6 (CBAHI), and 7 (CEBAHI) are intermediate in length, ranging from 68 to 82 mi (109 to 132 km), and segments JHI and AHI pass through the most mountainous portion of the area. Although erosion would be expected to be high in this area, shallow bedrock might limit total erosion losses. Corridors 8 (CBAG), 9 (CEBAG) and 10 (CJAG) are among the longest corridors, ranging from 90 to 95 mi (145 to 153 km), and cross through gently sloping terrain of Deadman and Brushkana creeks and the Nenana River Valley. Erosion losses for Corridors 8, 9, and 10 might be slight to moderate based on slope. However, the presence of wet soils and shallow permafrost in segment AG would increase the potential for localized settling, slumping, and solifluction of surface deposits during transmission tower and access road construction. No existing access roads are present in this area, except for the Old Corps Trail in Segment CD that extends from Gold Creek to Devil Canyon and the Denali Highway that parallels segment AG between Brushkana Creek and G. The amount of upgrading that would be required to allow the use of the Old Corps Trail as an access route is not known. No upgrading of the Denali Highway would be required. No agricultural soils are crossed by any corridors in this segment.

E.2.2.3.3 Healy-to-Fairbanks Segment

All corridors in this segment would cross wet, poorly drained soils and permafrost in the outwash plains and river valleys north of the Alaska Range. This would severely restrict the location and development of access roads and transmission towers (Sec. E.2.1.4). Where Corridors 3 (AEDC) and 4 (AEF) pass through very steep mountainous areas between segment AE, soil erosion losses during tower and access road construction and operation would be accelerated, although the limited extent and depth of these soils may limit total losses.

All corridors are expected to cross agriculturally suitable soils near the Tanana River Valley. The extent of these soils is unknown. Generally, however, only the small areas of soils under each tower would be lost to agricultural use. Greater areas of soils might be lost to access road development, but these losses would be minimized by the use of existing roads wherever possible. Movement of heavy machinery over these soils would result in soil compaction and losses in fertility. Measures to mitigate the effects of soil compaction are discussed in Section E.3.

From Healy to Browne, segment AB of Corridors 1 and 2 closely parallels the Parks Highway, the Alaska Railroad, and an existing transmission line. Segment BC of Corridor 1 is within several miles of these features; therefore, access road development and related construction impacts for Corridor 1 would be minimized. No known access routes are present for the 46-mi (74-km) BDC segment of Corridor 2. Segment AE of Corridors 3 and 4 parallels small roads, trails, and railways for part of the segment, and expansion and extension of these access routes would be required. No existing access routes are present along the 50-mi (80-km) length of segment EDC in Corridor 3. Segment EF of Corridor 4 parallels the Bonnifield Trail from Clear Creek Butte to Fairbanks. The amount of upgrading that would be required for use of this trail as an access route is unknown at this time.

E.2.2.4 Alternative Borrow Sites

Alternative borrow sites C, F and H would be located outside the reservoir area and their use would necessitate the construction of haul roads to the proposed project. Revegetation would be required following borrow area development. Borrow area B would be located inside the proposed reservoir area, which would minimize erosion impacts associated with excavation and use of this borrow area.

E.2.3 Non-Susitna Generation Alternatives

E.2.3.1 Natural-Gas-Fired Generation Scenario

Eight 200-MW combined-cycle units and two 70-MW combustion-turbine units would be constructed throughout the Cook Inlet region. Each unit would occupy a total of approximately 5 acres (2 ha), for a total land area of 50 acres (20 ha). During the development of these plants, soil compaction and accelerated erosion would be the primary impact of site construction activities (vegetation stripping, surface grading and excavation). All units except those located southeast of Anchorage and on the Chuitna River would be on level terrain where erosion losses would be easily controlled or minimized by conventional construction practices. Depending on the Chuitna River location, uncontrolled erosion losses due to construction could be moderate to severe.

Areas of agriculturally suitable soils are present at the lower Beluga River and Kenai site locations. More specific site information would be required to determine whether these soils would be affected by site development. Because of the small total areas involved in each unit, it is likely that with proper siting, these areas of agriculturally suitable soils could be avoided. No permafrost or mineral resources are known to exist in the vicinity of any of the ten sites.

An evaluation of the availability of natural gas for this scenario is presented in Section 1.4.4.

E.2.3.2 Coal-Fired Generation Scenario

Development of two 200-MW coal units at Willow would require the disturbance of 340 acres (140 ha) of land (including plant facilities, coal storage and handling facilities, and fly ash disposal areas). Similarily, operation of three 200-MW coal units at Nenana would require the disturbance of 435 acres (180 ha) of land. Approximately 900 acres (360 ha) of land would be disturbed for coal mining operations during the assumed 30-year life of the Willow plants. Approximately 1,350 acres (550 ha) would be disturbed by coal mining operations for the Nenana plants. The impacts associated with surface coal mining activities include increased sedimentation and wind erosion of soil from spoil piles; modification of topography and surface drainage, as well as slope instabilities resulting from surface excavations; and permafrost thaw during surface stripping of vegetation. All earthwork activities, such as excavation, grading, trenching, and soil treatment, would result in increased rates of erosion, sedimentation, and runoff; soil compaction; and increased levels of potentially hazardous materials in soils as a result of leaching from exposed coal materials or spills of materials used in the mining operation (U.S. Dept. of Energy, 1981).

Development of the coal units at Willow and Nenana would impact some agriculturally suitable soils, although the total areas of such soils that would be affected are unknown. Both areas are located in level terrain, and erosion losses due to construction activities would be relatively moderate. Impacts from permafrost thaw are expected to affect the Nenana site only. No non-coal mineral resources would be expected to be impacted in either area. Approximately 155 million tons (140 million MT) of coal would be consumptively used by the five 200-MW coal units over the 40-year life of the plants.

The ten 70-MW combustion-turbine units that would be located around the Cook Inlet would require about 5 acres (2 ha) each. Impacts such as increased soil erosion and soil compaction would arise from unit construction, excavation, grading, and vegetation stripping. The magnitude of such impacts would be highly site-specific. As the exact locations for the combustion-turbine units have not been specified, analysis of the specific impacts related to plant construction are not possible at this time. The absence of permafrost in this region precludes permafrost-related impacts.

An evaluation of the regional coal resources available for use under this scenario is presented in Section 1.4.

E.2.3.3 Combined Hydro-Thermal Generation Scenario

E.2.3.3.1 Johnson

The general impacts related to the development of the hydroelectric dam at the Johnson site and the appropriate mitigation measures to control the impacts are similar to those described for the Watana site in Section E.2.1.1. General impacts and mitigation measures related to the construction of access routes and power transmission facilities are presented in Sections E.2.1.3 and E.2.1.4.

Because of the relatively flat open terrain of the Tanana and Johnson river valleys, the Johnson reservoir would inundate an area of about 84,000 acres (34,000 ha). Flooding of the reservoir would result in the loss of some areas of potentially agriculturally suitable soils. The magnitude of this loss cannot now be determined at this time because only exploratory soil survey information is available. As discussed in Section E.2.1.1, vegetation stripping and reservoir flooding might result in the thaw of permafrost deposits within the reservoir area. Because of the large areal extent of the reservoir, many miles of beach would be formed. This beach would be susceptible to erosion, slumping, and sliding with reservoir filling. Unconsolidated materials on the low slopes that would surround the reservoir might be most susceptible to flow-type failures. Potential seismic activity in the vicinity of the dam and reservoir might also trigger slope instabilities and slumping. Site-specific geotechnical investigations would be required to allow the evaluation of these impacts. No known mineral resources are expected to be covered by the Johnson reservoir. Sand and gravel deposits near the site might be used for project construction purposes.

E.2.3.3.2 Keetna

The general impacts related to the development of a hydroelectric dam site at the Keetna site and the appropriate mitigation measures to control these impacts would be similar to those described for the Watana site in Section E.2.1.1. Approximately 4,800 acres (1,900 ha) of land would be inundated by the Keetna reservoir. No agriculturally suitable land or known mineral resources would be flooded. Sand and gravel deposits in the vicinity of the proposed site area would be available for construction purposes. Slumping and slope failure might be expected in the glacial deposits that would compose the shoreline of the proposed reservoir. The isolated permafrost present in the fine-grained sediments might also contribute to shoreline failures. Site-specific geotechnical investigations would be required to evaluate the potential for failure to occur within these deposits.

E.2.3.3.3 Snow

The general impacts related to the development of a hydroelectric dam site at the Snow site and the appropriate mitigation measures to control these impacts are similar to those described for the Watana site in Section E.2.1.1. General impacts related to the construction of access routes and power transmission facilities are presented in Sections E.2.1.3 and E.2.1.4. Because the site is located in a deep bedrock gorge, only 2,600 acres (1,050 ha) of land would be inundated by the Snow reservoir. The few areas of soils in the Snow River Valley that would be flooded by the reservoir are generally agriculturally unsuitable. Because of slopes surrounding the proposed reservoir site would be bedrock, no slump failures would be expected. Block failures might occur; however, detailed geotechnical investigations would be required to evaluate the potential for such failures. Although the Snow site is in an area identified as having the potential for several mineral resources, mineral claims appear to be concentrated along the Snow River from Moose Pass, just northeast of the project area, to Seward; no known mineral resources are present in the river valley. No permafrost-related failures would be expected for this area.

E.2.3.3.4 Browne

The general impacts related to the development of a hydroelectric dam at the Browne site and the appropriate mitigation measures to control these impacts are similar to those discussed in Section E.2.1.1. The Browne reservoir would inundate 10,640 acres (4,300 ha) and would result in the loss of some areas of potentially suitable agricultural soils. The exact magnitude of this loss cannot be determined at this time because only exploratory soil survey information is available. Development of the Browne alternative might result in the inundation of subbituminous coal reserves of the Nenana coal field, but determination of the exact amount of coal reserves that would be lost due would require more extensive investigation. Clay and cement minerals present in the area could be used for project construction.

Extensive slumping, slope failure, and beach erosion might be expected to occur in the soft Tertiary sedimentary rocks of the Alaska Range foothills and the extensive unconsolidated floodplain, terrace, alluvial, and drift deposits that are present throughout the reservoir site. Permafrost thaw-related impacts would also be probable in this area. Site-specific geotechnical investigations would be required to evaluate the potential for failure to occur within these deposits.

E.2.3.3.5 Chakachamna

Because the Chakachamna alternative would be a lake-tap, no additional areas would be inundated; therefore no additional loss of mineral or soil resources would be expected as a result of reservoir development. Changes in lake drawdown rates associated with the development of the Chakachamna alternative might affect slope stabilities around the lake, however, and geotechnical investigations would be required to evaluate the potential for additional slope failures.

The presence of Mt. Spurr, an active volcano, adjacent to the lake would require extensive consideration because reactivation of this volcano could seriously jeopardize the power facility. Failure of the existing lake during a volcanic event would be independent of the power development project.

E.2.3.3.6 Thermal Units

The impacts associated with the construction and operation of a 200-MW coal unit at Nenana are discussed in Section E.2.3.2. One coal unit would use approximately 21 million tons (19 million MT) of coal over the 30-year life of the plant.

Development of three 200-MW combined-cycle units on the Chuitna and Lower Beluga rivers would require the use of a total of 15 acres (6 ha) of land, as would three 70 MW combustion-turbine units near Anchorage and the lower Beluga River. The impacts related to the development of these units are discussed in Section E.2.3.1.

E.2.4 Comparison of Alternatives

E.2.4.1 Susitna Development Alternatives

E.2.4.1.1 Alternative Dam Locations and Designs

In each of the three Susitna development alternatives, development of the Watana I reservoir would result in the creation of fewer miles of beaches and the flooding of less land than for the proposed Watana project. From a geologic and soils perspective, however, the increased area flooded by the proposed Watana project is not significantly as neither valuable mineral or soils resources would be lost in either the Watana or Watana I developments. Because the Watana I reservoir height would be 100 ft (30 m) lower than for the proposed Watana project, slope stability problems might be more severe for the Watana I development (see Sec. E.2.2.1.1). Further geophysical investigations would be required to substantiate this expectation however.

Because the Modified High Devil Canyon and Reregulating dam reservoirs would inundate less land than the proposed Devil Canyon reservoir, the alternatives containing these two options might be considered preferrable to the Watana I-Devil Canyon alternative. As discussed above, however, no valuable soil or mineral resources are known to exist in the proposed Devil Canyon reservoir area, and from a geologic and soils perspective, the increased loss of land attributable to the development of the Devil Canyon reservoir would not be significant. Because slope failures would be more likely to occur in the upstream portions of the proposed Devil Canyon reservoir, which would also be the area affected by the Modified High Devil Canyon and Reregulating dam reservoirs, no alternative would be superior.

Because the Reregulating dam would be smaller than either the Modified High Devil Canyon or the Devil Canyon dam, construction material requirements and hence borrow site development would be less for this alternative. Likewise, construction material requirements would be less for the

Watana I dam than the proposed Watana dam. For any of the alternatives, however, the consumptive use of the materials for dam construction would not impact the area. Identification of the borrow sites to be used for each alternative would be needed to evaluate the relative erosion potential for the Susitna Basin alternatives.

E.2.4.1.2 Alternative Access Routes

Both the northern and southern access route alternatives would not require the development of an access road between the Watana dam site and the Denali Highway, thereby eliminating the clearing and disturbance of approximately 630 acres (250 ha) of potentially erodable and permafrost rich land as required for the proposed access corridor. Furthermore, absence of this access between the dam site and the Denali Highway for the alternatives would limit the accessibility of the Brushkana and Devil Creek area to off-road vehicle traffic and thereby reduce the erosion losses that might be expected in the area with the development of this section of the proposed access corridor.

Between the Devil Canyon and Watana dam sites, both the northern and southern access route alternatives would require more extensive sidehill excavation than the proposed access route and as a result, erosion losses would be expected to be higher for these two alternative routes than for the proposed route.

Because the southern alternative access route would require the development of an access corridor between Hurricane and the Devil Canyon dam site, as well as between Gold Creek and Devil Canyon, a greater amount of land would be disturbed for this alternative than for the northern alternative (which would require an access corridor between Gold Creek and Devil Canyon only). Development of a rail access between Gold Creek and Devil Canyon for the proposed alternative would require less land disturbance than the northern access alternative area both because of the shorter distance and the narrowness of a rail corridor in contrast to a road access corridor.

E.2.4.1.3 Alternative Power Transmission Routes

In the Willow-to-Anchorage segment of the transmission route, Corridor 3 and the proposed corridor (Corridor 2) would be similar in impacts. Impacts associated with Corridor 1 might be assumed to be greater than for either Corridor 2 or 3 because of its greater length [73 mi (117 km) for Corridor 1 compared with about 38 mi (61 km) for the other two corridors]. However, as Corridor 1 parallels existing transmission lines and highways for much of its length between Willow and Anchorage, the actual amount of land disturbed for access road and right-of-way development might be similar or less than for either Corridor 2 or 3, which do not follow existing right of ways.

Although a number of possible transmission route alternatives were proposed for the Dams-to-Gold Creek segment, only the southernmost corridors (Corridors 1, 3, 13, and the proposed Corridor 14) were considered by the Applicant. Between Watana and Devil Creek dam sites more rugged topography is crossed by Corridors 1 and 13 than by Corridor 3 and proposed corridor. Between Gold Creek and Devil Canyon, Corridor 3 crosses more rugged terrain than the proposed corridor. As a result, erosion losses during the construction of the proposed transmission line would be expected to be less than for the alternative corridors. Furthermore, as the transmission line would be within the proposed access corridor, additional access requirements for the transmission line construction and maintenance would be minimized, and off-road vehicle access would be confined to the proposed access corridor. Impacts related to access road development and off-road vehicle traffic would therefore be minimized for the proposed route.

In the Healy-to-Fairbanks segment, the proposed corridor (Corridor 1), although 4 mi (6 km) longer than Corridor 2, parallels existing access routes for almost its entire length, thereby reducing impacts related to access road development. Corridor 2, although the shortest of the alternatives, crosses more wetlands than Corridor 1 and lacks existing right-of-ways along most of its length. Corridor 3, the longest of the alternatives in this segment, would require extensive vegetation clearing in the Tanana and Wood river floodplains that could result in extensive erosion and soil disturbances, and passes through mountainous areas where erosion losses might be great. Corridor 3 also lacks right-of-way access.

E.2.4.2 Non-Susitna Generation Alternatives

E.2.4.2.1 Natural-Gas-Fired Generation Scenario

Under the natural-gas-fired generation scenario, a total of 50 acres (20 ha) of land would be disturbed by the construction of the ten gas-fired plants in contrast to the 42,000 acres (17,400 ha) of land that would be inundated by the proposed reservoirs alone. With proper construction practices, the total erosion losses for this scenario would be an insignificant fraction of the proposed project erosion losses. Similarly, no permafrost-related or slope-related erosional impacts would be expected for this scenario in contrast to potentially extensive impacts for the proposed project.

In contrast to the proposed Susitna project, small areas of agriculturally suitable land could be disturbed by the development of the gas-fired plants. With proper siting, however, these impacts could be avoided.

To date no valuable mineral resources are known to occur in the proposed site area or would be impacted by the proposed project development. Likewise, with adequate siting precautions no impacts to mineral resources in the Cook Inlet area would be expected as a result of the development of the gas-fired units. Natural gas reserves would be used consumptively under this scenario, however.

E.2.4.2.2 Coal-Fired Generation Scenario

Under the coal scenario, as much as 3,000 acres (1,200 ha) of land would be disturbed by the construction and operation of the five 200-MW coal units; this would approach in magnitude the amount of land that would be inundated by the proposed Devil Canyon reservoir. However, total land disturbances for both the Watana and Devil Canyon developments (including land disturbed by reservoir inundation and reservoir slope instability) would be far in excess of land disturbance under the coal-fired scenario.

In general, the erosion impacts related to surface coal mining activities would be similar in nature to those for construction activities for the proposed project, but the magnitude of such erosion losses would be expected to be greater for the proposed project. Coal mining, coal storage and handling, and fly ash disposal practices could result in the leaching of potentially hazardous materials from the exposed coal to nearby soils. No such impact would be expected as the result of the proposed project activities.

Development of the coal units at the Willow and Nenana sites would have the potential to affect small areas of agriculturally suitable land. In contrast, no agriculturally suitable land exists in the proposed project area.

Although no known mineral resources would be affected by the proposed project, the coal-fired scenario would require the consumptive use of approximately 107 million tons (97 million MT) of coal over the 30-year life of the five 200-MW units, which would be equivalent to approximately 18% of the proven Nenana coal field reserves or 56% of the proven Beluga coal field reserves (see Sec. 1.4).

E.2.4.2.3 Combined Hydro-Thermal Generation Scenario

JOHNSON

The Johnson reservoir would inundate an area twice what would be inundated by the Watana and Devil Canyon reservoirs combined. Because of the extent of the Johnson reservoir, the permafrost and unconsolidated surficial deposits in the Johnson area, slope failure and permafrost-thaw-related impacts would be expected to be greater for the Johnson project than for the proposed project.

No known mineral resources would be inundated by either the Johnson or the proposed reservoirs. An as yet undeterminable amount of agriculturally suitable land would be inundated by the Johnson reservoir, whereas none would be lost by development of the proposed project.

KEETNA

The Keetna reservoir would inundate about one tenth the area that would be flooded by the proposed project. Reservoir slope failures and slumping would be expected in the glacial deposits present at Keetna site, although the magnitude of the areas affected by such failures might be less for the Keetna alternative than the proposed project as a result of the smaller reservoir perimeter. No agriculturally suitable land or known mineral resources would be flooded by either the Keetna or the proposed project.

SNOW

The Snow reservoir would inundate only about 6% of the total area that would be flooded by the proposed project. Because the Snow site is in a deep bedrock gorge and because of its substantially smaller reservoir perimeter relative to the proposed reservoirs, reservoir slope-related failures would be substantially less than for the proposed project. Permafrost-related impacts would be expected for the proposed project only. No agriculturally suitable soils or known mineral resources would be flooded by either the Snow or the proposed projects.

BROWNE

The Browne reservoir would inundate an area about one quarter the size of the proposed reservoirs. The Browne reservoir, unlike the Watana and Devil Canyon reservoirs, would inundate some areas of potentially agriculturally suitable soils and might result in the flooding of some subbituminous coal reserves of the Nenana coal field. Reservoir slope failure and permafrost-thaw-related impacts would occur under this alternative. However, because the Browne reservoir perimeter would be considerably smaller than that of the proposed project, the magnitude of the impacts related to the development of the Browne reservoir would be expected to be substantially less than for the proposed project.

CHAKACHAMNA

Because the Chakachamna alternative would be a lake-tap, no additional areas would be inundated, and, as a result no known mineral resources or agriculturally suitable soils would be impacted by the Chakachamna alternative. Similarly no known mineral resources or agriculturally suitable soils would be lost by the development of the proposed project. Slope stabilities around Lake Chakachamna would be affected by changes in lake draw down as a result of the operation of the lake tap. Although the magnitude of such slope failure is unknown at this time, it should be substantially less than the slope failure impacts that would be expected for the proposed project. No permafrost impacts would be expected for the Chakachamna alternative.

THERMAL UNITS

In conjunction with the development of a specific hydro site, minor areas would be disturbed by the construction of combined-cycle and combustion-turbine units in the Cook Inlet area. The relation of such impacts to the proposed project are discussed in Sections E.2.4.2.1 and E.2.4.2.2.

E.3 MITIGATION

The methods proposed by the Applicant for dealing with expected impacts for the proposed project are discussed as appropriate in Section E.2.1. In general, these mitigative measures are felt by the Staff to be adequate to reduce the majority of project-related impacts to the extent possible. Several significant impacts associated with reservoir development, however, would be unavoidable. Included are the loss of inundated land, reservoir slope instability, and seismically induced land failures.

An additional mitigative measure that should be considered by the Applicant is the consultation and involvement of state geologic and soil conservation agencies in the analysis of all site-specific construction plans for all project facilities. This consultation, in conjunction with the proposed geotechnical studies, should ensure minimization of all potential construction-related impacts.

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUSITNA HYDROELECTRIC PROJECT, FERC NO. 7114

APPENDIX F

LAND USE

prepared by

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Argonne National Laboratory

APPENDIX F. LAND USE

F.1 AFFECTED ENVIRONMENT

F.1.1 Introduction

The facilities of the proposed Susitna project would be located primarily in Southcentral Alaska. Some project features and transmission line corridors also would extend into the Interior Region. Anchorage and Fairbanks are the major population centers of the state; other, smaller communities are scattered along the few transportation routes (e.g., George Parks Highway). Much of the region is sparsely inhabited, with recreation being the primary land use by man. Scattered timber and mining activities do occur throughout the region, and some agriculture of activities occur in a few river valleys. Most commercial and industrial developments in the region are located in Fairbanks and Anchorage.

The enactment of the Alaska Statehood Act of 1958, the Alaska Native Claims Settlement Act of 1971, and the Alaska National Interest Lands Conservation Act of 1981 has placed much of the land in Alaska, including land in the vicinity of various proposed project features, in a state of transition of ownership and management.

The Statehood Act authorized the state to select over 100 million acres [40 million hectares (ha)] of Federal land in Alaska. The Alaska Municipal Code allows the boroughs within the state to select 10% of the vacant unreserved state land holdings within borough boundaries for municipal purposes. Under the Alaska Native Claims Settlement Act passed by Congress in 1971, Alaska Natives received over 40 million acres (16 million ha) of land and approximately $1 billion. Nine regional commissions and associated Alaska Native villages were incorporated under state law to select and manage these lands. The Alaska National Interest Lands Conservation Act of 1981 placed over 100 million acres (40 million ha) of Federal lands in various conservation systems managed by such Federal agencies as the Bureau of Land Management, National Park Service, Fish and Wildlife Service, and the Forest Service. As a result of these actions, there is a great deal of uncertainty regarding ownership status of large amounts of land in the state.

When land transfers and conveyances are completed, the Federal government will own and manage about 225 million acres (91 million ha), or about 60% of the land in Alaska. The state will control nearly 28% and the Natives nearly 12%, leaving less than 1% of the land in private ownership (U.S. General Accounting Office, 1982).

Future use of lands in the study area will depend, in part, on final ownership decisions. Land value information for specific land parcels is often unknown.

F.1.2 Proposed Project

The sites of the proposed Watana and Devil Canyon dams and related facilities, including borrow areas, construction camps and settlement areas, access roads, and the Watana-to-Gold Creek transmission line segment [37 miles (mi), or 60 kilometers (km) long] are within the upper and middle Susitna River Basin. The 330-mi (530-km) power transmission line corridor between Fairbanks and Anchorage would extend through portions of the Tanana, Nenana, Chulitna, and Susitna river basins and parallel sections of the George Parks Highway (Route 3) and Alaska Railroad. The locations of these various project features in relation to the upper and middle Susitna River Basin and the Fairbanks to Anchorage areas are shown in Figure 2-1.

F.1.2.1 Upper and Middle Susitna River Basin

F.1.2.1.1 Existing and Future Uses

Patterns of human land use within the upper and middle Susitna River Basin are characterized by scattered areas of low intensity, but somewhat diverse uses (see Fig. F-1). The type of use is in part dependent on seasonal change. There are essentially no major areas of agriculture, timbering, or residential, commercial, or industrial activities within the area. The primary land use is recreation. Development within the upper and middle basin generally consists of individual cabins or small clusters of cabins. Ground access into the area is extremely limited, and the primary land use is recreation.

Concerning future land use development and activities, no significant change in current types or intensity of use is anticipated for the upper and middle Susitna River Basin unless the proposed

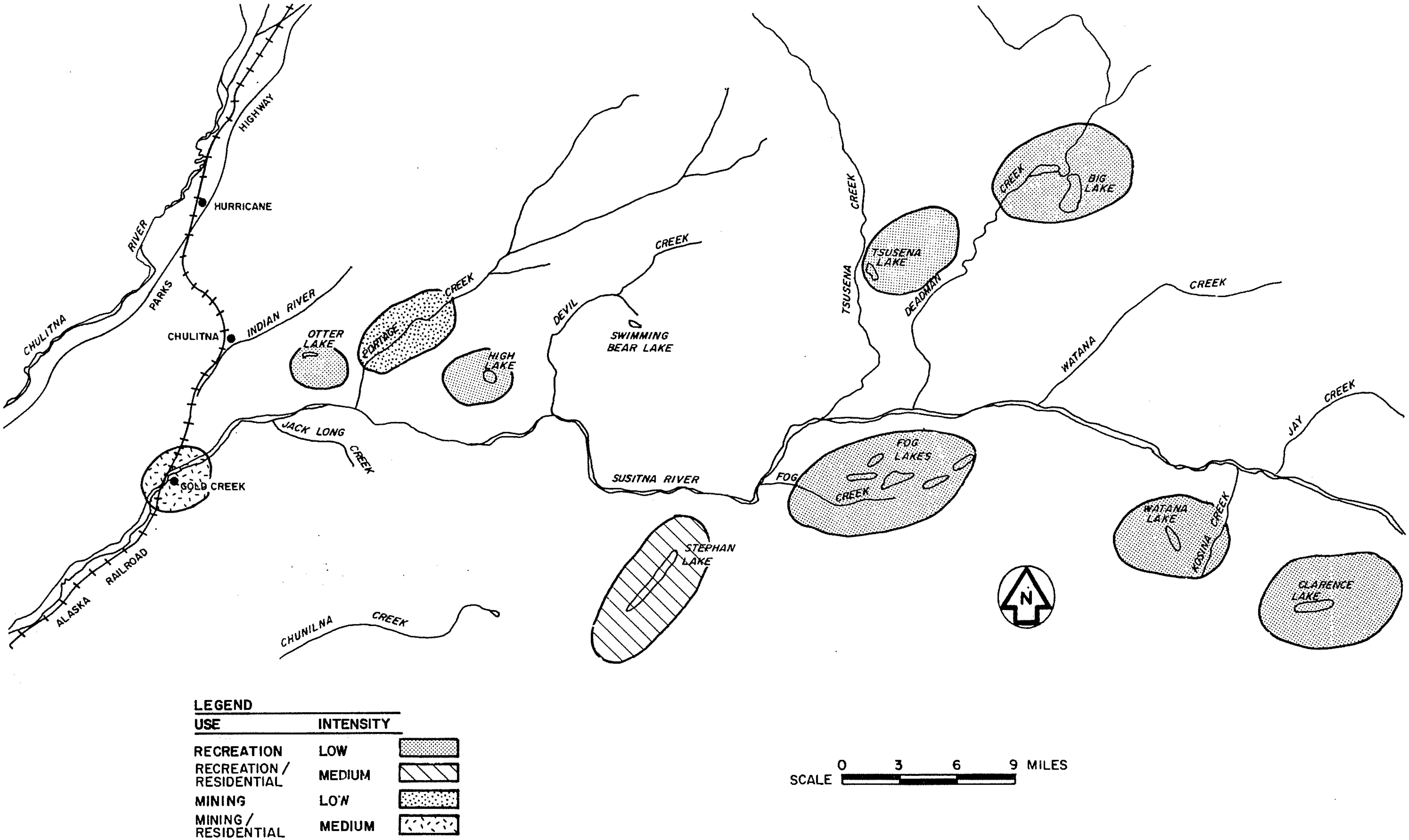

Figure F-1. Land Use Patterns within the Upper and Middle Susitna River Basin.
[Source: Exhibit E, Vol. 8, Chap. 9, Fig. E.9.8]

project is developed. In the future, significant land use change within the basin area would only begin to occur with the development of a road system.

AGRICULTURAL RESOURCE LANDS

No large-scale farming activities occur within the upper and middle Susitna River Basin. The U.S. Soil Conservation Service has determined that there are no prime or unique farmlands or rangelands located in the middle Susitna River Basin study area (Exhibit E, Vol. 8, p. E-9-27).*

In general, agricultural activities within Alaska are confined to relatively small areas, and there apparently is very little additional land suitable for agricultural development (Alaska Crop Livestock Reporting Service, 1978). The largest agricultural areas in the state include the Tanana Valley, Matanuska Valley, Kenai Peninsula, a section of the southeastern panhandle, and a section of the Southwestern Peninsula--all outside the upper and middle Susitna Basin (Alaska Northwest Publishing, 1981).

FOREST RESOURCE LANDS

Timber resources within the upper and middle Susitna River Basin area are virtually undisturbed except for limited use by local residents as a building material and heating fuel. Lands with highest commercial forestry potential within the area are located along the Susitna River downstream from the confluence with Portage Creek, essentially within the floodplain. Within the Watana-to-Gold Creek area, forest vegetation types are located at the lower elevations [below about 3,000 feet (ft), or 900 meters (m)] and cover more than 860,000 acres (348,000 ha) or more than 20% of the area (Exhibit E, Vol. 6A, Chap. 3, p. E-3-204). About 19% of the forested areas consists of conifers, principally white or black spruce. White spruce is most valued for saw timber and house logs; black spruce is a second choice for house logs. The remainder of the forested area consists of deciduous stands of paper birch, balsam poplar, and trembling aspen or mixed stands of coniferous and deciduous trees. Many of the birch stands are too young for industrial uses other than for pulp, but some stands are satisfactory for veneer or furniture. Birch is also the most popular firewood type. Cottonwood is often used for rough cut lumber (Alaska Dept. of Natural Resources, 1982). The forest cover is described in detail in Section 3.1.5.1 and Appendix J.

MINERAL RESOURCE LANDS

Part of the upper and middle Susitna River Basin is located in the Matanuska-Susitna (Mat-Su) Borough. Gold has been the primary mineral mined in the Mat-Su region for the last 80 years. Placer mines working alluvial deposits for minerals are located at sites throughout the entire Mat-Su Borough. At present, significant quantities of oil and gas and sand and gravel are also being extracted (Alaska Dept. of Natural Resources, 1982). Coal deposits of varying quality are located throughout the Mat-Su Borough, and further coal development may expand mineral production. The potential also exists throughout the Mat-Su region for further development of metallic (e.g., gold, copper, tin) and nonmetallic (e.g., limestone, gypsum) minerals.

Within the upper and middle Susitna River Basin, mineral exploration and mining activities have been limited (Fig. F-1). Scattered mining claims have been operated intermittently in the area. There currently are less than 50 mining claims in the study area; three gold claims that were active from 1976 to 1978 are located within the area that would be inundated by the proposed Watana reservoir (Terrestrial Environmental Specialists, 1982). The most active mining areas within the upper and middle basin are around Gold, Chunilna (Clear), and Portage creeks. Gold placer mines are still being worked on Chunilna Creek. Gold, copper, and silver placer mines were active on Gold Creek until the late 1970s. The Portage Creek area had deposits of silver, copper, magnesium, zinc, and molybdenum. All the claims were lode (composite mineral vein) deposits, and at present, only one claim is still active (Terrestrial Environmental Specialists, 1982). Some active claims also are located near Stephan and Fog lakes, Jay Creek, and in the Watana hills to the east of Jay Creek (Exhibit E, Vol. 8, Chap. 9, p. E-9-18). No coal is currently mined in the upper and middle Susitna River Basin area (Exhibit E, Vol. 8, Chap. 3, p. E-9-18).

RECREATION LANDS AND NATURAL AREAS

As previously indicated, the upper and middle Susitna River Basin is generally in a natural state without human development except for some scattered cabins and a few placer mines.

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*Throughout this document, references to specific "Exhibits" are to the exhibits submitted to FERC as part of Alaska Power Authority's Susitna Hydroelectric Project License Application. References to specific "Appendices" (App.) are to the appendices provided in Volumes 2 through 7 of this Draft Environmental Impact Statement.

Although the area may not be considered by some as aesthetic or picturesque as other parts of Alaska, the existence of a diverse landscape in a basically roadless and sparsely inhabited area offers a variety of views and recreational opportunities within a natural setting. Accordingly, the primary land use activity within the study area is recreation. Recreation activities occurring in the area include hunting, fishing, boating, canoeing, kayaking, camping, and cross-country skiing. A more detailed discussion of recreational activities within the upper and middle Susitna River Basin area is presented in Section 3.1.7 and Appendix L.

During the past decade, the middle Susitna River Basin has been evaluated by various state and Federal agencies for its natural attributes. To date, the area has not met the criteria required for inclusion in any of the following programs: National Park-Preserve System, National or Historic Landmark Status, Wilderness Preservation System, National Forest System, or State Park System. The Susitna River has not been studied for inclusion in the National and Wild Scenic River System (Exhibit E, Vol. 8, Chap. 7, p. E-7-16).

TRANSPORTATION AND UTILITY CORRIDORS

Few highway or major utility corridors pass through the upper and middle Susitna River Basin area. Highway transportation to or within the area is confined to the Denali Highway (Route 8) to the north (closed in winter), George Parks Highway (Route 3) to the west, Richardson Highway (Route 4) to the east, and Glenn Highway (Route 1) to the south. Ground access into the area is extremely limited and consists of a network of connecting trails. Modes of travel within the interior portion of the basin include walking, dog-sledding, snow-shoeing, cross-country skiing, all-terrain vehicles, tracked vehicles, and four-wheel drive vehicles on land; boats, canoes, kayaks, and rafts along rivers, streams, and lakes; and airplanes, floatplanes, and helicopters by air.

SETTLEMENT AREAS AND SPECIAL USE LANDS

Because of limited access, little development has taken place in the upper and middle basin area. As indicated above, the sparse development that does exist generally consists of single cabins and small clusters of cabins. Some of these structures are used year around, while others are used only seasonally or have been abandoned. There are about 110 structures within 18 mi (30 km) of the Susitna River between Gold Creek and Tyone River (Terrestrial Environmental Specialists, 1982). Almost 20% of these structures are associated with the four lodges located along Tsusena Creek near Tsusena Butte, High Lake, Stephan Lake, and Chulitna River Lodge (Fig. F-2 and Table F-1).

The greatest concentration of development is in the Stephan Lake area, where there are 13 isolated cabins and one lodge with out-buildings, and at Chunilna Creek, where there is an airstrip, several small mines, and 19 cabins and related structures (Terrestrial Environmental Specialists, 1982). In addition to the four lodge areas, concentrations of residences, cabins, and other structures occur near Otter Lake, Portage Creek, Gold Creek, Chunilna Creek, Clarance Lake, and Big Lake (Terrestrial Environmental Specialists, 1982). Many of these cabins are, or were, used on a intermittent basis by trappers, hunters, fishermen, and other recreationists. Locations of these structures are shown in Figure F-1.

Much of the land within the upper and middle Susitna Basin appears incapable of supporting significant human settlement (Alaska Dept. of Natural Resources, 1982). Based on evaluation of such physical factors as slope, soil drainage, soil load-bearing capacity, these lands have moderate to severe building limitation. Community and settlement areas in the upper and middle Susitna Basin are further discussed in Appendix N

No special use lands (such as military bases or reservations, firing ranges, testing or training areas) have been identified within the upper and middle Susitna River Basin area.

WETLANDS AND FLOODPLAINS

Wetlands cover a large portion of the middle Susitna River Basin. These areas include riparian zones along the mainstem Susitna, sloughs, and tributary streams, as well as numerous lakes and ponds on upland plateaus. Wetland areas of particular importance include portions of Brushkana Creek; Upper Deadman Creek; the area between Deadman and Tsusena creeks; the areas around Fog, Stephen, and Swimming Bear lakes; and in the vicinity of Jack Long Creek (Exhibit E, Vol. 8, Chap. 9, p. E-9-21). Many of the proposed Watana and Devil Canyon dam project features would be located in wetland areas. These wetland areas are described in detail in Section 3.1.5.1 and Appendix J. At present, little floodplain information is available for the Susitna River. The 100-year floodplain for the proposed reservoir areas is shown in Figures 2-2 and 2-6.

F.1.2.1.2 Ownership Status and Management

Most of the land in the upper and middle Susitna River Basin is currently owned by the U.S. Government and managed by the Bureau of Land Management. There are two state land disposal

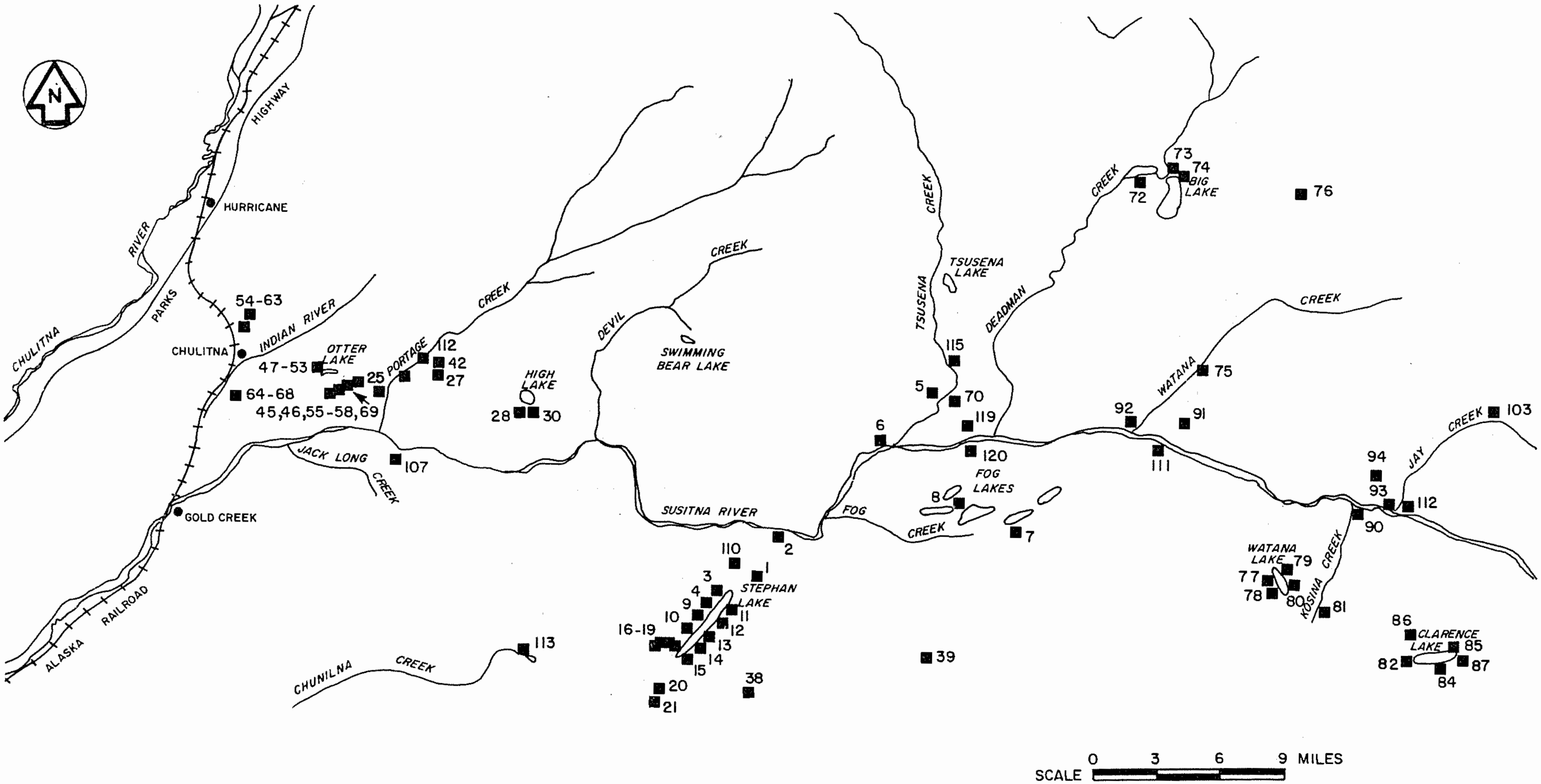

Figure F-2. Location of Existing Structures within the Upper and Middle Susitna Basin (Numbers are keyed to Table F-1). [Source: Exhibit E, Vol. 8, Chap. 9, Fig. E.9.9]

Table F-1. Description and Location of Existing Structures within the Upper and Middle Susitna River Basin

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
1	Cabin; meat house	2	Lake E. of Stephan Lake, 1850 ft elevation	Floatplane, skis	Yes	Built in 1960s and in current use for seasonal hunting, fishing, and boating.
2	Boat cabin	1	S. bank Susitna: on tributary 3 mi S.W. of Fog Creek/Susitna Confluence	Boat, foot	Yes	Built in 1960s for Stephan Lake Lodge; currently used seasonally by Stephan boating/hunting guests.
3 4	Cabin; shed Cabin	2	N.W. shore of Stephan Lake	Airplane	Yes	Built 1960s and in current use for seasonal hunting, fishing, and boating.
5	Cabin	2	Tsusena Creek: 3.5 mi from Tsusena/Susitna confluence	Foot, dog team	No	Built in 1940s as a trapline cabin and used until late 1950s; no longer in use.
6	Cabin foundations	1	N. shore of Susitna: W. bank of 1st tributary W. of Tsusena/ Susitna confluence	Foot, dog team	No	Built in 1939 by Oscar Vogel as a trapping line cabin; used until late 1950s, now collapsed; no longer used.
7	Cabin; shed	2	S. shore of Fog Lake #2	Floatplane	Yes	Built in 1960s and currently being used as a seasonal fishing and hunting cabin.
8	Cabin	2	On knob of Fog Lake #1	Airplane	Yes	Built in 1960s and currently being used as a seasonal hunting and fishing cabin.
9	Stephen Lodge (10 structures)	2	W. central shore of Stephan Lake	Airplane, foot	Yes	Built in 1960s and in current use as hunting, fishing, and recreation lodge; can accommodate up to 35 guests; operates year-round.
10	Cabin; shed	2	0.5 mi S.W. of Stephan Lodge on Stephan Lake shore	Airplane, foot	Yes	Built in 1960s and in current use seasonally as a hunting and fishing cabin.
11	Cabin; shed	2	E. shore of Stephan Lake	Airplane, foot	Yes	Hunting, fishing, boating, seasonal use; built in 1960s.
12 13 14 15	Cabin; shed Cabin; shed Cabin; shed Cabin; shed	2	E. shore of Stephan Lake	Airplane, foot	Yes	Built in 1960s and in current seasonal use as hunting, fishing, and boating cabins.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
16	Cabin; shed	2	Mouth of Prairie Creek at Stephan Lake	Airplane, foot, horse	No	Built in 1940s and used until late 1950s as a hunting, fishing, and trapping base and residence; no longer used.
17 18	Cabin Cabin	2	W. shore of Prairie Creek	Airplane, foot	Yes	Built in 1960 and 1979, respectively, and currently used as a year-round residence from which hunting, fishing, and trapping occur.
19	Cabin; meat house	2	E. shore of Murder Lake (S. of Stephan Lake)	Airplane, foot	Yes	Built in 1960s and used as a year-round residence; hunting and fishing.
20 21	Cabin; shed Cabin; shed	3	S.E. shore of Daneka Lake	Airplane, foot	Yes	Built in 1960s and currently used on a seasonal basis for hunting, fishing, and recreation by guests of Stephan Lodge.
22	Cabin; shed	3	Prairie/Talkeetna confluence	Foot, dog team, boat	Yes	Built in 1960s and currently used seasonally by Stephan Lodge for purposes of fishing and hunting.
23	Cabin; shed	2	Game Lake	Airplane, foot	Yes	Built in 1940s and used since then for trophy game hunting; now a part of Stephan Lodge's series of outreach cabins used on a seasonal basis.
25	Mining buildings (5)	2	Portage Creek: 2.5 mi N. of Portage/Susitna confluence	Airplane, ATV, foot, dog team, horse	No	Mining records exist as far back as 1890s; mined 1920 and sporadically 1930s, then 1950-1970s; currently inactive mining operations; buildings not in use.
26	Cabins (2)	2	1 mi N. of Portage Creek mining	Airplane, ATV, foot, dog team	Yes	Mining; built in 1950s; used creek seasonally.
27	Cabins (2)		N.W. shore of Dawn Lake	Airplane, ATV, horse, dog team	Yes	Built in 1960s by owners of High Lake; used currently as a hunting cabin on a seasonal basis.

Table F-1. (Continued)

Map Location[1]	Structure	Zone[2]	Location	Access[3]	Currently Maintained	Use Status
28	Lodge, High Lake (9 buildings)	2	S. shore of High Lake	Airplane, ATV, horse, dog team	Yes	Built in 1960s for use as an international hunting/fishing lodge; currently in use by Acres American Susitna project on a seasonal basis.
30	Cabin foundations	2	S. shore of High Lake	Airplane, ATV, horse, dog team	Yes	Built 1980.
34	Chunilna Creek Placer (7 buildings)	3	Chunilna Creek	Airplane, ATV, 4WD, snowmachine	Yes	Large placer mixing operation in existence since 1950 and currently mined on a seasonal basis.
36	Mining buildings	3	Chunilna Creek: 8 mi S.W. of VABM Clear	Airplane, ATV, 4WD, snowmachine, dog team, foot	Yes	Four buildings built in the 1920s, 1940s and 1960s and used seasonally for mining.
37	Cabin	3	3 mi N.E. of VABM Curry	Foot, dog team	No	Built in 1940s and used seasonally for trapping until early 1960s; no longer used.
38	Cabin	3	Grizzly Camp: 5 mi E. of Daneka Lake	Foot, dog team, airplane	Yes	Built by Vogel in the 1940s as a hunting cabin; currently used on a seasonal basis as a Stephan outreach cabin for hunting.
39	Cabin	2	9 mi from Stephan Lake: 7 mi S. of Fog Lake	Foot, airplane	Yes	Built in 1970s; current use not known at this time.
40	Cabin; shed	2	E. shore of Stephan Lake	Airplane, foot	Yes	Built in 1960s and in current seasonal use for hunting, fishing, and boating.
42	Cabin	2	Portage Creek: 2 mi N.W. of Dawn Lake	Foot, sled, road, airplane, ATV	Yes	Built in 1960s and currently used on a seasonal basis for hunting and fishing.
45	Cabin	2	1 mi W. of Portage Creek mining	Foot, airplane, ATV, 4WD	Yes	Currently used on a seasonal basis for recreational purposes.
46	Cabin	2	1 mi W. of Portage Creek mining, on sled road	Foot, airplane ATV, 4WD	Yes	Currently used on a seasonal basis for recreational purposes.
47 48 49	Cabin Cabin Cabin	2	Unnamed lake N. of Otter Lake	Foot, airplane, ATV, 4WD	Yes	Currently used on a seasonal basis for recreational purposes.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
50	Trailer	2	W. end of S. shore of unnamed lake N. of Otter Lake	Foot, airplane, ATV, 4WD	No	Currently not in use, abandoned.
51	Cabin	2	W. end of S. shore of unnamed lake N. of Otter Lake	Foot, airplane ATV, 4WD	No	Built in late 1960s and currently used for hunting and fishing on a seasonal basis.
52 53	Cabin Cabin	2	S. shore of unnamed lake N. of Otter Lake	Foot, airplane, ATV, 4WD	Yes	Built in late 1960s and is seasonally used for hunting and fishing.
55	Cabins (3)	2	W. end of Bear Lake	Foot, airplane, ATV, 4WD	Yes	Built in 1970s and currently used on a seasonal basis for hunting and fishing.
56	Cabin	2	N. shore of Bear Lake	Foot, airplane, ATV, 4WD	Yes	Built in 1970s and currently used on a seasonal basis for hunting and fishing.
57	Lodge	2	N. shore of Bear Lake	Foot, airplane, ATV, 4WD	Yes	Built in 1970s; lodge and cabin used for fishing, hunting, and skiing on a year-round basis; seasonal boating.
58	Cabin foundations	2	E. end of Bear Lake	Foot, airplane	No	Built in 1950s for trapping purposes; no longer in use.
59 60 61 62 63	Cabin Cabin Cabin Cabin Cabin	3	Chulitna Pass: near railroad	Foot, airplane, rail, car	Yes	Exact construction dates not known; currently used as year-round residences.
64 65	Cabin Cabin	2	Miami Lake	Rail, foot, car, airplane	Yes	Perhaps being used as recreational cabins.
69	Cabin	2	S. shore of Bear Lake	Airplane, foot, 4WD	Yes	Built in 1960s and currently used for hunting, fishing, and swimming.
70	Lodge	3	N. shore of Tsusena Lake	Airplane, ATV	Yes	Built in 1958; used for commercially guided hunts until 1976; presently used on a seasonal basis for private hunting, fishing, and skiing trips.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
72	Cabin	3	Deadman Lake: W. of Big Lake	Airplane, ATV	Yes	Built in 1960s for fishing and hunting purposes and currently used on a seasonal basis.
73 74	Cabin Cabin	3	Big Lake	ATV	Yes	Built in 1960s; currently used on a seasonal basis for hunting and fishing.
75	Cabin	2	4 mi from Watana/Susitna confluence	Airplane, ATV	Yes	Built in 1960s; currently used on a seasonal basis for hunting.
76	Cabin	2	7 mi E. of Big Lake	Airplane, ATV	Yes	Constructed in 1970s and currently used on a seasonal basis for hunting and fishing.
77 78	Cabin Cabin	2	W. end of Watana Lake	Airplane, dog team, snowmachine	Yes	Built in 1950s and 1960s, respectively, and currently used seasonally for hunting and fishing.
79 80	Cabin Cabin	2	E. end of Watana Lake	Airplane, dog team, snowmachine	Yes	Built in 1950s and 1960s, respectively, and currently used seasonally for hunting and fishing.
81	Cabin	2	E. end of Gilbert/Kosina confluence	Foot, dog team	No	Built in 1936 as a trapping line cabin; used until 1955; currently abandoned with everything intact.
82	Tent frame	2	S.W. foot, Clarence Lake	Foot, dog team	No	Built in 1950s and used until 1960s for seasonal hunting.
84	Cabins (2)	2	S.E. end of Clarence Lake	Airplane	Yes	Built in 1950s and currently used seasonally as a hunting and fishing cabin.
85	Cabin	2	E. end of Clarence Lake	Airplane	Yes	Built in 1970s and currently used on a seasonal basis for hunting, fishing, and trapping.
86	Cabin	2	N. end of Clarence Lake	Airplane	Yes	Built in 1960s and currently used on a seasonal basis for hunting, fishing, and trapping.
87	Cabin	2	On tributary 1 mi E. of Clarence Lake	Foot, dog team	No	Built in 1930 and used until 1950 for trapping, hunting, and fishing (Simco's line Cabin #4); currently used seasonally as a hunting shelter.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
88	Cabins (2)	2	Gaging station: S. bank of Susitna	Airplane	No	Built in 1950s for research purposes; currently not used or maintained.
89	Cabin	3	Unnamed lake 3 mi S.W. of Clarence Lake (island in middle)	Floatplane, boat	Yes	Exact construction date not known; currently used on a seasonal basis for fishing.
90	Hunting lean-to	1	S.E. bank of Kosina/ Susitna confluence	Boat, foot, floatplane	Yes	Built in late 1970s for hunting/ fishing purposes; fresh supplies indicate current use.
91	Cabin	1	2 mi N.E. of Watana/ Susitna confluence	Floatplane	No	Built in 1950s; used as a seasonal hunting and fishing cabin; supplies indicate current use.
92	Cabin/cache	1	N.W. bank of Watana/ Susitna confluence	Dog team, foot	No	Built in 1960s for hunting purposes; cabin collapsed; no longer in use.
93	Cabin	2	W. of Jay/Susitna confluence	Airplane	Yes	Built in 1960s and used currently on a seasonal basis for hunting and fishing.
94	Cabin	2	Laha Lake: 1.5 mi W. of Jay Creek	Floatplane, airplane	Yes	Built in 1960s and used currently on a seasonal basis for fishing.
95 96	Cabin Cabin	2	Unnamed lake: 2.5 mi S.E. of Vee Canyon gaging station	Airplane	Yes	Built in 1950s and used currently on a seasonal basis for fishing.
98	Cabin	3	Oshetna River: 10 mi S. of Oshetna/Susitna confluence	Dog team, foot, boat	No	Built by Simco in 1930 as a trap line cabin and used on a seasonal basis for hunting and fishing.
99	Cabin	2	Tyone River/Susitna confluence	Boat	Yes	Built in 1960s by Stephan Lodge owner as a river cabin for Stephan Lodge boating guests.
100	Tent platform	2	Susitna sandbar: S. of Tyone River/Susitna confluence	Boat, helicopter	No	Built in 1970s and used currently for transient boaters.
101	Cabin	3	0.2 mi S. of Maclaren/ Susitna confluence	Boat	Yes	Built in 1960s and currently used for boating on a seasonal basis.
103	Cabin	2	Jay Creek: 3 mi N. of VABM Brown	ATV	Yes	Built in 1970s for hunting and currently used on a seasonal basis.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
105	Cabin	3	Coal Creek	ATV, airplane	Yes	Built in 1970s for hunting and currently used on a seasonal basis.
106	Cabin	3	S. end of Coal Lake	ATV, airplane	Yes	Built in 1960s and currently used on a seasonal basis for mining and fishing.
107	Cabin	1	S. bank of Susitna at Devil Canyon	4WD	No	Built and used in 1950s for Bureau of Rec. study; currently not in use.
110	Cabin	2	N. end of Madman Lake	Airplane	Yes	Built in 1960s and currently used on a seasonal basis for hunting and fishing.
111	Cabin	1	S. bank of Susitna; 1 mi upstream of Watana/ Susitna confluence	Dog team, foot	No	Built in 1945 as a trapping line/ hunting cabin; used for trapping until mid 1950s, presently covered with brush; no longer used.
112	Line cabin	1	N.E. corner of Jay/ Susitna confluence	Foot, dog team, boat, floatplane	No	E. Simco's line (trapping) and hunting cabin built in 1939; dates and game records indicate annual use.
112	Cabin foundations	2	W. bank of Portage Creek: 4 mi from Portage/Susitna confluence	Dog team, foot	No	Built in 1940s as a mining/prospecting cabin; no longer in use.
113	Cabin	3	Unnamed lake: 6 mi W. of Murder Lake	Airplane	No	Built in 1960s for hunting purposes; no longer in use.
114	Cabin	3	7 mi N.E. of VABM Disappointment	Airplane	Yes	Built in 1970s for hunting use and currently used for seasonal hunting.
115	Cabin	3	2 mi of N. of Tsusena Lake	Airplane	Yes	Built in 1970s and currently used as a year-round residence by a guiding outfit.
116	Cabin	2	1 mi W. of VABM Oshetna	Airplane	Yes	Built in 1970s for hunting purposes and is currently used on a seasonal basis.
117	- Cabin	2	Tyone River/Tyone Creek confluence	Boat, dog team	Yes	Built in 1960s for hunting and fishing purposes and currently used on a seasonal basis.

Table F-1. (Continued)

Map Location†[1]	Structure	Zone†[2]	Location	Access†[3]	Currently Maintained	Use Status
118	Cabin	2	7 mi E. of Tyone River/ Susitna confluence	Boat, dog team	No	Built in 1960s for hunting and fishing purposes, no longer in use.
119	Trailer; work shack	1	N. bank of Susitna: 1 mi from Deadman/ Susitna confluence	Helicopter	Yes	Built in 1970s by Army Corps for Susitna study.
120	Shack	1	S. bank of Susitna: 1 mi from Deadman/ Susitna confluence	Helicopter	No	Used and built in 1970s as a research site; since Army Corps study, has collapsed; no longer used.

†[1] Numbers are keyed to map locations shown in Figure F-2.

†[2] Zone 1 is the impoundment zone plus a 200-ft perimeter; Zone 2 is the 6-mi perimeter around Zone 1; Zone 3 is that zone between 6 and 12 mi from the impoundment.

†[3] Almost all sites are accessible by helicopter.

Conversion: To convert feet to meters, multiply by 0.305; to convert miles to kilometers, multiply by 1.61.

Source: Modified from Exhibit E, Vol. 8, Chap. 9, Table E.9.5.

areas (see Table F-2) west of the area of the proposed project and some small private parcels and Native-conveyed lands in the project area (Exhibit E, Vol. 8, Chap. 9, p. E-9-3). However, much of the Federal land is in the process of being transferred to the state and the Cook Inlet Region, Inc. (CIRI), the Native regional commission for the area.

The major land management plans currently in use or being developed for the region including the upper and middle basin are the Denali Land Bank Study, Matanuska-Susitna-Beluga Area Plan, Matanuska and Susitna Transportation Study, Matanuska-Susitna Borough Comprehensive Plan, and Coastal Zone Management Plan. The lead agencies responsible for developing and implementing the provisions of these plans include the U.S. Bureau of Land Management, Alaska Department of Natural Resources, Alaska Department of Transportation and Public Facilities, and Matanuska-Susitna Borough Planning Department. Specific categories of land ownership and management in the upper and middle Susitna River Basin are discussed below. The present pattern of land ownership within the project area is shown in Figure F-3. Definitions of land ownership/status classification terminology are presented in Table F-2. A summary of the amount of acreage of various land holdings is presented in Table F-3.

FEDERAL LANDS

Most federal lands within the upper and middle Susitna River Basin are under the jurisdiction of the Bureau of Land Management. Locations of these land holdings are shown in relation to the proposed Watana and Devil Canyon dam project features in Figure F-3. Federal lands north of the basin area also are managed principally by the Bureau of Land Management. These lands are included in the Bureau's Denali Planning Block, for which a land use plan has been approved. The present management process is basically passive. The Bureau objectives include protecting the natural environment, with particular attention to caribou calving areas and river recreation routes. Fire control management is also an important factor. The Bureau has a cooperative agreement with the state regarding fire-control management that includes the project area (Terrestrial Environmental Specialists, 1982). Finally, the Bureau is also developing a wildlife habitat management plan in cooperation with Alaska Department of Fish and Game for the Alphabet Hills between the Tyone and Maclaren rivers (T11-12 N, R2-9 W, Copper River Meridian). This plan will involve moose habitat manipulation. As yet, however, only study plots for this project have been mapped out.

The Bureau has conveyed to CIRI some sections of land adjacent to the Susitna River in the upper and middle basin area (Fig. F-3). Some of these lands are within the proposed reservoir areas and have been filed as valuable lands to the United States for water-power sites, subject to the provisions of Section 24 of the Federal Power Act. Under the Act, these lands must remain available for entry and selection as a power site and cannot be destroyed for use as a power site by the owner. Furthermore, no claim to compensation for such land can be made by the land owners. However, owners would be paid for damages to land use improvements (e.g., crops, buildings, etc.) if the land is selected for water-power development. Because of the implications of the Act, controversy exists about the interpretation of the rights of the landowner and of the water-power licensee.

At present, the Bureau of Land Management is developing regulations for managing public easements across Native lands. Lands intended for conveyance to the Natives will have six public easements located across them. These easements include an access trail 50 ft (15 m) wide from the Chulitna wayside on the Alaska Railroad to public lands immediately east of Portage Creek, a state site easement and trail easements on Stephan Lake, and an access trail extending east from Gold Creek. Easements were identified only when it was shown that access to public lands was not possible from any other public land area. There are no easements immediately adjacent to the Susitna River above Gold Creek (Terrestrial Environmental Specialists, 1982).

STATE LANDS

State-owned land in the upper and middle Susitna River Basin (see Fig. F-3) has been categorized in the state's land resource evaluation system as agricultural, material, private recreation, resource management, utility, or unclassified (see Exhibit E, Vol. 8, Chap. 9, p. E-9-10, for a discussion of the classification system). Most of the state lands are under the jurisdiction of the Alaska Department of Natural Resources, and currently, the Department's Division of Research and Development is undertaking a comprehensive assessment of the resource base within the project area (Terrestrial Environmental Specialists, 1982). Elsewhere in the basin, the state is disposing of 1,500 acres (610 ha) of remote housing parcels north of Chulitna and 1,280 acres (518 ha) in a subdivision location south of Chulitna, to the west of the project area in the vicinity of the proposed access route. Conveyance by the Federal government of some state-selected lands in the project vicinity has been suspended until lands selected by the Natives have been conveyed under the provisions of the Alaska Native Claims Settlement Act. Under the terms and conditions of the Cook Inlet Land Exchange (Public Law 94-204), the state can acquire previously selected land after the completion of transfer of corporation-selected lands to CIRI.

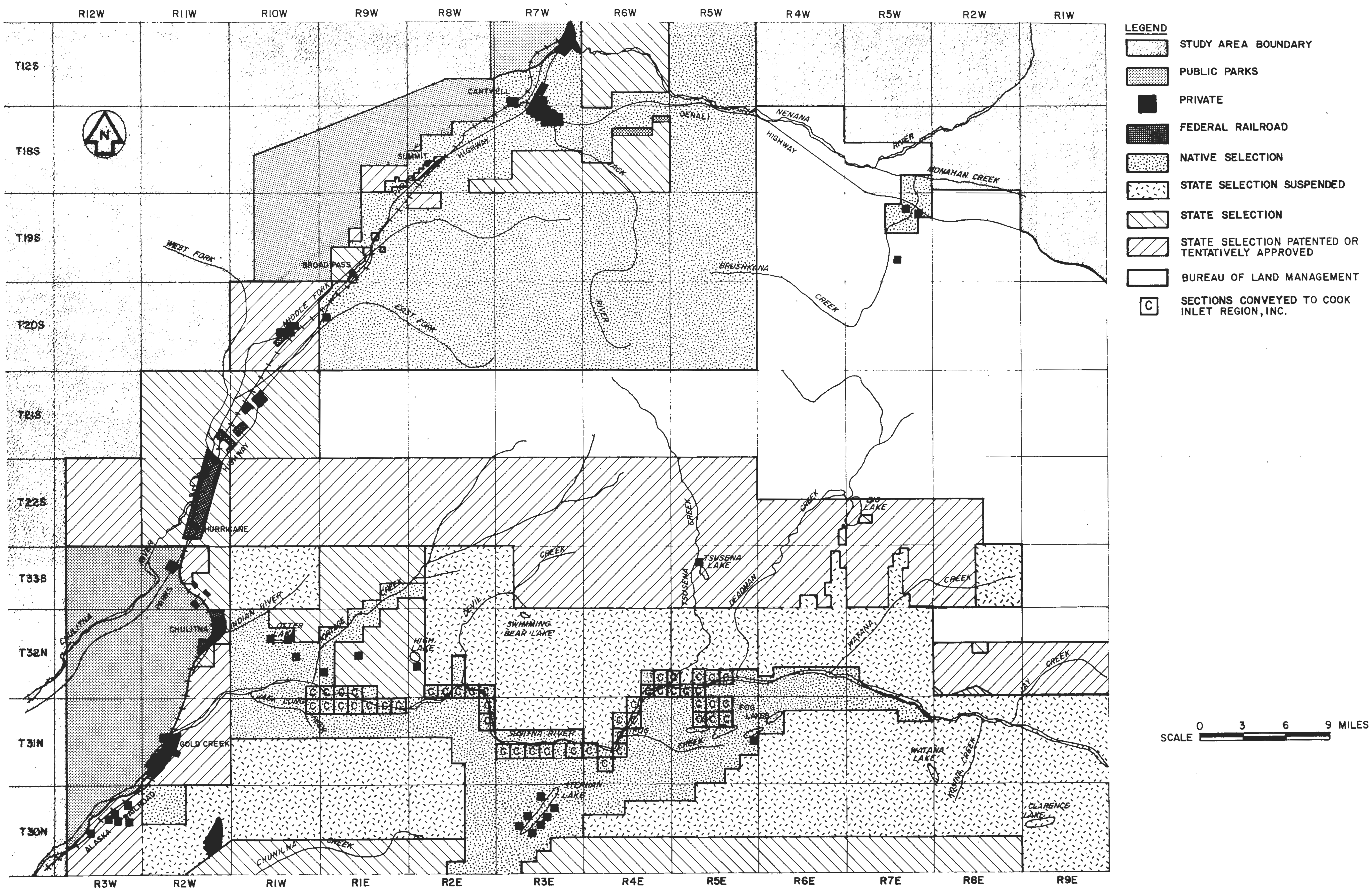

Figure F-3. Land Ownership and Management Patterns in the Upper and Middle Susitna River Basin Area. [Source: Exhibit E, Vol. 8, Chap. 9, Fig. E.9.3]

Table F-2. Land Ownership/Status Classification Terminology

- Federal: Those lands under jurisdiction of the Department of the Interior, the National Park Service, the Bureau of Land Management, or the Alaska Railroad.

- Federal State-Selected: Land is received by the state from the Federal government in a three-step process. The state first applies for land which is classified as State Selections Applications or Federal State-Selected.

- State Selections Tentatively Approved or State T.A.: State-selected lands approved by the Federal government for transfer to the state.

- State Selection Suspended: Due to the conditions in land status in south-central Alaska, some state selections in the project vicinity were suspended until lands selected by Natives have been conveyed under the provision of the Alaska Native Claims Settlement Act (ANCSA). The Cook Inlet Land Exchange, Public Law 94-204, has an extensive Terms and Conditions document which allows the state to acquire previously selected land after the conveyance of corporation selected lands to CIRI.

- State Selections Patented: Those Federal lands that are finally conveyed to the state.

- State Planned Land Disposals: Those state lands plotted for subdivision development. Two are located within the project area: Colorado Station and Indian River.

- Borough or Municipality Approved or Patented: State patented land not reserved for a particular use can be selected by a borough through a process similar to that used by the state in selecting Federal lands.

- Regional Corporation Selections: Those lands selected by the regional corporations under provisions of the ANCSA. Each region is composed of, as far as practical, natives having a common heritage and sharing common interests. The project area lies within the Cook Inlet and the Ahtna regional corporations.

- Regional Corporation-Selection Patented: Federal lands conveyed to the corporations. Interim conveyance is allocated to the corporation if the selected lands have not been surveyed.

- Village Selections: Those lands selected by Alaskan Natives, under provisions of the ANCSA, which have been traditionally used by Natives for their commercial resource value, subsistence hunting and fishing. These lands are located near villages or along rivers. The village receives the surface rights, the regional corporation receives the subsurface rights.

- Village Selection Patented: Village selection conveyed to the village corporation by the BLM. Interim conveyance is allocated to the corporation if the selected lands have not been surveyed. Village corporations in the Cook Inlet Region receive village-selected land by reconveyance from the regional corporation, not the BLM. The procedure for conveyance and reconveyance in the Cook Inlet Region is exceptional to ANCSA.

- Native Allotments: Natives, at the start of the century (1906), were allowed to file for allotments of up to 160 acres on unoccupied Federal lands. These are private holdings.

- Private: Those lands selected for private ownership under the Alaska Native Claims Settlement Act. Native lands are not included.

Source: Adapted from Commonwealth Associates (1982) and Exhibit E, Vol. 8, Chap. 9, p. E-9-9 through E-9-11.

Table F-3. Summary of Land Status and Ownership Acreage in the Upper and Middle Susitna River Basin Study Area

Land Status/ Ownership Category		Total Area (acres)
Federal		303,680
Federal (State Selection Suspended)		370,945
Federal (Railroad Withdrawal)		4,724
State Selection		569,883
State Selection Patented or TA		174,239
Denali State Park (within study area)		25,500
Regional Selection		31,040
Native Group Selection		3,840
Native Selection		207,487
Village Selections (included in Native selection total)		
Chickaloon	5,120	
Tyonek	20,480	
Knik	39,680	
Private		9,874
TOTAL		1,766,492

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Exhibit E, Vol. 8, Chap. 9, Tables E.9.1 and E.9.2.

NATIVE LANDS

Native individuals were allowed under the provisions of the Native Allotment Act of 1906 to file for allotment of up to 160 acres (65 ha) on unoccupied Federal land. Selection of lands by the Native regional corporations under the provisions of the Alaska Native Claims Settlement Act is similar to selection by the state. Federal lands conveyed to the regional corporation are entitled "regional corporation-selection patented." Interim conveyance of lands is allocated to the corporation if the selected lands have not been surveyed. Village corporations in the Cook Inlet region receive village-selected land by reconveyance from the regional corporations, not the Bureau of Land Management. The procedure for conveyance and reconveyance in the Cook Inlet region is exceptional to Alaska Native Claims Settlement Act. Under normal procedures, region and village corporations select preferred land and the Bureau of Land Management conveys land directly to the corporation (Exhibit E, Vol. 8, Chap. 9, p. E-9-11). CIRI-conveyed lands are held in trust until the land is conveyed to the appropriate villages. These villages are Chickalom-Moose Creek, Tyonek, and Knik. At present, no active land management programs are being carried out for these lands.

The Native village selections are generally those lands that have been traditionally used for their commercial resource value and for subsistence hunting and fishing. Most village corporations select land near villages or along rivers. The village receives the surface rights, and the regional corporation receives the subsurface rights (Exhibit E, Vol. 8, Chap. 9, p. E-9-11). When the villages obtain their lands, different ownerships will create a checkerboard pattern in the basin. Any land dispute or management problems that may result from this situation will be handled by the Village Deficiency Management Association, which consists of representatives from each of the villages. Because of the checkerboard ownership pattern, the management of Native lands may also be undertaken by the association.

Native-selected lands in the upper and middle Susitna River Basin area generally are located along both sides of the Susitna River and around the Stephan Lake area. Existing Native land ownership patterns are shown in Figure F-3.

BOROUGH LANDS

A borough or municipality can select state-patented land that is vacant, unappropriated, or unreserved for a particular use until the borough fulfills its entitlement allotment through a process similar to that used by the state in selecting Federal lands. These selections can be made from utility or unclassified lands. Once the land has been selected, the state classification becomes inapplicable. Existing borough and municipally owned lands are shown in Figure F-3.

The Mat-Su Borough is concentrating its selection of lands in the lower Susitna River Basin near existing highways and west of the Susitna River. The borough has received title to about 92% of its 355,200-acre (143,700-ha) land entitlement (Alaska Dept. of Natural Resources, 1982). It is unlikely that the borough will select any lands located in the dam site, reservoir, or access road areas.

The borough is involved in three separate management plans (Terrestrial Environmental Specialists, 1982)--(1) the Matanuska-Susitna Comprehensive Plan (1970), (2) the Talkeetna Mountains Special Use District, and (3) the Matanuska-Susitna Borough Coastal Zone Management Program. The borough can exercise its planning and zoning authority over all lands within the Special Use District boundaries, which includes the project area. The ordinance that established the Special Use District provides for multiple resource use and takes into account unique scenic values. Lands located in the Special Use District are subject to permit requirements for various developments (e.g., roads, subdivisions, etc.).

The borough has been updating the 1970 Matanuska-Susitna Borough Comprehensive Development Plan. A February 1983 draft of the updated plan is currently under review. The proposed project area is considered a mixed-use zone, which would permit hydroelectric development. The Mat-Su Borough, in conjunction with the National Oceanic and Atmospheric Administration, Office of Coastal Zone Management and the Alaska Coastal Zone Management Program under the Alaska Division of Community Planning, Department of Community and Regional Affairs, is preparing a Coastal Zone Management Plan. The Susitna River up to Devil Canyon is designated to be within the area covered by the program.

PRIVATE LANDS

There are only scattered private land holdings in the upper and middle Susitna River Basin. Most of these land holdings are concentrated along major roads, such as the George Parks and Denali highways. A few small private land holdings also are located in more remote areas as a result of state and borough land sales and patented Federal mining claims. In general, private lands are often located near waterfronts or airstrips to allow access (Alaska Dept. of Natural Resources, 1982). The Matanuska-Susitna Borough assessor's office estimates that of the approximately 45,550 private lots in the borough totaling slightly less than one-half million acres, approximately 80% remain undeveloped (Alaska Dept. of Natural Resources, 1982). Existing parcels under private ownership are shown in Figure F-3.

F.1.2.1.3 Land Values

Complete and accurate land value data for the upper and middle Susitna River Basin area are currently unavailable. This is primarily because of the ongoing changes in land ownership and the current lack of development and use in the Susitna River valley area that would indicate or assign a land value to a specific piece of property. Market values are available only for state, borough, Native, or private lands that have been or are about to be sold. Specific land values for the proposed Watana and Devil Canyon project lands would not be established until the project land acquisition process was started. Although precise land values can not be ascertained for lands located within much of the upper and middle basin area, an indication of representative Alaskan land values can be obtained from land value data provided by the Alaska Department of Natural Resources land disposal program. Calculations carried out for land values along the proposed transmission line corridor are discussed below in Section F.1.2.2.3.

F.1.2.2 Power Transmission Line Corridor

F.1.2.2.1 Existing and Future Uses

The proposed 330-mi (530-km) long transmission line corridor between Fairbanks and Anchorage would extend through portions of the Tanana, Nenana, Chulitna, and Susitna river valleys. The corridor would parallel portions of the George Parks Highway and Alaska Railroad. This region is commonly referred to as the Alaska Railbelt. The regional overviews and definitions given above for the various land use types also apply to the transmission line corridor. Even without the development of the proposed transmission line corridor, land use activities and development would likely continue to increase along the George Parks Highway and Alaska Railroad corridors as greater demands were placed on existing land resources for planned recreation, agricultural, utility, and mineral resource development within the Railbelt corridor.

AGRICULTURAL LANDS

Some farming and grazing occurs in the lower reaches of the Susitna River Basin and in the Tanana River Basin between the Fairbanks and Delta Junction areas. Along the Fairbanks-to-Healy segment of the transmission line corridor, agricultural lands are located near Fairbanks to the east and north of the proposed route and along the Parks Highway and Alaska Railroad between the communities of Dunbar and Nenana. Agricultural lands also occur immediately north of Healy. Between Healy and Willow (along the intertie route), there are agricultural lands in the vicinity of Talkeetna. These lands are generally to the west of the proposed transmission line route; however, a few parcels are immediately adjacent to the eastern side of the proposed line. Along the Willow-to-Anchorage segment of the transmission line, state agricultural sale areas include the Delta Island agricultural disposal about 5 mi (8 km) southwest of Willow, the Fish Creek Management Unit south of Red Shirt Lake, and the Point MacKenzie agricultural sale northwest of Point MacKenzie. Approximately 20,000 acres (8,000 ha) of state and borough lands were recently sold for agricultural use. Most of the sales have taken place along the southern portion of Parks Highway and in the Willow subbasin area. Many of these farms are not in production but are expected to begin once access has been achieved and the land cleared. Existing and potential agricultural lands and land sales are shown in Table F-4. Agricultural soils are discussed in Appendix E.

FOREST RESOURCE LANDS

A preliminary analysis by the state has indicated that forested areas along both sides of the George Parks Highway have high to moderate value as forestry lands (Alaska Dept. of Natural Resources, 1982). The forest land cover type is described in detail in Section 3.1.5.1 and Appendix J. To date, commercial use of wood resources has been limited to small logging operations along the Susitna River floodplain in the lower basin. Forestland with high potential for commercial value is located all along the Susitna floodplain downstream from Portage Creeks (Exhibit E, Vol. 6a, Chap. 3, p. E-3-195). The best commercial stands are within the upland spruce-hardwood forest type at elevations of 800 to 1,200 ft (120 to 370 m) (Commonwealth Assoc., 1982). Eleven timber sales that will total about 325,000 acres (132,000 ha) within the lower Susitna River Basin are planned by the Alaska Department of Natural Resources and the Mat-Su Borough (Exhibit E, Vol. 6a, Chap. 3, pp. E-3-195 - 196). However, most of these sales are not scheduled to begin earlier than 1992.

MINERAL RESOURCE LANDS

Mineral exploration and mining activities within the general area of the proposed transmission line corridor have been limited. Generally low-intensity mining claims have been operated in the area on an intermittent basis. Coal is a major resource within the Mat-Su Borough, with deposits of varying quality located throughout the borough (Exhibit E, Vol. 8, Chap. 9, p. E-9-18). Mining areas in the vicinity of the proposed transmission line corridor between Fairbanks and Healy are located west of Fairbanks, east of Dunbar, in the vicinity of Nenana, immediately south of where the George Parks Highway crosses the Alaska Railroad, and an extensive area east of Healy. Coal has been mined in the Healy area since 1918, and further exploration is continuing. Between Healy and Willow (along the Intertie route), the principal economic, non-metallic resources are coal and gravel. Coal is also located in the Broad Pass area (Commonwealth Assoc., 1982). Between Willow and Anchorage, little mining activity occurs within the proposed transmission line corridor area. Mineral resources are discussed further in Appendix E.

NATURAL AREAS AND RECREATION LANDS

The proposed transmission line corridor does not extend through a national park-preserve system, national historic landmark area, designated wilderness area, or national forest system. However, significant natural and recreation areas are located both to the east and to the west of the proposed corridor. The two most significant recreation areas to the west of the corridor are the Denali National Park and Preserve and the Denali State Park. In addition, the corridor does parallel a portion of the Denali State Park and extends through about 5 mi (8 km) of the Susitna Flats State Game Refuge located near Anchorage. The Nancy Lake State Recreation Area is located near the proposed route in the Willow area. Recreation activities in the area include hunting, fishing, boating, canoeing, kayaking, camping, backpacking, and skiing. Recreational activities within the proposed transmission line corridor study area are discussed further in Appendix L.

TRANSPORTATION AND UTILITY CORRIDORS

The proposed transmission line corridor essentially parallels the George Parks Highway and the Alaska Railroad from Fairbanks to Anchorage. The corridor would be crossed by the Denali Highway (Route 8) near the community of Cantwell. At present, this road is closed during the winter. River travel is possible along portions of the Tanana, Nenana, Chulitna, and Susitna rivers. Boats, canoes, rafts, and kayaks are used along these rivers and their adjacent tributaries. Major airports and air bases near the transmission line corridor are located at

Table F-4. Existing and Potential Agricultural Lands and Land Sales Located Along the Proposed Transmission Line Corridor

Northern Study Area (Fairbanks-to-Healy)		
Goldstream Agricultural Disposal	West of Bonanza Creek Experimental Forest	The agricultural sale is planned for Fiscal Year 1984. The proposed transmission corridor either crosses or is adjacent to approximately 3.5 mi of the Goldstream disposal.
Brown's Court Agricultural Disposal	10 mi south of Anderson	Agricultural sales were offered in 1983. The transmission corridor passes approximately 0.5 mi from the southeastern corner of the parcel.
Windy Agricultural Disposal	South of the Clear Missile Early Warning Station	Agricultural sales will begin in Fiscal Year 1985. The proposed transmission corridor crosses approximately 3 mi of the Windy disposal.
Healy Agricultural Disposal	Begins approximately 13 mi northwest of Healy and extends south for 6 mi between the Parks Highway and the Nenana River.	Agricultural sales will begin in Fiscal Year 1985. The proposed transmission corridor crosses 6 mi of the Healy disposal.
Central Study Area (Healy-to-Willow)		
Goose Creek Agricultural Disposal	Approximately 17 mi southeast of Talkeetna, north of Goose Creek and east of Emil Lake.	A 160-acre parcel (currently open for sale). The Intertie easement occupies the western portion of the parcel, running 0.5 mi in length and 400 ft in width.
Southern Study Area (Willow-to-Anchorage)		
Delta Islands Agricultural Disposal	Approximately 5 mi southwest of Willow	The area is currently open for agricultural sales. The proposed transmission corridor is more than 1 mi from the Delta Islands disposal area.
Fish Creek Management Unit	Between the Point MacKenzie project and Red Shirt Lake	Agricultural sales will begin within the next 2 years. The proposed transmission corridor crosses approximately 11 mi of the Fish Creek unit. Planning for this unit is currently taking place. Therefore, the extent of agricultural sales is unknown.
Point MacKenzie Agricultural Sale	Northwest of MacKenzie Point	The proposed transmission line extends across more than 5 mi of agricultural sale property.

Conversion: To convert miles to kilometers, multiply by 1.61; to convert acres to hectares, multiply by 0.405; to convert feet to meters, multiply by 0.305.

Source: Supplemental Information to Exhibit E, Chapter 9, Response to Comment 7.

Anchorage and Fairbanks. Numerous ground and float plane landing sites are also located along the corridor area with the majority of the float plane landing sites located south of Willow. Landing strips and float plane landing sites located along the transmission line corridor are listed in Table F-5.

Other transmission line corridors exist or are being constructed in areas near the proposed Susitna transmission line corridor (see Fig. 1-2). A Chugach Electric Association transmission line extends east from the Knik Arm near Anchorage and a Golden Valley Electric Association transmission line extends from Fairbanks to Healy. Right-of-way is being cleared for the Anchorage-Fairbanks Intertie between Healy and Willow. The Intertie, not part of the Susitna project, would be expected to be in place by the time the proposed Watana and Devil Canyon projects were completed.

SETTLEMENT AREAS AND SPECIAL USE LANDS

Between Fairbanks and Anchorage, the proposed transmission corridor would extend past a number of small communities, as well as undeveloped lands capable of supporting settlement. These lands have slight or moderate building limitation based on physical factors such as slope, soil drainage, and soil load-bearing capacity (Alaska Dept. of Natural Resources, 1982). Along the Healy-to-Fairbanks segment, residential and/or commercial land uses occur at the communities of Dunbar, Nenana, and Healy. The U.S. Air Force Clear M.E.W.S. Military Reserve is located in the vicinity of Anderson. The corridor also would extend past the Keystone Extension (Sec. 21, T1S, R3W, FM), Healy Small Tracts (Sec. 12, T1S, R8W, FM), and the Northridge Subdivisions (Sec. 17, T1S, R2W, FM) on the western side of Parks Highway. Residential development between the middle and east forks of the Chulitna River and along the mainstem Chulitna River is limited to a few residences on the Parks Highway.

Along the Healy-to-Willow segment, residential and commercial developments are located along the Nenana River and the Parks Highway near the Denali National Park and Preserve (e.g., McKinley Village) and just outside the Nenana Gorge area. Residential and commercial development also occurs at Cantwell, Summit, and Broad Pass. Development, such as the Cantwell Community Center, is expected to continue along the Denali Highway. Some scattered residences exist along the Parks Highway and the Chulitna River within Denali State Park. Land development occurs east of Curry Ridge along the Alaska Railroad, including the Indian River Land Disposal and the Indian River Remote Parcel. Both these areas are recreation oriented. Only a few residents remain there year-round. Homesteads occur along the Alaska Railroad at Chulitna, Gold Creek, and the Susitna and Indian rivers. Land use east of Talkeetna is dominated by the land disposals along the Talkeetna River. A few homesteads exist around Larson Lake, and local residents could develop the area for residential and recreation use (Exhibit E, Vol. 8, Chap. 9, p. E-9-20). Residential and commercial development does occur west of Curry Ridge and along Petersville Road near Trapper Creek.

Along the Willow-to-Anchorage segment of the transmission line residential use occurs at Willow, Red Shirt Lake, and on many of the small lakes east of the proposed route. Approximately 25 cabins are located along the shores of Red Shirt Lake (Exhibit E, Vol. 8, Chap. 9, p. E-9-49). Within the Willow area, scattered cabins are located near the Parks Highway and the Alaska Railroad. At Willow, the corridor area encompasses the Holstein Heights Subdivision and state and private recreation land (Sec. 20, T15N, R4W, SM). Lands managed by the U.S. Army (Fort Richardson) and U.S. Air Force (Elmondorf Air Force Base) are located along the southern end of the transmission line corridor area near Anchorage.

WETLANDS AND FLOODPLAINS

Wetlands occur in a number of areas along the entire proposed transmission line corridor. Wetlands along the corridor are described in detail in Section 3.1.5.1 and Appendix J. The U.S. Army Corps of Engineers has mapped the 100-year flood elevation on the Nenana River near the community of Nenana and at Chulitna on Pass Creek. The 100-year floodplain of the Talkeetna, Susitna, and Chulitna rivers has been mapped within the corporate limits of Talkeetna. Talkeetna is subject to flooding from all three rivers. The floodplain of the Talkeetna River at Talkeetna is wide and developed only on the southern side at the mouth of the river. Open spaces in the floodplain are extensive and may come under pressure for future development (Exhibit E, Vol. 8, Chap. 9, p. E-9-26).

F.1.2.2.2 Ownership Status and Management

Most of the land along the proposed transmission line corridor is currently owned by the State and managed by the Department of Natural Resources. Managing agencies for the land along the

Table F-5. Airports, Landing Strips, and Float Plane Landing Sites Along the Proposed Transmission Line Corridor

Landing Site Locations in Proximity to the Corridor	Landing Sites Located Less than One Mile from the Proposed Corridor
<u>Northern Study Area</u> (Fairbanks-to-Healy)	
Fairbanks	
Nenana	Float plane landing site within the proposed corridor
Near Clear M.E.W.S. Military Reserve	
Rex	
Ferry	
Lignite	
Healy	Landing strip and float plane landing site within 2,500 ft and 5,000 ft, respectively
<u>Central Study Area</u> (Healy-to-Willow)	
McKinley Park	
Mt. McKinley National Park	
Cantwell	Golden North Airport within 5,000 ft
Summit	
Colorado	
Chulitna	
Gold Creek	2 landing strips within 1,500 ft and a float plane landing site adjacent to the corridor
Curry	
Montana	
Kashwitna	
<u>Southern Study Area</u> (Willow-to-Anchorage)	
Willow	Numerous float plane landing sites within one mile of the corridor in Willow region
Elmendorf Air Force Base	
Anchorage	

Conversion: To convert feet to meters, multiply by 0.305.

Source: Exhibit E, Vol. 8, Chap. 9; Exhibit G, Vol. 4, Constraint Map, Appendix A; Commonwealth Assoc., 1982.

various transmission line corridor segments are as follows:

Route Segment	Land-Managing Agencies
Dams-to-Gold Creek	Matanuska-Susitna Borough; Alaska Department of Natural Resources; Cook Inlet Region, Inc.
Healy-to-Fairbanks	Fairbanks-North Star Borough; Alaska Department of Natural Resources; U.S. Air Force, National Park Service, and Bureau of Land Management; Ahtna Region, Inc.
Willow-to-Healy	Matanuska-Susitna Borough; Alaska Department of Natural Resources; U.S. National Park Service and Bureau of Land Management; Ahtna Region, Inc. and Cook Inlet Region, Inc.
Willow-to-Anchorage	Matanuska-Susitna Borough; Municipality of Anchorage; Alaska Department of Natural Resources; U.S. Army and U.S. Air Force.

In the Healy-to-Fairbanks segment, the Fairbanks-North Star Borough is preparing a comprehensive plan that will include approximately 25 mi (40 km) of the northeastern portion of the corridor area. The Alaska Department of Natural Resources has an on-going and active land disposal program in this region. The Department also is developing the Tanana Area Plan. Currently only baseline information has been prepared and no policies or draft plans have been published. The National Park Service manages activities within the Denali National Park and Preserve. Formal planning activities for Ahtna Region, Inc. lands have not begun.

Agency planning and management activities for the Healy-to-Willow and Willow-to-Anchorage portions of the transmission line route are similar to those described in the previous section on the upper and middle Susitna River Basin area. The final portion of the Willow-to-Anchorage segment would be located within the Anchorage municipality, which has both a current comprehensive plan and a draft utility plan. In this area the transmission line corridor also would extend across military reservation lands under the jurisdiction of the U.S. Air Force and the U.S. Army. Master plan programs exist for both military facilities.

FEDERAL LANDS

The Federal government owns only scattered parcels of land along the proposed transmission line corridor. The largest Federal land holding adjacent to the proposed corridor is the Denali National Park, managed by the U.S. Park Service. The U.S. Air Force manages a land reserve located near Anderson and the Elmendorf Air Force Base near Anchorage. The U.S. Army manages Ft. Richardson near Anchorage. Other Federally owned lands occur north of Cantwell and north of Talkeetna (Commonwealth Assoc., 1982). The Bureau of Land Management manages land in the vicinity of Broad Pass. The land on which the Alaska Railroad is located is also Federal property. Railroad holdings exists in various locations along the Railbelt corridor. The Alaska Railroad manages land east of Denali State Park and railroad withdrawls exist in the vicinities of Honolulu and Talkeetna.

STATE LANDS

The proposed transmission line route would be located principally on state-owned and -managed lands. The majority of these lands are in various stages of the state selection process and are classified as selected, tentatively approved, or patented. Between Fairbanks and Healy, the majority of land along the proposed corridor is either state patented or tentatively approved lands. The state also has selected land to the east and south of the community of Nenana. Along the Healy-to-Willow segment (along the Intertie route), state-selected lands are located to the northeast of the Denali National Park and Preserve. Denali State Park lands are located to the west of the proposed transmission line corridor and are managed by the Alaska Department of Natural Resources, Division of Parks. Most of these lands have been tentatively approved by the Federal government for patent land status to the state. A number of state land parcels will eventually be deeded to local agencies and relinquished for private land sales. Two state land disposal sites exist near the Indian River, just north of the Susitna River. Between Willow and Anchorage the proposed transmission line corridor extends through lands that are either state patented or tentatively approved. Much of the area is currently used as state recreation lands and game refuges.

NATIVE LANDS

The provisions for Native-selected lands were discussed in Section F.1.2.1.2. Between Fairbanks and Healy, Native-selected lands are located near the community of Dunbar and along the Parks Highway in the vicinity of Anderson. Along the Healy-to-Willow segment of the proposed transmission line corridor, Cook Inlet Region, Inc., has applied for the selection of state-owned lands in the Talkeetna area. At present, there are no Native-selected lands along the proposed transmission line corridor between Willow and Anchorage.

BOROUGH LANDS

Between Fairbanks and Healy the only Fairbanks-North Star Borough approved or patented lands along the proposed transmission line corridor are west of Fairbanks. Along the Healy-to-Willow segment, the Mat-Su Borough lands generally follow the Parks Highway and Petersville Road area. Only a small amount of these lands have been patented. The majority of the borough-selected lands are either selected or tentatively approved lands. Between Willow and Anchorage, the Mat-Su Borough has approved or patented lands in the vicinity of Red Shirt Lake and Big Lake. The borough is concentrating its selection of lands in the lower Susitna Basin near existing highways and west of the Susitna River.

PRIVATE LANDS

Privately owned land is scattered along the entire transmission line corridor, but generally is concentrated along highway and rail transportation corridors, near waterfront holdings, or in the vicinity of airstrips. Private property is located in the various Railbelt communities adjacent to the George Parks Highway and Alaska Railroad. Private parcels also occur in the vicinity of Ferry, near Nenana, and along Ester Creek in a mining district at the northern end of the proposed corridor near Fairbanks (Exhibit E, Vol. 8, Chap. 9, p. E-9-11). Along the Healy-to-Willow segment, private and leased lands occur primarily south of Curry. Most of these private lands are located in the Montana and Trappers Creek area and east of Chase and Talkeetna. Additional residential developments are located between the Chulitna and Susitna rivers, east of Denali State Park, in the Indian River Land Disposal and Indian River Remote Parcel, in Talkeetna, and along the remainder of Parks Highway. Private parcels also occur near Willow and throughout Anchorage along the southern portion of the transmission line corridor.

F.1.2.2.3 Land Values

As discussed in Section F.1.2.1.3, precise land value data for the transmission line corridor area are currently unavailable. Although precise land values can not be ascertained for lands located within much of the corridor, an indication of representative Alaskan land values can be established by using land value data from the Alaska Department of Natural Resources land disposal program.

The representative land value information presented in Table F-6 includes unit price, parcel size, and type of access availability for subdivision and agricultural land disposal areas. Because of land price discounts offered to qualified Alaska residents (50% to 75% of residents qualify), prices actually paid for specific land tracts may be substantially lower than the appraised values cited. The disposal sites shown are located within the general vicinity of the proposed transmission line corridor (Fig. F-4). However, the land value data do not represent the metropolitan Anchorage area, where individual lots may be valued as much as $75,000.

Although it is difficult to predict future land values accurately, it is anticipated that these values will increase with time. This is especially true for the Railbelt Region of Alaska because of existing and planned human development and activities, road and utility corridors, and resource development.

F.1.3 Susitna Development Alternatives

F.1.3.1 Alternative Dam Locations and Designs

In general, the areas of alternative dam locations and designs are all within the upper and middle Susitna River Basin. Land use of the basin was described in Section F.1.2.1. Present land ownership within the basin is shown in Figure F-3. Most of the land in the basin is currently owned by the U.S. Government and managed by the U.S. Bureau of Land Management. However, much of the federal land is presently in the process of being transferred to the state and to the Cook Inlet Region, Inc. Existing land use types, patterns, and development within the basin are scattered and of low intensity (Figs. F-1 and F-2). There are essentially no agriculture, large-scale timbering, large-scale mining, or significant residential, commercial, or industrial uses within the area. The primary land use activity is dispersed recreation.

In the case of the alternatives involving the Watana I and Reregulating dams, the nearest (low-use-intensity) recreational activities occur to the south in the Fog Lakes area. Sections of land along the Susitna River and to the south have been selected by the Natives or conveyed to the Cook Inlet Region, Inc., while lands to the north have been suspended for state selection. Low-use-intensity recreation activities also occur to the northwest of the alternative Modified High Devil Canyon dam in the High Lake area. A hunting and fishing lodge consisting of nine buildings is located along the lake. Sections of land along the Susitna River in that area have been conveyed to the Cook Inlet Region, Inc. Lands to the northwest of the site have been

Table F-6. Sample Land Value Data for the Alaska Department of Natural Resources Land Disposal Program

Disposal Name	Map Number†[1]	Access Code†[2]	No. of Parcels	Ave. Parcel Size (acres)	Ave. Parcel Price ($)	Ave. Per Acre Price ($)
SUBDIVISIONS						
Northridge	1	1	18	11.6	26,450	2,277
Parkridge	2	1	13	5.3	27,796	5,268
Farmview	3	1	21	23.7	16,571	699
Nenana South	4	1	35	4.2	3,497	832
Anderson	5	3	53	36.9	22,245	603
June Creek	6	1	255	5.0	5,000	994
Panguinque Creek	7	3	165	6.0	5,684	953
Indian River	8	1	60	4.4	4,362	985
Bald Mountain	9	3	173	4.8	1,692	356
South Bald Mountain	10	3	84	11.6	5,955	511
Puppy Haven	11	3	13	38.8	41,530	1,069

AGRICULTURAL DISPOSALS

Disposal Name	Map Number†[1]	Access Code†[2]	No. of Parcels	Acres	Percent in Class II/III Soils	Ave. Per Acre Price ($)
Two Mile Lake	12	1	17	3,101	74	136
Brown's Court	13	1	9	1,775	96	134
Moose Creek	14	2	4	667	60	103
Goose Creek†[3]	15	3	1	160	42	105
Delta Island	16	3	4	906	79	227
Nancy Lake	17	1	2	200	65	136
Little Susitna	18	2	3	560	73	152

†[1] Map numbers are keyed to Figure F-4.

†[2] Access Code: 1 - Adjacent to (within one or two miles) the Parks Highway; 2 - Served by major existing or planned secondary road; 3 - Not accessed by main road.

†[3] Crossed by proposed Susitna transmission corridor.

Conversion: To convert acres to hectares, multiply by 0.405.

Source: Modified from Alaska Department of Natural Resources, Division of Land and Water Management. Materials prepared for State Land Disposal Brochures for 1981-1983 period.

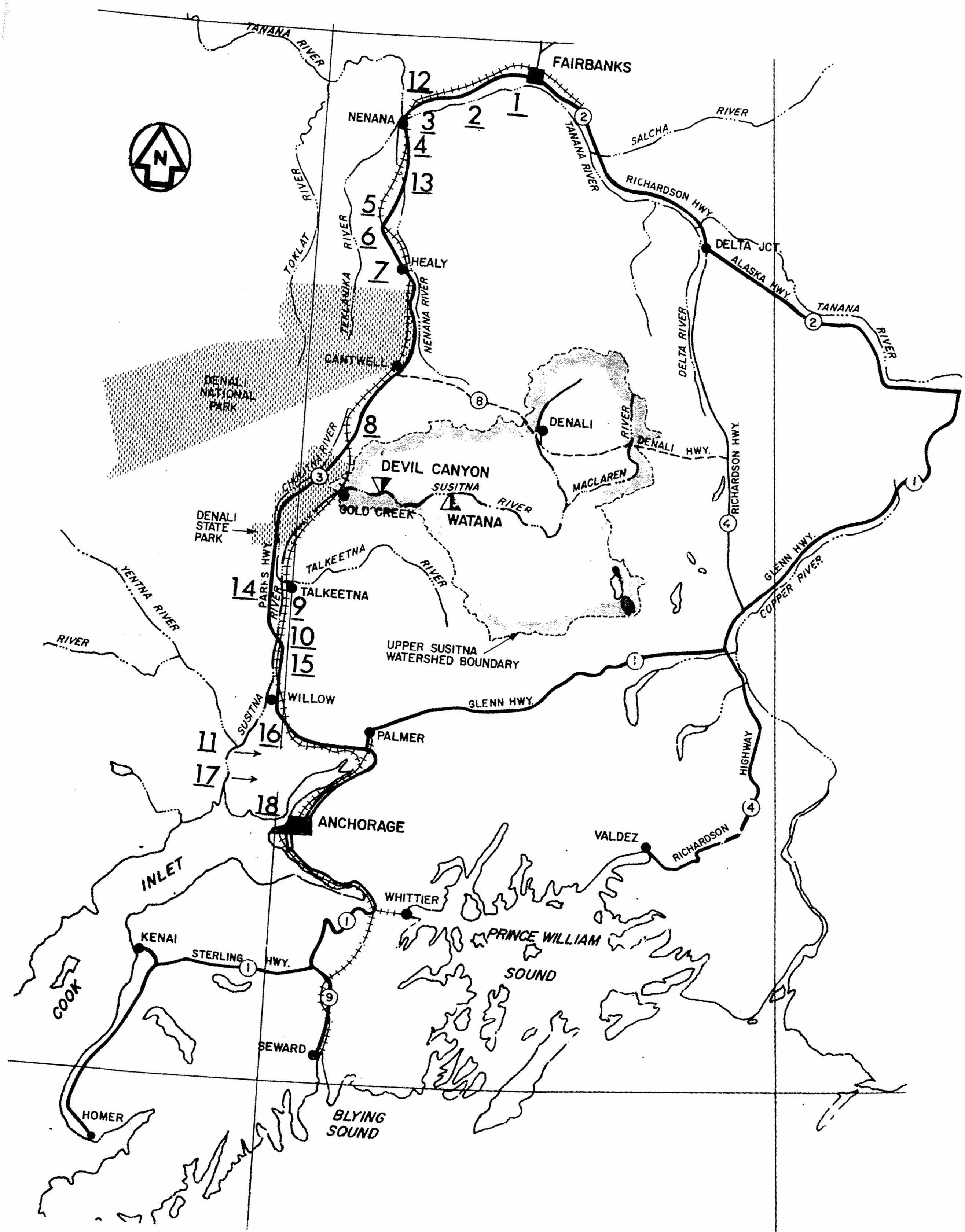

Figure F-4. Locations of Alaska Department of Natural Resources Land Disposal Sites for Representative Land Value Data. [Source: Modified from Alaska Department of Natural Resources, Division of Land and Water Management. Materials prepared for State Land Disposal Brochures for 1981-1983 period, and Exhibit G, Plate G.1] selected by the state, while lands to the north and east have been suspended for state selection, and lands to the south have been selected by Native Alaskans. A small amount of private land occurs near the High Lake area.

F.1.3.2 Alternative Access Routes

Two alternative access corridors were considered for the proposed Watana and Devil Canyon dam projects. Corridor 1 would extend from the Parks Highway (near Hurricane) to the Watana dam site on the north side of the Susitna River and Corridor 2 would extend from the Parks Highway to the Watana dam site on the south side of the Susitna River (see Sec. 2, Fig. 2-13).

As discussed in Section F.1.2.1.2, much of the land in basin area has been or is being conveyed to Native corporations, and the remainder of the lands are mostly under Federal or state ownership and management. Current land use is primarily dispersed recreation. Corridor 1 (River - north side) extends mostly through state-selected lands and some Native selected and private lands. Land use is currently low-density recreation and mining activities. Corridor 2 (River - south side) traverses more Native-selected lands. Native organizations have expressed interest in developing these low-density, intermittent use lands for mining, recreation, forestry, and residential use (Exhibit E, Vol. 9, Chap. 10, p. E-10-48).

F.1.3.3 Alternative Power Transmission Routes

The alternative power transmission line route segments are in three corridor areas: (1) the Northern Study Area between Fairbanks and Healy, (2) the Central Study Area, which includes the upper and middle Susitna River Basin area, and (3) the Southern Study Area between Willow and Anchorage. These alternative route segments are shown in Section 2, Figures 2-14 through 2-16. In general, land uses, ownership patterns, management plans, and land values are as discussed in Section F.1.2. Recreational use is discussed in Section 3.2.2.7 and Appendix L. Land use along each alternative transmission route segment is shown in Table F-7.

F.1.3.4 Alternative Borrow Sites

The alternative borrow site areas, all within the upper and middle Susitna River Basin study area, are shown in Figures 2-2 and 2-6. Land use within the borrow site areas is generally low-intensity, dispersed recreation. Most of the borrow site lands along the Susitna River have been selected by the Natives or conveyed to the Cook Inlet Region, Inc. Land ownership along the Tsusena Creek borrow site areas consists of state selection-suspended and state selection-approved lands. Land use, ownership, management, and values for these areas are discussed in more detail in Section F.1.2.

F.1.4 Non-Susitna Generation Alternatives

F.1.4.1 Natural-Gas-Fired Generation Scenario

F.1.4.1.1 Beluga and Chuitna Rivers

The Beluga/Chuitna rivers region is a relatively remote area and land use is diverse and of low intensity. Dispersed recreation activities occur within the region. Natural resources being developed in the area include oil, gas, coal, and timber. No major ground transportation routes occur in the region. Land ownership in the Beluga area is varied and includes the State of Alaska; Cook Inlet Region, Inc.; Tyonek Native Corp.; and the Kenai Peninsula Borough. State-owned lands have been designated as resource management lands, industrial lands, reserved use lands, and material lands. Most of the Beluga coal district is resource management land (Exhibit E, Vol. 9, Chap. 10, p. E-10-120).

F.1.4.1.2 Kenai Peninsula

Land use in the northwestern Kenai area is mixed and includes developed lands, as well as lands of low-intensity use. Much of the Kenai region is used for recreation. More than half of the Kenai Peninsula is encompassed by the major federal holdings of the Kenai Fjords National Park, the Kenai National Wildlife Refuge, and the Chugach National Forest. The major ground transportation corridor in the northwestern Kenai area is the Sterling Highway (Route 1).

F.1.4.1.3 Anchorage

Land use in the Anchorage region is mixed and ownership diverse. Land use in and surrounding the Anchorage metropolitan area includes residential, commercial, industrial, and recreation. Little agricultural or forest resource lands occur within the greater Anchorage area. The U.S. Army and U.S. Air Force manage lands near Anchorage. The area is served by the George Parks Highway (Route 3), Glenn Highway (Route 1), the Alaska National Railroad, the Anchorage International Airport, and an ocean port.

Table F-7. Land Uses Along Alternative Power Transmission Routes

Route Segment	Length (mi)	Land Use
Northern Study Area (Fairbanks-to-Healy)		
1. ABC (Proposed Route)	90	Air strip; residential areas and isolated cabins; some U.S. Military withdrawal and Native land.
2. ABDC	86	No known existing right-of-way (ROW) north of Browne; scattered residential and isolated cabins; airstrip; Fort Wainwright Military Reservation.
3. AEDC	115	No existing ROW beyond Healy/Cody Creek confluence; isolated cabins; airstrips; Fort Wainwright Military Reservation.
4. AEF	105	Air strips; isolated cabins; Fort Wainwright Military Reservation.
Central Study Area (Upper and Middle Susitna River Basin)		
1. ABCD	40	Little existing ROW except Corps Road; mostly village selection and private lands.
2. ABECD	45	Little existing ROW except Corps Road; and at D; recreation and residential areas; float plane areas; mostly village selection and private lands.
3. AJCF	41	No existing ROW except at F; recreation areas; float plane areas; mostly village selection and private land; residential and recreational development in area of Otter Lake and Old Sled Road.
4. ABCJHI	77	No existing ROW; recreation areas and isolated cabins; lakes used by float planes; much village selection land.
5. ABECJHI	82	Same as Corridor 4
6. CBAHI	68	No known existing ROW; recreation areas and isolated cabins, float plane area; Susitna area and near I are village and selection land.
7. CEBAHI	73	Same as Corridor 6

Table F-7. (Continued)

Route Segment	Length (mi)	Land Use
8. CBAG	90	No existing ROW; recreation areas and isolated cabins, float plane areas; air strip and airport; much village selection and Federal land.
9. CEBAG	95	Same as Corridor 8
10. CJAG	86	No existing ROW; recreation areas and isolated cabins, float plane areas; air strip and airport; mostly village selection and Federal land.
11. CJAHI	69	No existing ROW; recreation areas and isolated cabins; float plane area; mostly village selection and private land.
12. JA-CJHI	70	No existing ROW; recreation areas and isolated cabins; float plane area; mostly village selection and private land.
13. ABCF	41	No known existing ROW except at F; recreation areas; float plane areas; residential and recreation use near Otter Lake and Old Sled Road; isolated cabins; mostly village selection land and some private land.
14. AJCD (Proposed Route)	41	Little existing ROW except Old Corps Road and at D; recreation areas; isolated cabins; much village selection land; some private land.
15. ABECF	45	No known existing ROW except at F; recreation areas; float plane areas; residential and recreation use near Old Sled Road; isolated cabins; mostly village selection land with some private land.
Southern Study Area (Willow-to-Anchorage)		
1. ABC'	73	No existing ROW in AB, residential uses near Palmer; proposed capitol site; much U.S. Military land, private and village selection land.
2. ADFC (Proposed Route)	38	Trail is only existing ROW; residential and recreation areas; Susitna Flats Game Refuge; agricultural land sale.
3. AEFC	39	No known existing ROW; residential and recreation use areas, including Nancy Lakes; lakes used by float planes; agricultural land sale.

Conversion: To convert miles to kilometers, multiply by 1.61.

Source: Adapted from Exhibit E, Vol. 9, Chap. 10, Tables E.10.21 through E.10.23.

F.1.4.2 Coal-Fired Generation Scenario

F.1.4.2.1 Nenana

Land use in the Nenana/Healy area is generally of low intensity. Some agricultural lands occur immediately north of Healy. Mining activities occur in the Nenana vicinity and extensively in the Healy area. Communities located between Nenana and Healy include Anderson, Ferry, and Suntrana. Development is continuing in the Healy area. A major recreation area, the Denali National Park and Preserve, is located to the southwest of Healy. The U.S. Air Force Clear M.E.W.S. Military Reserve is located in the vicinity of Anderson. The majority of the land is in various stages of the state-selection process and is classified as selected, tentatively approved, or patented. Major transportation routes include the George Parks Highway and the Alaska National Railroad.

F.1.4.2.2 Willow

Residential use occurs in the Willow area and includes the Holstein Heights subdivision and scattered cabins along the George Parks Highway and Alaska Railroad. State and private recreation lands also occur in the area. Agricultural lands sales have occurred along the George Parks Highway in the Willow Subbasin area and include the Delta Island agricultural disposal located 5 mi (8 km) southwest of Willow. Little mining activity occurs within the area. Major transportation routes include the George Parks Highway and the Alaska Railroad.

F.1.4.2.3 Cook Inlet

Land use and ownership in the Cook Inlet area is diverse. Much of the region is relatively remote, and current land use is generally of low intensity. Dispersed recreation activities occur within the region. Natural resources being developed include oil, gas, coal, and timber. The City of Anchorage is the major metropolitan area located in the region and is described in Section F.1.4.1.3.

F.1.4.3 Combined Hydro-Thermal Generation Scenario

F.1.4.3.1 Chakachamna Lake

The Chakachamna Lake area is remote, and current land use is diverse and of low intensity. Recreational activities within the area are limited but increasing in popularity (Bechtel, 1983). Future land use will probably revolve around resource extraction, processing, and transportation. State land classification in the project area includes resource management lands and industrial lands. Resources in the area include oil, gas, coal, and timber. Industrial sites include the Kodiak Lumber docking facility at North Foreland and various sites operated by Texaco and Atlantic Richfield (Bechtel, 1983). The state has sold timber rights to Kodiak Lumber Mills, Inc. on 223,000 acres (90,245 ha) of land. A network of logging roads has been constructed to gain access to the timber. Several gas fields have been discovered onshore, and both gas and oil fields have been discovered offshore. State, Federal, and private lease sales have occurred. Two petroleum-related facilities, Marathon Oil Company oil and gas treatment plant and Drift River Petroleum Terminal, are located on the west side of Cook Inlet (Bechtel, 1983). The three major coal leases located in the area are the Capps lease area, the Chuitna lease area, and the Three Mile lease area; most of these areas would be open-pit mined.

Land ownership and management in the Chakachamna Lake area have not been made final. Large portions of Federal land holdings have been or are in the process of being transferred to the Alaskan Natives and the state; and, subsequently, some lands will be transferred to the Kenai Peninsula Borough. A few small parcels are privately owned, primarily along the coast (Bechtel, 1983). Federal lands in the area include the Lake Clark National Park, Lake Chakachamna power site, and a number of townships surrounding the power site. Most of the Bureau of Land Management lands are passively managed. State-owned lands are presently classified as resource management lands and industrial lands. The Trading Bay State Game Refuge is located in the alternative site area. The four major owners and managers of Native lands in the project area are the Cook Inlet Region, Inc.; Tyonek Native Corporation; Native Village of Tyonek; and individual Native allotments. Five private land holdings are known to occur in the project area (Bechtel, 1983).

F.1.4.3.2 Browne

The Browne site is located within the Alaska Railbelt near the vicinity of the communities of Healy, Suntrana, and Ferry. Land use is diverse and of low intensity. Dispersed recreation use occurs throughout the area. Extensive coal deposits and mining occur in the vicinity east of Healy. Major transportation routes in the area include the George Parks Highway and the Alaska National Railroad.

As is the case elsewhere in the state, land ownership and management is in a state of flux due to land transfers. The largest Federal land holding in the area is the Denali National Park and Preserve, managed by the U.S. Park Service. State, Native Alaskan, and borough lands are located at various points in the area. Private land holdings are generally concentrated in communities along the George Parks Highway and Alaska National Railroad. Land use, ownership, and management for this area are discussed further in Section F.1.2.2.

F.1.4.3.3 Keetna

Land use in the Keetna area is characterized by dispersed, low-intensity recreation and subsistence activities. The community of Talkeetna is located about 15 mi (24 km) west of the site. Land use east of Talkeetna is dominated by land disposals along the Talkeetna River. The closest land development, consisting of several homesteads at Parson Lake, is about 13 mi (21 km) southwest. Recreation activities in the Keetna area include boating, fishing, and off-road driving. Access within the site area is limited. The nearest major transportation routes are the George Parks Highway and the Alaska National Railroad, located approximately 15 mi (24 km) west of the area.

Land ownership and management are currently in a state of flux. Federally owned land occurs north of Talkeetna. The land on which the Alaska Railroad is located is also Federal property. Railroad land holdings exist in various locations along the Railbelt corridor, including east of Denali State Park. The largest state land holdings occur northwest of the Keetna site at Denali State Park. The Cook Inlet Region, Inc., has applied for the selection of state-owned lands in the Talkeetna area. Mat-Su Borough lands generally are around the George Parks Highway area. Private and leased lands occur south of Curry. Most of these private lands are located in the Montana and Trappers Creek area and east of Chase and Talkeetna. Land use, ownership, and management for this area are discussed further in Section F.1.2.2.

F.1.4.3.4 Snow

The Snow area is located within the Chugach National Forest. The forest is managed for multiple use. Intermittent land uses in the region include recreation, sport hunting and fishing, subsistence living, seasonal residences, and resource exploration (Selkregg, 1974). Communities include Moose Pass to the north and Seward about 20 mi (32 km) to the south. Major transportation routes in the area include the Alaska Highway and the Alaska National Railroad.

F.1.4.3.5 Johnson

Intermittent land uses in the Johnson area include recreation, sport hunting and fishing, subsistence living, seasonal residences, and resource exploration. Some rural settlements are located along the Tanana River east of the Johnson River confluence (Selkregg, 1977). The nearest community is Dot Lake, located about 15 mi (24 km) east of the Johnson site on the Alaska Highway. Some agricultural use also occurs in the area, with 25% to 50% of the upland soils suitable for farming.

F.1.4.3.6 Nenana, Chuitna River, and Anchorage

Land use and ownership patterns for the Nenana area are described in Section F.1.4.2.1. The Chuitna River and Anchorage land use and ownership patterns are described in Section F.1.4.1.

F.2 ENVIRONMENTAL IMPACTS

F.2.1 Proposed Project

F.2.1.1 Watana Development

F.2.1.1.1 Construction

The proposed construction of the Watana dam and associated power-generation and transmission facilities (e.g., substation); the impoundment area; the construction camp and village; and the permanent settlement would produce a significant change in the character and use of the land in the upper and middle Susitna River Basin area. The remote, highly inaccessible, largely undisturbed area would become one of greater human activity and development. Land that was used primarily for dispersed recreational activities, subsistence living, and small mining operations would become more highly developed for hydroelectric power generation and result in induced residential, commercial, recreation, and natural resource development.

Construction activities and the associated noise around the dam and reservoir project area would adversely affect those persons using the area for recreational and subsistence purposes. The proposed dam and reservoir would inundate approximately 36,000 acres (14,600 ha) of land within the Susitna River valley. The Watana impoundment would inundate six structures--a hunting lean-to, four cabins (two no longer in use), and a collapsed shack. The locations of these and other structures in the upper and middle Susitna River Basin area are shown in Figure F-2. The Watana construction camp and village would be located northeast of the dam site between Deadman and Tsusena creeks. The construction camp, temporary village, and airstrip would cover about 290 acres (120 ha) of wetlands. Facilities at the construction camp and village would consist of dormitories, a hospital, recreation facilities, administrative buildings, single and multifamily dwellings, schools, stores, a sewage treatment plant, and a landfill (Figs. F-5 and F-6). During the construction phase, increased human activity patterns in the area surrounding the camp and village would likely further disturb surrounding vegetation and increase pressures on wildlife and fisheries resources because of increased hunting and fishing. These impacts are discussed further in Appendices J, K, and L.

Construction of the Watana dam and its associated facilities would require the transfer of ownership of substantial areas of Federal, Native, and private lands to the state of Alaska. These transfers would occur either through actual purchase or through right-of-way easement for project lands. At present, the transfer of lands is a complex process because of the current land exchanges allowed under the Alaska Statehood Act of 1958, the Alaska Native Claims Act of 1971 and the Alaska National Interest Lands Conservation Act of 1981.

Current land management plans in the project area are limited. Land management is essentially passive with few definitive or comprehensive management plans or regulations specifically applicable to the project area. The Talkeetna Mountain Special Use District (managed by the Mat-Su Borough) would require permits for specified developments such as roads. Because of the lack of development and land exchanges occurring in the project area, land value data for project lands are also limited. Specific land values for required project lands have not been established. It is anticipated that land values would not be determined until the land acquisition process for the project is started.

F.2.1.1.2 Operation

The remote and natural character of the land in the upper and middle Susitna River Basin study area would continue to change during the operation of the Watana dam and the establishment of a permanent town. The permanent townsite, located to the north of the dam, would occupy about 90 acres (36 ha) of land. The town would consist of a central area with approximately 20 buildings, a hospital, 93 single and multifamily dwelling units by 1992 (125 units by the year 2001), a water and sewage treatment plant and a landfill. The location and facilities of the proposed town are shown in Figure F-6.

Much of the land in the Watana project area appears to have moderate to severe limitation to concentrated, high density, human development based on physical limitations such as slope, soil, drainage, soil land-bearing capacity, and other natural constraints (Exhibit E, Vol. 8). Settlement pressures could increase near the Watana damsite and permanent town as a result of the potential demand for increased recreation services (e.g., supply stores, outfitters). Increased human activity and development at the town and increased recreation activities on and surrounding the Watana reservoir would cause further fundamental changes in the land use in the area, degrading the vegetation and increasing the pressure on hunting and fishing resources in the upper and middle Susitna River Basin area.

The lands within the proposed project area are not conducive to farming activities, and no impacts to future agricultural development would be expected as a result of project operation. Timber resources could be affected. At present, these resources are virtually undisturbed and presently used only as a local fuel source and for building materials. Forest lands with the highest potential commercial value are located downstream from the confluence of Portage Creek, essentially within the Susitna River floodplain. The newly created road and rail access for the proposed Watana and Devil canyon projects would allow for easier access and exploitation of timber resources. Also, increased opportunities for mineral exploration and mining activities would result from increased access into the area and the availability of support services at the permanent Watana dam settlement. New mineral exploration and increased mining activities could cause additional development pressures at the Watana dam settlement for commercial and industrial support services associated with mineral exploration and mining activities. The actual level of resource development to occur in the upper and middle Susitna River Basin area as a result of project operation would depend on numerous factors, including the amount and type of access into the area, final land ownership and management patterns, resource market demands, labor supply, development constraints, and the actual quality and quantity of mineral resource found in the upper and middle Susitna River Basin area.

Land value data for the Watana project area are currently unavailable. This is primarily due to the on-going changes in land ownership and the current lack of development and use in the Susitna River valley area that would indicate or assign a land value to a specific piece of property. Although precise land values can not be ascertained for project lands, an indication of representative Alaskan land values is presented in Sections F.1.2.1.3 and F.1.2.2.3. In general,

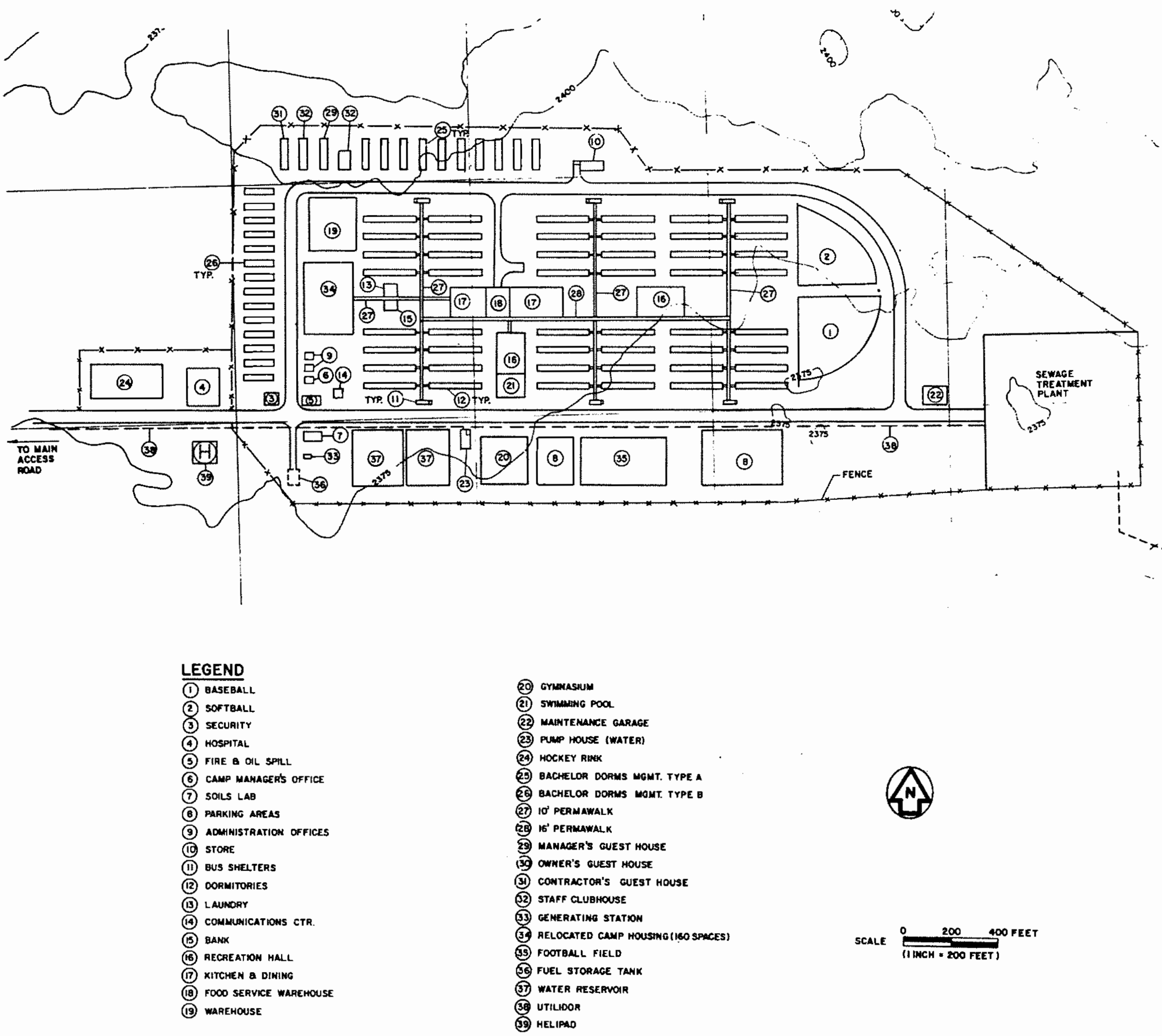

Figure F-5. Proposed Watana Construction Camp. [Source: Exhibit F, Vol. 3, Plate F36]

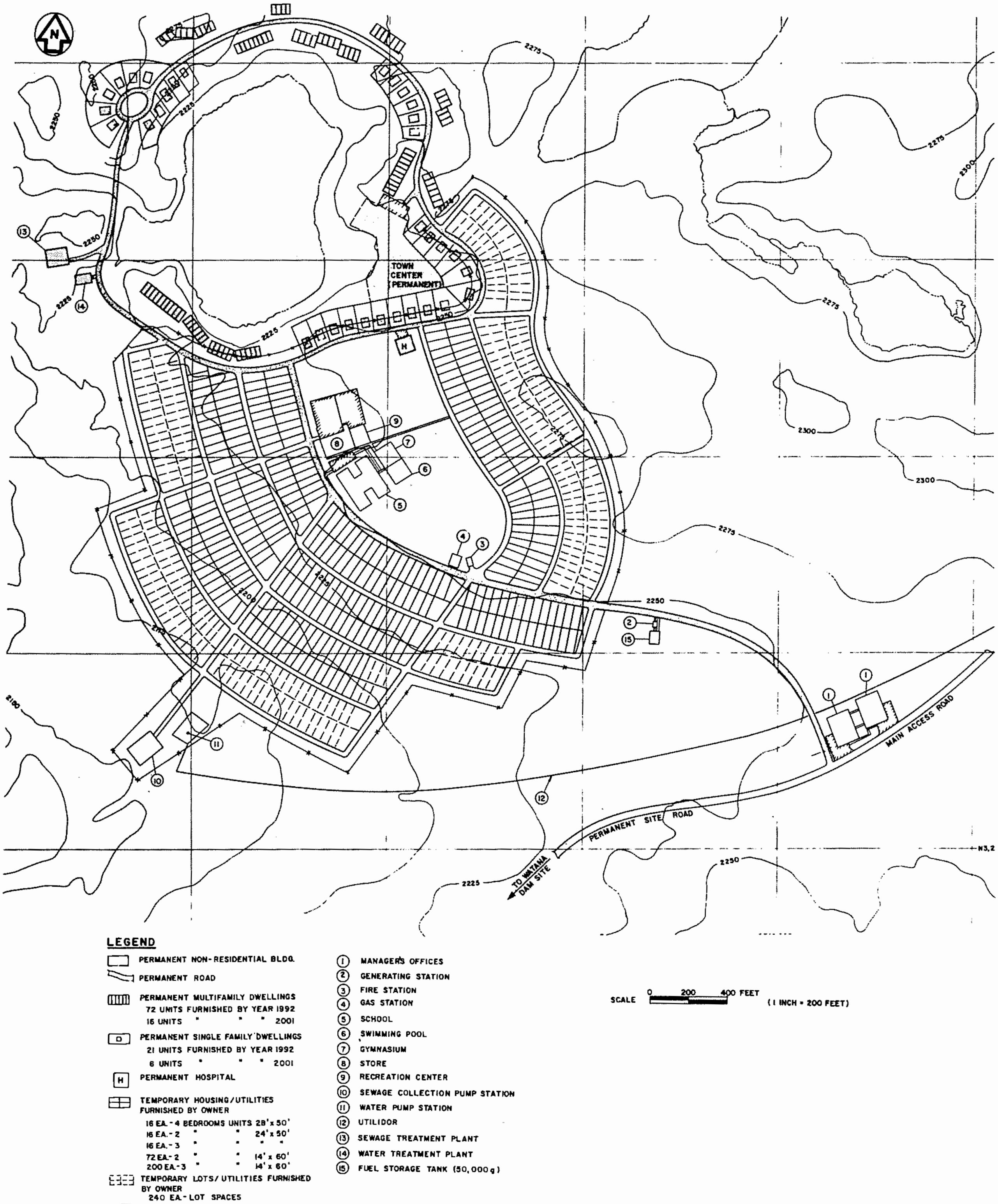

Figure F-6. Proposed Watana Construction Village and Permanent Town Facilities.
[Source: Exhibit F, Vol. 3, Plate F37]

land values in Alaska have greatly increased over the past 15 years, much as they have all over the United States. As a result of the Watana dam project, land values would probably increase for properties located near the permanent town, adjacent to the reservoir and access roads, along the Denali and George Parks Highways, and in the communities of Talkeetna, Cantwell, and Gold Creek. Future land values would depend in part on the supply of land made available by the major landowners, parcel size, location in relation to access, natural resources located on the property, and the planned type of development.

At present, no single comprehensive land management plan exists for the entire upper and middle Susitna River Basin area. Current land managers include the U.S. Bureau of Land Management (BLM), Alaska Department of Natural Resources (ADNR), the Matanuska-Susitna Borough and the Cook Inlet Region Inc. (CIRI). BLM lands within the Denali Planning Block Unit are essentially passively managed. BLM objectives to protect the natural environment, especially caribou calving areas and river recreation routes, could be adversely affected by increased recreation pressures around the Watana project area. Another BLM management objective, adequate fire control, could be affected by an influx of recreationists. BLM is developing a wildlife habitat management plan in cooperation with the Alaska Department of Fish and Game for the Alphabet Hills area between the Tyone and Maclaren Rivers. Since this plan is in an early development stage it cannot be determined if the plan would be adversely impacted by the Watana project.

At present, state-managed lands in the proposed Watana dam area are being passively managed. The Alaska DNR is preparing a resource assessment of state selected lands in the area (Exhibit E, Vol. 8). It is anticipated that the Watana project would have no significant impact on that assessment plan.

The Matanuska-Susitna Borough is involved in three management plans for the project area, including the Mat-Su Borough Comprehensive Plan, the Talkeetna Mountains Special Use District, and the Mat-Su Borough Coastal Management Program. The proposed Watana dam project should not adversely affect the management of borough lands as described in the Comprehensive Plan, since most of the planning effort concerns borough lands along the Parks Highway, outside of the Watana dam project area. In the Comprehensive Plan the project area is classed as a mixed-use zone, which would permit hydro development. However, the Mat-Su Borough has planning and zoning authority for all land within the district boundaries. The Talkeetna Mountain Special Use District also includes the project area. The ordinance that created the district provides for multiple resource use of the district, and lands are subject to permit requirements for specified developments, such as roads and subdivisions. The Watana dam area is not considered to be within the coastal zone management area and thus would not directly affect or be affected by the Coastal Management Plan. No known land management plans or activities are currently being administered by the Cook Inlet Region, Inc.

F.2.1.2 Devil Canyon Development

F.2.1.2.1 Construction

The construction of the proposed Devil Canyon dam and associated facilities, the impoundment area, and the construction camp and village would produce further changes in the use and character of land in the upper and middle Susitna River Basin area. As would be the case for the Watana Site, the remote, highly inaccessible, and largely undisturbed Devil Canyon area would be subjected to greater human activity and development. Land that is now used primarily for dispersed recreation activities (e.g., hiking, hunting, and fishing), subsistence living, and small mining operations would be converted to a highly developed area for generation of hydroelectric power. Recreation and natural resource development in the area would also increase.

Development of the 32-mi (53-km) long reservoir with an impoundment area of 7,900 acres (3,200 ha) would not inundate any existing structures. However, construction activities and the noise around the project area could adversely affect those persons using the area for recreation, subsistence living, and trapping purposes. The Devil Canyon construction camp and village would be located to the south of the damsite on approximately 185 ac (75 ha) of land. The temporary construction camp and village facilities would consist of various structures, including dormitories, a hospital, recreation facilities, warehouse, administrative buildings, single and multi-family dwellings, a school, a store, a sewage treatment plant, and a landfill (Figs. F-7 and F-8). The increased human activity in the area surrounding the camp and village, could degrade surrounding vegetation and would increase pressures on hunting and fishing. However, no permanent town is to be located in the Devil Canyon dam area, and removal of the camp and village upon the completion of the construction project would eliminate this particular source of pressure on recreational activities and natural resources in the area.

The construction of the Devil Canyon dam and associated facilities would require the transfer of ownership or control of substantial areas of Federal, Native, and private land to the state. As previously discussed, land transfers would occur either by actual purchase or by acquiring right-of-way easements for project lands. Relationships between construction impacts and management plans and land values are similar to those discussed in Section F.2.1.1.

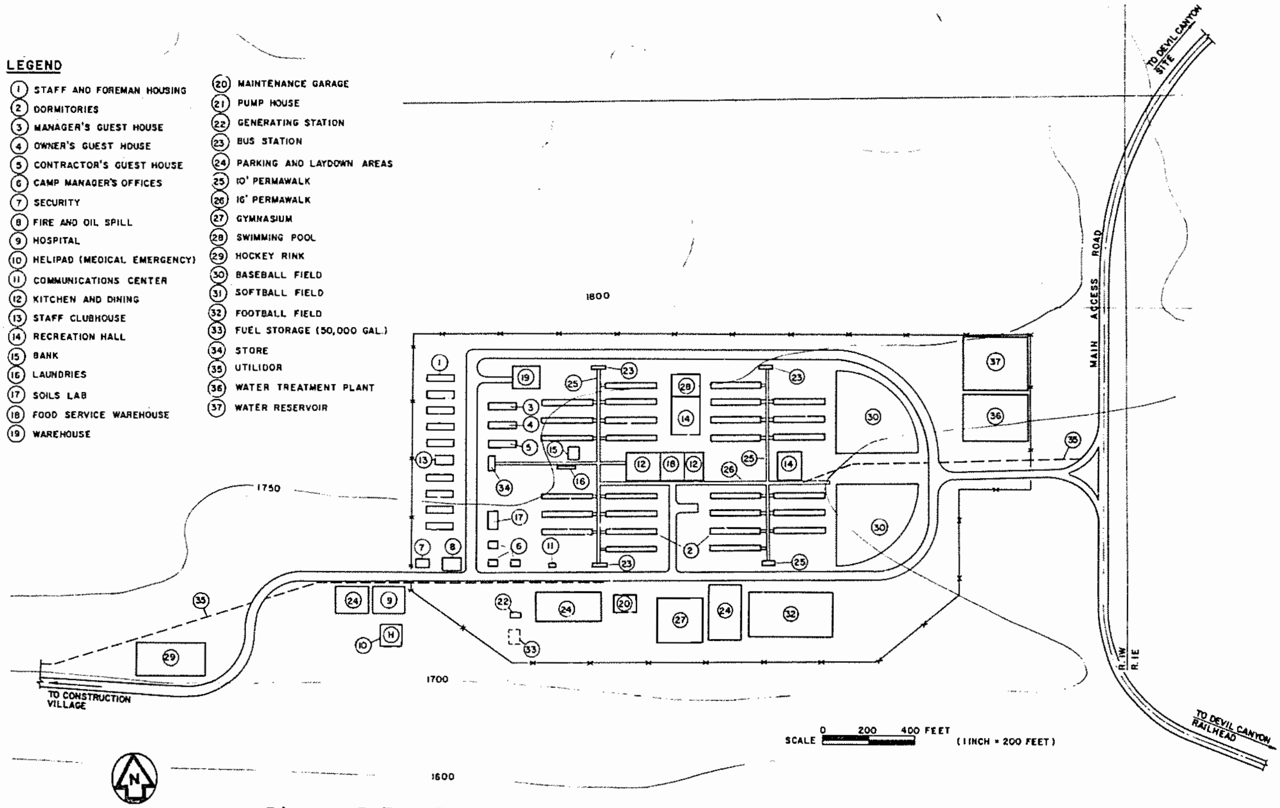

Figure F-7. Proposed Devil Canyon Construction Camp.
[Source: Exhibit F, Vol. 3, Plate F72]

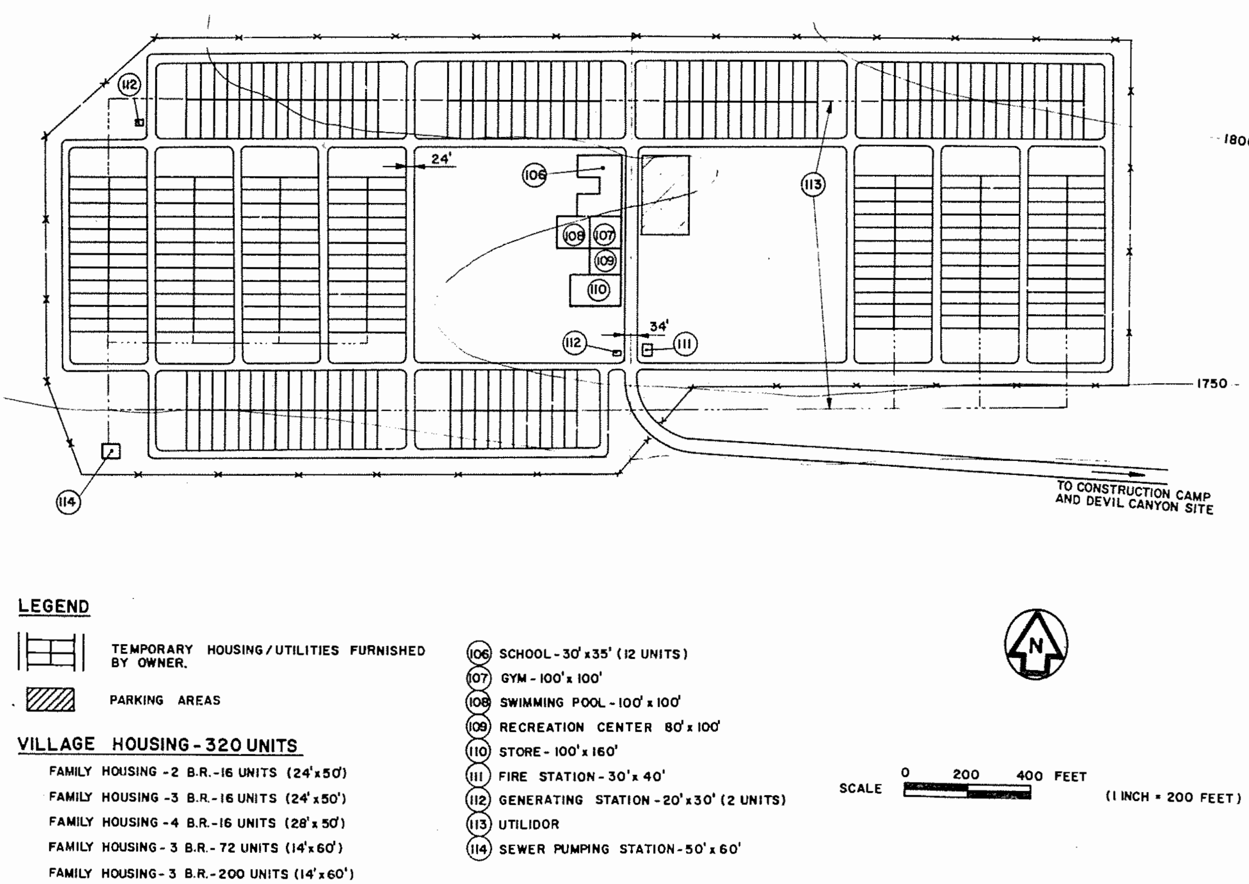

Figure F-8. Proposed Devil Canyon Construction Village.
[Source: Exhibit F, Vol. 3, Plate F73]

F.2.1.2.2 Operation

The remote and natural character of the land in the Devil Canyon area would continue to be altered with the operation of the Devil Canyon dam, the inundation of the Devil Canyon Rapids, and the opening of the visitor center at the dam. Increased human activities around the dam and reservoir would place increased pressure on hunting and fishing activities in the Susitna River region. The development of the Devil Canyon area also would increase the likelihood of natural resource exploration and development in the area. The potential impact of such development is discussed in Section F.2.1.1.

Like the Watana dam project area, much of the land in the Devil Canyon project area appears to have moderate to severe building limitations to accommodate concentrated, high-density human development (Exhibit E, Vol. 8). However, settlement pressures could increase near the Devil Canyon dam and reservoir area as a result of the potential demand for increased recreation services.

As discussed previously land-value data for the upper and middle Susitna Basin area are currently not available. Although specific future land values can not be determined, it is anticipated that land values would tend to increase around the Devil Canyon reservoir area. The assumptions and factors concerning increased land values are discussed in Section F.2.1.1.

At present, no single comprehensive land management plan currently exists for the entire upper and middle Susitna River Basin study area. Current land management plans that could be impacted by the Devil Canyon project are the same as discussed in Section F.2.1.1 for the Watana development.

F.2.1.3 Access Routes

Transport of materials, equipment, and personnel needed to construct the various Susitna project facilities would necessitate the construction of access roads from Denali Highway to the Watana dam site and from Watana to the Devil Canyon dam site, as well as a rail spur from Gold Creek to the Devil Canyon site.

Construction of these access facilities would contribute to significantly changing the use and character of the land in the upper and middle Susitna River Basin. For the first time, the highly inaccessible, remote, and largely undisturbed Susitna River area would become accessible by automobiles, trucks, and heavy equipment vehicles. Land that is now used primarily for dispersed recreation, subsistence living, and small mining operations would be made accessible for large-scale hydropower development and its various associated facilities. Construction activities and the associated noise created while the access routes were being built would adversely affect those persons using the areas for recreation and trapping. The construction of the access roads and the rail spur would result in the destruction of vegetation, slumping, and erosion of soils during the construction period.

Construction of the access facilities would require the transfer of ownership or control of Federal, Native, and private land to the state of Alaska. These transfers would occur either through actual purchases or right-of-way easements. As previously discussed, the transfer of land in Alaska is a complex issue because of the current land exchanges allowed under various Federal acts. Most of the significant changes in land use patterns that would result from construction of the access facilities would continue during the operational period of the project and for as long thereafter as the access routes were open and usable. Previously remote areas in the vicinity of the Watana and Devil Creek developments would be accessible for recreation, mineral exploration, harvesting of timber, and settlement. Although these changes could be of positive commercial value, all would produce increased pressure on, and in many cases degradation of, the natural resources of the basin because of unwanted development, conflictive land uses, and unlimited off-road access. At present, no single comprehensive land management plan exists for the entire upper and middle Susitna River Basin area to regulate uncontrolled access. Increased accessibility could also be expected to increase land values in the opened areas. Site-specific impacts of these access facilities are discussed in more detail below.

F.2.1.3.1 Denali Highway-to-Watana Route

The proposed 40-mi (67-km) gravel access road between the Denali Highway and the Watana site would require about 630 acres (255 ha) of land. Pullouts and trailheads would be constructed along the route to permit viewing and access into the interior region of the basin. The new gravel road would provide access to the permanent townsite located near Watana dam, as well as access to CIRI and village corporation lands. The Alaska Natives have expressed interest in the development of their lands for recreation, mining, and timber activities (Exhibit E, Vol. 8).

F.2.1.3.2 Watana-to-Devil Canyon Route

The proposed 37-mi (60-km) Watana to Devil Canyon route would require approximately 400 acres (160 ha) of land. A high-level suspension bridge would extend across the Susitna River below the damsite and connect the access road with the terminus of the rail spur from Gold Creek.

The access road would alter the current recreational land use pattern surrounding High Lake Lodge. Outdoor recreational vehicle use would increase and contribute to hunting and fishing pressures as well as the degradation of vegetation in the area. Although no permanent town is planned for the Devil Canyon area, increased commercial development may occur in response to the number of persons visiting the dam facilities and the proposed visitor center or pursuing recreation opportunities in the area. Improved access to the mining areas along Portage and Gold creeks might also improve the economic feasibility of mineral exploration and mining.

F.2.1.3.3 Rail Access-to-Devil Canyon

The proposed 12-mi (20-km) rail extension from Gold Creek to the Devil Canyon site would require about 72 acres (29 ha) of land. Rail access would allow for the transportation of construction materials, equipment, and personnel to the Devil Canyon damsite. Increased development would occur in and surrounding the Gold Creek area, which would be a staging area for items to be transported for construction of Devil Canyon dam and its support facilities. Land development and future land values along the railspur would depend on whether public use of the rail facility is allowed.

F.2.1.4 Power Transmission Facilities

As is the case for other project-related features, construction of the various power transmission facilities would contribute to significant changes in the use and character of the land. In many cases, land that now is used primarily for dispersed low-density activities, such as recreation and small mining operations, would be cleared for the transmission line right-of-way. Adjacent areas also might be made more accessible. In some cases, the lines would extend through developed areas. The construction and mere presence of the line could also affect adjacent land uses.

Construction activities and the associated noise created during clearing of the transmission line rights-of-way, construction of tower structures, and stringing of transmission lines could adversely affect nearby residents or recreationists. The construction of the transmission lines would require the transfer of ownership or control of Federal, Native, and private lands to the state of Alaska. These transfers would occur either through actual right-of-way purchase or easements of project lands.

A minimum standard access road would be created along the entire length of the transmission line route for maintenance purposes. Routine maintenance activities should not adversely impact surrounding land uses. However, float plane flight patterns could be adversely affected where the transmission line extended near lakes used for takeoffs and landings.

Because of the present low-intensity use and undetermined land values along much of the proposed transmission line route, it is not anticipated that there would be significant impact to adjacent land values along most of the route. However, the resale value of land might be limited for residential or recreational lands located adjacent to the transmission line route.

Information on specific segments of the transmission line system is provided in the following sections.

F.2.1.4.1 Dams-to-Gold Creek Segment

The proposed 45-mi (72-km) long Dams-to-Gold Creek transmission line segment would require a 300-ft (90-m) right-of-way between the Watana and Devil Canyon dams and a 510-ft (155-km) right-of-way from Devil Canyon Dam to Gold Creek. Total right-of-way requirements would be 1,500 acres (600 ha) of land.

The new right-of-way within the remote and natural area of the upper and middle Susitna River basin would allow increased recreational access into the area, affecting hunting, fishing, trapping, and other recreational activities. However, because of the remote location and low intensity of land use, values of land adjacent to the right-of-way are not expected to be adversely affected by the transmission line. Float plane takeoff and landing activities in the High Lake area could be adversely impacted due to the proximity of the proposed transmission lines.

F.2.1.4.2 Gold Creek-to-Fairbanks Segment

The 185-mi (300-km) transmission line segment between Gold Creek and Fairbanks would occupy a 300-ft (90-m) right-of-way. However, between Gold Creek and the Healy substation, the transmission line would parallel the 110-ft (34-m) wide Anchorage-Fairbanks Transmission Intertie for approximately 95 mi (145 km) and require only 190 ft (58 m) of new right-of-way. Only incremental impacts on land use would be expected because of the existence of the Intertie Transmission Line. From the Healy Substation to the terminus at the Ester Substation, a new 300-ft (90-m) transmission line right-of-way would be necessary. Total right-of-way requirements between Gold Creek and Fairbanks would be approximately 5,500 acres (2,200 ha) of land.

Land use conflicts could occur in the communities of Cantwell, Healy, Nenana, and Ester, and in other more sparsely settled residential areas adjacent to the transmission line, such as Lignite, Ferry, Browne, and other small residential areas along the George Parks Highway and Alaska National Railroad. Approximately 12.5 mi (20 km) of existing or proposed agricultural sale lands would be traversed by the transmission line corridor between Gold Creek and Fairbanks (Exhibit E, Suppl. Information, Sec. 9, Item 7). These lands are located at the Goldstream, Windy, and Healy agricultural disposal site areas. Total land acreage impacted due to construction, tower placement, and access requirements would depend on the amount of land actually developed for agricultural use, final right-of-way alignment (e.g., along fence lines or access fields), and type of agricultural use (e.g., pasture or row crops). However, it is anticipated that the total amount of potential farmland that would be required for tower placement would be minimal [6 to 11 acres (2-4 ha)]. The Healy-to-Fairbanks segment also would extend across about 10 mi (16 km) the U.S. Air Force Clear M.E.W.S. Military Reserve near Anderson. The proposed transmission line and cleared right-of-way could potentially affect existing and planned military activities and security. Land use conflicts also could occur where sections of the northern transmission line segment would extend across land that has been designated for village selection within the boundaries of Doyon, Ltd. Depending on final alignment of the proposed transmission lines, takeoffs and landings at landing strips and float plane sites could be adversely affected near Nenana, Healy, Cantwell, and Gold Creek.

F.2.1.4.3 Gold Creek-to-Anchorage Segment

The 145-mi (233-km) power transmission line segment between Gold Creek and Anchorage would be on a 400-ft (120-m) right-of-way. Between Gold Creek and the Willow substation the transmission line would parallel the Anchorage-Fairbanks Transmission Intertie for about 75 mi (120 km) and require only 290 ft (88 m) of the 400-ft (122-m) right-of-way. Because of the existence of the Intertie Transmission Line, only incremental impacts to land use would be expected. From the Willow substation to the terminus at Anchorage, a new 400-ft (122-m) transmission line right-of-way would be necessary. Total right-of-way requirements between Gold Creek and Anchorage would be about 4,700 acres (1,900 ha) of land.

Land use conflicts could occur in areas of moderate concentrations of residential development, such as in the communities of Talkeetna, Willow, and Anchorage, and in other residential areas adjacent to the transmission line. Depending on final transmission line alignment, up to 16.5 mi (26.5 km) of potential agricultural land between Gold Creek and Anchorage could be traversed by the transmission line at the Goose Creek Agricultural disposal, Fish Creek Management Unit, and Point MacKenzie Agricultural Sale (Exhibit E, Suppl. Information, Sec. 9, Item 7). However, the maximum amount of potential farmland to be used for tower placement would be minimal [9 to 15 acres (4-6 ha)]. The route would extend across 5 mi (8 km) of the northeast corner of the Susitna Flats State Game Refuge. Potential impacts to the refuge are discussed in Appendix K. About 18 mi (29 km) of the transmission line would extend across the Fort Richardson Military Reserve and could adversely affect training maneuvers and base security. The proposed line would also extend near the Elmendorf Air Force Base lands near Anchorage. The transmission line locations, design, and tower height could adversely affect flight activities, communications, and base security. Also, depending on final transmission line alignment, takeoffs and landings could be adversely affected at landing strip and float plane landing sites near Gold Creek, Curry, Willow, and south of Willow. Land use conflicts also could occur where sections of the transmission line corridor extented across lands owned by CIRI. The proposed transmission line would cross or parallel numerous trails, including the Iditarod Trail, seismic survey lines, tractor and pioneering ORV trails, and several recreation trails near Willow.

F.2.2 Susitna Development Alternatives

F.2.2.1 Alternative Dam Locations and Designs

The construction and operation of the alternatives involving the Watana I, Reregulating, and Modified High Devil Canyon dams would result in essentially the same type of land use impacts discussed in Section F.2.1.1 and F.2.1.2. The Modified High Devil Canyon dam would inundate approximately 6,800 acres (2,750 ha) of land. The Watana I and Reregulating dams would inundate 28,300 acres (11,450 ha) and 4,000 acres (1,600 ha), respectively. The remote, highly inaccessible, largely undisturbed upper and middle Susitna River Basin would become one of greater human activity and development as a result of the construction and operation of hydroelectric power generation facilities and associated induced residential, commercial, recreation, and natural resource developments.

F.2.2.2 Alternative Access Routes

In a similar fashion as the proposed access route, the northern and southern alternative access routes would make the highly inaccessible and remote Susitna River area accessible by automobiles, trucks, and heavy equipment vehicles. Land that is now used primarily for dispersed recreation, subsistence living, and small mining operations would be made accessible for large-scale hydropower facilities and associated development. The 48-mi (77-km) northern access route (corridor 1) would impact lands along the north side of the Susitna River from Hurricane (along the George Parks Highway) to the Watana damsite and along a 7-mi (11-km) road spur to the Devil Canyon damsite. The northern access route would require about 810 acres (330 ha) of land. The southern access route alternative (corridor 2) would impact 12 mi (19 km) of land along the south side of the Susitna River (rail spur between Gold Creek and the Devil Canyon damsite) and another 35 mi (56 km) of lands between the Devil Canyon and Watana damsites. The southern access route would also include a 20 mi (32 km) access road between the Devil Canyon damsite and Hurricane located along the George Parks Highway. The southern access route would require about 980 acres (400 ha) of land.

F.2.2.3 Alternative Power Transmission Routes

In general, the construction and operation of the alternative power transmission route segments would result in the same types of land use impacts discussed in Section F.2.1.4. Total land area required would vary depending on the segment configuration of the transmission line. Approximate acreages required and potential land use impacts for the alternative segments are shown in Table F-8.

F.2.2.4 Alternative Borrow Sites

All the alternative borrow sites are located within the upper and middle Susitna River Basin. Land use impacts associated with the alternative borrow site areas are discussed in Sections F.2.1.1 and F.2.1.2. Borrow sites located completely within the proposed areas of inundation for Watana and Devil Canyon dams would have no long-term impacts to surrounding land use. Two borrow areas located along Tsusena Creek (Site C) and adjacent to Fog Creek (Site H) would require the construction of extensive haul roads, which could potentially impact future adjacent land use.

F.2.3 Non-Susitna Generation Alternatives

F.2.3.1 Natural-Gas-Fired Generation Scenario

Each of the 200-MW combined cycle units and 70-MW combustion turbines for the natural gas-fired generation scenario would require a 5-acre (2-ha) site. Therefore, a total of only 50 acres (20 ha) of land would be needed for the ten combined-cycle and combustion-turbine units. In addition, right-of-way would be required for gas pipeline spurs and power transmission lines to the plant. Depending on final plant sitings, significant land use impacts could occur if extended access or transmission line routes would be required to the alternative sites or if the site locations were adjacent to an existing land use that was not considered to be compatible with an industrial use (e.g., dispersed recreation or residential area). It is estimated that over 9,000 acres (3,600 ha) of land would be required for transmission line facilities. The land requirements and major regional land uses that would be affected by the natural gas-fired generation scenario are shown in Table F-9.

F.2.3.2 Coal-Fired Generation Scenario

The construction and operation of coal-fired generation plants could produce significant land use impacts at all the alternative sites. Approximately 200 to 300 acres (80 to 120 ha) would be needed for the plant and associated structures, coal unloading facilities, and coal storage piles; and an additional 1.5 acres (0.6 ha) of land per year would be required for waste disposal. In addition, it is estimated that to supply coal for a 200-MW coal-fired power plant unit would require strip mining 450 acres (180-ha) of land over the 30-year life of the plant.

The five 200-MW coal-fired units (located at Nenana and Willow) and the ten 70-MW gas combustion turbines for the coal-fired generation scenario would require a total of 600 acres (240 ha) for plant site facilities, 225 acres (90 ha) of land for waste disposal sites, and about 2,250 acres (910 ha) of land for surface coal mining operations during the 30-year operating life of the facilities. Similar to the natural-gas-fired generation scenario, additional impacts could result from additional land requirements for pipeline and transmission line right-of-way extending from the plant sites to existing utility corridors. Also, it is estimated that more than 9,000 acres (3,600 ha) of land would be required for transmission line right-of-way. The land

Table F-8. Land Requirements and Potential Conflictive Uses Along the Alternative Power Transmission Routes

Segment	Length (mi)	Acreage Required†[1]	Potential Conflictive Land Use Impact
Northern Study Area (Fairbanks-to-Healy)			
1. ABC (Proposed)	90	3,300	Minimal conflictive use
2. ABDC	86	3,200	Natural areas
3. AEDC	115	4,200	Natural areas
4. AEF	105	3,800	Active bombing range
Central Study Area (Upper and Middle Susitna River Basin)			
1. ABCD	40	1,700	Extensive Native Village selection and private lands
2. ABECD	45	1,900	Residential and recreational use near Stephan Lake
3. AJCF	81	1,300	Recreational use at High and Otter lakes
4. ABCJHI	77	4,100	Recreational land use near High Lake
5. ABECJHI	82	4,300	Recreational land use near High Lake and Stephan Lake
6. CBAHI	68	3,500	New access would be required; impacts to natural area and recreation lands
7. CEBAHI	73	3,700	Residential and recreational facilities near Stephan Lake
8. CBAG	90	4,700	Recreational use; float plane and land based air strips
9. CEBAG	95	5,100	Recreational use near Stephan Lake
10. CJAG	86	4,700	Recreational use
11. CJAHI	69	3,500	Recreational use; natural areas
12. JA-CJHI	70	3,600	Extensive Native Village selection and private lands
13. ABCF	41	1,500	Recreational use near Otter Lake
14. AJCD (Proposed)	41	1,500	Recreational use near High Lake
15. ABECF	45	1,800	Recreational use at Stephan, High, and Otter lakes
Southern Study Area (Willow-to-Anchorage)			
1. ABC'	73	3,600	Extensive developed areas between Eklutna and Anchorage; military lands
2. ADFC (Proposed)	38	2,000	Planned agricultural sales; Susitna Flats Game Refuge; residential areas
3. AEFC	39	1,900	Residential development; Nancy Lake Recreation Area

†[1] Based on 36.4 acres/mile for 300-ft right-of-way, 48.5 acres/mile for 400-ft right-of-way, and 61.8 acres/mile for 510-ft right-of-way.

Conversion: To convert miles to kilometers, multiply by 1.61; to convert acres to hectares, multiply by 0.405; to convert feet to meters, multiply by 0.305.

Table F-9. Land Requirements and Major Regional Land Use Affected by the Natural-Gas-Fired Generation Scenario

Alternative Site Location	Plant Type†[1]	Number of Units	Acreage Required†[2]	Major Regional Land Use
Lower Beluga River	Combined-cycle	2	10	Recreation/natural resource
Chuitna River	Combined-cycle	3	15	Recreation/natural resource
Kenai	Combined-cycle	2	10	Recreation
Southeast of Anchorage	Combined-cycle	1	5	Recreation
Anchorage	Combustion-turbine	2	10	Residential/commercial/industrial
TOTAL			50	

†[1] Combined-cycle units would be 200 MW each; combustion-turbine units would be 70 MW.

†[2] Does not include land and easement requirements for access routes, pipeline right-of-way, and transmission line right-of-way.

Conversion: To convert acres to hectares, multiply by 0.405.

Table F-10. Land Requirements and Major Regional Land Use Affected by the Coal-Fired Generation Scenario

Alternative Site Locations	Plant Type†[1]	Number of Units	Acreage Required†[2] Permanent: Plant Facilities	Acreage Required†[2] Temporary: Solid Waste Disposal†[3]	Acreage Required†[2] Temporary: Surface Mining†[3]	Major Regional Land Use
Willow	Coal unit	2	250	90	900	Residential/recreation
Nenana	Coal unit	3	300	135	1,350	Residential/recreation
Tyonek/Beluga area	Combustion-turbine gas	6-7	30-35	0	0	Recreation/natural resources
Anchorage	Combustion-turbine gas	2	10	0	0	Residential/commercial/industrial
Kenai	Combustion-turbine gas	1-2	5-10	0	0	Recreation
TOTAL			595-605	225	2,250	

†[1] Combustion-turbine units would be 70 MW each; coal units would be 200 MW each.

†[2] Does not include land and easement requirements for access routes, pipeline right-of-way, and transmission line right-of-way.

†[3] Assumes 30-yr operating life of each unit.

Conversion: To convert acres to hectares, multiply by 0.405.

requirements and major regional land uses that would be impacted by the coal-fired generation scenario are shown in Table F-10.

F.2.3.3 Combined Hydro-Thermal Generation Scenario

In general, the types of land use impacts that would be incurred at the alternative dam sites would be similar to those described in Section F.2.1. The hydro portion of the combined hydro-thermal alternative would inundate about 102,000 acres (41,300 ha) of land, not including lands required for access routes, power transmission right-of-ways, borrow areas, or support facilities (e.g., construction camp sites). The Browne alternative would inundate 10,640 acres (4,310 ha) and cause significant land use impacts by inundating portions of the existing George Parks Highway and Alaska Railroad. The Johnson site would result in substantial acreage [84,000 acres (33,990 ha)] being inundated, including a portion of the Alaska Highway (Route 2) and an oil products pipeline. Land use impacts would be minimal at the Chakachamna site since no dam and associated reservoir would be required. Land use impacts in relation to the thermal (coal and gas) portion of the combined hydro-thermal alternative were discussed in Sections F.2.3.1 and F.2.3.2. The land requirements and major regional land uses that would be impacted by the combined hydro-thermal generation scenario are shown in Table F-11.

F.2.4 Comparison of Alternatives

F.2.4.1 Susitna Development Alternatives

The construction and operation of the in-basin dam alternatives would result in the same type of land use impacts discussed for the proposed project in Section F.2.1. All the alternative dam sites would change the character and use of the land in the upper and middle Susitna River Basin from a remote and largely undisturbed area to one of greater human activity and development.

The alternative access routes would affect the level of land use development in different areas of the upper and middle Susitna River Basin. The northern access route would promote greater land use activity and development along the north side of the Susitna River between Hurricane and the Devil Canyon and Watana damsites, whereas the southern access route would promote land use development along the south side of the Susitna River between Gold Creek and the damsites and from the Devil Canyon damsite north to Hurricane located on the George Parks Highway. The proposed access route would promote development from along the Denali Highway to the damsites and from the Devil Canyon damsite to Gold Creek.

Concerning the alternative power transmission routes, in the northern corridor area (Healy-to-Fairbanks), alternatives ABC and ABDC would impact lands along the George Parks Highway between Healy and Browne and also would extend across a portion of the U.S. Air Force CLEAR military reservation lands. The alternative route ABC would again extend near lands along the George Parks Highway north of Goldstream Creek to the Ester substation, while alternative route ABDC would extend through a more isolated area to the east of the highway. Alternatives AEF and AEDC would impact lands along Healy Creek, the Wood River, and the open flatland area south of Fairbanks. In addition, alternative AEF would extend across the Blair Lake Air Force active bombing range and Fort Wainwright Military Reservation.

In general, the alternative transmission routes in the central corridor area (Upper and Middle Susitna River Basin) that extend from the proposed dam site areas north towards the Denali Highway or the George Parks Highway in the Broad Pass Area would produce greater land use impacts than those route segments extending in an easterly direction toward Gold Creek. This is primarily due to the greater land acreage required, and extending through an essentially natural area proposed for recreation development. In addition, segment AB would parallel the scenic Denali Highway area for about 23 mi (37 km), which is used by recreationists for scenic road touring.

In the southern corridor area (Willow-to-Anchorage), alternative route ABC' would impact lands along the Little Susitna River Valley, around the community of Palmer, and along the Glenn Highway to Anchorage. Alternative ADFC would impact residential and recreational areas in the Red Shirt Lake region, and Alternative AEFC would impact lands along the eastern edge of the Nancy Lake State Recreation area. All of the transmission line segments mentioned above would result in greater impacts to land use than the proposed transmission line route.

Most of the borrow sites would produce land use impacts similar to those discussed in Section F.2.1. Only borrow sites C and H near Tsusena and Fog Creeks would require extensive haul roads that might cause unwanted access or development.

F.2.4.2 Power Generation Scenarios

A comparison of land acreages required and the major regional land use affected by the alternative power generation scenarios is presented in Table F-12. The comparison indicates that the natural-gas-fired generation scenario would require the least amount of land and would have

Table F-11. Land Requirements and Major Regional Land Use Affected by the Combined Hydro-Thermal Generation Scenario

Alternative Site Location	Plant Type†[1]	Number of Units	Acreage Required†[2] With Chakachamna	Acreage Required†[2] Without Chakachamna	Major Regional Land Use
Johnson	Hydro (dam and impoundment)	-	84,000†[3]	84,000†[3]	Recreation
Keetna	Hydro (dam and impoundment)	-	4,800†[3]	4,800†[3]	Recreation
Snow	Hydro (dam and impoundment)	-	2,600†[3]	2,600†[3]	Recreation
Browne	Hydro (dam and impoundment)	-	10,640†[3]	10,640†[3]	Recreation
Lake Chakachamna	Hydro (lake tap)	-	Negligible†[3]	0	Recreation
Nenana	Coal unit	1	695†[4]	695†[4]	Recreation/Residential
Chuitna River	Combined-cycle gas	2	10	10	Recreation/Natural Resource
Anchorage	Combustion-turbine gas	3	15	15	Residential/Commercial/Industrial
Lower Beluga River	Combined-cycle gas	1 or 2†[5]	5	10	Recreation/Natural Resource
TOTAL			102,765	102,770	

†[1] Combined-cycle and coal units would be 200 MW each, combustion-turbine units would be 70 MW each; hydro units would vary.

†[2] Does not include land and easement requirements for access routes, pipeline right-of-way, and transmission line right-of-way.

†[3] Acreages are estimates only of area to be inundated. Land area required for support facilities (e.g., construction camp, airstrip, etc.) is not included.

†[4] Includes 200 acres for plant facilities, 45 acres for solid waste disposal, and 450 acres for surface mining over the 30-year operating life of the unit.

†[5] One unit with Chakachamna and two units without Chakachamna.

Conversion: To convert acres to hectares, multiply by 0.405.

Table F-12. Comparison of Land Requirements and Major Regional Land Uses Affected by the Power Generation Scenarios

Scenario	Acreage Requirements: Dams, Impoundments†[1], Construction of Permanent Facilities	Access	Temporary Facilities, Borrow Areas, Waste Disposal, Mining†[2]	Transmission Facilities†[3]	Total	Potential Land Use Affected†[4]
Proposed Susitna Project						
Watana-Devil Canyon	44,900	1,100	6,400	11,700	64,100	A,C
Alternative Susitna Developments						
Watana I-Devil Canyon	36,200	1,100	6,400	11,700	55,400	A,C
Watana I-Reregulating dam	32,300	1,100	6,400	11,700	51,500	A,C
Watana I-Modified High Devil Canyon	35,100	1,100	6,400	11,700	54,300	A,C
Natural Gas-Fired	50	U.D.†[5]	N.A.†[6]	9,000+†[7]	9,050+	A,C
Coal-Fired	600	U.D.	2,475	9,000+	12,075+	A,B,C
Combined Hydro-Thermal						
Johnson, Keetna, Snow, Browne, Chakachamna	102,040	U.D.	U.D.	13,600	115,640+	A,C
Thermal units	230	U.D.	495	200+	925+	A,B,C
Total	102,270	U.D.	495+	13,800+	114,340+	
Johnson, Keetna, Snow, Browne	102,040	U.D.	U.D.	12,300	114,340+	A,C
Thermal Units	235	U.D.	495	200+	930+	A,B,C
Total	102,275	U.D.	495+	12,500+	115,270+	

†[1] Total area inundated.

†[2] The use of the word temporary implies that the area would eventually be rehabilitated.

†[3] For natural-gas-fired, coal-fired, and combined hydro-thermal scenarios, assumes (1) construction of two 345-kV lines from Willow to Anchorage and from Healy to Fairbanks and (2) upgrading of existing Intertie between Healy and Willow to two 345-kV lines as well as construction of lines described in Sections 2.3.3 and 2.5.3 to the various dam sites and thermal units.

†[4] Land Use designations: A = Recreation, B = Residential, C = Natural setting.

†[5] U.D. = Undetermined.

†[6] N.A. = Not applicable.

†[7] "+" indicates an additional undeterminable acreage; these amounts would likely be higher for hydro sites than for thermal sites because of greater constraints on siting.

Conversion: To convert acres to hectares, multiply by 0.405.

fewer direct land use impacts to surrounding areas than the other scenarios. The combined hydro-thermal generation scenario would require the greatest amount of acreage for project facilities. In particular, the Browne site would significantly impact transportation and utility corridors by inundating portions of the George Parks Highway and Alaska Railroad, while the Johnson site would inundate portions of the Alaska Highway and a petroleum products pipeline. Although the coal generation scenario would require significantly less acreage than the combined-hydro-thermal alternative, coal-fired plant locations at Nenana and Willow could adversely affect surrounding recreational and residential lands.

F.3 MITIGATION

F.3.1 Mitigative Measures Proposed by the Applicant

The land use mitigation measures proposed by the applicant were developed in relation to the various proposed project facilities and are described in Appendix E (Vol. 8, Chap. 9). These mitigative strategies include the following.

F.3.1.1 Dams and Impoundment Areas

The land management plans developed with the cooperation of jurisdictional agencies would include control of land use activities and would be implemented upon operation of the facilities. The plans would direct land use activities for the reduction of the impact on the game, fish, and furbearers resulting from increased land use activity.

F.3.1.2 Construction Camps and Villages

Proposed development focuses recreational activities on core recreational facilities and indirectly diverts the users away from sensitive environmental areas outside the project area. Impacts from human use could be reduced if trails outside the proposed camps are established and if specific areas are designed for leisure activity. Land use activities could also be confined to project construction areas to discourage increased hunting, fishing and trapping in the project area.

Posting and enforcing construction camp rules would help make project personnel aware of adverse environmental impacts. Other mitigation measures to reduce increased land use development of the camp and village might include restricting the use of private vehicles and providing transportation services. Transportation services could include air, bus, or van services, park and ride lots, travel schedules and/or travel allowances. Travel services may also influence construction worker travel schedules, which would alleviate pressure on land use development and activity. Impacts from facilities associated with housing, such as sewage treatment lagoons and landfills, could be reduced if they are located away from existing or proposed developments.

F.3.1.3 Recreational Use

The impacts of construction and operation activities extend beyond the physical areas being disturbed and could be partially mitigated by careful management of the remaining lands for public recreation and appreciation. The recreation plan proposed for the Susitna Hydroelectric Project would provide organized recreational development for project waters and adjacent lands. Road and ORV access would be limited. Other access options such as boating, hiking and skiing would be provided in certain areas. Recreational development focuses activities on core recreational facilities and diverts the greatest number of users away from sensitive operations or environmental areas.

F.3.1.4 Access Route Corridors

To reduce impacts from the proposed access route, several management techniques could be designed. The access route should not cross unstable soils or wetlands to the greatest degree practical. Disturbed sites could be restored to a stable condition. Staging areas and parking lots used during construction could be planned and designed to be used for future scenic and recreation pullouts for the public. A fire protection and prevention plan could be formulated to decrease the fire hazard associated with increased access. Land use activity would be confined to within project construction areas until the facilities are built. This would reduce the impact of land use activity until the implementation of the land use management plans take place.

If the use of off-road vehicles (ORV) originating from the access route becomes a disturbance, measures would need to be taken to inhibit this activity. Such measures would include a buffer strip designated for non-motorized use adjacent to the access route, natural conditions employed as subtle but absolute deterrents to ORV use, designated and planned ORV trails in locations that would neither conflict with other land use nor damage the environment, and, if necessary, ORV restriction between the proposed damsites. Spur roads to private holdings and mining claims would be designed, located, and constructed similarly. Recreational use extending from the access route would be directed to sites designed to support such use.

F.3.1.5 Transmission Line Corridors

Efforts were made to select transmission line routes that would minimize negative impact. Proper alignment of the transmission line right-of-way within the route could reduce the line's obtrusiveness. Techniques employed to further reduce the impact of the transmission line would include following the Chugach and GVEA existing transmission corridors and initiating their structure design, spacing, and conductor material. Other techniques used to minimize disturbance would include right-of-way clearing designed to be unobtrusive by breaking up the linearity and feathering the tree height, locating the right-of-way away from private and special interest land, and by maintaining the access roads only when necessary in winter.

The impact of the transmission line routes from Gold Creek to Healy and Willow would be minimal because the route would be within the same corridor as the Alaska Power Authority's Healy-Willow intertie transmission line. The construction of the Power Authority's Willow-Healy Intertie will be complete upon commencement of the proposed Susitna transmission construction. The impact of the proposed transmission lines would be reduced because they would parallel and be adjacent to the approved intertie right-of-way.

F.3.2 Additional Mitigative Measures Recommended by the Staff

At present, no single comprehensive land management plan exists for the entire upper and middle Susitna River Basin area. In order to control unwanted development, conflictive land uses, and unlimited off-road access into the region, the Applicant must continue to coordinate with the various Federal, state, Native, and local governing agencies and with private landholders. The Applicant should assist in the development and implementation of appropriate land management practices through land use and comprehensive plans, special purpose functional plans, zoning ordinances, and other pertinent land use controls. Agency coordination that has begun in the planning and design stage of the Susitna project should continue through the construction and operation phases of the proposed developments. The Applicant also should continue to monitor the land status and ownership changes within the proposed project area and keep the new landowners and managers informed of project status and any changes in design, construction methods, access required, and operational procedures to be used.

To minimize conflictive land use along the proposed power transmission line corridor, the Applicant should avoid, to the extent feasible, recreation lands, residential areas, and any existing or planned agricultural use areas. If a transmission line tower is located on agricultural land, the use of guyed X-frame towers should be avoided if feasible. The amount of land removed from crop production can be minimized by using self-supporting, H-frame or single-pole towers where feasible. Wherever possible, any tower structures in an agricultural area should be located along the edge of an agricultural field to lessen the probability of operational damage to farm equipment and/or the transmission line tower and to minimize the amount of cropland (existing or potential) removed from production. Where feasible, the proposed transmission line should be placed adjacent to existing transmission line corridors to minimize the amount of new right-of-way required.

Measures to mitigate impacts to recreational land use are discussed in Sections 2.1.12.6 and 5.3.6 and Appendix L, while mitigative measures to minimize aesthetic impacts to landowners and users adjacent to project facilities are described in Appendix M.

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DRAFT ENVIRONMENTAL IMPACT STATEMENT

SUSITNA HYDROELECTRIC PROJECT, FERC NO. 7114

APPENDIX G

CLIMATE, AIR QUALITY, NOISE

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APPENDIX G. CLIMATE, AIR QUALITY, NOISE

G.1 AFFECTED ENVIRONMENT

G.1.1 Proposed Project

G.1.1.1 Climate

The climate of Alaska exhibits wide seasonal and geographic variability. Climate is influenced primarily by latitude (Alaska lies between 60° and 70° north), areal extent, topography (e.g., large mountain masses traversing the state), and the presence of oceans on three sides of the state. Four major climatic zones have been delineated for the state (Fig. G-1). The proposed Susitna project would be located mainly within the Continental Zone, although the lower portion of the transmission line corridor would extend into the southern Transition Zone near Anchorage.

The Continental Zone covers the interior of Alaska and is larger than all other climatic zones combined. Continental climate in Alaska is characterized by low precipitation and extreme daily and seasonal temperature variations. Most of this zone receives 10 to 20 inches (in) [25-50 centimeters (cm)] of precipitation annually, with about 50 to 95 in. (125-250 cm) of total snow accumulation, depending on altitude. The range in recorded maximum and minimum temperatures is about 144F° (80C°). Monthly average temperatures are below freezing for up to seven months of the year, and low winter temperatures below -58°F (-50°C) are occasionally recorded. Summer temperatures sometimes exceed 95°F (35°C).

Eight meteorological stations were installed within the study area for the Susitna project (Acres American, 1983: Vol. II, pp. 3B-10-3 - 3B-10-140). The stations were at Susitna Glacier, Denali, Tyone River, Kosina Creek, Sherman, and Eklutna Lake, and near the proposed Watana and Devil Canyon dam sites. Parameters measured at each station were air temperature, average wind speed, wind direction, peak wind gust, relative humidity, precipitation, and solar radiation. Snowfall amounts were measured only at Watana, and evaporation measurements were made daily during May-September in 1981. Most representative of the study area are the Watana measurements reported from April 8, 1980 through September 30, 1981. The Watana station is located about 1 mile (mi) [1.6 kilometers (km)] north of the Susitna River, about midway between Tsusena and Deadman creeks.

At Watana, winds were rarely above 22 miles per hour (mph) [10 meters per second (m/s)], with directions typically from the southwest or northeast. Other stations reveal the same range in wind speed but with the predominant wind direction altered by topographical features. For example, the upper and middle Susitna River Valley area has a higher elevation than locations like Willow and Anchorage, and as a result, greater wind speeds are to be expected, in the area, with an extreme gust wind speed anticipated to be 120 mph (54 m/s) over a 50-year period.

The range in temperatures was typically -58°F (-50°C) to 95°F (35°C) at all stations in the study area. Data from nearby locations supports the data from the Watana site. Since records have been kept at Willow, for example, the record low temperature has been -56°F (-49°C) and the record high temperature 90°F (32°C). For the Anchorage-Fairbanks Transmission Intertie region, estimated temperature ranges were greater, with a low of -93°F (-69°C) and a high of 103°F (39°C) over a 50-year period (Commonwealth Assoc., 1982).

G.1.1.2 Air Quality

No data on air quality have been presented by the Applicant for the project area. Some general comments can be made, however, using data from nearby regions. The air quality is generally excellent since there are no urban or industrial complexes within about 100 mi (160 km), and few anywhere within the state. The large industrial sources that do exist are isolated by distance and by precipitous mountain ranges into separate air basins.

An important feature characteristic of Alaska and the project area in particular in terms of air quality is the so-called "extreme" meteorology. Because of the dramatic topographical and meteorological conditions in Alaska, the potential for air pollution is far greater than in the rest of the United States. The winter inversions in Alaska are among the strongest anywhere in the world. Strong inversions occur when the ground surface cools faster than the overlying air, a condition common in the Arctic winter when there is little sunlight to heat the ground surface. The long winter nights prolong these inversion periods, and a strong potential for air pollution

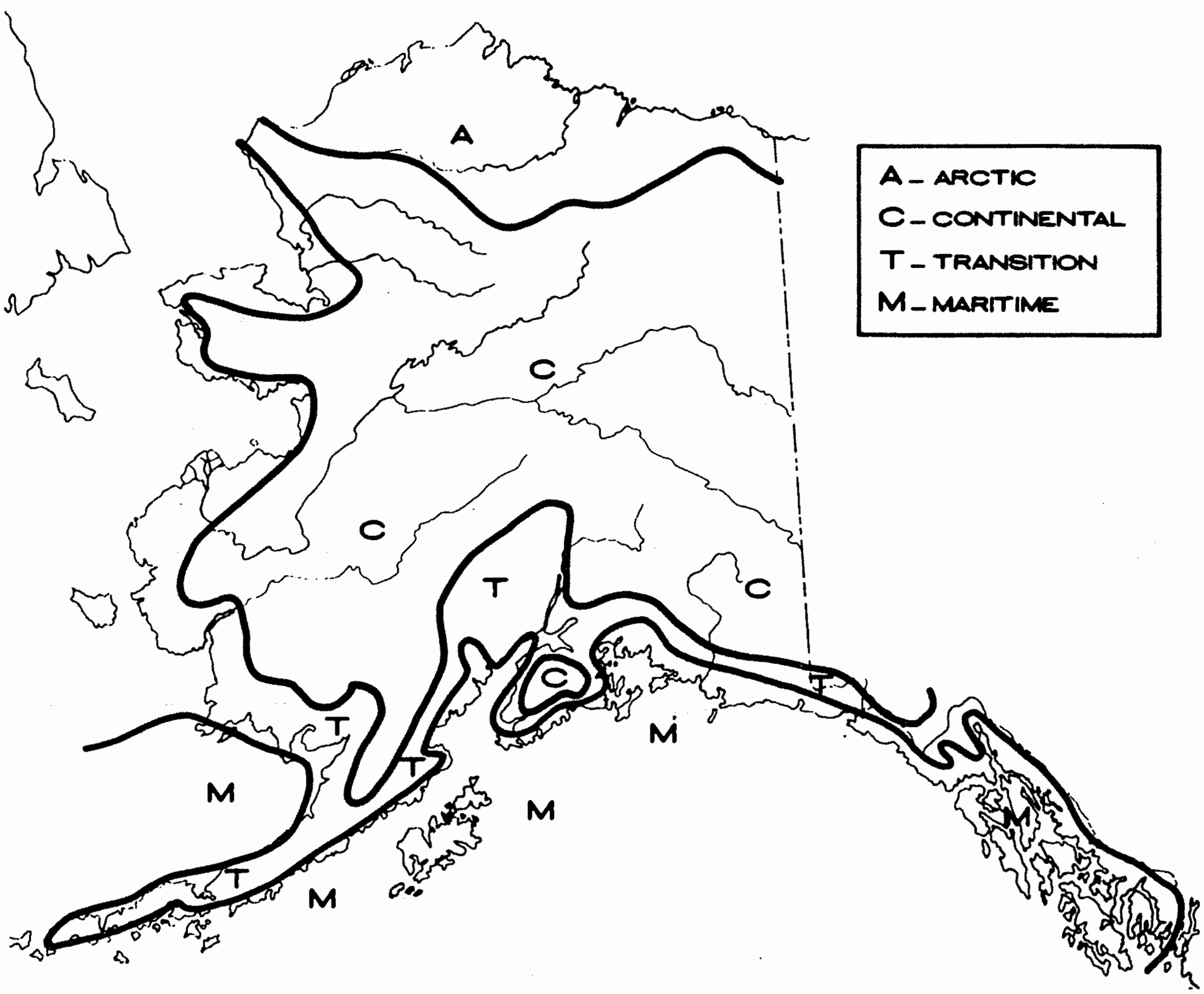


Figure G-1. Climatic Zones of Alaska.
[Source: Selkregg, 1974]

may last for several weeks. In the Fairbanks area, for example, very strong inversions--temperature is sometimes 50F° (28C°) warmer at an elevation of 1,500 feet (ft) [460 meters (m)]--combined with low wind speeds allow little dilution of pollutant emissions.

Although no direct measurements of air quality and meteorology were made at the Susitna site, measurements in similar rural areas provide the following estimates of the background levels (U.S. Environmental Protection Agency, 1980): oxides of nitrogen (NO_x), 8 micrograms per cubic meters ($\mu g/m^3$); total suspended particulates (TSP), 15 $\mu g/m^3$; and sulfur dioxide (SO_2), 0.0 $\mu g/m^3$.

G.1.1.3 Noise

No ambient noise measurements have been made at the Susitna project site, which is in an isolated, rural area. Very few ambient noise measurements have been made in any rural areas. The site most similar to Susitna where such data have been measured is "Location Q-Farm in Valley" (U.S. Environmental Protection Agency, 1974). At that location, an L_{90} of 27 dBA was measured for the nighttime period of 12-2 a.m. L_{90} represents the level which is exceeded 90% of the time; it is often used as a measure of quiet. Considering both daytime and nighttime periods, rural areas typically have background noise levels of L_{90} = 27-45 dBA. Levels below the ambient L_{90} are assumed to be inaudible, and nighttime values are considered most representative of the true noise residual.

At present, there are no Environmental Protection Agency (EPA) standards for noise exposure to the general public. However, EPA-recommended noise levels to prevent hearing loss and minimize potential public health and welfare effects of noise are often used as criteria. Noise levels at Susitna are expected to be extremely low under low wind conditions; high winds would add some noise from increased atmospheric turbulence.

G.1.2 Susitna Development Alternatives

Because of the short distances between the sites of the proposed Susitna project and those of the Susitna development alternatives, the conclusions reached in Section G.1.1 also apply to the alternatives. That is, these sites are characterized by Continental Zone climate, excellent ambient air quality, and very low ambient noise levels.

G.1.3 Natural-Gas-Fired Generation Scenario

G.1.3.1 Climate

All of the plants in the natural-gas scenario would be located in the Transition Zone between the inland Continental Zone and the Maritime Zone. The sites near Anchorage, Chuitna River, Beluga River, and Kenai are in this Transition Zone. At these locations, there is a less extreme climate than that in the Interior, with temperatures being moderated somewhat by the nearby seas.

The Cook Inlet area, in general, is in a transitional climate zone between the Continental Zone of the Interior and the Maritime Zone more common to the coastal areas farther south. The Aleutian and Alaska mountain ranges to the northeast are effective in preventing the large, extremely cold air masses that typically settle in the interior basin from causing comparably frigid conditions along the inlet during winters. The Kenai and Chugach ranges, which extend in a northeastern direction to the south of this area, protect the Inlet from moist air from the Gulf of Alaska and from potentially heavy precipitation. The higher elevations experience colder temperatures, more precipitation, and stronger winds than the low-lying coastal areas.

The four seasons are not well defined in the region. Winter generally begins mid-October and lasts until mid-April. Heavy fog occurs mainly during this season. Monthly average temperatures vary between 10°F and 30°F (-12°C and -1°C) during winter. However, temperatures fall well below freezing, with some inland locations reaching -50°F (-46°C). Springtime occurs from mid-April to June, when the average daily temperatures rise from 30°F (1°C) in April to near 50°F (10°C) in June. Precipitation is lowest in the spring, with monthly averages about 1 in (2.5 cm). The relative humidity is moderate, but increases to high during the summer. Precipitation also increases rapidly during the summer: about 40% of the total annual precipitation falls between mid-July and the end of summer. July is also the warmest month of the year, with the average daily temperature near 55°F (13°C). Autumn is brief, accompanied by a decrease in precipitation. Most precipitation occurs as rain early in the season and snow later, although snow may predominate throughout the season at the higher elevations. Temperatures also fall rapidly during this short season; monthly average temperatures for September and October differ by 15F° (8C°).

The Transition Zone has a less extreme climate than that of the Interior, with temperatures being moderated by the nearby seas. Precipitation is generally within the same range as the Interior, but can reach about 60 in (150 cm) in the southern part of the area adjacent to the Maritime Zone. None of the alternative sites is located in the Maritime or Arctic zones.

Figure G-2 shows the locations of weather stations associated with the National Oceanographic and Atmospheric Administration in the Cook Inlet area. Stations represented by double circles monitor wind speed and direction, sky cover, and cloud ceiling heights in addition to measuring temperatures and precipitation. Wind profiles for the Kenai and Anchorage stations indicate that a general wind pattern exists for the entire inlet region. However, local variations in wind profiles and turbulent diffusion are expected. This is because the terrain roughness increases mechanical turbulence, allowing for the atmosphere to be well-mixed during periods of high winds. During the winter, winds from the north-northeast are dominant; as summer approaches, the prevailing winds are from the south-southwest. The annual average wind speed at both Kenai and Anchorage is approximately 7 mph (3 m/s). Monthly average wind speeds range from 4 to 9 mph (2 to 4 m/s) at Anchorage. Figure G-3 illustrates wind roses for Kenai, Anchorage, and the Phillips Petroleum's Platform "A" located approximately 5 mi (8 km) east of Tyonek.

Observations from the weather stations at Kenai and Anchorage have been analyzed (DOWL Engineers, 1981) to describe the turbulent structure of the atmosphere. For Kenai, the annual frequencies of occurrence of the various stability classes are Class A - 0%, Class B - 1%, Class C - 10%, Class D - 62%, Class E - 9%, Class F - 18%. This distribution reflects the rather common occurrence of cloudy skies (Class D). It also suggests that the dispersion of contaminants released into the atmosphere will be controlled most of the year by wind speed and roughness of the ground surface.

Weather data from the monitoring station at Kenai indicate cold winters and cool summers with moderate winds. Most of the light annual precipitation total is recorded in the summer and fall, although substantial snowfall occurs in the winter. Skies are frequently cloudy and the relative humidity ranges from moderate in the spring to high in the summer. Thunderstorms are rare and heavy fog occurs mainly in the winter.

The long-term (1941-1970) temperature average at Anchorage, located about 70 mi (113 km) northeast of Kenai, is 35°F (2°C). This is comparable to the average temperature of 33.8°F (1°C) for the monitoring year at the Tesoro refinery monitoring site located near Kenai. The average daily temperature at the Tesoro monitor ranged from 9.3°F (-12.6°C) in January to 53.1°F (11.7°C) in July.

G.1.3.2 Air Quality, Noise

National and Alaska Ambient Air Quality Standards set maximum levels of several pollutants: ozone (O_3), carbon monoxide (CO), sulfur dioxide (SO_2), total suspended particulates (TSP), hydrocarbons (HC), nitrogen dioxide (NO_2), and lead (Pb). The Cook Inlet Air Quality Control Region is designated a Class II attainment area for all criteria pollutants. The Tuxedni National Wildlife Refuge, about 100 mi (160 km) southwest of the Tyonek area, is the closest Class I area. Anchorage is one of two areas of Alaska (along with Fairbanks) that is non-attainment in terms of ambient air quality standards for carbon monoxide.

The actual air quality on the western shore of Cook Inlet near Tyonek is not documented. Several sources of emissions of particulate matter, sulfur oxides, carbon monoxide, nitrogen oxides, and hydrocarbons are scattered throughout the onshore area, with a number of offshore oil and gas platforms concentrated in the Nikishka/Kenai area. Nitrogen dioxide emissions are greatest, with combustion products representing the majority of emissions from both offshore and onshore sources. The impact of these sources on ambient air quality tends to be very localized, with the highest concentrations of pollutants occurring where source congestion is greatest. The most congested areas include Trading Bay and Salamatof, and even in these areas separation between individual sources is good. For these reasons, air quality within the area is expected to be well within the National and Alaska Ambient Air Quality Standards. Details concerning these standards are presented below in Section G.2.3.

Visibility is occasionally a problem throughout the Cook Inlet area. At Anchorage, the visibility is one-half mile or less (<1 km) 5% of the time during December and January, primarily because of fog. In addition, snows frequently decrease visibility to less than 3 mi (5 km). The Alaska Department of Environmental Conservation, at its discretion, may require any person proposing to build or operate an industrial process, fuel-burning equipment, or an incinerator in areas of potential ice fog to obtain a permit to operate and to reduce water emissions (Alaska Dept. of Environment Conservation, 1983).

Air-quality data do exist for the Kenai Peninsula. A sketch of this region and the land uses there is shown in Figure G-4. A monitoring station was set up about 9 mi (14 km) north-northwest of Kenai and 0.9 mi (1.3 km) south of the Tesoro refinery to provide ambient data for a potential expansion of the refinery. Monitoring was conducted from June 1, 1981, to May 31, 1982. The air quality data collected there are summarized in Table G-1. The National Ambient Air Quality Standards (same as Alaska Ambient Air Quality Standards for the pollutants listed) are also shown. The table reveals that the ambient pollutant levels in the Kenai area are well within those standards.

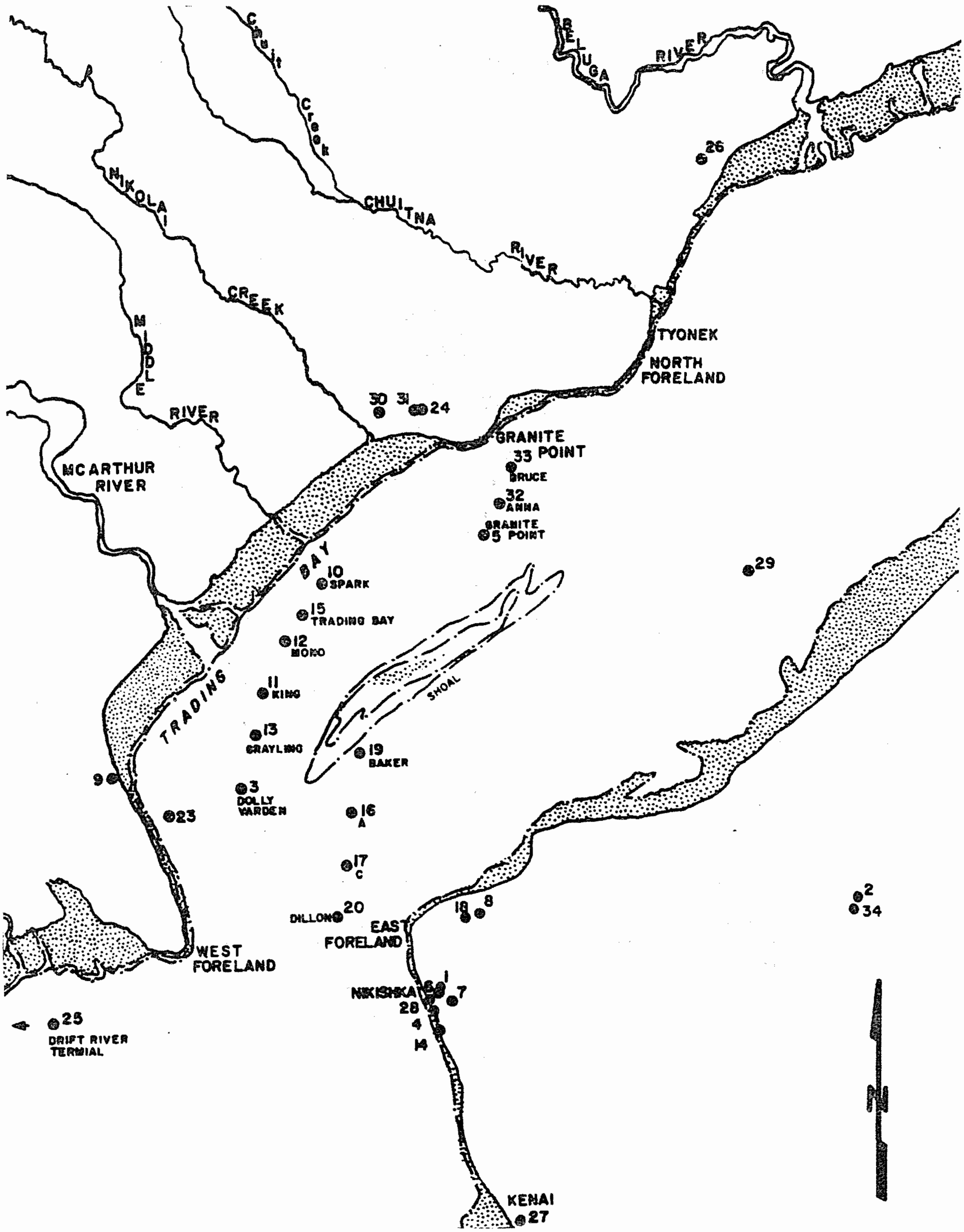
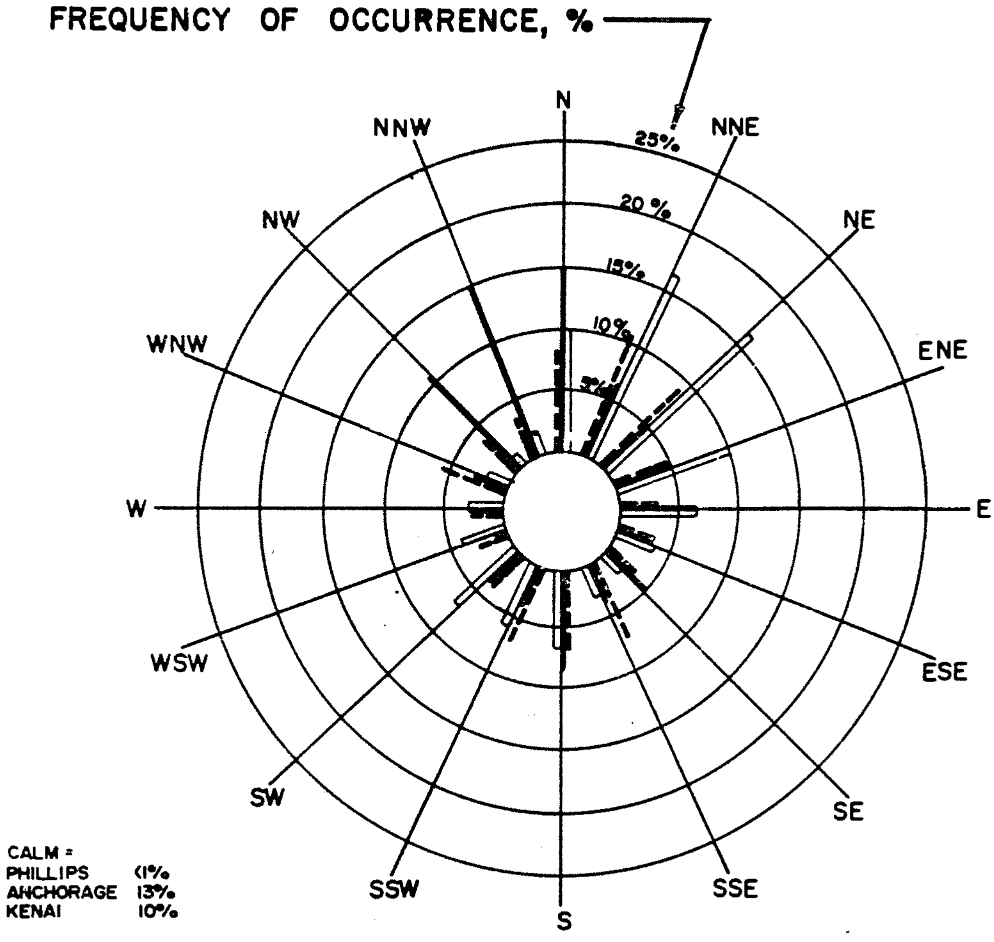


Figure G-2. Locations of Weather Monitoring Stations in Cook Inlet Area.
[Source: DOWL Engineers, 1981]



LOCATION	SYMBOL	SEASON	DATA PERIOD	NUMBER OF OBSERVATION DAYS
PHILLIPS PLATFORM	————	ANNUAL	74 - 79	2
ANCHORAGE	▬ ▬ ▬ ▬	ANNUAL	51 - 60	24
KENAI	▭	ANNUAL	64 - 70	8

NOTE: KENAI ROSE HAS CALMS DISTRIBUTION BETWEEN THE 1-3 & 4-6 KNOT GROUPINGS.

Figure G-3. Wind Rose for Anchorage, Tyonek, and Kenai Areas. [Source: DOWL Engineers, 1981]

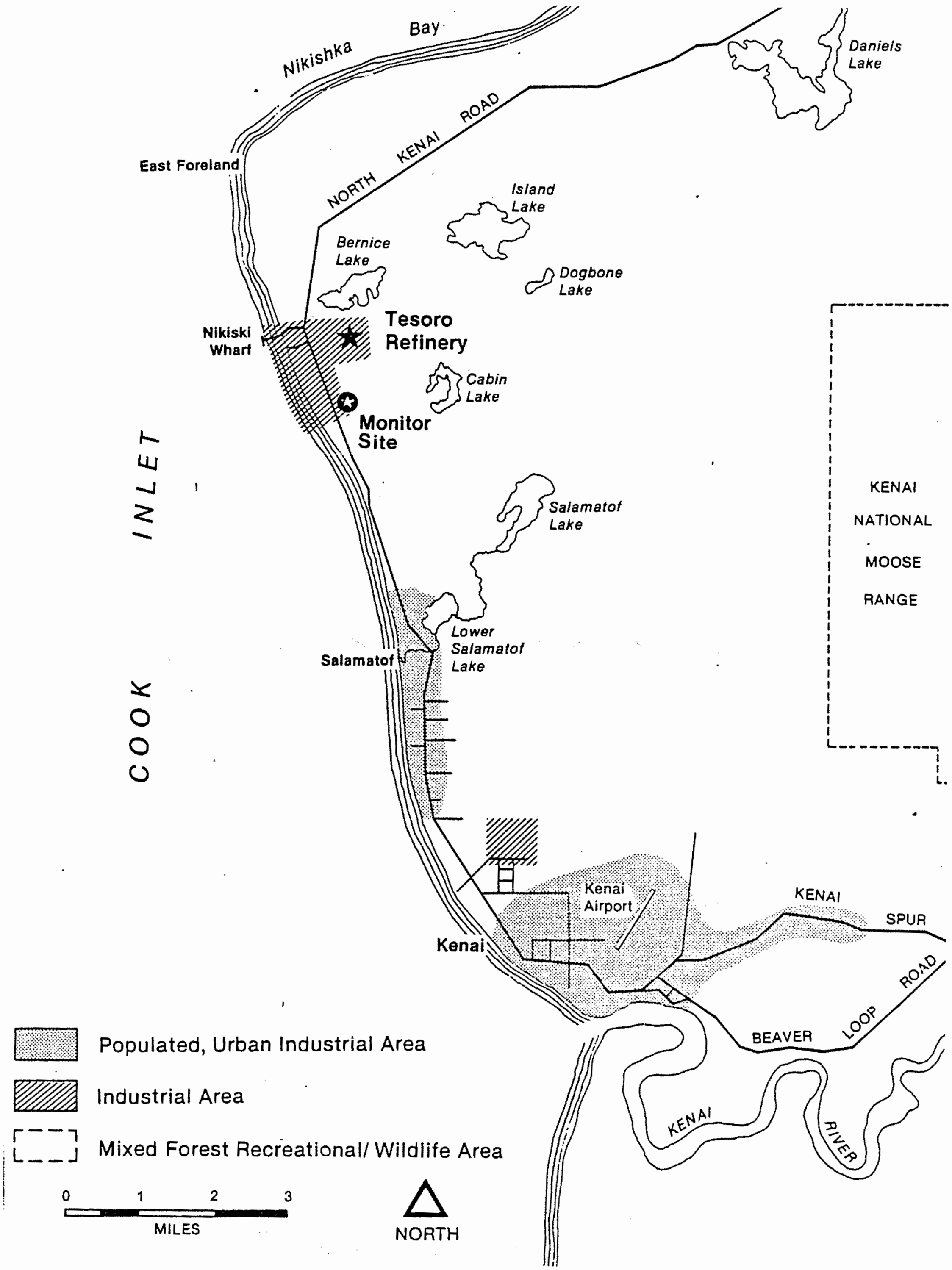


Figure G-4. Land Use in the Kenai Area.
[Source: Radian Corp., 1983]

Table G-1. Summary of Air Quality Maxima at Kenai Peninsula Monitoring Site for the Tesoro Refinery

Pollutant	Highest Value ($\mu g/m^3$)	Second Highest Value ($\mu g/m^3$)	Federal Standard ($\mu g/m^3$)
NO_x (1-hr)	580.0 (2/19)†[1]	436.0 (2/19)	None
NO (1-hr)	197.0 (2/8)	152.0 (10/24)	None
NO_2 (1-hr)	560.0 (2/19)	406.0 (2/19)	None
NO_2 (arithmetic mean)	6.3†[2]	-	100†[2]
SO_2 (3-hr)	69.6 (5/29)	35.0 (4/9)	1,300†[3]
SO_2 (24-hr)	8.6 (5/28)	7.0 (8/4)	365
SO_2 (arithmetic mean)	0.3†[2]	-	80†[2]
CO (1-hr)	2,560.0 (5/18)	2,190.0 (1/13)	40,000
CO (8-hr)	1,660.0 (1/13)	1,411.0 (12/7)	10,000
O_3 (1-hr)	96.0 (5/15)	94.0 (5/1)	235
TSP (24-hr)	60.0 (10/1)	50.0 (6/27)	150†[3]
TSP (geometric mean)	9.0†[2]	-	75†[2]

†[1] Number in parentheses is the date of occurrence.

†[2] Annual.

†[3] Secondary.

Source: Radian Corp. (1983).

The northern Kenai Peninsula is the site of several industrial plants, including two oil refineries, a liquified natural gas (LNG) plant, a major ammonia-urea complex, petroleum storage facilities, and a proposed second LNG facility. Recent TSP data from the area have shown some excursions beyond the 24-hr average standard, but these are thought to be due to natural dust rather than plant emissions. The occurrences were recorded simultaneously at both the sampling site in the city of Kenai and the industrial site 10 mi (16 km) north of town on dry, windy days. Of special significance is the 20-40 $\mu g/m^3$ increase in TSP concentrations in the industrialized area since land was cleared for construction of the new LNG facility and a major construction project commenced at the ammonia-urea plant.

Anchorage has air-quality monitors inside the city limits and one in an outside rural area to measure SO_2, NO_x, O_3, CO, and TSP. Measurements of SO_2 in Anchorage have rarely exceeded 25 $\mu g/m^3$, the minimum detection limit for the pollutant. Concentrations of NO_2 in Anchorage also have been found to be relatively low. A summary of NO_x and ozone measurements in Anchorage is given in Table G-2. As mentioned above, Anchorage is designated nonattainment with respect to CO from automobile emissions. It is strictly nonattainment from TSP but is designated attainment since the TSP violation is due largely to natural sources of particulates. No large stationary source of TSP exists in Anchorage. A sampling of TSP measurements at Anchorage and Kenai are presented in Figure G-5. Air quality data taken in Anchorage would not necessarily be representative of air quality at the possible alternative project areas, because of the large number of industrial, residential, and automobile sources of pollution that exist. These data should, however, provide an upper bound.

As described in Section G.1.1, ambient noise levels are expected to be very low in rural areas such as those designated for the alternative gas-fired plants.

G.1.4 Coal-Fired Generation Scenario

G.1.4.1 Climate

The coal generation scenario involves construction and operation of power plants at Willow and Nenana. These locations are in the Continental Zone and should have climatic features similar to those in the proposed Susitna project area. Data available since 1963 at Willow reveal a record high temperature of 90°F (32°C) and record low temperature of -56°F (-49°C).

Table G-2. Summary of NO_2 Measurements in Anchorage

Measurement	NO_2 Concentration ($\mu g/m^3$)
Annual average†[1]	16
Maximum 24-hr average†[2]	81
Second High 24-hr average	51

†[1] The Alaska standard is 100 $\mu g/m^3$, annual average.

†[2] There is no 24-hour average standard for NO_2.

Source: Alaska Department of Environmental Conservation (1977).

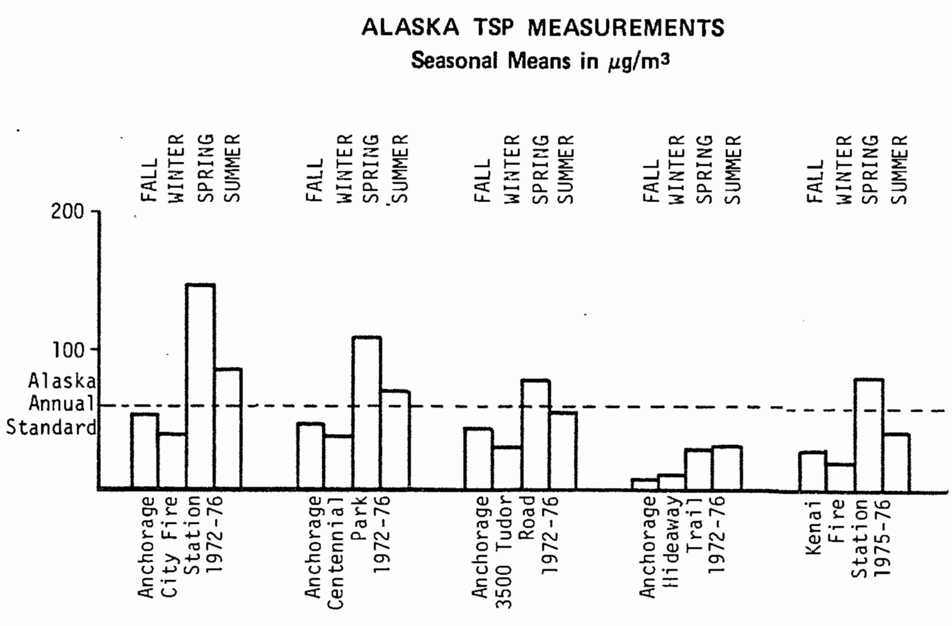


Figure G-5. Seasonal TSP Measurement at Anchorage and Kenai. [Source: Alaska Dept. of Environmental Conservation, 1977]

G.1.4.2 Air Quality

The nearest air quality monitoring stations to Willow are at Palmer and Eagle River. These stations, which measure only TSP, show that the 24-hr TSP standard has frequently been exceeded because of fugitive emissions. Recent data collected at Palmer, however, indicate much lower TSP concentrations (below the standard). This improvement is probably due to recent paving of a nearby road. It should be noted that TSP samples are usually taken near anthropogenic sources of particulates to determine the effects of man-made activities. Very few are taken in isolated rural areas (such as at the alternative plant sites).

Data from the Healy area measurement stations at North Nenana and Garner indicate excellent air quality. Data available are for January 1979 through August 1979 (SO_2 in 1-hr, 3-hr, and 24-hr averages, and meteorological variables of temperature, wind speed, wind direction, and pressure) and March 1978 through July 1979 (TSP in 24-hr averages). The SO_2 data revealed no exceedence of standards; the TSP data indicated increases from very low levels only when the wind was blowing from the river bank. At both sites, ambient levels of all pollutants were extremely low, except occasionally for TSP.

G.1.4.3 Noise

Ambient noise levels are expected to be very low in the rural environment in which the coal-fired plants would be located. Noise levels should be similar to levels described in Section G.1.1.3 for the proposed Susitna project area.

G.1.5 Combined Hydro-Thermal Generation Scenario

The coal-fired, combined-cycle, and combustion-turbine plants would be located primarily near Anchorage and Nenana. The existing environments of these areas were described in Sections G.1.1 through G.1.4. The alternative hydropower units at Johnson, Browne, Keetna, and Snow should have climate, air quality, and noise features similar to those in the Susitna project area. The Chakachamna site is close to Tyonek; that area was discussed in Section G.1.3.

G.2 ENVIRONMENTAL IMPACTS

G.2.1 Proposed Project

G.2.1.1 Climate

The Watana and Devil Canyon dams and reservoirs would cause no significant changes in the microclimate. The surface area of each of the reservoirs would be too small to produce measurable differences in the basic meteorological variables beyond 50 ft (15 m) from the reservoir. The water surface should be frozen in the winter, further lessening the changes between land and water conditions.

G.2.1.2 Air Quality

G.2.1.2.1 Watana Dam Site

During the period of construction, four sources of air quality impacts would occur at the Watana dam site: fugitive dust, diesel generator exhausts, incinerators at the construction camps, and ice fog. Each of these is discussed below. It should be noted that during operation of the Watana dam, there would no longer be fugitive emissions from construction activities. There also would no longer be any temporary diesel generators. The permanent workers village would, however, contain small incinerators which would be regulated by the state for the emission of particulates and the opacity of the stack plume.

FUGITIVE DUST

Fugitive dust is any particulate matter not emitted through a normal exhaust vent. At the Susitna project sites, the largest sources would be road dust raised by truck traffic and wind-blown dust from storage piles. The major sites, sources, and quantities of fugitive dust releases, and the period of operation of equipment in those areas, are listed in Table G-3. The quantities of fugitive dust releases were computed using EPA-recommended methodos (Bowles et al., 1979). Figure G-6 shows the location of the sources. Most would be within the Watana site boundary; however, fugitive emissions might be transported beyond the site boundary by the wind.

Fugitive dust would also be produced from trucks and cars passing over unpaved access roads to the site. Because of the intermittent and temporary nature of traffic on these roads, however, the overall impact is expected to be insignificant.

Table G-3. Projected Major Sources of Fugitive Dust Emissions and Estimated Release Rates for Susitna Construction Activities

Site	Source/Activity	Emissions†[1] lb/day†[2]	tons/yr	Days of Activity Per Year	Months of Operation	Control Technique
Dams, quarry A	Drilling	312	19	121	April-July	Water spray
	Blasting	33	2	121	April-July	Water spray
Quarry A, borrow sites D&E, dam	Truck loading	1,443	87	121	April-July	Water sprinkle
	Truck hauling	1,973	482	121	April-July	
	Truck unloading	78	5	121	April-July	
Borrow site E, batch plant	Storage piles (wind-blown removal)					
	River gravel	8,064	399	182	April-September	
	Aggregate storage	40	2	182	April-September	
Borrow sites D&E, quarry A, dam	Overburden removal	450	30	135	April-Mid August	
	Concrete batch plant operation	200	18	182	April-September	Bag house

†[1] Values are rounded to nearest whole number.

†[2] Computed using EPA-recommended methodologies (Bowles et al., 1979).

Conversion: To convert pounds to kilograms, multiply by 0.454.
To convert tons to metric tons, multiply by 0.907.

Source: Acres American (1983).

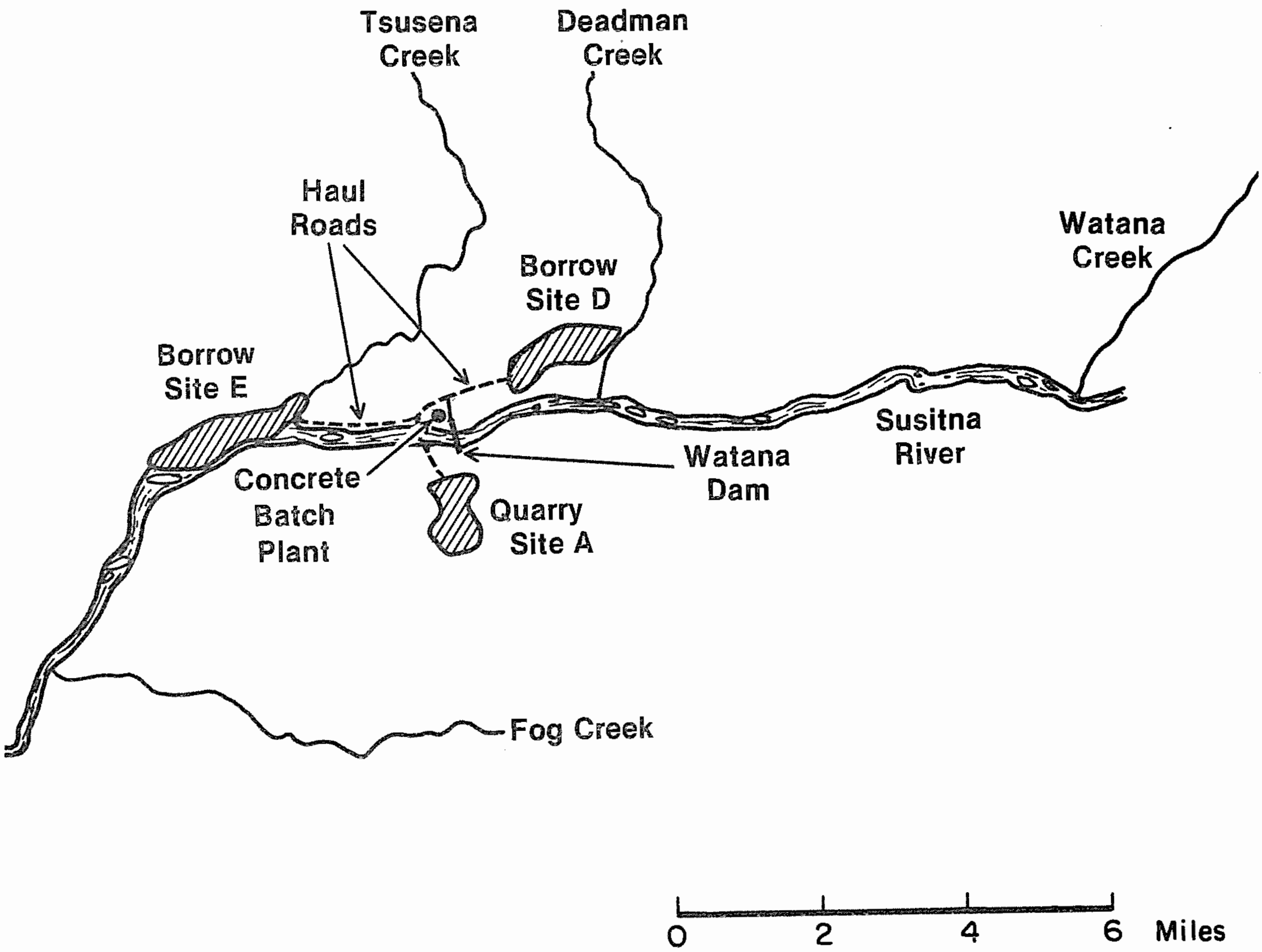


Figure G-6. Location of Major Sources of Fugitive Dust Release during Construction of Watana Dam. [Source: Based on Acres American, 1983]

Sources of fugitive dust account for some of the small particles and a major portion of the larger particles in a TSP sample. TSP measurements throughout Alaska often exceed the 24-hr particulate matter standard of 150 $\mu g/m^3$. This number is the secondary Federal standard on TSP, adopted by Alaska as its state standard. Exceedences of this standard usually are a result of dispersion of large-diameter dust particles during dry weather (Alaska Dept. of Environmental Conservation, 1977); rainfall or snow on the ground reduces generation of fugitive dust. As mentioned above, particulate samplers are usually placed near areas of man-made activity; and reported exceedences of TSP standards are usually traceable to such activities. In rural areas in Alaska, TSP levels are generally only about 15 $\mu g/m^3$.

Under a worst-case scenario developed to calculate the concentration of fugitive dust a storage pile 3 mi (4.8 km) long (east to west) by 220 ft (67 m) wide was hypothesized (Acres American, 1983). Vehicular traffic was assumed to travel parallel to the storage pile on a roadway 2 mi (3.2 km) long by 50 ft (15 m) wide. Using meteorological data from the Watana climate station, a worst day was chosen to maximize the 24-hr TSP concentration. Calculations with the EPA-approved model ISCST (Bowles et al., 1979) indicated a TSP concentration of 627 $\mu g/m^3$ at a point 1,300 ft (400 m) from the storage pile. This value exceeds the Alaska TSP standards of 150 $\mu g/m^3$. Although this point would probably be inside the plant boundary, it raises the possibility that the regulations might also be exceeded outside the site boundary. If so, then mitigative measures should be taken, such as watering roads on days after dry periods, using stabilizing agents on storage piles to maintain a surface crust and to hold down fugitive emissions, and restricting vehicle speeds and denying access to unauthorized vehicles on unpaved roads.

It is not clear whether the Susitna project would be subject to PSD review on TSP since (a) it is not definite that there would be a release of any pollutant with emissions above the trigger level of 250 tons (225 MT) per year, and (b) it has not yet been determined by the Alaska Department of Environmental Conservation whether the anticipated releases would be classified as temporary, thus exempting the project. Fugitive emissions are not considered in computing whether particulate emissions are above 250 tons (225 MT) per year. However, if that limit were exceeded by process particulate emissions, then fugitive emissions would be included in plans to reduce TSP below the regulated concentration increment of 37 $\mu g/m^3$.

DIESEL GENERATOR EXHAUST

Twelve temporary diesel generators would be installed at the Watana site to provide 10.3 megawatts (MW) of power for the first three years of construction. These generators would burn 723 gallons (gal) [2,740 liters (L)] per hour of No. 2 diesel fuel and would be used continuously throughout the year. This is a low-sulfur oil and meets state regulations on the maximum sulfur content a fuel can have. Estimates of the emissions from these generators have been computed based on EPA emission factors and engineering calculations (U.S. Environmental Protection Agency, 1982). The major pollutants and the estimated emission rates are listed in Table G-4.

The EPA-approved PTPLU model (U.S. Environmental Protection Agency, 1983) was also used, together with data recorded at the Watana weather station on July 18, 1981, to estimate the maximum 1-hr concentration of each pollutant. The results are shown in Table G-4. The predicted values are quite small compared with PSD increment values: for particulates, a 24-hr average of 37 $\mu g/m^3$ (no more than once a year); and for sulfur dioxide, a 24-hr average of 91 $\mu g/m^3$ and a 3-hr average of 512 $\mu g/m^3$, each exceeded no more than once per year.

Table G-4. Estimated Emission Rates and Ground-Level Pollutant Concentrations from 12 Temporary Diesel Generators During Plant Construction

Pollutant	Emissions (lb/hr)	Emissions (tons/yr)	Maximum 1-hr Concentration ($\mu g/m^3$)
Particulates	1.4	6.3	1.6
Sulfur dioxide	11.6	50.7	12.9
Carbon monoxide	3.6	15.8	4.0
Hydrocarbons	0.7	3.2	0.8
Nitrogen oxides	15.9	69.7	17.7

Conversions: To convert pounds to kilograms, multiply by 0.454; to convert tons to metric tons, multiply by 0.907.

Source: Acres American (1983).

The calculations were made with only one day's meteorological data; however, that day was chosen because of its high persistence in wind direction, which would tend to maximize the impact for a 24-hr averaging period. The comparison confirms that air quality impacts from the diesel generators should be minimal in terms of state or EPA air quality standards.

INCINERATORS

Incinerators would be used to burn garbage at the temporary camps for workers. Alaska has particulate and opacity regulations (Alaska Dept. of Environmental Conservation, 1983) on such small incinerators. The particulate emissions may not exceed 0.15 grains per cubic foot. Opacity is a measure of the density of the stack plume on a percentage basis from 0 to 100. For such incinerators, visible emissions (excluding condensed water vapor) may not reduce visibility through the exhaust effluent by more than 20% for a total of more than three minutes in any one hour.

Pollutant emissions from incinerators depend to a great degree on how the incinerators are operated. It is important to control combustion conditions to minimize carryover of unburned material or to prevent blowing too much air through the incinerator, leading to the emission of too many particulates. State regulations should ensure efficient operation of the temporary incinerators.

ICE FOGS

Ice fogs are a potential problem in inland Alaska, especially at Fairbanks. When the air cools to extremely low temperatures [-30°F to -40°F (-34°C to -40°C)], the water vapor in the air condenses, forming ice crystals around particulate matter in the air. When the temperature is low enough, water vapor from the combustion of fuel by automobiles and trucks will freeze, enhancing any ice fog condition. Additionally, the temporary diesel generators would produce several tons of water vapor per hour. The exhausts of the generators would be 20 ft (6 m) off the ground, and the buoyant nature of the plume would tend to keep it and the ice fog aloft under low wind conditions. The increase in particulate matter in the air during Susitna construction activities should enhance ice fog formation. However, in very cold conditions, even if natural ice fog conditions did not occur, a visible plume would persist with ice crystals present.

Very little can be done to avoid the ice fog problem. Placing condensers on the exhausts of the diesel generators is one possible mitigative measure. Locating the generators so as to avoid potential ice fog impacts on roads should be sufficient, however, since the area would be largely isolated except for plant workers.

The Alaska Air Quality Regulations provide that the Alaska Department of Environmental Conservation "will, in its discretion, require any person proposing to build or operate an industrial process, fuel burning equipment, or incinerator, in areas of potential ice fog to obtain a permit to operate and to reduce water emissions" (Alaska Dept. of Environmental Conservation, 1983).

C.2.1.2.2 Devil Canyon Dam Site

Like the Watana site, Devil Canyon would have diesel generators and incinerators at the temporary workers camp and would experience ice fogs during the construction phase. However, the fugitive dust problem would be significant only at Watana since construction at Devil Canyon would take place within the river bed, and thus very little fugitive dust would be released.

The pollutant emissions released by the diesel generators would be very low (low ground-level concentrations are predicted); no permit would be required to operate these generators. The camp incinerators would be subject to Alaska state regulations to ensure efficient operation in terms of particulate emission and opacity of the stack discharge. Ice fogs could affect visibility if the generators were positioned near roads. However, the small rise achieved by the exhaust plume should be sufficient to avoid significant visibility reduction, except perhaps under the most stable, calm conditions.

During operation of the Devil Canyon dam site, the potential for such impacts would be eliminated. No diesel generators or incinerators would be used since a workers village would be at the Watana site only.

G.2.1.3 Noise

During construction, the principal sources of noise would be blasting, drilling, bulldozer operations, and truck loading, unloading, and hauling operations. The noise from blasting can be annoying, but should be limited to short periods. In any case, the closest towns are sufficiently distant and the construction period temporary, so that annoyance to area residents would be minimal.

The operation of the generating facilities would involve the use of transformers that emit tones in the 120, 240, 360, and 480 Hz octave bands. Because of the low ambient sound level expected at the site, audible tones from the transformers might be heard at distances of 3,000 ft (900 km) or so, if the terrain were flat. However, the powerhouse would be located at the bottom of the river valley, and the nearest town is on the top of the ridge above the proposed powerhouse site. The tonal noise would be directed upwards by reflection on the side walls of the valley and would not impact the village. No noise impacts of the plant operation are expected to be experienced by the nearest residents.

Transmission lines cause ionization of the surrounding air layers when the field intensity exceeds the breakdown strength of the air. The resulting corona formation gives rise to audible noise and generates ozone and NO_x (Appendix D). For both the 138-kV and the 345-kV transmission lines, the increment of O_3 and NO_x to ambient levels during line operation probably would not be measurable. Although no audible noise should result from operation of the 138-kV line, there would be audible noise from the 345-kV line. This noise would be more pervasive in extent and intensity during periods of rainy weather. Noise from transmission lines is of both broadband and tonal character. The broadband noise is characterized by a crackling sound occurring from high frequency components. Superimposed on this spectrum is a 120-Hz tone that sounds like the hum of a transformer. The high-frequency broadband components have rapid attenuation because of air absorption, however. Audible noise impacts depend greatly on ambient meteorological conditions and ambient noise levels. Conservative calculations based on data from the Bonneville Power Administration (1983) and Chartier and Stearns (1981) reveal that in fair weather, audible noise of broadband and tonal character should extend only about 50 ft (15 m) from the transmission lines. Under worst-case conditions (during rain), however, annoying tonal and broadband noise could extend approximately 500 ft (150 m) from the lines. At about 1,000 ft (300 m), the tones should become inaudible, but the broadband crackling noise should still be audible and remain annoying. At approximately 2,000 ft (600 m), no noise of either type should be audible.

G.2.2 Susitna Development Alternatives

The impacts on climate, air quality, and noise from the Susitna development alternatives are very similar to those described in Section G.2.1 for the proposed project. The Modified High Devil Canyon alternative would involve dam construction at a nearby location. The Reregulating dam alternative would involve construction of a reregulation dam downstream of the Watana I dam. For all dam configurations and alternatives, fugitive dust emissions might extend beyond site boundaries, as indicated from the calculations discussed above for the proposed Watana dam.

G.2.3 Natural-Gas-Fired Generation Scenario

Climatic impacts of the eight 200-MWe combined-cycle gas units and the two 70-MWe combustion-turbine units would be negligible. Impacts would involve changes in surface albedos and heat capacities over small areas as a result of land clearing, paving, and erection of buildings. Also involved would be very slight temperature and humidity increases in the local area of the plants. The visible plume from the wet/dry cooling towers that would be used when the plants were in operation would extend 0-300 ft (0-100 m) downwind, depending upon air temperature and relative humidity. (Vapor plume lengths increase as the ambient temperature and the ambient saturation deficit decrease.) Ground-level fogging and icing would be very unlikely from such wet-dry towers. Specific data on the design characteristics of the towers and on local meteorological conditions would be required in order to make quantitative predictions of cooling tower impacts.

Pollutant emissions from a typical 200-MWe combined-cycle gas unit are given in Table G-5. Also listed are the stack dimensions and exit and emission characteristics of the two plumes from such a plant. Note that the exit plumes are very hot, indicating a high-rising buoyant release.

Only the NO_x emissions levels from these combined-cycle gas units would be significant in absolute terms. The NO_x release rate for each 200-MWe plant would vary from 138 g/s (no steam injection) to 34 g/s (steam injection). Without steam injection to reduce NO_x emissions, the three units (600 MWe) located near the Chuitna River would emit 414 g/s of NO_x. The Chuitna plant might have three identical 200-MWe units, two stacks per unit. The potential air quality impact of this plant is evaluated in some detail here since it would have the largest emission rates of all the combined-cycle plants that would be operated under the natural-gas generation scenario. The emission rates cited here were calculated on the basis of no steam injection; this assumption was made in order to provide conservative predictions.

Ground-level concentrations should be in compliance with Alaska ambient air quality standards and PSD regulations promulgated by the U.S. Environmental Protection Agency. These regulations are summarized in Tables G-6 and G-7. Each combined-cycle gas unit would be located in a PSD Class II area, with the nearest Class I area distant from the site.

To ensure that Alaska air quality standards and local PSD Class II requirements were met for NO_x, the EPA screening model PTPLU was used to calculate maximum predicted ground-level concentrations for NO_x. PTPLU is a point-source Gaussian model that is used to predict maximum 1-hr concentrations of any pollutant based on stack characteristics and pollutant emission rate. The model includes 7 stability classes (A-F) and 14 wind-speed ranges. A maximum ground-level concentration is calculated for each of the approximately 100 combinations of stability class and wind speed.

This model was applied to the three 200-MW combined-cycle units at Chuitna as representing the worst-case situation. The maximum 1-hr concentration occurred for Stability Class C and a wind speed of 38.5 mph (17.2 m/s). The maximum concentration of 23 $\mu g/m^3$ occurred 3 mi (4.7 km) downwind. An estimate for the maximum 24-hr average concentration was 9.2 $\mu g/m^3$. Alaska air quality regulations require that the concentration be less than 100 $\mu g/m^3$ on an annual average basis at any ground location. Clearly, since the maximum 24-hr average was less than the annual average limit, the annual standard would be met.

It should be noted that no site-specific meteorological data are required in the use of PTPLU. If this screening model led to a potential violation of standards, site-specific data would be required, along with a more detailed model--perhaps ISC or VALLEY (Burt, 1977)--in order to provide more accurate predictions. Once PTPLU screening model predictions indicate compliance with standards, no further analysis is required.

Table G-5. Characteristics of 200-MWe Combined-Cycle Gas Plant Used in Air Quality Modeling

Parameter		Value
Stack Characteristics		
Number of stacks		2
Dimensions of each stack (ft)		11 × 17
Height of each stack (ft)		65
Stack exit temperature (°F)		350
Stack gas velocity (ft/s)		70
Emissions (per stack)		
	No Steam Injection	With Steam Injection of 52,530 lb/hr
NO_x (lb/hr)	545	136
SO_2	Depends on sulfur in fuel (very low values, however)	
CO (lb/hr)	21	21
Particulates	0	0

Conversion: To convert feet to meters, multiply by 0.305; to convert pounds to kilograms, multiply by 0.454.

Source: Stepien (1984).

Table G-6. Alaska Ambient Air Quality Standards†[1]

	Controlling NAAQS, (μg/m³)	
Contaminant and Time Period	Primary	Secondary
Total suspended particulates		
Annual	60	60
24-hr†[2]	150	150
Sulfur dioxide		
Annual	80	-
24-hr†[2]	365	-
3-hr†[2]	-	1,300
Carbon monoxide		
8-hr†[2]	10,000	10,000
1-hr†[2]	40,000	40,000
Nitrogen dioxide		
Annual	100	100
Ozone		
1-hr†[2]	235	235
Lead		
Quarterly	1.5	1.5

†[1] Alaska standards are identical to National Ambient Air Quality Standards (NAAQS) except that for Alaska (a) the primary and secondary standards for TSP are replaced by a single standard, the more stringent secondary standard; and (b) the reduced sulfur standard is made more stringent (however, reduced sulfur is not of concern here). Alaska standards are from the Air Quality Control Regulations 18 AAC 50, Alaska Department of Environmental Conservation. NAAQS standards are from the Code of Federal Regulations, 40 CFR Part 50.

†[2] Not to be exceeded more than once in a calendar year.

Table G-7. Summary of PSD Increments†[1]

Contaminant and Averaging Time	Allowable Increment ($\mu g/m^3$)		
	Class I	Class II	Class III
Total suspended particulate			
Annual	5	19	37
24-hr†[2]	10	37	75
Sulfur dioxide			
Annual	2	20	40
24-hr†[2]	5	91	182
3-hr†[2]	25	512	700

†[1] Alaska PSD increments are identical to Code of Federal Regulations, 40 CFR Part 52.

†[2] Not to be exceeded more than once in a calendar year.

Although the combined-cycle plant stacks would be only 65 ft (20 m) high, the very high temperature at plume exit [about 350°F (180°C)] would lead to a very buoyant plume and high plume rise. As a result, low concentrations are predicted at ground level. Other pollutants released from the combined-cycle gas unit would be at extremely low levels. PSD limits on SO_2 and TSP should be satisfied, given the very low emission levels of these pollutants from such units. It should also be noted that the combined-cycle plants would not be located close to elevated terrain. Thus, there should be no PSD Class II violations.*

No significant impact on nearby Class I areas is expected, given the low pollutant emission levels for SO_2 and TSP and the large distances between any of these units and the Class I areas of Alaska. Carbon monoxide emissions from the 200-MWe unit southeast of Anchorage would be sufficiently diluted during transport to have an insignificant impact on the Anchorage nonattainment area. The predicted ground-level concentrations at the Anchorage municipal boundary were below significant levels for carbon monoxide. Carbon monoxide concentrations at the boundary of Anchorage from a source originating outside the municipality are regulated by the State of Alaska: an increase of no more than 500 $\mu g/m^3$ is allowed for a maximum 8-hr average, or 2,000 $\mu g/m^3$ for a maximum 1-hr average.

Climatic and air quality impacts of the 70-MWe combustion-turbine units would be negligible because of the small heat, moisture, and pollutant releases. Noise impacts should also be insignificant if the turbines were sited at least 3,000 to 6,000 ft (900 to 1,800 m) from the nearest noise-sensitive areas.

G.2.4 Coal-Fired Generation Scenario

The potential impacts of the coal-fired generation scenarios are analyzed in this section. The scenarios involved are (1) one 200-MWe unit at Nenana to be built between the years 2010 and 2020 as part of the impact comparison involving the proposed Susitna project, (2) two 200-MWe coal units at Willow and three at Nenana as part of the coal-fired generation scenario, and (3) one 200-MWe coal unit at Nenana as part of the combined hydro-thermal generation scenario. Also analyzed is the coal-generation scenario in which five 200-MWe coal units would be sited at Nenana. As will be seen, that latter scenario would have difficulty in meeting air quality regulations and was rejected from detailed consideration in the remaining portion of the document.

The coal-fired plants (up to five 200-MWe units at Nenana, two at Willow) would be too small to significantly affect the climate in the Nenana and Willow areas. The effect of land clearing, paving, and erection of buildings would involve a change in the surface albedos and heat capacities over small area. A small vapor plume approximately 0-300 ft (0-100 m) long would be expected from the wet/dry cooling towers; only very small increases in temperature and humidity would be expected in small areas near the tower structures. A vapor plume from the plant stacks would be

*This problem does arise with the coal-generation scenario at Nenana as will be seen in the next section.

visible over tens of feet in the summer and up to 2,000 ft (600 m) in the winter; the precise length of the plume depends on the air temperature and humidity. Ground-level fogging and icing would be very unlikely. Specific calculations could, however, be made once a design for the cooling towers is made available.

These are the major air quality issues involving the coal-fired plant stack releases: (1) maintaining Alaska ambient air quality standards, (2) meeting PSD increments not only in the Class II area in which Nenana and Willow are located, but at the Class I Denali National Park approximately 60 mi (100 km) south of the Nenana site (see Fig. G-7), (3) ensuring no significant impact on the nearby non-attainment area for CO at Fairbanks, and (4) ensuring no impairment of visibility at the Denali National Park. To investigate these issues, the Staff made numerical computations with EPA-approved screening models.

First, in response to items (1) and (2), EPA models were used to evaluate compliance with Alaska ambient air quality standards and PSD Class II increments in the vicinity of Nenana and Willow. Two different issues are involved here:

1. Compliance in areas of flat terrain about the Willow and Nenana sites. Here, the EPA screening model PTPLU was employed,

2. Compliance in the mountainous area just northeast of Nenana. Here, a simplified form of the VALLEY Model (Budney, 1977) was used to simulate worst-case conditions.

Special consideration needs to be given to the potential for the Nenana plume to impact on this area, violating PSD and possibly Alaska air quality standards.

Table G-8 lists the stack characteristics and emissions of the 200-MWe coal-fired plants employed in the air-quality calculations.

Calculations with PTPLU at Nenana and Willow (see Table G-9) revealed that maximum 3-hr and 24-hr concentrations for SO_2 and maximum 24-hr concentrations for TSP would be well within PSD increments. Additionally, Alaska ambient air quality standards should be met for SO_2, TSP, and NO_x. Although no air quality monitors are located at Willow and Nenana, it is highly unlikely that ambient concentrations of SO_2, TSP, and NO_x are sufficiently high to cause an exceedence of Alaska ambient air quality standards. Willow and Nenana are not near major industrial sources and, as a result, ambient levels are very low. Although the maximum 24-hour average NO_x concentrations would be greater than 100 $\mu g/m^3$, the annual average concentrations should be less than 100 $\mu g/m^3$. This is due to variation in wind directions over the year and because of only minor differences between the maximum 24-hr average prediction and the annual NO_x standard. Increments contributed by the coal-fired plants would be sufficiently small that, when added to the background, the total would fall far below Alaska standards. For example, for three 200-MWe units operating at Nenana, the predicted maximum 3-hr SO_2 concentration was 90.3 $\mu g/m^3$ and the maximum 24-hr TSP concentration was 2.8 $\mu g/m^3$. PSD Class II increments for these pollutants are 512 $\mu g/m^3$ and 37 $\mu g/m^3$, respectively. All predicted maxima occurred 0.9 mi (1.4 km) downwind of the stacks.

One additional factor that must be taken into account in this air quality screening analysis is the presence of elevated terrain near Nenana. The coal-fired units would be located in terrain 400 ft (125 m) above sea level. To the northeast of Nenana there is elevated terrain 1,400 ft (425 m) above sea level. Plumes from the one to five (depending on scenario) coal-fired units at Nenana would not rise over that elevated terrain under worst-case meteorological conditions, according to the formulas recommended by Budney (1977). To be evaluated are plume predictions as compared with Alaska ambient air quality standards and the Class II PSD standards at the location of plume impaction with the elevated terrain. A sketch illustrating the situation is presented in Figure G-8, and the predicted plume concentrations at the point of impaction are listed in Table G-10. PSD limits are also presented for comparison. It appears that operation of three, four, and five 200-MWe units at Nenana might lead to a violation of PSD Class II increments for SO_2. A more detailed analysis using the VALLEY model and employing site-specific meteorological data would be required to verify these findings. At present, it seems likely that 600, 800, or 1000 MWe of coal-fired generating capacity at Nenana would violate PSD standards.

The issue of Class I area impacts was addressed using a simplified version of the VALLEY model to predict maximum incremental concentrations under a worst-case scenario at the Denali National Park. Nenana is about 51 mi (85 km) north of the northern boundary of the park, and Willow is about 96 mi (160 km) south of the southern boundary. The calculations, shown in Table G-11 revealed very low SO_2 and TSP increments at this Class I area. For instance, maximum 24-hr concentrations of SO_2 at Denali resulting from plant emissions at Nenana were predicted to be 4.1 $\mu g/m^3$; the PSD Class I increment is 5 $\mu g/m^3$. It is also seen that four and five 200-MWe units at Nenana would violate PSD Class I increments for SO_2. More refined calculations again would involve the use of the VALLEY model and site-specific meteorological data.

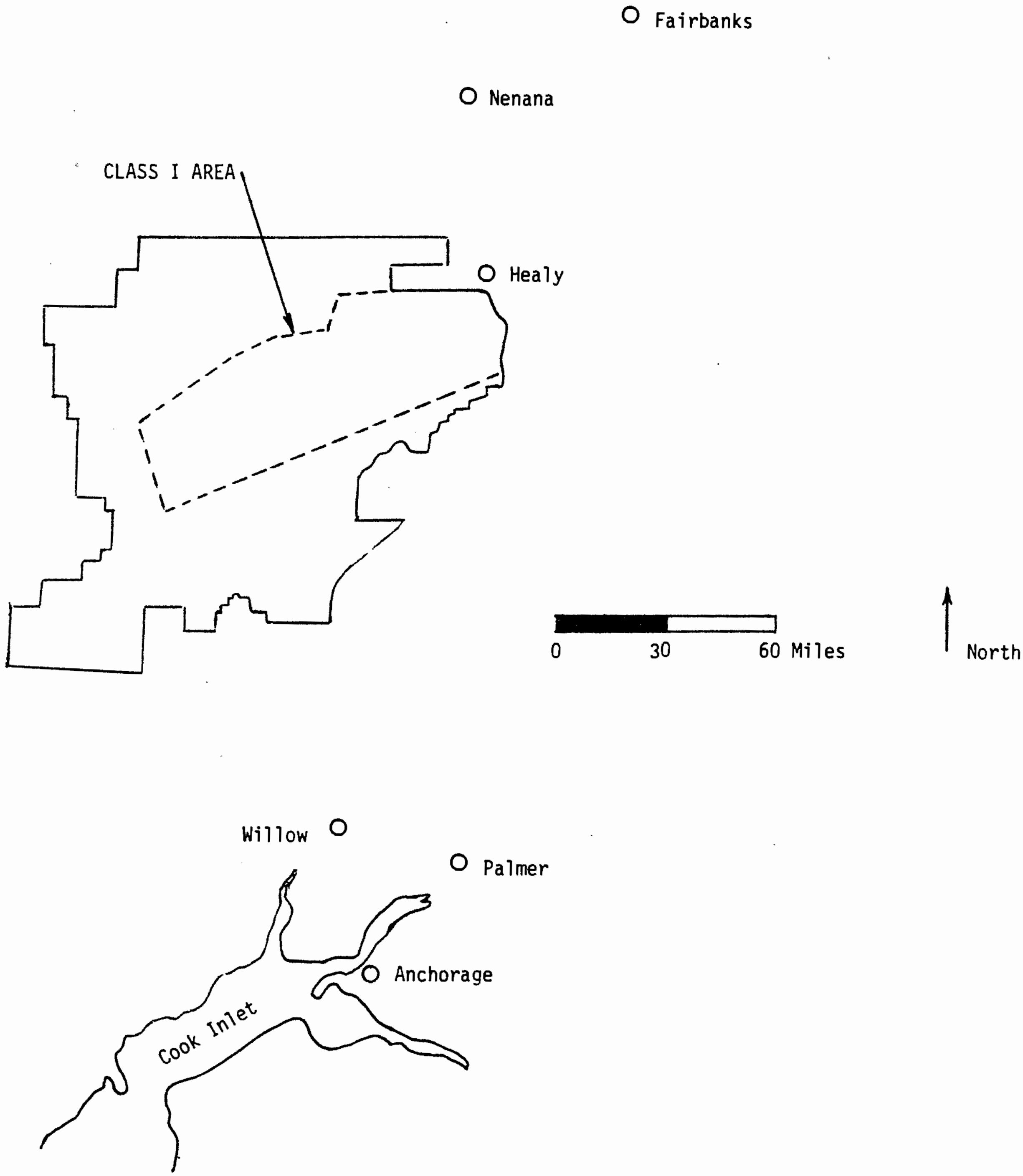


Figure G-7. Relative Location of Nenana and Willow with Respect to the Class I Area at Denali National Park.

Table G-8. Stack Characteristics and Emissions for Each 200-MWe Standard Coal-Fired Unit

Parameter	Value
Stack Characteristics	
Stack height (ft)	440
Exit diameter (ft)	18
Building dimensions (ft)	
Height	210
Width	175
Length	175
Stack exit velocity (ft/s)	66
Stack exit temperature (^{o}F)	190
Emissions†[1] (g/s)	
SO_2	56.5†[2]
TSP	1.2†[3]
NO_2	176.0†[4]
CO	7.9†[5]

†[1] Emissions for multiples of 200 MWe are obtained by simply multiplying the 200 MWe emission rates by that multiple.

†[2] 0.3% sulfur in Healy coal is assumed with a 70% efficient dry scrubber in removing SO_2.

†[3] Assumptions are: ash content of coal, 9.9%; ash partitioning is 24% bottom ash, 76% fly ash; baghouse efficiency is 99.95%.

†[4] 0.6 lb NO_x/million Btu is assumed for NO_x emissions for Healy coal. This level meets New Source Performance Standards (NSPS).

†[5] 1.0 lb CO/ton of coal is assumed, based on U.S. Environmental Protection Agency (1982).

Table G-9. Maximum Ground-Level Concentrations (μg/m³) of Pollutants from Operation of 200-MWe Coal-Fired Units at Nenana and Willow†[1]

Pollutant	Predicted Concentration	PSD Increment	Estimated Background	Predicted Total	Alaska Standard
One 200-MWe Plant at Nenana					
Maximum 3-Hour Average					
SO_2	30.1	512	0.0	30.1	-
TSP	1.6	-	15.0	16.6	-
NO_x	93.7	-	8.0	101.7	†[2]
Maximum 24-Hour Average					
SO_2	13.4	91	0.0	13.4	365
TSP	0.7	37	15.0	15.7	150
NO_x	41.6	-	8.0	49.6	†[2]
Two 200-MWe Plants at Willow					
Maximum 3-Hour Average					
SO_2	60.2	512	0.0	60.7	-
TSP	3.2	-	15.0	18.2	-
NO_x	187.4	-	8.0	195.4	†[2]
Maximum 24-Hour Average					
SO_2	26.8	91	0.0	26.8	365
TSP	1.4	37	15.0	16.4	150
NO_x	83.2	-	8.0	91.2	†[2]
Three 200-MWe Plants at Nenana					
Maximum 3-Hour Average					
SO_2	90.3	512	0.0	90.3	-
TSP	4.8	-	15.0	19.8	-
NO_x	281.1	-	8.0	289.8	†[2]
Maximum 24-Hour Average					
SO_2	40.2	91	0.0	40.2	365
TSP	2.8	37	15.0	17.8	150
NO_x	166.4	-	8.0	174.4	†[2]
Four 200-MWe Plants at Nenana					
Maximum 3-Hour Average					
SO_2	120.4	512	0.0	120.4	-
TSP	6.4	-	15.0	21.4	-
NO_x	374.8	-	8.0	382.8	†[2]
Maximum 24-Hour Average					
SO_2	53.6	91	0.0	53.6	365
TSP	2.8	37	15.0	17.8	150
NO_x	166.4	-	8.0	174.4	†[2]
Five 200-MWe Plants at Nenana					
Maximum 3-Hour Average					
SO_2	150.5	512	0.0	150.5	-
TSP	8.0	-	15.0	23.0	-
NO_x	468.5	-	8.0	476.5	†[2]
Maximum 24-Hour Average					
SO_2	67.0	91	0.0	67.0	365
TSP	3.5	37	15.0	18.5	150
NO_x	208.0	-	8.0	216.0	†[2]

†[1] In all cases, the maximum concentration would occur 0.9 mi (1.4 km) downwind.

†[2] Alaska air quality standard for NO_x is an annual average of 100 μg/m³ and should be met in all cases.

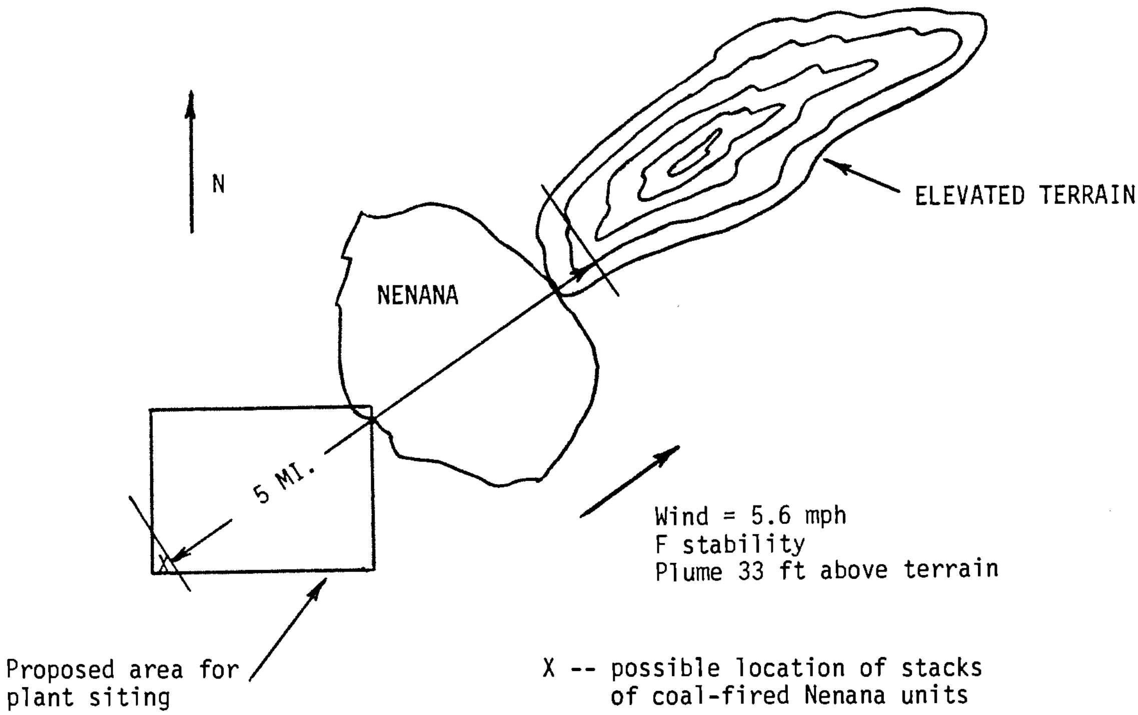


Figure G-8. Location of Plume Impaction with the Elevated Terrain near Nenana.

Table G-10. Comparison of Simplified VALLEY Model Predictions for Maximum 24-hour Averages of SO_2 and TSP at Elevated Terrain near Nenana for 200 to 1000 MWe of Coal-Fired Generation

	Simplified VALLEY Model Predictions†[1] (24-hr averages, in $\mu g/m^3$)					PSD Class II
Pollutant	200 MWe	400 MWe	600 MWe	800 MWe	1000 MWe	Limits
SO_2	33.9	67.8	101.7	135.6	169.5	91
TSP	0.7	1.4	2.2	2.9	3.6	37

†[1] According to screening model predictions, PSD Class II limits at the elevated terrain locations would be exceeded for maximum 24-hour averages of SO_2 for 3, 4, and 5 units of 200 MWe each.

Table G-11. Comparison of Predicted Maximum 24-hr Concentrations of SO_2 and TSP to PSD Class I Increments at Denali National Park from Nenana and Willow Coal-Fired Units

Pollutants	Simplified VALLEY Model Prediction	PSD Class I Increment
NENANA SITE		
200 MWe		
SO_2	1.4	5.0
TSP	0.04	10.0
600 MWe		
SO_2	4.1	5.0
TSP	0.11	10.0
800 MWe		
SO_2	5.4	5.0
TSP	0.14	10.0
1000 MWe		
SO_2	6.8	5.0
TSP	0.18	10.0
WILLOW SITE		
400 MWe		
SO_2	3.4	5.0
TSP	0.07	10.0

A simplified version of the VALLEY model was used to estimate long-distance [55-mi (88-km)] dispersion from five units at Nenana to the nearest nonattainment area for CO (the city of Fairbanks). A worst-case mixing scenario was simulated, represented by stability Class F, wind speed of 5.6 mph (2.5 m/s), and a plume 32 ft (10 m) above the terrain. The prediction for this worst case revealed an extremely small CO increment (1.1 $\mu g/m^3$ for a maximum 24-hr average) at Fairbanks. This predicted increment would not likely violate any standards (increment of 500 $\mu g/m^3$ for an 8-hr average or 2,000 $\mu g/m^3$ for a 1-hr average).

Section 169A of the Clean Air Act requires visibility protection for mandatory Class I Federal areas where it has been determined that visibility is an important value. Consequently, a Level-1 screening analysis was performed to assess potential visibility impacts on Denali National Park from the operation of one to five coal-fired units at Nenana.

The Level-1 visibility screening analysis is based on assumptions regarding worst-case meteorological conditions, and is intended to evaluate two potential types of visibility impairments that might be caused by plumes from stack emissions. Figure G-9 illustrates the two types of plume impacts considered. One is a discolored, dark plume observed against a bright horizon sky (labeled 1 in Fig. G-9). This effect is caused principally by NO_2 gas formed from NO_x emissions, though particulates can contribute in some cases. The other type is a bright plume observed against a dark terrain viewing background (labeled 2 in Fig. G-9). This effect is caused principally by particle emissions and sulfate aerosol formed from SO_2 emissions.

Figure G-10 illustrates the geometry of the plume, observer, and line of sight assumed for this screening analysis. The plume was assumed to pass very close to the observer, with its centerline located half the width of a 22.5° sector away from the observer at the given downwind distance x. The observer's line of sight was assumed to be perpendicular to the plume centerline. The viewing background was assumed to be either the horizon sky or a black terrain object located on the opposite side of the plume at a distance equivalent to a full sector from the observer.

Three values were computed: C_1 (the sky/plume contrast), C_2 (the reduction in sky/terrain contrast), and C_3 (the change in sky/terrain contrast caused by primary and secondary aerosols).

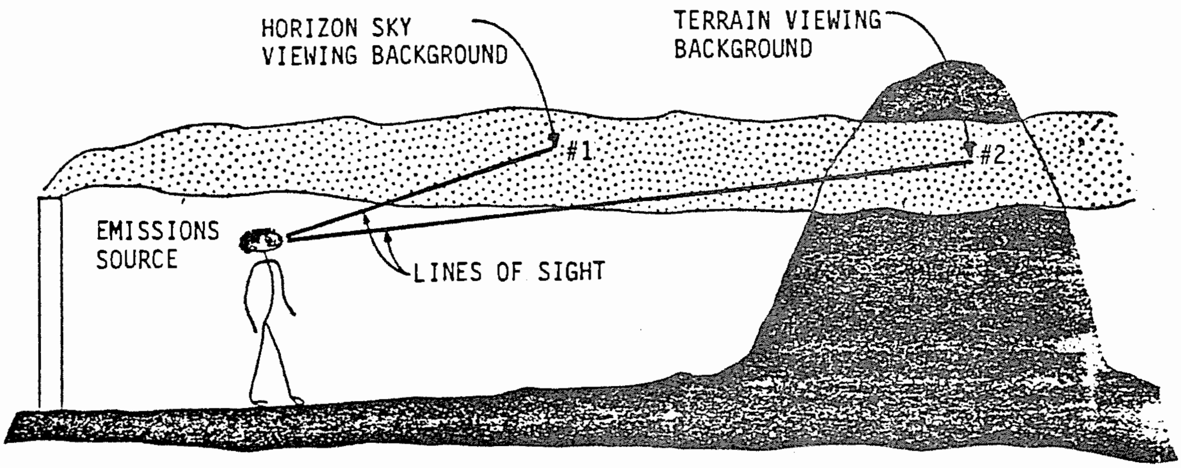


Figure G-9. Two Types of Plume Visibility Impairment Considered in the Level-1 Visibility Screening Analysis. [Source: Latimer and Ireson, 1980]

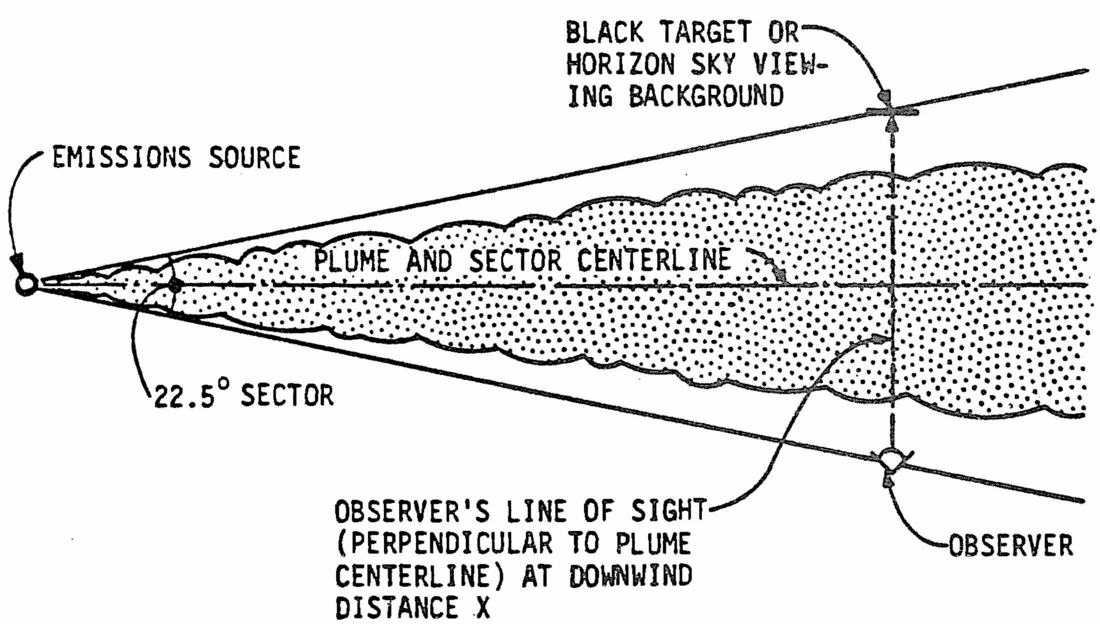


Figure G-10. Geometry of Plume, Observer, and Line of Sight Used in Level-1 Visibility Screening Analysis. [Source: Latimer and Ireson, 1980]

If the absolute value of either C_1, C_2, or C_3 is greater than 0.10, the emissions source fails the Level-1 visibility screening test, and further screening analysis is required to assess potential visibility impairment. If the absolute value of C_1, C_2, or C_3 is less than 0.10, it is highly unlikely that the emissions source would cause adverse visibility impairment in Class I areas, and further analysis of potential visibility impacts would be unnecessary.

The Level-1 screening analysis was based on worst-case meteorological conditions. For C_1 and C_2, these occur when the plume material is concentrated in stable (Pasquill-Gifford stability category F), light-wind conditions, with a 12-hr transport time to the closest Class I area. For C_3, the worst case occurs in limited mixing conditions, say with a vertically well-mixed plume with a 3,000-ft (1,000-m) mixing depth and a 7.5 ft/s (2 m/s) wind speed.

Five additional input parameters were also used to evaluate potential visibility impacts with this screening analysis procedure: minimum distance of the emissions source from a potentially affected Class I area, location of the emissions source and Class I area, particulate emission rate, NO_x emission rate, and SO_2 emission rate. Table G-12 presents the results of the screening calculations for one to five units at Nenana and two units at Willow.

As the table shows, there was no visibility impairment with one and two coal-fired units, although some plume contrast with the sky would still be noticeable at Denali. For the three, four, and five units, however, there was visibility impairment, largely because of NO_x emissions and chemical conversions during transport of the Nenana plume to Denali. The large background visual range at Denali [100-235 mi (170-390 km)] is a contributing factor in this visibility impairment. Level-2 and Level-3 analyses may lead to the same results because of the extreme meteorology in that area, i.e., high frequency of inversions and poor mixing of pollutants. Control technology applied to NO_x might, however, permit the siting of three units at Nenana. Another possibility is the placement of, say, three units at Willow and two at Nenana. This latter possibility would not lead to PSD or visibility impairment problems at either Nenana or Willow.

Visibility screening for the plume from the two-unit plane at Willow indicated no visual impairment at Denali, although a plume contrast with the sky would be observed over Denali National Park.

Construction and operational noise impacts from the coal-fired plants would be minimal if siting were at least 1,500 to 3,000 ft (450 to 900 m) from the nearest residences. The major noise sources during plant operation would be the coal-handling equipment, the cooling tower, and the transformers. An in-depth analysis of noise impacts requires a precise location of the plant with respect to the nearest noise-sensitive areas, data on ambient noise levels, and an identification of specific equipment to be used in plant construction and operation.

G.2.5 Combined Hydro-Thermal Generation Scenario

The thermal portion of the combined hydro-thermal generation scenario was discussed in Sections G.2.1 through G.2.4. The impacts of the non-Susitna Basin hydropower alternatives would be similar to those of the in-basin alternatives. Depending on the site boundaries for construction and operation of Johnson, Keetna, Snow, and Browne, fugitive emission and noise impacts might extend beyond those boundaries. No noise impacts would be expected, however, if no noise-sensitive areas were within 1,500 to 3,000 ft (450 to 900 m) of the plant site.

The 85,000-acre (34,400-ha) impoundment associated with the Johnson alternative might cause occasional fogging and icing effects up to 150 ft (45 m) beyond the reservoir boundaries.

Table G-12. Results of Level-1 Screening Analysis Based on Nenana and Willow Emissions

	Background Visual Range (miles)											
	C_1†[1]				C_2†[2]				C_3†[3]			
Scenario	100	120	150	240	100	120	150	240	100	120	150	240
Nenana												
1 unit	0.035	0.037	0.040	0.044	0.010	0.011	0.011	0.010	0.004	0.005	0.006	0.010
2 units	0.068	0.072	0.077	0.085	0.021	0.021	0.021	0.020	0.009	0.010	0.012	0.019
3 units	0.103*†[4]	0.105*	0.112*	0.124*	0.031	0.032	0.032	0.030	0.013	0.015	0.019	0.028
4 units	0.128*	0.136*	0.145*	0.161*	0.042	0.043	0.043	0.040	0.017	0.020	0.024	0.037
5 units	0.156*	0.165*	0.177*	0.195*	0.052	0.054	0.054	0.051	0.021	0.024	0.030	0.046
Willow												
2 units	0.028	0.034	0.077	0.045	0.009	0.011	0.021	0.012	0.009	0.010	0.012	0.019

†[1] C_1 refers to sky/plume contrast.

†[2] C_2 refers to reduction in sky/terrain contrast.

†[3] C_3 represents the contrast reduction of the plume with respect to terrain.

†[4] An asterisk ("*") means that the Level-1 screening analysis exceeds 0.1, indicating visibility impairment.

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