DOCUMENT CONTROL

EXHIBIT E

Chapters 4, 5, & 6

FEBRUARY 1983

Prepared by

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT
FERC LICENSE APPLICATION
PROJECT NO. 7114-000
As accepted by FERC July 29, 1983

BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E

Chapters 4, 5, & 6

FEBRUARY 1983

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ACRES

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SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E CHAPTER 4

HISTORIC AND ARCHEOLOGICAL RESOURCES

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SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E CHAPTER 4

HISTORIC AND ARCHEOLOGICAL RESOURCES

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4 - HISTORIC AND ARCHEOLOGICAL RESOURCES

1 - INTRODUCTION AND SUMMARY

To date, three field seasons of reconnaissance level survey and two field seasons of systematic testing have been conducted in association with the Susitna Hydroelectric Project (1980, 1981 and 1982). The results of the first two years of the project are presented in "Cultural Resources Investigation for the Susitna Hydroelectric Project: A Preliminary Cultural Resource Survey in the Upper Susitna River Valley" (Dixon et al. 1982a). The final results of the field work conducted in 1982 will be submitted to FERC in March 1983. Preliminary results on the 52 sites documented in 1982 are included in this report.

A five-step cultural resource program was developed to comply with federal and state laws and regulations concerning protection of cultural resources for the proposed Susitna Hydroelectric Project. The five steps, listed in Section 1.1, were aimed toward locating and documenting archeological and historical resources within preselected survey locales (areas affected by preconstruction activities were also examined) and testing and evaluating these resources to determine potential eligibility to the National Register of Historic Places and proposing mitigation measures to avoid or lessen the adverse impact which may result from the proposed project. This application presents the results of a three-year cultural rescurce survey in the middle to upper Susitna River region, an impact analysis, a proposed mitigation plan to mitigate the adverse effects of the proposed project on significant cultural resources known to date and recommendations for continued studies. Further study is scheduled for 1983 and 1984 to complete the cultural resource inventory and necessary systematic testing.

In preparation for field studies, all necessary permits were obtained; literature pertaining to the archeology, ethnology, history, geology, paleoecology, paleontology, flora and fauna in and near the study area was reviewed; and available aerial photographs were examined. These data were used to develop a tentative cultural chronology for the study area and focused effort toward defining types of archeological site locales for each culture period within the geochronologic units. These data, coupled with paleoecological information, were used to select survey locales, 126 of which were surveyed during the 1980, 1981 and 1982 field seasons.

To date, 167 sites have been documented. It is estimated that continued survey will locate an additional 80 sites. Using this projection of the number of new sites expected, 67 percent of the sites have been located to date. Because of the nature of this calculation, i.e.

being based on a projected number of new sites, the percentage of sites found to date is preliminary.

The methods and defined study area varied for each aspect of study, i.e., archeology and geology (Figure E.4.3). The archeological and historical reconnaissance implemented surface and subsurface testing within the preselected survey locales in an effort to locate historic and archeologic sites. Survey data were consistently recorded on Site Survey forms which enabled systematic recording of information for each site and survey locale.

For each site located during reconnaissance level testing, regional maps, site maps, soil profiles, photographs, and other data were recorded. All specimens collected were accessioned into the University of Alaska Museum. Sites were given both University of Alaska Museum accession numbers and Alaska Heritage Resources Survey numbers.

Geological studies generated data that were used in selecting archeological survey locales. Data concerning surficial geological deposits and glacial events of the last glaciation as well as more recent volcanic ashes were compiled and provided limiting dates for human occupation of the middle Susitna River valley. This information was collected by literature review and field studies. Geological data collected during 1980 were incorporated into the 1981 and 1982 archeological programs.

Archeological reconnaissance in 1980, 1981 and 1982 located and documented 6 historic and 161 prehistoric sites, 5 of which were originally located by other investigators during brief surveys in 1971 and 1978 and 6 sites were documented in the files of the Alaska Office of History and Archeology, bringing the total known to date to 167. It is expected that continued survey will locate additional sites. Sites are also known adjacent to the study area near Stephan Lake, Fog Lakes, Lakes Susitna, Tyone and Louise, and along the Tyone River.

Systematic testing was designed to collect data on which to base the evaluation of significance for cultural resources discovered, which will assist in determining the eligibility of sites for nomination to the National Register of Historic Places, and to assess impact in order to develop mitigation measures and a general mitigation plan for significant sites located to date. Although in most cases systematic testing is necessary to address significance, the fact that many of the sites can be placed stratigraphically in relation to three distinct volcanic ashes makes it possible to consider the collective significance of all the sites because of the potential they hold for delineating the first cultural chronology for the middle Susitna region, as well as addressing questions concerning lifeways and cultural processes.

Because of the large size of the study area, number of sites located and available field time, it was possible to systematically test only 21 sites to date. Because of the minimal amount of data available pertaining to the cultural history of south-central Alaska and the middle Susitna River in particular, the primary reason for selecting these 21 sites was that they appeared to have the potential for providing data that could be used to document the cultural chronological sequence for this region of Alaska.

Both reconnaissance and systematically tested sites were evaluated to delineate the previously undocumented prehistory and history of the middle Susitna River region. These data enabled a cultural chronology to be developed which includes the following periods: Contemporary (1945 - present); Trapping (1920 - 1945); Exploration/Goldrush (1897 - 1920); Athapaskan Tradition (A.D. 1900 - A.D. 500); Choris/Norton Tradition (ca. 1500 B.C. - ca. A.D. 500); Northern Archaic Tradition (ca. 3000 B.C. - ca. 1500 B.C.); and the American Paleoarctic Tradition (ca. 9000 B.C.? - ca. 3000 B.C.?).

Impact on cultural resources will vary in relation to the type of activities that occur on or near them. Based on the present two-dam proposal (Devil Canyon and Watana) and the resultant increase in public access, 70 of the sites known to date within the study area will be directly or indirectly impacted and 89 could potentially be impacted during construction and subsequent use and operation of the facility. Because of their location away from impact areas, it appears that eight sites will not be impacted by the project.

The impact of recreational activities, upriver and downriver changes in hydrology, land access and use, and the proposed transmission corridors cannot be assessed at this time because of the lack of information concerning the amount, type and location of disturbances associated with these activities. Once all of the development plans are finalized, those sites in the potential category can be designated as likely to receive direct, indirect, or no impacts by project-related activities.

Thirty sites are presently known in areas that will be affected by the Watana Dam and its impoundment. All 30 sites will be directly impacted.

Seven sites are presently known within the area to be affected by the Devil Canyon dam and its impoundment. All seven sites will be directly impacted by the project.

Seven archeological sites were found and documented in proposed borrow sites, associated facilities, and areas disturbed by geotechnical testing. One will be directly impacted and two have the potential of being impacted. It appears that four sites will not be impacted by the project.

Five sites are presently known along the proposed access route and associated proposed borrow sites. All five sites will receive indirect pertaining to the cultural history of south-central Alaska and the middle Susitna River in particular, the primary reason for selecting these 21 sites was that they appeared to have the potential for providing data that could be used to document the cultural chronological sequence for this region of Alaska.

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Five sites are presently known along the proposed access route and associated proposed borrow sites. All five sites will receive indirect impact. Although twelve sites occurred within proposed borrow sites for the access corridor, these areas have been subsequently eliminated from consideration as borrow sources.

Thirteen sites have been recorded within the proposed transmission corridors. At this time, it appears that one site will be indirectly impacted and twelve sites could potentially be impacted. Further impact assessment must await detailed information on these corridors. The transmission corridor from the Watana damsite was selected after the 1982 field season and remains to be surveyed at the reconnaissance level. One hundred three sites are presently documented in areas outside the above categories but within the project area. Twenty-six sites will be indirectly impacted and 75 could potentially be impacted. It appears that four sites will not be impacted by the hydroelectric project.

To date, approximately 85-90 percent of the portion of the Devil Canyon damsite and impoundment considered to have cultural resource potential (including both direct and indirect impact area) has been surveyed. Approximately 50 percent of the Watana damsite and impoundment considered to have site potential (including both direct and indirect impact areas) has been surveyed. For other ares that will be disturbed by the Susitna Hydroelectric Project--borrow sites, camps, geotechnical testing areas, and the proposed airstrip--approximately 50-60 percent of these areas have been examined to date. The proposed access road [approximately 79 miles (131.7 km)] and transmission corridor [Fairbanks-Healy and Willow-Anchorage, approximately 170 miles (283 km)] have received only preliminary survey to date with less than 1 percent of the area receiving on-the-ground investigation in both these areas. No survey has been conducted on the proposed railroad [approximately 12 miles (20 km)].

No sites on the National Register of Historic Places were known in the study area prior to this study. Of the 167 known sites, 20 of the 21 sites systematically tested to date appear to qualify for inclusion in the National Register. Based on the results of the reconnaissance survey and the limited systematic testing of the selected archeological sites, the project area holds excellent potential for addressing mar long-standing anthropological questions. Three tephras permit stratigraphic correlation between many sites and site components. This presents a uniquely significant opportunity to define the development of these archeological traditions which has not been possible elsewhere in interior or south-central Alaska.

No single site has been found which preserves the cultural chronology from deglaciation to historic times, but the tephras enable cultural development to be traced through time based on comparisons of a series of sites which can be clearly documented to be temporally discrete.

1 - Introduction

With all this information, it is possible to state that most of the sites found to date in the study area are likely significant and could collectively hold the potential for defining the prehistory for this region of Alaska and, therefore, may be eligible for inclusion in the National Register of Historic Places.

Given this level of significance, it may be appropriate to nominate these sites to the National Register as an archeological district because of the unique opportunity the known sites in this area (as well as the yet undiscovered sites) have for addressing questions concerning the prehistory and history of a large portion of interior Alaska which is presently not well defined. If a nomination of this type is made, it should be done in concert with the State Historic Preservation Officer and the FERC.

Continued reconnaissance and systematic testing is necessary to locate and document as many sites as possible, given the present level of technology, to assist in the mitigation of impacts. A mitigation plan to lessen project impacts on cultural resources is a basic management tool providing options to be considered during the overall decision-making and planning process. Although the concept has and is presently undergoing refinement, it clearly consists of three options: avoidance, preservation, and investigation.

For sites to be adversely impacted by the Susitna Hydroelectric Project, either directly or indirectly, systematic testing is currently recommended in order to determine significance and eligiblity to the National Register of Historic Places. Based on this testing level, a decision on the level of investigation required can be made through consultation with the SHPO and appropriate land managing agency. For all sites that could be potentially damaged, avoidance with an accompanying monitoring plan is currently recommended. This monitoring plan should be developed in concert with the appropriate land managing agency and the SHPO. When all the activities associated with construction and use of the project are identified, it will then be possible to determine whether sites in this category will receive direct impact, indirect impact, or no impact. The appropriate mitigation measures can then be developed.

It is presently estimated that it will take two years to complete the archeological and historical inventory and the necessary systematic testing. The scope and duration of any mitigation program must await completion and evaluation of systematic testing. However, a preliminary estimate for an investigation program to mitigate adverse effects is 5 to 7 years. The estimated cost of completing the cultural resource inventory and the necessary systematic testing is $2,391,152. The cost estimate for mitigating adverse effects to cultural resources can only be made after the cultural resource inventory and systematic testing are completed and the number of sites requiring investigation and/or preservation determined. However, a preliminary estimate for mitigation activities, not including logistics support, is $8,000,000 (see Section 4.2.3 for details on cost estimates).

1.1 - Program Objectives

In order to comply with cultural resource laws and regulations, and to meet the criterion for the FERC license application, a five-step program was developed to document, evaluate, and recommend mitigation measures for these resources. These steps include:

- Step 1: Study Design and Field Study Preparation
- Step 2: Reconnaissance Level Survey
- Step 3: Systematic Testing
- Step 4: Analysis and Report Preparation
- Step 5: Curation

The five steps outlined above are aimed at fulfilling the two objectives of the project:

Identification of archeological and historical resources. This process was implemented during the 1980 field season and continued through the 1981 and 1982 field seasons. However, only a portion of the project area has been examined to date, and additional survey is required to complete the cultural resource inventory.

To date, approximately 85-90 percent of the surveyable portions of the Devil Canyon dam and impoundment and approximately 50 percent of the Watana dam and impoundment have been examined. For other areas that will be disturbed by the project--borrow sites, camps, and geotechnical testing areas--approximately 50-60 percent of these areas have been investigated. Less than 1 percent of the proposed access road and the transmission corridor have received on-the-ground investigation to date. No survey has been conducted along the route of the proposed railroad.

Based on the portion of the areas investigated to date, 167 sites have been documented. It is estimated that an additional 80 sites will be located during continued survey in areas remaining to be examined.

Systematic testing and evaluation of these resources in order to evaluate significance and make recommendations for mitigating potential adverse effects that preconstruction studies, dam construction, and/or dam operation may have on them. Systematic testing was conducted in 1981 and 1982 on 21 sites. Continued systematic testing is required to determine potential National Register eligibility of the remaining sites that will be adversely impacted by the project.

1.2 - Program Specifics

At present, there are 49 sites requiring systematic testing. It is estimated that continued archeological surveying will result in an additional 25 sites that will require this same level of testing. The actual number of sites requiring systematic testing will depend on the results of continued survey scheduled for 1983 and 1984.

1.2 - Program Specifics

1.2.1 - Archeology

(a) Step 1: Study Design and Field Study Preparation

Prior to implementing the field program it was necessary to complete the following tasks:

(i) Permits

Federal and state archeological permits were applied for and received.

(ii) Literature

Literature pertaining to the archeology, ethnology, history, geology, paleontology, flora and fauna of the study area as well as adjacent regions was reviewed prior to preparing the research design.

(iii) Archeological, Ethnological, and Historical Data

Archeological, ethnological, and historical data were synthesized into a regional and local chronology in an effort to predict the types and ages of sites that could be expected to occur within the study area. In addition to cultural data, geological data concerning the last glaciation were also examined in order to establish limiting dates for human occupation of specific areas within the middle Susitna River basin. Objectives of the geoarcheology portion of the cultural resource studies are discussed in this section. Results of 1980, 1981 and 1982 field studies indicate that prefield season projections of site locations and temporal placement provided reliable estimates of what has been subsequently documented.

(iv) Aerial Photographs

Aerial photographs of the study area were examined, the interpretation of which focused on identifying probable areas containing cultural resources as well as supplementing geoarcheological data.

(v) Cultural Resources

All previously recorded cultural resources in the study area were plotted on 1:63,360 USGS maps in order to document the location of sites within and adjacent to the study area.

(vi) Areas with Low Potential for Cultural Resources

Areas were identified that had no or very low potential for cultural resources: steep canyon walls, areas of standing water, and exposed gravel bars. These areas were eliminated from reconnaissance level testing unless ground disturbing activities were scheduled, in which case testing (when possible) was conducted.

(b) Step 2: Reconnaissance Level Testing

The purpose of this step was to identify, locate, and inventory archeological and historical sites within the study area, which can then be systematically tested. Data synthesized and generated about the study area were used to select survey locales for testing. Maps of each survey locale examined in 1980 and 1981 can be found in Appendix E of Dixon et al. (1982a). Survey locales examined in 1982 are included in the report documenting this field season (Dixon et al. 1982b).

During the 1980, 1981 and 1982 field seasons, 126 survey locales were examined using surface and subsurface testing procedures. In addition, reconnaissance testing was conducted as needed at boreholes, auger holes, proposed borrow sites, helicopter landing zones, and the proposed Watana airstrip along seismic lines and along proposed access routes. The proposed transmission corridors from Fairbanks to Healy and Willow to Anchorage and the proposed access route have received preliminary reconnaissance survey.

(c) Step 3: Systematic Testing

The purpose of this step was to test sites located during the reconnaissance level survey in order to collect sufficient data to address site significance, eligibility to the National Register, and impact, in order to develop mitigation measures and a general mitigation plan. Systematic testing, which began in 1981 and continued in 1982, required transit surveys of sites, topographic mapping, and excavation of selected units using standard archeological methods.

In addition, site maps and soil profiles of excavation units producing cultural material were drawn and photographs taken.

(d) Step 4: Analysis and Report Preparation

This step was an integral part of each step of the project. It entailed compilation of the individual reports for the other steps of the project as well as synthesizing all data recovered and making recommendations for mitigating adverse effects on cultural resources when sufficient data were available to make recommendations.

(e) Step 5: Curation

Recording of recovered artifactual material and associated contextual data was and will be an ongoing program throughout the duration of and after the project. As specified by the Federal Antiquity Permit obtained for this project, materials and supporting documentation must be stored and maintained in a suitable repository. The designated repository is the University of Alaska Museum.

Artifacts recovered to date have been accessioned into their appropriate collections at the University of Alaska Museum in accordance with state and federal requirements pertinent to the preservation of antiquities.

1.2.2 - Geoarcheology

In order to accomplish the archeological objectives, it was necessary to conduct geoarcheological studies to generate baseline data on the surficial geological deposits and glacial events in the study area which provided one of several criteria subsequently applied to the selection of survey locales during 1980, 1981, and 1982. Additionally, geoarcheological studies provide limiting dates for the earliest possible human occupation of specific areas within the region as well as baseline data on volcanic ashes (tephras) within the study area which can be used to provide relative dates for many of the archeological sites.

2 - BASELINE DESCRIPTION

2.1 - The Study Area

2.1.1 - Archeology

The general cultural resource study area was defined as those lands within approximately 3 km (2 mi) of the Susitna River from just below Devil Canyon to the mouth of the Tyone River (Figures E.4.1, E.4.2, E.4.3 and E.4.4). With respect to the dams, the areas expected to be impounded, plus a 100-m (330-ft) zone beyond this, were given priority for testing. Also included were the proposed access corridor and transmission corridors from Fairbanks to Healy and Anchorage to Willow. Areas outside the defined study area were examined when it was necessary to obtain data essential to the cultural resource study, as well as to examine areas that could be impacted by changes in the project and those that would likely be affected by recreational use of the area.

The study area delineated for cultural resource studies included direct, indirect, and potential impact areas. Direct impact is the immediately demonstrable effect of a land modification project on the resource base. Indirect impact relates to adverse effects that are secondary but clearly brought out by the land modification project which would not have occurred without the project. Potential impact is connected with ancillary development which can be predicted to occur as a result of the project and which may or may not impact sites.

Direct impact areas include the proposed reservoirs of the Devil Canyon and Watana dams, proposed dam construction sites and associated facilities, proposed borrow sites, proposed access and transmission corridors, and any other areas subject to subsurface disturbance during preconstruction, construction, or operation of the Susitna Hydroelectric Project including downcutting and erosion caused by changes in stream and river flow resulting from fluctuation of water levels of the reservoir. Indirect impact areas are those outside the above areas but nonetheless affected by the project because of such activities as increased access to remote areas afforded by roads into the project area. Potential impact can be expected to occur as a result of increased access. The exact nature of this impact remains to be demonstrated.

The study area is not static. It has changed and will continue to change in response to modifications in the engineering of the hydroelectric project, as well as to new data provided by ongoing studies associated with the overall project, such as land use analysis and recreation planning.

Should the definition of the project area change, the FERC, the Alaska SHPO, and the appropriate land managing agencies will be informed of said changes. For any new areas, the appropriate inventory measures would be implemented and a cultural resources management plan developed in consultation with these agencies as soon as possible after the identification of these areas.

2.1.2 - Geoarcheology

The study area for geoarcheological studies supporting cultural resource analysis was approximately 16 km (10 mi) wide on each side of the Susitna River extending from the Portage Creek area to the mouth of the MacLaren River (Figure E.4.3). When necessary, contiguous areas were examined.

2.2 - Methods - Archeology and History

In preparation for field studies, a research design based on current data was developed. The research design integrated the current data (Appendices A, B in Dixon et al. 1982a) into a cultural chronological framework and developed a research strategy that was structured to predict archeological site locations in relation to physical and topographic features within the limits of contemporary archeological method and theory. Based on the delineated cultural chronology, documented site locales for each culture period, geoarcheologic evaluation, and paleoecological data of the project area, survey locales were identified as exhibiting relatively high potential for archeological site occurrence. These locales were subject to preliminary examination for cultural resources representing various periods of Alaska prehistory. Additional high-potential areas remain as well as areas that have varying degrees of site potential which must also be examined. The data used in selecting the survey locales are presented below (see Section 1.1 for percent of areas examined to date).

2.2.1 - Application of Data Base

(a) Cultural Chronology

A tentative cultural chronology was constructed utilizing archeological data from known sites in or adjacent to the study area. Archeological sites of several cultural periods spanning the past ca. 10,000 years and several cultural/historical periods are known. These data assisted in selecting survey locales.

Archeological sites which were expected to occur in the middle Susitna region were not expected to exceed 9000 B.C. in age, based on the sequence of deglaciation that occurred in the area. The earliest sites that were expected in the study area were those representing the American Paleoarctic Tradition, specifically the Denali Complex for which West (1975) ascribes a date of ca. 10,000 B.C. to 4500 B.C. This distinctive and long-lasting stone tool industry is characterized by wedge-shaped microblade cores, microblades, core tablets, bifacial knives, burins, burin spalls and end scrapers. Incorporation of Denali into the American

Paleoarctic Tradition follows Dumond (1977) who suggests that the Denali Complex is a regional variant of the American Paleoarctic Tradition as defined by Anderson (1968a).

The Denali Complex has been dated between 8600 B.C. and 4000 B.C. in interior Alaska. There appears to be a hiatus of Denali sites in the interior archeological record after 4000 B.C.; however, several sites in the Tanana Valley which contain elements thought to be distinctive of the Denali Complex date between 2400 B.C. and A.D. 1000. This may suggest a late persistence of this stone industry. Sites representative of the Denali Complex are located in areas adjacent to the study area. The oldest dated Denali Complex site in the Alaska Range area is Component II, at the Dry Creek site which dates to ca. 8600 B.C. (Powers and Hamilton 1978).

Other sites containing the Denali Complex in surrounding regions are Teklanika 1 and 2 near Mt. McKinley; MMK-004 at Lake Minchumina; the Campus site; the Village site at Healy Lake; site FAI-062 (central Tanana Valley); the Donelly Ridge site; several undated Denali sites on the Ft. Wainwright Reservation in the central Tanana Valley; several sites at Tangle Lakes; two sites near Lake Susitna and upper Cook Inlet; the Beluga Point site; and the Long Lake site in the Talkeetna Mountains. These suggest that the Denali peoples were extremely widespread and occupied both inland and coastal zones. If a continuum beween early and late Denali proves to be real, a time span of over 9000 years would exist for Denali peoples. The available information suggested that sites representing the Denali period existed within the study area. Sites containing elements associated with the Denali complex were found as a result of surface and subsurface testing in the study area (see Chapters 3, 4, and 7 in Dixon et al. 1982a).

The question of the late duration of the Denali Complex is not settled. Several sites in regions adjacent to the study area have yielded materials similar to those of the Denali Complex, i.e., microblades, microblade cores, and burins, which have late dates. These are the Village site at Healy Lake with a date of ca. A.D. 500 (Cook 1969), and MMK-004 at Lake Minchumina dated ca. A.D. 800-1000 (Holmes 1978). At the Dixthada site, similar material has been dated to ca. 470 B.C. Several as yet undated sites containing Denali-like material were also located during a 1979 survey in the central Tanana Valley (Dixon et al. 1980a) and could represent late Denali occupation.

Sites potentially of late Denali age in areas near the upper Susitna study area suggest that late Denali sites could also exist in the study area. Several sites documented during the 1980 and 1981 field seasons may represent this period; however, further testing and evaluation are necessary in order to support this hypothesis.

Areas surrounding the study area have produced sites representative of the Northern Archaic Tradition as defined by Anderson (1968b) which date from ca. 4500 B.C. Northern Archaic sites include Lake Minchumina, Dry Creek, the Campus site, the Village site at Healy Lake, several sites found at Ft. Wainwright in 1979, Tangle Lakes, Lake Susitna, Beluga Point, and the Ratekin site. The distribution of these sites is similar to that for the Denali Complex sites. This tradition is characterized by notched projectile points, notched pebbles, a variety of bifaces, end scrapers, and notched boulder chip scrapers. A site on Stephan Lake (TLM 007) dating to ca. 4000 B.C. suggested the presence of the Northern Archaic Tradition in the study area. Several projectile point types indicative of this tradition were found during the 1980, 1981 and 1982 field seasons and, along with several radiocarbon dates that correspond to the time span for this culture period, indicate that this tradition is present in the upper Susitna valley (Section 3.1 and Chapters 3, 4, and 7 in Dixon et al. 1982a).

The Arctic Small Tool Tradition is characterized by assemblages containing microblade cores, microblades, burins, burin spall artifacts, flake knives, and bifacial end blades. This tradition is represented by coastal and non-coastal sites, several of the latter being known from the Alaska interior. Dumond (1977) suggests that the Arctic Small Tool Tradition can broadly encompass a Denbigh-Choris-Norton continuum, and this is how the tradition is used here. One site adjacent to the study area, Lake Susitna Site 9, has been suggested as a possible Arctic Small Tool Tradition (Irving 1957). A date of 2200 to 2800 B.C. has been documented for the Artic Small Tool occupation at Onion Portage (Anderson 1968) but may be somewhat later in the southern interior.

Norton period sites, the late end of the Arctic Small Tool Tradition continuum, first appear on the Bering Sea coast about ca. 500 B.C. Norton does not predate 400 B.C. in the upper portion of the Naknek drainage, and lasts to ca. A.D. 1000 around much of the Bering Sea area (Dumond 1977). Shortly after its appearance (ca. 500 B.C.), Norton may be represented in interior Alaska archeological

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The Arctic Small Tool Tradition is characterized by assemblages containing microblade cores, microblades, burins, burin spall artifacts, flake knives, and bifacial end blades. This tradition is represented by coastal and non-coastal sites, several of the latter being known from the Alaska interior. Dumond (1977) suggests that the Arctic Small Tool Tradition can broadly encompass a Denbigh-Choris-Norton continuum, and this is how the tradition is used here. One site adjacent to the study area, Lake Susitna Site 9, has been suggested as a possible Arctic Small Tool Tradition (Irving 1957). A date of 2200 to 2800 B.C. has been documented for the Artic Small Tool occupation at Onion Portage (Anderson 1968) but may be somewhat later in the southern interior.

Norton period sites, the late end of the Arctic Small Tool Tradition continuum, first appear on the Bering Sea coast about ca. 500 B.C. Norton does not predate 400 B.C. in the upper portion of the Naknek drainage, and lasts to ca. A.D. 1000 around much of the Bering Sea area (Dumond 1977). Shortly after its appearance (ca. 500 B.C.), Norton may be represented in interior Alaska archeological sites. This is suggested by artifacts from Lake Minchumina, the Beluga Point site in upper Cook Inlet and possibly one site in the Upper Susitna River Valley.

It should also be noted that Norton period sites in the Bristol Bay region tend to occur well up major salmon streams, presumably exploiting this rich resource (Dumond 1977). Inland Norton period sites demonstrate the importance of caribou in the Norton subsistence strategy (Dumond 1977). The Beluga Point site in upper Cook Inlet may represent the maritime portion of the Norton subsistence cycle. Norton populations employed a subsistence pattern that included the seasonal exploitation of both coastal resources (sea mammals, shell fish, and fish) and interior resources (caribou, moose, salmon, etc.). This shift in subsistence strategy may have been a response to climatic amelioration which occurred after 1000 B.C. and preceded the "Little Ice Age" (ca. A.D. 1600-A.D. 1800). This change in resource exploitation may be reflected by the occurrence of a possible Norton period archeological site in the Susitna study area.

Late prehistoric Athapaskan and historic period sites have also been documented in areas adjacent to the study area. Late prehistoric Athapaskan sites are presented at Lake Minchumina; the upper component at the Healy Lake Village site; the upper component at Dixthada; several sites at Tangle Lakes; other sites on Lakes Susitna, Louise, and Tyone; a reported site on the Tyone River; and another site in the vicinity of upper Cook Inlet. These late prehistoric Athapaskan sites indicate widespread occupation of several regions in Alaska by these groups. Dumond and Mace (1968) have suggested, based on archeological and historical data, that Tanaina Athapaskans may have replaced the Pacific Eskimo in upper Cook Inlet sometime between A.D. 1650 and A.D. 1780. Possibly this replacement occurred somewhat earlier in the study area. Several sites representing this period were documented in the upper Susitna River valley during this study (see Chapters 3, 4, and 7 in Dixon et al. 1982a).

The chronology presented here is speculative and was intended to provide a baseline from which archeological sites of different periods in the project area could be expected. This chronology is presently being tested and refined using data from archeological sites located in the study area. The relationship of this chronology to actual sites found is discussed in Chapter 7 of Dixon et al. (1982a).

2.2 - Methods - Archeology and History

In order to evaluate the significance of archeological sites located during survey and testing (with respect to National Register criteria), as well as aid in the analysis of archeological materials collected, it was necessary to explicate hypotheses which could be tested and evaluated utilizing the project data.

A fundamental hypothesis examined in this study was the validity of the cultural chronology which was proposed. To test the cultural chronology, each period must be examined separately against archeological data from sites located during survey. To evaluate a site against a proposed period in the chronology, it is necessary that the full range of artifactual material from the site, not just selected types, and nonartifactual contexts be compared against the known range of artifactual material from sites of the period and the attempt made to explain the range of variability and the anomalies. This should lead to a fuller understanding of periods involved, or the elimination of invalid periods for the study area and possibly the delineation of others presently unknown.

(b) Geoarcheological Data

Geoarcheological data was reviewed, aerial photographs examined, and a preliminary data base developed which provided information on glacial events and [illegible] geological deposits within and adjacent to the study area [illegible] 5 in [illegible] et al. 1982a). These data were used in conjunction with archeological data to select survey locales for testing. Updated geoarcheological data were [illegible] into ongoing cultural resource surveys during the course of the project.

During the [illegible] field season, [illegible] conducted in order to [illegible] tion and range of [illegible] to examine [illegible] graphic reconnaissance [illegible] order to generate data on [illegible] events. [illegible] order to examine [illegible] glacial events in the [illegible] plains, and eskers, in order to [illegible] cultural resources in specific [illegible].

Based on the analysis of the [illegible] archeological [illegible] resource field studies. [illegible]

2.2 - Methods - Archeology and History

University of Alaska, Fairbanks. In addition, organic samples collected and submitted for radiocarbon analysis were used to provide keys to stratigraphic units within the study area, information which was applied to site age whenever possible. Tephra samples were also collected in order to identify ash horizons noted in archeological sites and stratigraphic sections. As with the other geoarcheological data, this information was used to date cultural resources when possible.

2.2.2 - Permits

Federal Antiquities permits and State of Alaska permits were obtained for the project.

[illegible]

2.2 - Methods - Archeology and History

2.2.4 - Cultural Chronology

The data resulting from the review of the archeological and historical literature was used to construct a tentative cultural chronology for cultural resources expected in the study area; provide data for the delineation of a predictive model for archeological potential of various project areas; and e[illegible]plicate hypotheses that could aid in the evaluation of sites located during survey and testing. A tentative chronology suggested that sites spanning the past ca. 10,000 years would be found in the study area. Preliminary analysis of cultural resources located during the three field seasons of this project indicates that sites representing all culture periods outlined in the research [illegible] occur in the study area.

[illegible] - [illegible] Design and Strategy

[illegible] of the data derived from the literature search fo[illegible] site locales has established that archeological sites [illegible] pattern in relation to associated physical, [illegible] features. Based on the analysis of [illegible] from regions adjacent to the study area, the [illegible] associated with archeological site [illegible] below. All sites located during this [illegible] be placed in one or more of these cate[illegible]

[illegible]

[illegible] areas of higher topographic relief than much [illegible] terrain. These areas are characteris[illegible] and command a view of the surrounding [illegible] generally inferred that overlooks served as [illegible] possibly short-term campsites. [illegible] occur in elevated areas, soil deposition [illegible] they are frequently easily discovered [illegible] or examination of natural expo[illegible] sites ascribed to the Denali Complex [illegible] are the Campus site, Donnelly [illegible] and the Teklanika sites. Northern [illegible] to occur on overlooks are [illegible] sites in the Tangle Lakes area, [illegible] site, and a site near the Watana [illegible] sites ascribed to the [illegible] frequently occur on overlooks; [illegible] Arctic Small Tool sites [illegible] reported from the study [illegible] adjacent to it. The Nenana [illegible] the Tangle Lakes sites, and Lake [illegible] period sites which occur on [illegible]

(b) Lake Margins

Sites ascribed to all defined traditions have be dis-covered on the margins of major lakes. It is generally inferred that they are frequently more permanent seasonal camps and that fishing, the exploitation of freshwater aquatic resources, and large mammal hunting were the primary economic activities associated with these sites. These inferences are primarily based on the location of these sites rather than an analysis of faunal and artifactual material. Sites on lake margins may exhibit greater soil deposition than overlooks because of their lower topographic position. Sites in this setting are frequently discovered through subsurface testing, the observation of surface features, or through the examination of natural exposures. Athapaskan sites on lake margins include those at Lake Minchumina, Healy Lake, Tangle Lakes, Lake Susitna, Lake Louise, and Lake Tyone. Archeological sites ascribed to the Arctic Small Tool Tradition reported to occur on lake margins include Healy Lake, Tangle Lakes, Susitna Lake, and Stephen Lake. Sites which may be ascribed to the Northern Archaic Tradition are also known to occur on lake margins, such as the Norton component reported at Lake Minchumina. Denali Complex sites which have been found near lakes include the Tangle Lake sites, Lake Minchumina, Healy Lake, Long Lake, and Lake Susitna.

(c) Stream and River Margins

Numerous sites have been reported along the banks of abandoned channels of streams and rivers. They vary from large semipermanent seasonal camps to what appear to be brief transient camps. Soil deposition at such locales may be greater than either lake or overlook sites because of the low topographic setting of streams and an active agent (the stream or river) for soil deposition. Sites may be discovered through the examination of natural exposures, subsurface testing, and visual observation of cultural features. Denali Complex sites reported along stream and river margins or abandoned channels include Dry Creek, Carlo Creek, and the Campus site. Northern Archaic Tradition sites found in this type of locale are Dry Creek and the Campus site. The Merrill site, which is ascribed to the Norton period of the Arctic Small Tool Tradition, is a former meander of the Kenai River. Athapaskan sites on stream and river margins include Dixthada, Dakah De'nin's Village and the Nenana River Gorge site.

(d) Natural Constrictions

Areas where the topographic setting and surrounding terrain form natural constrictions tend to funnel game animals using the area. Lakes, rivers, streams, incised abandoned channels, as well as mountains and hills, can produce, either singularly or in combination, natural funnels, concentrating game animals (especially herd animals) into areas that afford more efficient and effective exploitation of this resource by human populations. Sites in the form of "lookouts" or actual kill sites could be associated with these areas. In the upper Susitna River valley extant caribou herds presently use the area for summer and calving ranges and are subject to this funneling. Presumably this was the case in the past.

(e) Areas Eliminated from Testing Program

In addition to those areas mentioned above, areas that appeared to have no or very low archeological potential were also identified and eliminated from extensive study. These include areas of steep slopes (greater than 15 degrees) such as the walls of Devil Canyon; areas of standing water including the Susitna River itself, lakes and low swampy areas; and exposed gravel bars on the Susitna River. These areas were eliminated from survey except when slated for ground-disturbing activities such as auger and boreholes, seismic testing, and the proposed Watana airstrip. In these cases, low-level helicopter reconnaissance, surface reconnaissance, and subsurface testing were conducted where possible. Numerous reconnaissance surveys were conducted in these types of areas, all with negative results.

It can easily be noted in the review of site locational data that many sites h .e been subject to reoccupation and share more than one of the defined physical, topographic, or ecological features characteristic of archeological site locales. It would appear that there may be a compounding effect in human utilization of a locale, if more than one of these major variables occur, thus possibly increasing the probability of its use and subsequent reuse. It is also recognized that this analysis is limited because it does not address known chronological and settlement pattern gaps in the archeological record. Additionally, sites such as caves, rock shelters, quarry sites, etc., are not reported immediately adjacent to the study area, although they may occur in the Susitna region. By focusing initial survey efforts in these locales, as well as natural exposures, it was anticipated that most of the archeological sites that can easily be discovered would be found during initial stages of the project, thus providing maximum time for evaluation and planning to ensure their protection. One hundred and sixty-seven archeological/ historic sites were recorded during the 1980, 1981 and 1982 field seasons through implementation of this research design and strategy.

However, a problem in the delineation of the topographic, physical, and ecological features listed above is that a variety of specific settings are subsumed under these general categories and little precise detail about individual sites is available. One objective of the research design was to attempt to obtain more precise data relevant to prehistoric settlement patterns and the juxtaposition of individual sites in relation to the natural environment. Forms used to compile these data are discussed below and presented in Appendix C in Dixon et al. (1982a). It is anticipated that analysis of these data will increase predictability for locating archeological sites. Additionally, this examination may permit detailed analysis of shifting subsistence patterns during various cultural historical periods which in turn may enable correlation of changing settlement patterns with environmental change(s).

Recorded field data gathered detailed site-specific information such as the geomorphic feature on which sites were located, topographic position and elevation, slope, exposure, view, stratigraphy, as well as details about the surrounding terrain and environment. This specific kind of information may enable an analysis of settlement patterns in relation to ecological variables and human response to changes in these variables through time. A Site Survey form was developed which outlines the specific kinds of information that field personnel were required to record. This form is presented in Appendix C of Dixon et al. (1982a). Similar information was also collected at locales where test pits did not yield cultural evidence to facilitate analysis of areas where sites do not occur.

The research design and strategy developed for this project were based on a plan designed to provide feedback data throughout the project so that new data could be used to modify, refine, and further develop the cultural resources investigation. Primary objectives of the field research program were: (1) examination of areas which would be immediately affected by the Susitna Hydroelectric Project (proposed airstrips, borrow sites, drilling locales, etc.);

(2) survey and testing of the documented archeological site locales; (3) an on-the-ground survey of preselected survey locales within the study area, and (4) systematic testing of sites discovered to determine spatial limits, depth of deposits, stratigraphic placement of cultural materials, probable age and function of sites, etc.

Cultural resources were located in 29 percent of the 126 survey locales examined over the past three years. A total of 73 sites were documented for these locales, representing approximately 44 percent of the sites known to date. The remaining 94 sites (56 percent) were located in proposed borrow sites, areas disturbed by geotechnical testing, along the proposed access routes and transmission corridors, and in other portions of the study area. As previously mentioned, the research design was developed to provide feedback data throughout the project so that new information could be used to modify, refine, and further develop the cultural resource investigation. A two-fold increase (25 percent in 1980 and 1981 to 53 percent) in the number of survey locales producing sites during the 1982 field season is directly attributable to the refinement of site locational data made possible by the analysis of data collected during the previous field seasons.

The effectiveness and efficiency of this program are also increased by the fact that areas considered to have no and/or very low archeological potential (steep canyon walls, gravel bars, and areas of standing water) were eliminated from survey. Therefore, survey efforts are placed in areas that have the potential of producing cultural resources while areas of little or no potential are not examined unless other activities such as seismic testing, boreholes, auger holes, hammer holes, test trenches, helicopter landing pads, airstrip, or other ground disturbing activities are scheduled for these areas. Although archeological potential may be considered low for these areas, examining these types of areas (when possible) acts as a check on the validity of the assessment of the potential of these types of areas. To date, no archeological or historical sites have been found in any area indicated as having no or very low potential, based on testing associated with the abovementioned activities, which includes over 100 testing areas and large tracts of wet, steep land selected as proposed borrow sources.

2.2 - Methods - Archeology and History

2.2.6 - Data Collection and Field Procedures

(a) Reconnaissance Testing

To insure consistent data collection in the field and provide a systematic format for data retrieval, a Site Survey form was used for this project (Form 1, Appendix C in Dixon et al. 1982a). The form served as a basis for recording specific information on each site located during the reconnaissance level survey as well as a basis for systematic testing. The form is organized into major categories including: site location, environment, site description and condition, photographic records, and additional information such as a site map and location of test pits. Subcategories within each of these headings provide specific data on these topics.

Daily field notes were kept by each crew member. Each page was numbered in the upper right hand corner along with the date or dates included on that page. Each site was noted by bold or underlined numbers (i.e., TLM 027) at the beginning of the notes associated with that site. Field notebooks for survey recorded much of the same information found on the Site Survey forms, such as site location, topography, vegetation, soils, extent of site, and photographs taken. Field notebooks for systematic testing also recorded a detailed description of soils; drawings of stratification of soils; drawings of significant features or artifacts in situ; horizontal and vertical placement of artifacts and features excavated at the site; site maps; methods of excavation; and collection of nonarcheological samples (soil, pollen, radiocarbon). A space was left on each page for additional notes and corrections. Crew leaders kept a continuous log of all areas surveyed, noting both the location of all test pits and natural exposures and the presence and absence of cultural material.

Once an archeological site was located, additional shovel tests were excavated, when possible, to the north, south, east and west of the test pit which first documented the site. This testing was designed to assist in determining extent of the site as well as to locate additional cultural material. In an effort to keep site disturbance to a minimum, preliminary testing at each site was limited, and the number of tests made at each site varied with the nature of the specific site. All test pits were numbered, mapped, and backfilled.

2.2 - Methods - Archeology and History

The location of all excavated and surface-collected artifacts was recorded. Specimens recovered during reconnaissance level survey were bagged by arbitrary 5-cm (2-in) levels, unless natural stratification was encountered. Each bag contained the following information: location (i.e., Devil Canyon, Survey Locale 15), date, University of Alaska Site Number or AHRS number (i.e., UA80-23 or TLM 123), name of excavator, test number (as recorded on site map, i.e., Test #1), depth, and specimen(s) in bag. Radiometric samples collected were double wrapped in aluminum foil and placed in ziplock bags with the following data recorded on each: location, date, site number, collector's name, test number, depth, specimen. All individual bags from each test were placed in a larger bag with site number, name, date and location on the outside. All test pit bags were placed in a site bag with the site number and date on the outside. All site bags were organized by survey locale.

A site-specific and regional map was made for each site. Site maps included horizontal and vertical datum points, site grid, all test pits made, location of surface artifacts, features (such as hearths, cabin remains, house pits), distance and direction to other sites or major land features, a scale, date, name of person drawing map, name of person recording data, and reference to pages in field notebooks on which additional information was recorded. Regional maps showed the site in relation to a larger portion of the study area including nearby rivers, lakes, topographic features, vegetation communities, and other sites in the immediate area.

Photographs were taken of each site located. The first picture at each site was an identification shot indicating site number, date, and crew. Other photographs recorded the environment around the site, features at the site, soil profiles exposed in test pits, and artifacts or features in situ before removal by excavation. Each photograph was recorded by roll and frame and recorded on the survey form. Direction of view, if applicable, was noted for each photograph taken, along with a short statement of content and any other data pertinent to the photograph. When practicable, a metric scale or other reference object was included. Photographs are on file at the University of Alaska Museum.

Detailed soil profiles were drawn of soil deposits exposed during excavation. These included a description of color, grain size, and consistency. Measurements documenting depth and thickness for each unit were also recorded. Soil profiles are on file at the University of Alaska Museum.

A catalog of all specimens collected in the field during survey or excavation was prepared during Step 5, Curation. Pertinent data were recorded for each specimen, including its museum accession and catalog number, description of specimen, excavation or collection unit, level or depth from which it was collected, date of collection, and collector or excavator. Site information collected and recorded during survey and testing was recorded on Alaska Heritage Resource Site Survey long forms, a sample of which is presented as Form 3 in Appendix C of Dixon et al. (1982a). These become a permanent public record of the state of Alaska.

The reconnaissance level survey was directed toward on-the-ground evaluation of preselected survey locales that have been identified for the project area. Along with the evaluation, an attempt was made in the field to identify areas that potentially may be eliminated from further survey and the location of as many site locales as possible. Form 2 in Appendix C of Dixon et al. (1982a) was developed to aid this evaluation.

(b) Systematic Testing

Prior to systematic testing, a mapping crew established horizontal and vertical site datums, topographically mapped each site, and superimposed a horizontal grid on each site. To facilitate recording data, the datum was located, when possible, so that the entire site area would fall north and east of the datum point. A 30-cm (12-in) spike was placed at the datum location with an aluminum tag containing site information including the state AHRS number, the date and "University of Alaska Museum." Two methods were used to establish a site datum elevation. Where it was possible to tie the datum into the elevation of the Susitna River, the datum elevation was determined by its elevation above the Susitna at the closest point of the river to the site. If this was not practical because of the distance from or elevation above the river, half the elevation between the contour line above and below the site was added to the lower contour elevation and this elevation used to establish elevation.

A Sokkisha BT 20 transit, 50-m (165-ft) tape and metric stadia rod were used to establish a baseline oriented to conform to local site topography in an effort to facilitate excavation. The northern end of this baseline was established as "Grid North"; all subsequent horizontal measurements referenced to grid north. A survey notebook was kept by the mapping crew with all mapping information which included magnetic declination, angles between grid north and true north, and triangulation data necessary to relocate datums in the event of disturbance. Wherever topographic considerations allowed, True North was used as Grid North; however, in most cases this was not possible.

Working from the baseline, the mapping crew used the transit and tape to establish a site grid, placing wooden stakes at 5-m or 10-m (16.5-ft or 33-ft) intervals. An east-west project baseline was established along a line at right angles to the baseline at the datum location. At larger sites, additional east/west- placed lines at right angles to the baseline were established. All stakes were placed directly at intersecting points of the grid system with the exception of a stake to insure relocation of site datum which was offset 10 cm (4 in) from the datum spike. Grid coordinates north and east of datum were written on all wooden stakes and elevations in relation to datum recorded for the top of the stake and the ground elevation at the stake location. Additional elevation measurements off the grid were recorded using a stadia rod so that a topographic map with 50-cm or 1-m (1.6-ft or 3.3-ft) contour intervals could be drawn.

The mapping crew provided the systematic testing crew with a topographic map of the site vicinity, a grid layout diagram, and elevation of all stakes prior to testing of the site.

Placement of test squares was determined by the crew leader in charge in consultation with the project supervisor and principal investigator and was based on the results of preliminary reconnaissance testing, site topography, surface cultural and noncultural features, and additional shovel testing. Coordinates of test squares located off the initial grid system were determined by triangulation from the nearest two grid stakes. Individual test square elevations were established from the closest grid stake elevation by use of a string and line level. After completion of systematic testing, all reconnaissance level test pits, systematic test squares, and shovel test locations were recorded on the site map.

After the site was mapped and gridded, a three-person crew began systematic testing. Frequently, systematic testing was initiated adjacent to the test which produced cultural material during reconnaissance level testing. Subsequent 1-m by 1-m (3.3-ft by 3.3-ft) squares were laid out to assist in determining the spatial extent of the site and to collect information for evaluating and dating the site. Systematic testing was designed to efficiently collect enough data with which to address site significance. Weighted against this consideration was the question of how much testing is necessary to adequately address this problem. An attempt was made to excavate the minimum number of tests needed to address this problem. The average number of tests placed on a site was four. However, in a few cases, additional tests were necessary because of the low frequency or, in some cases, the lack of cultural material in the initial tests.

Excavation of 1-m by 1-m (3.3-ft by 3.3-ft) squares was conducted by natural stratigraphic levels when possible. However, in a few cases soil stratigraphy was not conducive to this method, and excavation by arbitrary levels was employed. Careful attention was paid to the identification of tephras in relation to cultural remains because their relationship provided relative dating and intersite correlation. Test squares were excavated with trowels and all dirt was screened through 6-mm (1/4-in) screen unless the soil was too wet, in which case it was examined by hand. Artifacts were measured from the south and east walls of each test and vertical measurements were made with string and line level tied to the square datum. When possible, tephra samples and organic material for C14 dating were collected. C14 samples were wrapped in two layers of aluminum foil, placed in plastic bags, and oven dried at the University museum's archeology lab as soon as possible.

Soil profiles for test squares that produced cultural material were drawn. Soil colors were determined using a Munsell color chart on dry samples. Composite soil profiles were also drawn summarizing soil stratigraphy at the site. Composite soil profiles are included with each individual systematic test report (Dixon et al. 1982a). All artifacts collected were cataloged and accessioned into the University of Alaska Museum. All test squares were backfilled upon completion of testing, and each site was restored as much as possible to the condition in which it was originally found.

During systematic testing, soil profiles were drawn to scale for all four walls of 1-m (3.3-ft) test squares which produced cultural material. These profiles are on file at the University of Alaska Museum. For the purpose of the 1982 report, however, only a single composite soil profile was included for each site, or site locus, systematically tested. The composite soil profile is schematic and does not necessarily represent any individual test square at the site. Its intent is to graphically represent the sequences of all soil/sediment units that occur at the site because individual tests often do not contain the full range of soil units at a given site.

No standard technique for drawing a composite soil profile was used because test pit placement and soil deposition at each site varied considerably. The method most often utilized to abstract individual test square soil profiles into a composite site profile was to draw a diagram correlating profiles from all individual test squares. This was usually done by selecting the profile from each test square that revealed the greatest number of distinct soil units, which were drawn to scale with similar sections from profiles of all other test squares. Correlations of soil units between test squares were then matched and a composite site profile drawn by determining the average thickness of each soil unit which occurred at the site and drawing all soil units in their correct stratigraphic sequence.

The thickness of soil units sometimes varies greatly even between adjacent squares, as does the occasional presence or absence of specific soil units. The composite soil profile is a generalized profile. Elevation above or below datum and provenience of artifacts from individual test squares cannot be directly correlated with the composite site profiles. However, in a broad sense, associated soil units and contact between soil units are accurate for each site.

Three distinct tephra have been identified in the study area. These units were given regional names for purposes of field identification and nomenclature. The names given the tephra in order of increasing age are as follows: Devil (1800-2300 B.P., A.D. 150-350 B.C.); Watana (2300-3200 B.P., 350 B.C.-1250 B.C.); and Oshetna (greater than 4700 B.P., 2750 B.C., and possibly as old as 5000-7000 B.P., 3050 B.C.-5050 B.C.). These ash falls have not yet been correlated to tephra from other regions known to date to the last 7000 years. Munsell color designations were used to describe tephra color. Whenever possible, color matching was done using dry samples. For a more detailed discussion of tephra, see Chapter 5 in Dixon et al. (1982a). The relationship of cultural components to the tephra are indicated in Chapter 7 of Dixon, et al. (1982a).

2.3 - Methods - Geoarcheology 1980

2.3.1 - Literature Review

Prior to the 1980 field season, all published geologic reports were collected and reviewed for information relevant to the study. This literature survey was updated during 1981. Because specific glacial/climatic studies are not available for the immediate study area, literature for the adjacent regions was heavily relied on. The review concentrated on those areas for which radiocarbon dates were available from meaningful stratigraphic contexts. Because of the relatively high quality of climatic sequences from the Glacier Bay-Boundary Ranges region, southeast Alaska, and Brooks Range, these areas were also reviewed. No attempt was made to review the geologic literature for northern and southeast Alaska.

2.3.2 - Geoarcheologic Terrain Unit Mapping

During May of 1980, a preliminary regional map of the Susitna Valley was prepared for a first-order interpretation of the geologic history and terrain units to be studied by the archeologists. The map extended to at least 10 km (6 mi) and usually 15 - 20 km (9 - 12 mi) from the Susitna River. Units, which were defined completely from air-photo interpretation, using 1:20,000 false color infrared U-2 flight lines, were subdivided on the basis of age and surface characteristics. This preliminary map, though not detailed in the immediate vicinity of the Susitna Canyon, was used in the archeologic research design. This map is on file at the University of Alaska Museum.

2.3.3 - Field Study

Field studies were carried out during June and August, and relied almost completely on helicopters for logistical support. Four major objectives of the field program were to ascertain ground truth and reinterpret the preliminary regional geoarcheologic map; to carry out a regional stratigraphic reconnaissance; to help interpret and describe significant archeologic sites; and to examine some of the more critical glacial-geomorphologic features in the region near the proposed impoundment area.

(a) Aerial Reconnaissance

The first field objective was to get a regional overview of the Susitna Valley in order to become familiar with the distribution and range in surface landforms and deposits, and to examine the potential for stratigraphic work. In addition, this overview was necessary to examine the mapping done from airphotos in order to test its reliability and accuracy. This reconnaissance was done in conjunction with project archeologists in order to provide collective agreement on the basis for revised mapping. This joint examination allowed the geologist and archeologists to define the map units that best accommodate both needs.

(b) Stratigraphic Reconnaissance

A second objective was to determine the number and quality of river bluff exposures that might provide stratigraphic information needed to interpret and date the major valley-forming geologic events. After a "fly-by" look at all river bluffs along the Susitna and all of the tributaries from the Chulitna River to the Tyone River, 25 exposures were selected for further study. Those not selected for further study were observed from the helicopters, and only briefly described. At each selected exposure, the entire bluff face was examined and a selected stratigraphic section measured. The sediments were divided into significant natural units, and the character and height of each unit was described above "recent high water" which was used as an altitude datum. Study of each exposure resulted in a detailed sketch and description of units, including the character of the surface above the exposure. In addition to measuring and describing all units, as many as possible were sampled for various reasons. Organic matter in key units was sampled whenever possible for radiocarbon dating. Organic horizons with well-preserved plant macrofossils were sampled for paleobotanical analysis. Some sediment units were sampled to obtain a representative sample of the unit lithology. In addition, many exposures contained one or more volcanic ash layers, which were also sampled (see Chapter 5 in Dixon et al. 1982a).

(c) Archeologic Sites

During the 1980, 1981 and 1982 field seasons, the geological examination of archeologic sites was conducted, particularly those that were well stratified. Geologic descriptions of the sediment units and regional relationships at the sites greatly aided in site interpretation.

(d) Geomorphic Reconnaissance

A final field objective was to examine the landforms within the study area. Major glacial moraines, deltas, lake plains, eskers, and terraces were described and their heights and gradients measured. Most examination was done from the air, but many glacial-geologic features were studied on the ground. Also the geomorphic character of each of the geoarcheologic terrain units within the impoundment area were briefly described from the air.

(e) Revised Geoarcheologic Terrain Unit Mapping

A week was spent refining the earlier preliminary map to make it more detailed and, therefore, more useful for archeological purposes. Twenty-six units were defined and mapped directly on the U-2 images. These photographs are on file at the University of Alaska Museum. During map revision, much more attention was focused on surface relief and drainage characteristics of each unit than on its estimated age. This mapping was done during the field season because the archeologists needed to have the best possible data available for the remainder of the season.

(f) Data Organization and Compilation

Field data was organized, clarified and tabulated where possible. All short written descriptions were transferred to the 1:63,360 scale base maps. All stratigraphic diagrams and descriptions were redrawn and edited. All samples were double-checked and curated, and a detailed sample list was prepared. All photographs were labeled and keyed to geologic steps and exposures.

2.3.4 - Investigation and Dating of Samples

Nine organic samples were submitted for radiocarbon dating, and all have provided good dates for key stratigraphic horizons. One faunal sample of a fossil mammoth was examined and identified by University of Alaska scientists. One paleobotanical sample has been tentatively identified by the herbarium staff at the University of Alaska Museum. One tephra sample has been submitted to Pullman, Washington, for bulk- and trace-element analysis, the results of which are not available at this time.

2.3.5 - Methods - Geoarcheology 1981

(a) Geoarcheologic Terrain Unit Mapping

Considerable effort was expended to revise the geoarcheological terrain unit mapping during the 1981 field season. This mapping proved very useful for the selection of archeological survey locales.

(b) Glacial-Stratigraphic Mapping

Portions of the 1981 field season were devoted to continuing investigations of the distribution and extent of past glaciers during late Wisconsin time. To assess this, it was necessary to map older glacial sequences as well. This mapping effort consisted of reconnaissance mapping of glacial limits by helicopter, with numerous ground trips during which the surficial character of the glacial landforms was assessed.

(e) Revised Geoarcheologic Terrain Unit Mapping

A week was spent refining the earlier preliminary map to make it more detailed and, therefore, more useful for archeological purposes. Twenty-six units were defined and mapped directly on the U-2 images. These photographs are on file at the University of Alaska Museum. During map revision, much more attention was focused on surface relief and drainage characteristics of each unit than on its estimated age. This mapping was done during the field season because the archeologists needed to have the best possible data available for the remainder of the season.

(f) Data Organization and Compilation

Field data was organized, clarified and tabulated where possible. All short written descriptions were transferred to the 1:63,360 scale base maps. All stratigraphic diagrams and descriptions were redrawn and edited. All samples were double-checked and curated, and a detailed sample list was prepared. All photographs were labeled and keyed to geologic steps and exposures.

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2.4 - Known Sites in Project Area

(c) Archeological Stratigraphy

The major effort of the 1981 field season was devoted to interpreting the geological context of the cultural horizons at numerous archeological sites. All important sites were visited and interpreted in the field by the geologist. Sites that were not visited in the field were interpreted by the geologist on the basis of field drawings and descriptions made by the archeologists.

As part of the archeological stratigraphy effort, a major portion of the geologists' time was spent informing and educating the excavators about the landforms, soils and volcanic ash layers found throughout the study area. The standardization of techniques and descriptions which resulted from numerous instructional situations greatly improved the quality of the resulting data collected by all investigators during the field season.

Following the field season, a final interpretation of the archeological stratigraphy was made by synthesizing over 250 stratigraphic drawings made during the field season. This interpretation was supported by some laboratory investigations. Samples for radiocarbon dating were selected, prepared and sent by the geologist on the basis of their stratigraphic importance, the results and interpretation of which are discussed in Chapter 5 of Dixon et al. (1982a).

2.4 - Known Archeological and Historic Sites in the Project Area

2.4.1 - Introduction

In addition to archeological investigations, geoarcheological studies were conducted in order to provide data which would enhance the location and evaluation of cultural resources within the study area. Prior to and during field studies, geoarcheological studies were conducted to provide data that would define the ages of surficial deposits and provide limiting dates for human occupation of the area. The results of the cultural resources studies are included in this section. Federal law mandates that site locational data not be released if it might create a risk of harm to the site. Therefore, site location maps are not provided with this application but can be found in Appendix E of Dixon et al. (1982a) and the appendix of Dixon et al. (1982b).

2.4 - Known Sites in Project Area

Surface reconnaissance, subsurface testing, and review of records at the State Office of History and Archeology documented 6 historic and 161 prehistoric sites during the three field seasons of the project. One hundred and one historic period cabins were located and recorded by the land use analysis team (Subtask 7.07) under the direction of Dr. Alan Jubenville and are described in that report. Of the 101 historic cabins recorded by the land use study only 12 fell within the archeological study area. Of this number only four were older than the 1950s, which was the arbitrary cutoff date for cultural resource studies. These sites were recorded by the cultura resource study team.

Cutural resources were located in 36 (29 percent) of the 126 survey locales examined. A total of 73 sites were documented for these locales. The remaining 94 sites were located in proposed borrow areas, areas disturbed by geotechnical testing along proposed access routes and transmission corridors, and in other portions of the study area. Sites reported to the archeology study team by other project personnel were subsequently documented even if they were outside the study area for cultural resources. Four sites were originally recorded during a 1978 survey (TLM 015, 016, 017, 018) and one during a survey in 1970 (TLM 007); an additional 9 sites (HEA 026, HEA 030, HEA 035, HEA 037, HEA 038, HEA 080, HEA 083, HEA 119, HEA 137) were reported in the files of the State Office of History and Archeology.

The fact that no sites were located during reconnaissance testing in 90 (71 percent) of the survey locales could be due to the testing level employed, sampling bias, or the fact that site locational data used for selecting survey locales need to be further refined to reflect specific topographic settings in the middle Susitna River region. Although it is possible that no sites exist within the limits of these selected survey locales, the fact that testing in 29 percent of the areas did locate cultural resources suggests otherwise. This is also supplemented by the fact that in 1981 archeological sites were found in three survey locales that were reconnaissance tested in 1980 with negative results. This suggests that increased testing levels will increase the number of sites located and documented.

A preliminary evaluation of survey locales tested to date suggests that further subsurface testing may be warranted in some of these locales. Analysis is underway that will identify which locales would benefit from continued testing. This analysis will be completed prior to the 1983 field season so that this testing can be incorporated into the 1983 and 1984 field seasons.

2.4 - Known Sites in Project Area

Survey locales examined were selected based on the application of archeologic, ethnographic, historic, and geologic data compiled and refined prior to and during the 1980, 1981, and 1982 field seasons. Maps depicting these locales are presented in Appendix E of Dixon et al. (1982a) and in the appendix of Dixon et al. (1982b). Specific criteria used for defining and selecting survey locales are discussed in Section 2.2.5.

The sites documented in 1980, 1981 and 1982, as well as the sites located in 1971 and 1978 are discussed below. Each site summary contains information concerning the setting and the results of reconnaissance testing and systematic testing. Detailed site reports can be found in Dixon et al. (1982a, 1982b). Maps showing the location of each site on USGS 1:63,360 scale maps are located in appendices of Dixon et al. (1982a, 1982b). Artifacts specifically discussed in the text are presented in Artifact Photos at the end of Chapter 3 in Dixon et al. (1982a) and in Dixon et al. (1982b).

To avoid confusion, the meaning of certain terms as used in this application are discussed below:

Site: Any location with detectable physical evidence of prehistoric and early historic human activity in the Susitna Valley within the confines of a defined topographic setting. Physical evidence deposited as a result of human activity includes but is not limited to tools, lithic debitage, animal bones, and features (including hearths, house pits, cairns, etc.).

Locus: One of two or more concentrations of cultural material within a site which is spatially discrete from other concentrations of cultural material.

Scatter: A concentration or cluster of cultural material at a site or within a locus.

Shovel test: A subsurface testing method using a shovel. For this project, ca. 30-cm by 30-cm (12-in by 12-in) shovel tests were excavated in each survey locale in 5-cm (2-in) arbitrary levels and were excavated to at least 50 cm (1.6 ft) where possible.

2.4 - Known Sites in Project Area

Test pit:	A systematic excavation conducted with a trowel. Tests varied in size depending on the terrain but were usually less than 50 cm by 50 cm (1.6 ft by 1.6 ft). In some cases, shovel tests were turned into test pits when cultural material was encountered.
1m test square:	The standard excavation unit used during systematic testing.
cmbs:	Centimeters below the surface.
asl:	Above sea level.
I.L.:	Impoundment limit. Used on survey locale maps.
Survey locale:	An area selected for reconnaissance level testing based on the application of archeologic, ethnologic, historic, and geologic data.
Flake:	A fragment of rock culturally removed from a parent rock by percussion or pressure flaking. The remains of lithic tool manufacturing or repair, usually characterized by a bulb of percussion, a striking platform, and radiating ripples or force lines from the point of impact or pressure on the ventral surface.
Retouch:	The occurrence of small flake scars along the edge of a lithic artifact.
Component:	The manifestation of a given archeological phase at a site (Willey and Phillips 1958). Sites may be single component (representing only one cultural period) or multicomponent (representing two or more distinct cultural periods).
Level:	The vertical subdivision of an excavation unit, generally a naturally deposited stratigraphic unit.
Horizon:	In soil science, a natural developmental zone in a soil profile.
Tephra:	Solid material ejected during the eruption of a volcano and transported through the air. Three tephras have been identified in the middle Susitna River valley.

2.4 - Known Sites in Project Area - Watana

Sites in this section are listed by area: Watana Dam and impoundment; Devil Canyon Dam and impoundment; proposed borrow sites; and areas disturbed by geotechnical testing, access route and associated borrow areas, transmission lines, and other areas outside the above categories but within the study area.

2.4.2 - Watana Dam and Impoundment

(a) Archeological Sites

(i) TLM 017

The site is located east of Tsusena Creek, north of the Susitna River. It is situated on a level bench near the top of a northwest slope which descends to Tsusena Creek. A 180° field of view from the southwest to the northwest encompasses the Tsusena Creek drainage although the creek itself is not visible.

The site was identified during a brief 1978 survey. No surface artifacts were observed at the site, but a single subsurface test produced 372 basalt flakes, a large portion of which were cortex flakes. No diagnostic artifacts were recovered from this test, and eight additional shovel tests excavated in 1980 failed to produce additional subsurface cultural material. The 1978 test was reopened in 1980, and an additional 285 basalt flakes were recovered during wall preparation for profiling. Cultural material is associated with the contact between the Watana and Oshetna tephra.

(ii) TLM 018

The site is located east of Tsusena Creek north of the Susitna River near the 1978 Corps of Engineers Camp. Situated on an east-west trending ridge, the site is located on a low knoll which forms one of the highest points of relief along this ridge and affords an expansive view of a broad kettle and kame plain extending northeast of the site. Artifacts have been exposed in large blowouts which occur on the northern slope of this knoll.

The site was identified in 1978, and 29 flakes and a bifacially flaked triangular basalt projectile point were surface collected. An additional 138 flakes were recovered from the single test at the site. In 1980, the site was revisited and three additional artifacts were surface collected. These included a basalt biface, a chert flake with a blade facet, and a chert burin spall. Two distinct lithologies were noted among surface artifacts at the site; basalt flakes concentrated on the southwest side of the knoll and chert flakes on the northwest side.

This site was systematically tested in 1981 and all surface artifacts were collected in 1-m (3.3-ft) square units. Three 1-m by 1-m (3.3-ft by 3.3-ft) test squares were excavated at the site. A total of 1414 surface artifacts and 570 subsurface artifacts were collected. The 1981 surface collection, with the exception of a boulder chip scraper and a chert flake core, is composed totally of flakes, consisting of 1078 chert flakes, 332 basalt flakes, 2 rhyolite flakes and 2 flakes of unidentified material.

Subsurface material found in two of the three test squares consisted of 2 basalt biface fragments, an obsidian core fragment, 3 obsidian flakes, 1 chert, blade-like flake, 62 chert flakes and 503 basalt flakes. No diagnostic artifacts were recovered from the test squares. Cryoturbation and poor stratigraphy do not allow the clear division of artifacts into separate components, although it appears that an upper component, above the Devil tephra, and a lower component, below the Devil tephra, may be present.

(iii) TLM 026

The site is located north of the mouth of Goose Creek on the north side of the Susitna River. The site is situated at the southwestern point of a peninsula around which the Susitna River forms a tight bend. The view both downriver and upriver from the site is excellent for a distance of 3 to 4 km (2 to 2.5 mi).

The site consists of both surface and subsurface cultural material. Surface artifacts exposed at the top of an eroded bank overlooking the Susitna River consisted of a chert endscraper, 2 chert flakes and a rhyolite flake. Three test pits and seven shovel tests excavated during initial reconnaissance testing in 1980 did not reveal subsurface cultural material. Continued reconnaissance testing in 1981 involved systematic shovel testing along east-west transects.

Eighty-five additional shovel tests were dug, only one of which revealed cultural material consisting of 134 burned bone fragments. This shovel test was not expanded into a test pit and consequently the stratigraphic position of the faunal material is uncertain, although it appeared to be associated with the A horizon directly below the organic mat.

(iv) TLM 033

The site is located downriver from the mouth of Kosina Creek on the north side of the Susitna River near the outlet of a small lake. Situated on the point of a flat terrace, the site overlooks the lake outlet stream. The view from the site is best to the west and northwest overlooking a lower terrace and the stream drainage. The stream itself and its confluence with the Susitna River is not visible.

There is no surface indication of a site at this location. A total of three test pits and one shovel test were dug during reconnaissance level testing. The only artifact recovered was a brown chert biface fragment of uncertain provienence stratigraphically since it was found during shove testing. Systematic testing at the site included the excavation of six 1-m by 1-m (3.3-ft by 3.3-ft) test squares and five shovel tests. No additional cultural material was recovered. Extensive soil movement caused by solifluction was noted during systematic testing.

(v) TLM 039

The site is located on the western margin of a lake east of the mouth of Watana Creek on the north side of the Susitna River. It is situated at the highest elevation of a knoll at the southwestern end of the lake and is the highest point on the perimeter of the lake. The view from the knoll is panoramic, encompassing the entire lake margin.

No cultural material was observed on the surface. Reconnaissance level testing involved the excavation of three test pits, only one of which revealed subsurface cultural material. A burin spall and 14 quartzite flakes were recovered from this test. Subsequent systematic testing consisted of three 1-m by 1-m (3.3-ft by 3.3-ft) test squares all of which produced cultural material. One obsidian and two black chert microblade fragments, along with a tuffaceous flake core fragment and 45 waste flakes were recovered during systematic testing. Lithologies present include basalt, quartzite, chert, tuff and rhyolite. A single fire-cracked rock was recovered. Charcoal was present in association with the cultural material. The site appears to be multicomponent with a component above the Devil tephra and another component at the contact between the Watana and Oshetna tephra.

(vi) TLM 040

The site is located downriver from the mouth of Kosina Creek on the southern margin of the Susitna River. It is situated on an old river terrace approximately 30 m (100 ft) from the river margin. The view is obstructed in all directions by vegetation, although the river is visible through the trees.

There is no surface indication of a site at this location. A shovel test produced a jasper blade-like flake with retouch along two margins and a tuffacious flake. This shovel test was enlarged into a test pit, and an additional test pit was also excavated. No additional artifacts were recovered during reconnaissance testing, although charcoal was noted in one of the test pits.

Systematic testing of this site included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares and 10 shovel tests. Lithic material of obsidian, basalt, chert and rhyolite was recovered from three of these five test squares. None of the shovel tests produced cultural material. A total of 182 lithic artifacts were recovered during systematic testing. Artifacts recovered included 22 obsidian microbalde fragments, 4 obsidian blade-like flakes, one chert blade fragment, a possible chert graver, a chert scraper, a rhyolite boulder chip scraper, a chert flake core fragment, a chert core/chopper tool, 29 obsidian flakes, and 130 additional flakes of basalt and chert. More than one component appears to be present at this site; however, frost action has mixed the cultural material stratigraphically. Osidian and basalt lithic material including microblades are distributed through seven of the thirteen soil units recognized at the site; whereas the gray-banded chert appears to be associated within or below the Oshetna tephra. Cultural material was recovered from below, within, and at the upper contact of the Oshetna tephra and above the Devil tephra.

2.4 - Known Sites in Project Area - Watana

(vii) <u>TLM 042</u>

This site comprises two loci (A, B) and is located on the north side of the Susitna River on a peninsula across from the mouth of Goose Creek. Both loci are situated on the southeastern crest of a high river terrace which forms the peninsula around which the Susitna River makes a tight bend. Eroded bluffs form the northwest and southeast banks of this terrace; however, the top is relatively level and varies between 100 m (330 ft) and 300 m (1000 ft) in width.

Both surface and subsurface cultural material was recovered from this locus. One basalt and one siltstone biface fragment were surface collected, along with two siltstone, blade-like flakes and 25 siltstone and basalt flakes. Approximately half of the surface lithic material observed exposed in the eroding bluff edge was collected during the reconnaissance level testing. Two test pits were excavated at the top of the slope, one of which produced five additional siltstone flakes and two siltstone, blade-like flake fragments just below the organic horizon.

Three of five test squares and one of four shovel tests dug during systematic testing of this locus yielded cultural material. A total of 151 lithic artifacts and three bone fragments were collected from both surface and subsurface areas of the locus. Soil stratigraphy was dominated by solifluction features, and the bulk of the artifacts was collected from the eroding bluff face. Systematic testing yielded three retouched siltstone flakes and one possible siltstone graver in addition to 130 siltstone, 15 basalt and 2 rhyolite flakes. Lithic and faunal material, both in the test squares and in the surface flakes scatters, was uncovered in the upper organic-rich layers or an underlying yellow-brown oxidized zone. No diagnostic artifacts were found and the recovered faunal remains were too fragmentary for identification.

Locus B also consists of both surface and subsurface cultural material. Surface artifacts collected during the reconnaissance testing of the site included a side-notched basalt point base, a retouched chert flake, a basalt flake core fragment, and a chert flake. Of two test pits excavated at the edge of the eroding bluff face, one produced a basalt end scraper fragment.

Systematic testing at Locus B consisted of excavating six 1-m (3.3-ft) test squares and one test pit. Five of the six test squares yielded cultural material consisting of 109 flakes, 1 point base, 4 fire-cracked rocks, and 5 unidentified bone fragments. Cultural material was recovered from the organic horizon and above the Watana tephra. A radiocarbon determination on charcoal from above the Watana tephra resulted in a modern date (DIC-2282).

(viii) TLM 043

The site is located downriver from the mouth of Watana Creek on the north side of the Susitna River. It is situated west of a tributary creek that joins the Susitna River from the north. Located approximately 400 m (1320 ft) north of the river margin, the site sits on a river terrace in a relatively flat, open area. The view is restricted to approximately 30 m (100 ft) in all directions by trees which limit visibility to the immediate clearing in which the site is located.

No cultural material was observed on the surface. Reconnaissance level testing consisted of three test pits, two of which revealed subsurface faunal material. A dense concentration of bone fragments directly below the organic horizon yielded 48 long bone fragments, 1 rib fragment, 3 phalanges identified as caribou (Rangifer tarandus), and approximately 350 very small bone fragments too small to identify. No lithic artifacts were recovered during reconnaissance testing.

Systematic testing included the excavation of six 1-m by 1-m (3.3-ft by 3.3-ft) test squares and 11 shovel tests. Cultural material was recovered from the upper two organic soil units above the Devil tephra and consisted of 17 chert flakes, 36 fire-cracked rocks, and burned and unburned bone including 32 large fragments and a large quantity of very small fragments. All cultural material appears to be from a single occupation of the site. None of the shovel tests produced cultural material and no diagnostic artifacts were recovered.

(ix) TLM 048

The site is located at the northern end of a lake east of Watana Creek and north of the Susitna River.

Situated at the top of a 20-m-high (66-ft-high) rounded knoll, the site overlooks the lake outlet stream. The view encompasses the outlet stream, the entire northern margin of the lake, and a low marshy area to the northeast where the lake outlet stream joins a small, slow-moving creek.

No cultural material was observed on the surface at the site location. Three shovel tests and two test pits were dug during reconnaissance testing with only one of the test pits producing cultural material. A gray chert biface fragment was found in one of the initial shovel tests associated with the lower tephra. This shovel test was expanded to a test pit, but no additional cultural material was recovered.

Systematic testing included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares, four of which contained cultural material. Two components were recognized during systematic testing. The one component above the Devil tephra was represented primarily by a hearth feature containing over 1000 bone fragments and more than 300 fire-cracked rocks. Nine flakes of chert, basalt, and quartzite, showing evidence of heat spalling, and a flake core were associated with this hearth. The second component associated with the Oshetna tephra was represented by a single microblade fragment of tuffaceous rock and 12 flakes of chert, rhyolite, and tuffaceous rock. The second component is definitely associated with the Oshetna tephra, but because of cryoturbation it is not clear whether it is associated with the upper or lower contact of this tephra.

(x) TLM 050

The site is located upriver from the mouth of Watana Creek near the mouth of an unnamed creek which joins the Susitna River from the northeast. The site is situated on a small alluvial bench on the east bank of the creek approximately 40 m (132 ft) upstream from the creek mouth. The view is limited to the immediate vicinity of the site by dense vegetation, although the Susitna River is visible through the trees.

No cultural material was observed on the surface at this site. Only one of three test pits excavated during reconnaissance level testing revealed cultural material. A concentration of charcoal associated with burned bone and 34 thermally fractured rocks were found between 14 and 30 cm (6 and 12 in) below the surface between the organic mat and a yellow sand. Over 200 burned bone fragments were recovered including three phalanges and two metatarsal fragments identified as caribou. One tibia fragment identified as possible caribou was also recovered. One of the unidentified bone fragments recovered exhibits a distinct butchering mark. No lithic material other than fire-cracked rock was recovered during reconnaissance testing. A radiocarbon determination of 280 ± 110 years: A.D. 1670 (DIC-1905) was obtained on a charcoal sample.

Systematic testing of this site included the excavation of six 1-m by 1-m (3.3-ft by 3.3-ft) test squares and five shovel tests. All five test squares produced cultural material with faunal material, thermally fractured rock and lithic material recovered from two levels of the site. Nineteen flakes and 105 fire-cracked rocks were recovered. Cultural material was associated with a dark brown silt and a very dark brown silt. These two units are separated by a dark grayish brown poorly sorted sand. No diagnostic lithic artifacts were recovered.

(xi) TLM 058

The site is located on a terrace north of the Susitna River, downriver from the mouth of Watana Creek, and 100 m (330 ft) east of an unnamed creek.

No surface artifacts were observed. A shovel test subsequently widened into Test Pit 1 revealed a black chert flake, two brown chert flakes (one with bifacial end retouch), and a white chalcedony flake. The lithic material is associated with the contact of the humic zone and the Devil tephra. Six additional shovel tests and an additional test pit failed to reveal further cultural material at the site.

(xii) TLM 059

The site is located east of an unnamed creek between the Watana and Deadman Creek drainages, north of the Susitna River. The site is situated on a low, rounded knoll which is part of a series of kame ridges that line the eastern boundary of the creek drainage to the west.

The site, discovered during reconnaissance testing and later systematically tested, consists of a rectangular depression at the top of the low, rounded knoll. The dimensions of this depression are 2 by 1.8 m (6.6 by 6 ft) across and 35 cm (14 in) deep. Around the depression is a diffuse berm which is slightly higher than the surface of the knoll top. Test Pit 1 was placed along the southern interior edge of the depression; and decayed logs, charcoal, burned and unburned bone fragments, and some possible fire-cracked rock were observed. Test Pit 2, placed 7.5 m (25 ft) to the northeast of the feature, was sterile, and Test Pit 3 placed 2.1 m (7 ft) west of the feature, revealed one small burned bone fragment at the contact of the humic zone and the Devil tephra. Eleven additional shovel tests were dug around the base of the knoll, but all were sterile.

Systematic testing of the site involved excavating three 1-m by 1-m (3.3-ft by 3.3-ft) test squares, as well as further testing in Test Pit 1. A radiocarbon date on charcoal collected from the charcoal and burned bone level produced a date of 440 ± 70 years: A.D. 1510 (DIC-2253). The depression truncates all three tephra units as indicated by the testing of the berm during systematic testing. The cultural debris outside the depression is characterized by a gravelly sand unit above the Devil tephra which contains some burned bone fragments and a single chert flake. The identifiable faunal material within the feature has been identified as caribou.

(xiii) TLM 060

The site is located on the northern shoulder of the Susitna River canyon west of the mouth of Watana Creek and west of a major unnamed tributary. It is situated on the highest end of a 100-m (330-ft) long ridge.

The site consists of both surface and subsurface material. A black chert biface fragment was surface collected from an exposed soil slump, but no other surface material was observed. Eight shovel tests were placed along the ridge top, one of which revealed a subsurface artifact. This shovel test was expanded into a test pit but no additional artifacts were found. The subsurface artifact was a light olive brown tuff flake with possible retouch along one margin. The flake was found in association with the Devil tephra. Two additional test pits failed to reveal further cultural material.

(xiv) TLM 061

The site is located west of Watana Creek on the northern shoulder of the Susitna River canyon. The site is situated at the top of a 20-m (66-ft) high kame knoll which is the highest point of land for 300 m (1000 ft) in the vicinity of the site. To the east of the site is a clearwater stream and to the west lies a 1-hectare (2.5-acre) kettle lake.

No cultural material was observed on the surface of the knoll, but a shovel test near the center revealed charcoal and burned bone during reconnaissance testing. The expanded test revealed a total of 300 burned mammal bone fragments, 15 pieces of fire-cracked rock, and a quantity of charcoal. The material was present in two distinct soil horizons and may represent a multicomponent site. A total of 9 shovel tests, one of which was expanded into a test pit, were excavated at the site. Seven of these produced cultural material including the test pit.

One soil sample containing bone fragments, 15 fire-cracked rock fragments, 1 basalt flake, and 3 pieces of red ochre was collected during reconnaissance testing. Identified faunal material collected from Test 1 represented caribou. Cultural material was found above the Devil tephra.

(xv) TLM 062

The site is located on the south margin of the Susitna River west of the mouth of Kosina Creek, on a relatively flat river terrace 50 m (165 ft) above the level of the Susitna. The terrace point is the highest and most prominent landform in the immediate vicinity of the site.

Eight shovel tests were dug at the site during reconnaissance testing, one of which was expanded into Test Pit 1 when a chert core was recovered. Test Pit 1 revealed two red jasper, end scraper fragments which articulated to form a complete tool. These artifacts were associated with the Devil tephra and appear to be from the same stratigraphic context.

The site was chosen for systematic testing, and a total of six 1-m by 1-m (3.3-ft by 3.3-ft) test squares were excavated. An additional 49 shovel tests were dug to delineate site boundaries. Two and possibly three archeological components are present at the site. Chert and basalt flakes and burned bone fragments were associated with the Devil tephra, and basalt flakes and burned bone fragments were associated with the Oshetna tephra. A third component may be present in the Watana tephra, but the cultural material recovered from this tephra unit may represent mixing as the result of cryoturbation. A total of 180 basalt flakes, 1 basalt biface, and 4 basalt retouched flakes were recovered during systematic testing. Twenty-five chert flakes and over 1600 burned bone fragments were also recovered.

(xvi) TLM 063

The site is located southeast of the Susitna River and southeast of Watana Creek mouth. It is situated on top of a 20-m (66-ft) high, steep-sided, isolated kame knoll. The kame knoll is part of a low glacial outwash terrace. Numerous small streams and a 1-hectare (2.5-acre) kettle lake are located within 300 m (1000 ft) of the site.

No cultural material was observed on the surface of the knoll, and only one of 11 shovel tests revealed cultural material during reconnaissance testing. This test was expanded into a test pit, and about 700 small burned bone fragments and one jasper flake were collected.

(xvii) TLM 064

The site is located on the south side of the Susitna River southeast of the mouth of Watana Creek. Two site loci (A, B) are located on two knolls about 90 m (300 ft) apart on a northeast-southwest axis. A small lake and a clear-water tributary are located within 500 m (1650 ft) of the site.

The site contains both a surface lithic scatter and subsurface lithic material. A total of 5 shovel tests and 2 test pits were excavated at the site. Artifacts collected from the surface of the site consisted of 12 basalt flakes and 1 quartz flake. Additional basalt flakes were observed but not collected. Test Pit 2 revealed a brown rhyolite flake and a basalt projectile point base associated with the contact between a black humic soil and the Devil tephra.

(xviii) TLM 065

The site consists of two loci (A, B) located on a broad terrace south of the confluence of Kosina Creek and the Susitna River. The terrace is demarcated by a creek drainage to the east.

The site was discovered during reconnaissance testing and was later systematically tested. Locus A is characterized by a rectangular 30-cm (12-in) depression 2.3 m by 2.7 m (7.6 ft by 8.9 ft) oriented north-south, a circular depression 1 m (3.3 ft) in diameter, and an area 2 m by 5 m (6.6 ft by 16.5 ft) of sedges, moss and grass comprising a discontinuity in the general site vegetation. None of the features were tested during reconnaissance testing, but a 40- by 40-cm (16-in by 16-in) test within 6 m (20 ft) of the main feature revealed bone and fire cracked rock located beneath the vegetal mat. Locus B consists of a single circular depression 43 cm (17.2 in) in diameter and 20 cm (8 in) deep which was tested during reconnaissance survey. Two unburned innominate fragments of caribou were collected.

Systematic testing of the site included excavating four 1-m by 1-m (3.3-ft by 3.3-ft) test squares. One test bisects the circular depression at Locus A where six bone fragments, one piece of wood, one blue glass bead, three fire-cracked rock fragments, and a sheet of birch bark were recovered. Another test square was positioned to bisect an apparent wall of the rectangular feature. Heavily decayed wooden logs ran parallel to the embankment which may represent wall structures of a house depression. Eight glass beads and four fire-cracked rocks were collected from this unit. Other test squares at the site revealed additional glass beads, flakes, bone fragments, and fire-cracked rocks. Cultural material was found above the Devil tephra.

(xix) TLM 072

The site, a large circular depression, is located northwest of the mouth of Jay Creek. The site is situated at the southwestern end of an isolated, low, rounded ridge which parallels the general slope of the valley wall.

The circular depression is 90 cm (3 ft) deep and measures 4.2 m by 4.5 m (13.9 ft by 14.9 ft) across. Seven shovel tests were excavated around the outside of the pit, only one of which produced cultural material: large pieces of burned wood and charcoal. An eighth shovel test was begun near the center of the depression and a complete unburned moose metacarpal was exposed in the vegetative mat at the bottom of the pit. This was left in place and the test was discontinued so that that integrity of the feature would be intact until further testing could be carried out. The depression truncates the Devil tephra.

(xx) TLM 073

The site is located east of the Oshetna River and south of the Susitna River on a northwest-southeast oriented river terrace.

No surface artifacts were observed at the site, but two test pits and one shovel test revealed subsurface lithics during reconnaissance testing. Twelve basalt flakes, 2 brown chert flakes, 2 rhyolite flakes, 1 cryptocrystalline flake, and 1 flake of undetermined lithology were recovered from as many as 5 soil units. These are: the contact of the Oshetna tephra and the glacial drift; within the Oshetna tephra; at the contact of the Watana and Oshetna tephra; within the Watana tephra; and at the contact of the decomposed organic layer and the Devil tephra.

(xxi) TLM 075

The site is located on the south side of the Susitna River southwest of the mouth of Jay Creek. It is situated on a knoll which is part of a ridge system on the north-facing slope of the river valley.

The site comprises two areas of subsurface lithic artifacts; no surface indications were observed at the site during reconnaissance testing. Test Pit 1 produced a black chert flake and a possible black chert core tablet from the contact of the humic mat and the Devil tephra. Test Pit 2 produced two pale brown rhyolite flakes from the Watana tephra.

(xxii) TLM 077

The site is located south of the confluence of Kosina Creek and the Susitna River. It is situated on the southern end of an esker which runs north-south across the present Susitna floodplain. The site is located on the highest point of the esker, 5 m (16.5 ft) above the floodplain.

No surface artifacts were observed at the site during reconnaissance testing. Test Pit 1 produced one basalt flake below the Oshetna tephra at the contact with the glacial drift. Another flake was discovered in the backdirt of the initial shovel test. Five additional shovel tests were excavated but failed to produce further cultural material.

(xxiii) TLM 102

The site is located on the western end of a ridge crest on the northern side of the Susitna River, downriver from the mouth of Kosina Creek.

No surface artifacts were observed at the site. A black chert waste flake was found in the backdirt of a shovel test which was then expanded to become Test Pit 1. Three additional waste flakes were located in Test Pit 1. One black chert waste flake was located just beneath the humic mat at the contact of the Devil tephra unit. Two additional flakes were recovered from the Watana tephra unit.

(xxiv) TLM 104

The site is located northwest of the confluence of Watana Creek and the Susitna River. The site is situated on the south slope of an esker ridge which curves around the northern edge of a 2-hectare (5-acre) lake.

The site consists of a rectangular depression (Feature 1) of horizontal dimensions 1.4 m by 1.2 m (4.6 ft by 4 ft) and 65 cm (26 in) deep. A diffuse berm is visible around the perimeter of the depression. Test Pit 1 was placed 70 cm (28 in) from the feature and revealed charcoal and partially burned wood in a sand and gravelly matrix beneath the moss cover. Two rib fragments from a large mammal were recovered from the charcoal-wood-sand unit above the Devil tephra. Four additional shovel tests were placed within 20 m (66 ft) of Feature 1, but all were sterile.

(xxv) TLM 115

The site is located on a flat bench which occurs on a sinuous finger ridge that descends to the north side of the Susitna canyon northwest of the Kosina Creek mouth. The sides of the bench slope steeply into a tributary ravine to the east and the Susitna canyon to the south. The site is at a point of high relief which overlooks adjacent irregular and deeply incised canyon slopes, the south side of the river valley, and the river bottom, despite some obstruction by present vegetation.

No surface cultural material was observed at the site. One black basalt projectile point biface was found in place in the sod plug of a shovel test in the Oshetna tephra near its lower contact with glacial drift. Five other shovel tests on the bench failed to produce further artifactual material.

(xxvi) TLM 119

The site is located on the north side of the Susitna canyon southeast of Watana Creek mouth on a finger ridge which is roughly perpendicular to the river. The east side of the ridge is defined by a deep ravine. The site occurs at a relatively flat point of high relief on the ridge crest. Present vegetation obscures the field of view from the site.

A diffuse surface lithic scatter was observed at the site on a deflated surface and on a nearby game trail. Three chert flakes were surface collected, and two basalt flakes were observed on a game trail but not collected. One shovel test produced a single subsurface chert flake occurring in a silty-sandy matrix with finely divided organics immediately below the vegetation mat and above a discontinuous layer of pure charcoal overlying the Devil tephra. Two test pits, one superimposed on the positive shovel test, were excavated but no additional artifactual material was found.

(xxvii) TLM 126

The site is located north of the Susitna River and northeast of the Watana Creek mouth of a ridge crest. To the south, east, and west, the sides of the ridge drop moderately steeply to marshy ground. To the north, the ridge merges into high ground with further ridge systems. With some obstruction due to present vegetation, the field of view from the site is panoramic, including boggy ground to the edge of the Watana Creek canyon to the west, kame terrain to the south and east, and rising terrain to the north.

No surface indication of the site was observed. One white rhyolite and one light gray cryptocrystalline flake were found in a test pit, but their stratigraphic provenience is uncertain. They appear to have come from below the Devil tephra and above the glacial drift. No additional artifactual material was found during the excavation of two shovel tests and the examination of soil exposures on the ridge.

(xxviii) TLM 137

The site is located northeast of the Tsusena Creek mouth near the southeastern end of Seismic Line 82-A on the summit of a discrete kame which is the highest of the small set of kame ridges and knolls which abut the eastern slope of the Tsusena Creek drainage in the vicinity. Field of view from the site encompasses neighboring ridges and knolls and gradually westward descending terrain to the north and northwest, as well as gradual north-facing slopes to the south.

No surface indication of the site was observed. A brown chert flake was found in a shovel test, which was expanded into a test pit which produced a small basalt flake from a lens of coarse sand in a disturbed stratigraphic context. Six other shovel tests on the kame produced no further artifactual material.

(b) Historic Sites

(i) TLM 079

The site, a trapper's line cabin complex built by Elmer Simco in the mid-1930s is located on a low alluvial plain east of the confluence of Jay Creek and the Susitna River.

The site consists of a cabin, three outbuildings, a tree cache structure, a garbage dump, and associated historic debris. The cabin is a one room (13 by 9 feet) structure built of horizontally stacked spruce logs. A few supplies present inside the cabin are probably from the late 1950s-1960s and consist of cooking utensils and cans. The cabin is sparsely furnished but is in relatively good condition overall. Outbuilding 1 is an outhouse; Outbuilding 2 is a storage shed but is collapsed and overgrown with vegetation. Outbuilding 3 is probably a dog kennel but has been destroyed by flooding. The tree cache is dilapidated but consists of two 3.3-m (11-ft) vertical beams and a 2.1-m (7-ft) long horizontal crossbeam. A deposit of historic debris was found northeast of the cabin including such items as plastic, a sleeping bag, and cans, as well as a sheet metal stove and oven.

(ii) TLM 080

The site is a historic trapper's line cabin located on the south side of the Susitna River, east of the mouth of Watana Creek. The cabin is situated on a low, flat, poorly drained, alluvial terrace 40 m (132 ft) east of a small braided stream. The cabin has one room 2.1 m by 3 m (7 by 10) and a dirt floor. The structure is built of horizontal moss-chinked spruce logs. Interior furnishings are sparse. A built-in bunk, a low bench, two shelves, a table made of wooden boxes, and a rusted stove and pipe make up the furnishings. No outbildings or historic period debris were observed outside the cabin.

2.4.3 - Devil Canyon Dam and Impoundment

(a) Archeological Sites

(i) TLM 022

The site is situated east of the confluence of Tsusena Creek with the Susitna River. Located on an alluvial terrace overlooking the creek, the site affords a view of both the north and south banks of the Susitna River for approximately 800 m (2640 ft) to the west.

2.4 - Known Sites in Project Area - Devil Canyon

There are no surface indications of a site at this location. Reconnaissance testing consisted of one test pit and four shovel tests which revealed charcoal and burned bone associated with a hearth and fire-cracked rock. Fifty-one burned bone and tooth fragments were collected. Two phalanx fragments were identified as caribou and one canine tooth fragment as possibly bear (Ursus spp.). Radiocarbon determinations on charcoal produced modern dates (DIC 1879, DIC-2252).

Systematic testing included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares and five additional shovel tests. Two components, both represented by hearth features with associated faunal material, were identified. Most of the faunal material (487 pieces) was too fragmentary for identification; however, five phalanges and a portion of a mandible were identified as caribou. Sixty-two fragments of fire-cracked rock were recovered. No lithic artifacts were recovered. Deposition at the site is fluvial and tephras is not present in the stratigraphy.

(ii) TLM 024

The site is located in proposed Borrow Site E and within the Devil impoundment, northwest of the mouth of Tsusena Creek. It is situated at the end of a ridge overlooking an alluvial terrace to the south. The view from the site is presently restricted by a dense stand of mixed spruce and birch.

There is no surface indication of a site at this location; however, a shovel test produced a single basalt cortex flake. Three additional shovel tests and two test pits failed to reveal cultural material. The site is restricted topographically to a small bench below the point of the ridge. The provenience of the basalt flake was uncertain and it is not possible to relate this artifact to the tephra deposits which are present at the site.

(iii) TLM 027

The site is located on the south shore of the Susitna River at the mouth of an unnamed stream which joins the Susitna River upriver from the mouth of Fog Creek. Because the site is situated on the summit of a discrete knoll, the view from the site is excellent in all directions except to the south where it is obstructed by dense tree growth. Below the site there is evidence of terracing by the Susitna River.

Testing at this site included both reconnaissance and systematic testing. No surface artifacts were observed at the site. Three test pits excavated during reconnaissance testing produced 29 light green tuffacious flakes (7 with retouch), 1 tuffacious core, and 5 basalt flakes. Systematic testing, consisting of three 1-m by 1-m (3.3-ft by 3.3-ft) squares, produced 199 basalt flakes, 5 basalt flakes with cortex, 2 basalt biface fragments, 1 retouched basalt flake, 1 basalt fragment, 196 tuffacious flakes, 7 tuffacius blades, 5 possible tuffacious blades, 5 tuffacious microblades, 3 tuffacious uniface fragments, 1 tuffacious core, 1 possible tuffacious core tablet, 40 chert flakes, 1 obsidian flake, 1 cobble, and 12 flakes of undetermined material type. The site contains several components with artifacts occurring below the Oshetna tephra, at the contact between the Oshetna and Watana tephra, and above the Devil tephra.

A radiocarbon determination of 3210 ± 80 years: 1260 B.C. (DIC 2286) was obtained on charcoal associated with artifacts at the contact between the Watana and Oshetna tephra deposits.

(iv) TLM 029

The site is located upriver from the mouth of Fog Creek at the mouth of an unnamed stream which joins the Susitna River from the east. The site is situated at the edge of an alluvial terrace on the south side of this stream and overlooks the mouth of the stream. Both the Susitna River and the stream are visible and easily accessible from the site. The view is blocked to the east by topography and somewhat restricted in other directions by fairly dense black spruce.

There is no surface indication of a site at this location. Four shovel tests and one test pit were excavated. Only the test pit revealed cultural material. A total of 224 flakes were recovered from this test pit and included 213 basalt flakes, 10 chert flakes and 1 chalcedony flake. No diagnostic artifacts were recovered. The site appears to be a single component with cultural material occurring at the contact between the Devil and Watana tephra.

(v) TLM 030

The site is located on the south margin of Fog Creek upstream from the confluence of Fog Creek and the Susitna River. It is situated on the point of an alluvial terrace overlooking Fog Creek. The view is primarily northeast up Fog Creek and west down Fog Creek to the mouth, encompassing a distance of approximately 1.5 km (0.9 mi). Visibility in other directions is limited by topography and dense spruce forest.

The site contains both surface and subsurface cultural material. A side-notched basalt point was surface collected from a game trail that traverses the site. Other observed surface flakes exposed in the game trail were left in place. A total of five test pits were excavated, four of which produced cultural material. Over 500 flakes and 6 tools are included in the assemblage from the site. Diagnostic artifacts associated with charcoal concentrations include a side-notched basalt biface (backed knife), a side-notched point base of chert, 3 basalt blade-like flakes, a basalt blade core fragment and a large argillite blade-like flake. Artifacts occur above the Devil tephra, within the Watana tephra, at the contact between the Watana and Oshetna tephra and below the Oshetna tephra. A radiocarbon determination of 2310 + 220 years: 360 B. C. (DIC-1877) was obtained on charcoal associated with flakes in Test 1. Charcoal from Test 4, also associated with flakes, produced a radiocarbon determination of 4730 ± 130 years: 2700 B.C. (DIC-1880).

(vi) TLM 034

The site is located downriver from the mouth of Fog Creek on the west side of the Susitna River on the crest of a low ridge 30 m (100 ft) northwest of a small pond. Scattered spruce and birch cover the slopes of the ridge restricting the view to the immediate vicinity of the site.

There is no surface indication of a site at this location. Two test pits were excavated, one of which produced 2 rhyolite flakes, including the proximal end of a blade-like flake. Both flakes were excavated from the same soil unit, a brown mottled silt directly under the humus. Additional shovel testing along the ridge away from the immediate vicinity of the site did not produce additional artifacts.

(b) Historic Sites

(i) TLM 023

The site, a collapsed trapper's cabin, is located in proposed Borrow Site E, west of the mouth of Tsusena Creek, at the mouth of an unnamed creek which joins the Susitna River from the north. The cabin remains, not visible from the river, are located on a relatively flat alluvial terrace 50 m (165 ft) east of the braided mouth of the creek.

The fallen wall logs are partially decomposed and covered with soil and vegetation. The ground in the immediate vicinity of the cabin is littered with historic cultural debris including the remains of a dog sled. One glass jar was collected and all other historic artifacts were left in place. There is no evidence of outbuildings or a cache in the area. None of the four shovel tests excavated at the site produced cultural material. This cabin may be a line cabin used by Oscar Vogel in the 1930s and 1940s.

2.4.4 - Proposed Borrow Sites, Associated Facilities, and Areas Disturbed By Geotechnical Testing

(a) Archeological Sites

(i) TLM 035

The site is located upstream from the mouth of Tsusena Creek on the west side of the creek. It is situated on the point of an older river terrace west of Tsusena Creek. Except for isolated openings in the tree cover, the view in all directions is severely restricted by the existing vegetation and obstructed to the north by intervening topography.

There is no surface indication of a site at this location. Two of three test pits excavated at this site produced cultural material. Two waste flakes, one of rhyolite and one of basalt, were recovered from these test pits. The cultural material was associated with the contact between a dark brown silt and a gray silt (Devil tephra). No diagnostic artifacts were recovered.

2.4 - Known Sites in Project Area - Borrow Sites

(ii) TLM 068

The site is located on the southeastern slope of a low knoll on the crest of a discontinuous end moraine at the northern terminus of a 2-km (1.2-mi) wide, U-shaped valley east of Stephan Lake.

The site consists of a surface lithic scatter exposed on the deflated slope of the moraine as well as isolated surface lithics located along the moraine crest to the north of the main lithic concentration. Artifacts that were collected during reconnaissance testing include 1 black chert projectile point, 1 burinated gray chert flake, 1 gray chert biface, 1 black chert knife, 1 black chert flake, and 1 whitish-gray flake.

(iii) TLM 070

The site is located east of Stephan Lake at the northern end of a 2-km (1.2-mi) wide glacial valley which is oriented north-south. It is situated on the deflated summit of a low knoll which is part of a lateral moraine system on the eastern side of the glacial valley.

The site consists of a surface lithic scatter exposed at the summit of the knoll. A gray chert end scraper, two light gray rhyolite flakes, and a black chert flake were surface collected from the exposure during reconnaissance testing. Subsurface testing at the site failed to reveal any additional cultural material.

(iv) TLM 082

The Black River moraine site consists of two loci (A, B) located on top of a moraine north and parallel to the Black River, upstream from its confluence with the Oshetna River.

Surface reconnaissance of the moraine resulted in the collection of four out of a total of the seven flakes observed. The material was found in two concentrations located 171 m (565 ft) apart along the axis of the northeast-southwest oriented moraine. A test pit was excavated at each of the two loci, but no subsurface cultural material was observed.

(v) HEA 177

The site consisting of three loci (A, B, C) is located on the east side of a northeast-southwest trending lateral moraine east of where Butte Creek leaves Butte Lake. The top of the moraine offers an unobstructed panoramic view of the large lakeplain to the north, Butte Lake to the west, and upland hills to the south and southwest.

Of the two test pits excavated at the site during reconnaissance testing, only Test Pit 1 produced cultural material, 1 chert flake. Surface cultural material was present at all three loci and collectively consisted of 1 dark gray chert flake, 25 gray chert flakes, 2 gray chert rocks, and 1 gray chert tabular core.

(vi) HEA 178

The site is located on a moraine running east-west along the north edge of a kettle lake located northeast of the north end of Butte Lake and consists of two loci (A, B). The view from both loci is panoramic.

The one test pit at Locus A excavated at the site during reconnaissance testing did not produce any cultural material. All cultural material collected at the site was collected on the surface and collectively consisted of 4 rhyolite flakes, 23 chert flakes, and 1 basalt blade-like flake with retouch.

(vii) HEA 179

The site is located north of the Denali Highway southeast of the intersection of Canyon Creek and the highway. The view from the site is unobstructed to the northwest, north, and east overlooking the extensive southern drainage of the Alaska Range.

The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The only artifact collected at the site was a black chert flake recovered in a blowout.

2.4 - Known Sites in Project Area - Access Routes

(b) Historic Sites

None located to date.

2.4.5 - Proposed Access Routes and Associated Borrow Sites

(a) Archeological Sites

(i) TLM 051

The site is located near the southeastern boundary of proposed Borrow Site F, east of Tsusena Creek. It is located in kettle and kame topography near the top of the highest knoll in an area of numerous knolls and ridges. Approximately 17 lakes and ponds are located within 1-km (0.6-mi) radius of the site. The site location provides a view of many of the kettle lakes in the area but the principal view is of a 7-hectare (17.5-acre) lake with a long finger extending to the northwest.

No cultural material was observed on the surface. Only one of five reconnaissance level test pits excavated at the site produced cultural material. Five tuffacious rhyolite flakes, one of which exhibits retouch along one margin, were recovered from this test.

(ii) TLM 098

The site is located near the center of an elongated knoll east of a major northern tributary of Deadman Creek and north of the confluence of two streams.

The site is a surface lithic scatter consisting of two patinated gray chert flakes, one of which was collected. Additional surface reconnaissance and the excavation of a test pit in the vicinity of the surface artifacts failed to reveal cultural material.

(iii) TLM 099

This two-loci (A, B) site is located on two adjacent knolls southwest of Deadman Lake and north of the confluence of Deadman Creek and one of its northern tributaries.

(b) Historic Sites

None located to date.

2.4.5 - Proposed Access Routes and Associated Borrow Sites

(a) Archeological Sites

(i) TLM 051

The site is located near the southeastern boundary of proposed Borrow Site F, east of Tsusena Creek. It is located in kettle and kame topography near the top of the highest knoll in an area of numerous knolls and ridges. Approximately 17 lakes and ponds are located within 1-km (0.6-mi) radius of the site. The site location provides a view of many of the kettle lakes in the area but the principal view is of a 7-hectare (17.5-acre) lake with a long finger extending to the northwest.

No cultural material was observed on the surface. Only one of five reconnaissance level test pits excavated at the site produced cultural material. Five tuffacious rhyolite flakes, one of which exhibits retouch along one margin, were recovered from this test.

(ii) TLM 098

The site is located near the center of an elongated knoll east of a major northern tributary of Deadman Creek and north of the confluence of two streams.

The site is a surface lithic scatter consisting of two patinated gray chert flakes, one of which was collected. Additional surface reconnaissance and the excavation of a test pit in the vicinity of the surface artifacts failed to reveal cultural material.

(iii) TLM 099

This two-loci (A, B) site is located on two adjacent knolls southwest of Deadman Lake and north of the confluence of Deadman Creek and one of its northern tributaries.

Fourteen black-flecked gray rhyolite flakes were located on the surface of Locus A, three of which were collected. Two flakes were found at Locus B: a white patinated chert flake and a black basalt flake; both were collected. A test pit at each locus failed to produce subsurface cultural material.

(iv) TLM 101

The site is located on the southern edge of a large terrace, north of Devil Creek mouth on the east side of the creek.

The site consists of a single banded chert flake located on the surface of a gravel exposure on the southern end of the terrace. Test Pit 1 revealed no subsurface cultural material, and further reconnaissance survey of the exposures failed to reveal any more cultural material.

(v) TLM 103

The site is located on the eastern edge of a terrace north of the mouth of Devil Creek, east of and 91 m (300 ft) above the creek.

(vi) TLM 106

The site is located on a prominent knoll located centrally along an esker overlooking the valley of a creek which flows southeast into the Susitna River, east-southeast of Swimming Bear Lake. The site location affords a panoramic view of the creek valley to the east, south, and southwest. To the north, the uplands are clearly visible.

One test pit was excavated during reconnaissance testing at the site. However, the only artifact recovered was a gray chert biface fragment recovered on the surface of the large exposure on the southeastern portion of the site.

(vii) TLM 107

The site is located northwest on the confluence of Tsusena Creek and the Susitna River on a west-northwest trending esker. The view from the site is extensive in all directions.

The site consists of a surface lithic scatter on a deflated surface. Recovered artifacts included 3 chert flakes, 5 rhyolite flakes, 1 basalt flake, 1 quartzite flake, 1 cobble spall (with possible retouch), 1 biface fragment, and 1 chert point fragment (midsection). Additional flakes were observed but were not collected. A test pit was excavated on the knoll top where the vegetation mat provided soil deposition. No subsurface material was located.

(viii) TLM 108

The site is located on a prominent esker feature southeast of Swimming Bear Lake along an unnamed stream drainage. The site itself is located on the flat, oval-shaped, exposed top of the high southern end of the esker overlooking the creek and associated marsh areas to the south and west. The gradually rolling and steep uplands to the north, east and west are visible from the site.

One test pit was excavated at the site during reconnaissance testing, but no subsurface cultural material was found. A surface lithic scatter consisting of more than 100 flakes was noted at the site, but only 16 black basalt flakes and 2 gray chert flakes were collected.

(ix) TLM 109

The site is located on a peninsula at the east end of Swimming Bear Lake north of the narrowest point in the lake. The view from the site includes all of the lake as well as the uplands to the north, south, east and west.

One test pit and 13 shovel tests were excavated on the site during reconnaissance testing; however, all cultural material recovered was collected on the surface and consisted of 2 gray chert flakes and 2 brown chert flakes.

(x) TLM 110

The site is located on the top of an east-west oriented ridge northwest of Swimming Bear Lake and is about 30 m (100 ft) above the lake. The view from the site is panoramic with total visibility of the lake and surrounding terrain for approximately 2 km (1.2 mi).

The one test pit excavated during reconnaissance testing, at the highest point of the ridge, produced 20 black basalt flakes, 4 black chert flakes, 2 gray chalcedony flakes, and 1 black basalt biface fragment. Surface material collected from the site included 11 black basalt flakes, 2 gray chert flakes, 1 gray rhyolite flake, 1 white rhyolite flake, and 1 chert biface fragment. Subsurface cultural material was fround on the contact between the Watana and Devil tephra, in the Devil tephra, and above the Devil tephra.

(xi) TLM 111

The site is located at the northwest end of Swimming Bear Lake. The site is approximately 10 m above the present lake level on a spit protruding southeast into the lake. The view is extensive in all directions. The site consists of a 1.3-m by 1.5-m by 45-cm (4.4-ft by 5.0-ft by 1.5-ft) rectangular depression.

The one test pit excavated adjacent to the depression and the nine shovel tests excavated during reconnaissance testing did not reveal any cultural material.

(xii) TLM 112

The site, an irregular circle of stones, is located on a dicontinuous ridge overlooking Devil Creek and a major unnamed creek, northeast of the confluence of Devil Creek and the Susitna River, and north of Swimming Bear Lake. The view from the site is good and includes portions of the glacial valley to the north and south. However, a portion of the view to the south is obstructed by slightly higher terrain.

The one test pit placed on the site during reconnaissance testing did not reveal any cultural material. The site consists of 30 stones forming an irregular circle which ranged in size from cobbles to small boulders. The stones were partially embedded in the surrounding soil.

(xiii) TLM 113

The site is located along a southeast facing bluff northwest of Devil Creek and northeast of High Lake. From the site, a panoramic view of the Devil Creek drainage and associated lower terraces to the east, southeast and south is available.

2.4 - Known Sites in Project Area - Access Routes

The one test pit and eleven shovel tests excavated on the site during reconnaissance testing did not reveal any cultural material. All artifacts were collected on the surface. Artifacts collected included 1 gray rhyolite projectile point, 1 white rhyolite stemmed point 1 white rhyolite flake, and 1 black basalt flake with possible retouch.

(xiv) TLM 114

The site is located on the northeastern end of a north-south oriented terrace overlooking Devil Creek, due north of the confluence of Devil Creek and the Susitna River. The site commands a view of Devil Creek and its valley to the east, north, and northwest.

One test pit and three shovel tests were excavated on the site during reconnaissance testing. However, all cultural material was recovered on the surface and consisted of 5 white rhyolite flakes.

(xv) TLM 153

The site is located in a borrow area along the proposed access route. The site was field-visited but has not been recorded.

(xvi) TLM 155

The site is located along the proposed access route. It was field-visited but has not been recorded.

(xvii) HEA 181

The site is located northwest of Deadman Lake outlet at the outlet of a small lake at the southern end of a glacial valley. The view from the site is most extensive to the north, encompassing a small nearby lake and the valley walls.

The one test pit excavated at the site during reconnaissance testing revealed one chert flake. Three shovel tests in the area did not reveal any additional material. Seven surface flakes were noted at the site, four of which were collected: 3 basalt flake and 1 chert flake. The one subsurface flake was recovered from the contact between the Devil and Watana tephra.

(xviii) HEA 182

The site is located northwest of Deadman Lake on the western tip of a glacially formed knoll east of a wide, meandering, south-flowing creek. The site is located in a deflated area which extends along the western edge of the knoll. The knoll is one of the highest spots in the area affording an excellent panoramic view from the site.

The one test pit placed on the site during reconnaissance testing did not produce any cultural material. The artifacts collected from the site were recovered from the surface and consisted of 1 rhyolite side-notched point fragment, 2 basalt flakes, and 1 quartz biface fragment.

(xix) HEA 211

The site is located along the proposed access route. The site was field-visited but has not been recorded.

(b) Historic Sites

None located to date.

2.4.6 - Transmission Corridors

Preliminary aerial reconnaissance was conducted of the proposed transmission line routes from Fairbanks to Healy and Willow to Anchorage. The transmission corridor from the Watana Dam to the intertie was selected after the 1982 field season and remains to be surveyed.

(a) Archeological Sites

(i) HEA 026, HEA 030, HEA 035, HEA 037, HEA 038, HEA 080, HEA 083

The above sites are reported in the files of the Alaska Office of History and Archeology. The sites were not visited by the personnel of the Susitna Archeological Project.

(ii) HEA 119, HEA 137

These sites are reported in the files of the Alaska Office of History and Archeology. The sites were not visited by the personnel of the Susitna Archeological Project.

(iii) HEA 120

The site is located southeast of the confluence of Healy Creek with the Nenana River on the middle terrace of a series of at least three alluvial terraces. View from the site includes hilly uplands north of Healy Creek, the Nenana River valley to the west, and the southward continuation of the terrace system to its terminus against the north-facing slope of Healy Creek valley.

During surface reconnaissance, a brown agate flake (Locus A) was found 40 m (132 ft) south of a gray chert retouched flake (Locus B). Locus B in contrast to Locus A is situated on the terrace margin overlooking Healy Creek. The terrace surface was largely wind-scoured and no subsurface testing was conducted, but extensive additional surface reconnaissance failed to reveal further artifactual material.

(iv) FAI 213

The site is located northeast of the confluence of Birch Creek with the Nenana River. The site is situated on the top of a steep, south-facing bluff. At the base of the bluff is a 300-m (1000-ft) wide abandoned stream channel which is presently well vegetated. Visibility from the site is excellent to the northwest, where the channel begins to open out onto the Tanana Flats outwash plain. Mountainous uplands are visible to the south and southeast. Visibility in other directions is restricted by brushy ground along the level bluff top.

Both surface and subsurface cultural material were collected during reconnaissance testing. Twenty-nine flakes were recovered from a deflated area on the edge of the bluff. An additional flake was observed but not collected about 50 m (165 ft) to the northeast. Three shovel tests were dug, one of which produced a basalt flake. A test pit was excavated on the north edge of the surface exposure and an additional gray chert flake was recovered. A massive charcoal lens with oxidized soil was observed within this test pit.

(v) FAI 214

The site is located on the eastern end of a ridge in the hilly uplands forming the west Nenana valley wall southwest of the confluence of Birch Creek and the Nenana River. The field of view from the site is obstructed to the west by the forested ridge, but is panoramic in other directions encompassing a section of the Tanana Flats, the constricted river valley east of the site, and the widening valley to the south.

No surface indication of the site was noted. An obsidian flake was found in a shovel test. A test pit superimposed on the shovel test produced 4 basalt flakes from a red-brown silt unit. A second shovel test near the test pit produced 6 basalt flakes from the same stratigraphic unit.

(b) Historic Sites

None located to date.

2.4.7 - Other Areas

During the course of the cultural resource study a number of sites were located outside the areas already addressed in this application by project personnel (helicopter pilots, land use planning team, geologist, etc.). Although no subsurface disturbance was scheduled for these areas, location and documentation of these sites were very important because little is known about the history and prehistory of the upper Susitna region and each site studied increases the data base. In addition, since these sites were located and could potentially be impacted by future recreation use, it is in the best interest of any cultural resource management plan to include them as part of this study.

(a) Archeological Sites

(i) TLM 007

The site is reported in the files of the Alaska Office of History and Archeology. The site was not field-visited by the personnel of the Susitna Archeological Project.

(ii) TLM 015

The site is located east of Tsusena Creek north of the Susitna River in kettle and kame topography. Located at the top of a kame, the site offers an unrestricted view of numerous knolls, ridges and kettle lakes.

This site was tested in 1978 and revisited in 1980 without additional testing. In 1978, a single test produced two waste flakes from different soil units suggesting that the site may be multicomponent. No tephra deposits were noted in descriptions of the soil units at the site. No surface artifacts were observed at the site.

(iii) TLM 016

The site is located in an area of kettle and kame topography bordered to the west and east by Tsusena and Deadman Creeks and to the south by the Susitna River. It is situated at the highest elevation of a low, rounded kame knoll which is the highest point of relief within a 600-m (2000-ft) radius. The view from the site is panoramic, but the principal view is to the west and north encompassing portions of four lakes.

Both surface and subsurface cultural material were found at this site in 1978. The site was revisited in 1980, but no additional testing was done. During testing in 1978, six basalt and rhyolite flakes were recovered from a blowout, and five test pits were excavated at the site. Forty bone fragments and six waste flakes associated with charcoal were recovered from Test 1. A radiocarbon date of 3675 $\pm$ 160 years; 1725 (B.C.) (GX-5630) was obtained from this charcoal. Two other tests produced subsurface cultural material, including a unifacially retouched rhyolite pebble from Test 2 and six waste flakes from Test 5.

(iv) TLM 021

The site, consisting of three loci (A, B, C), is situated on an east-west trending ridge northwest of the confluence of Kosina Creek and Gilbert Creek. The easternmost locus, Locus A, overlooks Kosina Creek which is not visible from the other loci. All three loci are exposed in deflated areas along the crest of the ridge.

Testing was concentrated at Locus A where four surface flake scatters were identified. Two scrapers (chert and rhyolite) and a retouched rhyolite flake were found spacially isolated from the flake scatters. A total of 570 rhyolite flakes, 9 chert flakes, and 1 basalt flake were surface collected from this locus, approximately half of the surface flakes observed. Four test pits were excavated, only one of which produced subsurface material consisting entirely of waste flakes.

Locus B consists of six flake scatters from which all observed surface artifacts were collected. Diagnostic surface artifacts included the medial section of a projectile point, a scraper, and a biface, all of rhyolite. A single test pit excavated at this locus produced one chert flake associated with burned bone and charcoal. A radiocarbon determination of 1160 $\pm$ 100: A. D. 790 (DIC-1878) was obtained from this charcoal. One hundred and fourteen rhyolite, 4 chert, and 2 basalt flakes were surface collected. Four of the rhyolite flakes showed retouch.

Locus C consists of a single flake scatter containing 21 brown chert flakes, 6 basalt flakes, and 2 rhyolite flakes, all of which were collected. One test pit was dug which produced a single gray chert flake directly below the vegetative mat.

(v) TLM 025

The site is located south of the Susitna River and southwest of the mouth of Watana Creek. It is situated at the highest elevation of a glacial crag and tail feature which exhibits sharp relief in relation to the surrounding terrain. The view from the site is excellent in all directons for a distance of over 10 km (6 mi).

2.4 - Known Sites in Project Area - Other Areas

(iv) TLM 021

The site, consisting of three loci (A, B, C), is situated on an east-west trending ridge northwest of the confluence of Kosina Creek and Gilbert Creek. The easternmost locus, Locus A, overlooks Kosina Creek which is not visible from the other loci. All three loci are exposed in deflated areas along the crest of the ridge.

Testing was concentrated at Locus A where four surface flake scatters were identified. Two scrapers (chert and rhyolite) and a retouched rhyolite flake were found spacially isolated from the flake scatters. A total of 570 rhyolite flakes, 9 chert flakes, and 1 basalt flake were surface collected from this locus, approximately half of the surface flakes observed. Four test pits were excavated, only one of which produced subsurface material consisting entirely of waste flakes.

Locus B consists of six flake scatters from which all observed surface artifacts were collected. Diagnostic surface artifacts included the medial section of a projectile point, a scraper, and a biface, all of rhyolite. A single test pit excavated at this locus produced one chert flake associated with burned bone and charcoal. A radiocarbon determination of 1160 ± 100: A. D. 790 (DIC-1878) was obtained from this charcoal. One hundred and fourteen rhyolite, 4 chert, and 2 basalt flakes were surface collected. Four of the rhyolite flakes showed retouch.

Locus C consists of a single flake scatter containing 21 brown chert flakes, 6 basalt flakes, and 2 rhyolite flakes, all of which were collected. One test pit was dug which produced a single gray chert flake directly below the vegetative mat.

(v) TLM 025

The site is located south of the Susitna River and southwest of the mouth of Watana Creek. It is situated at the highest elevation of a glacial crag and tail feature which exhibits sharp relief in relation to the surrounding terrain. The view from the site is excellent in all directons for a distance of over 10 km (6 mi).

The site contains both surface and subsurface cultural material. A surface flake scatter is exposed in a blowout covering an area 4 m by 35 m (13 ft by 116 ft). Diagnostic artifacts collected from the surface include a chert core tablet, a rhyolite, bipolar-flaked, cylindrical core, a rhyolite core tablet, two rhyolite microblade midsections, a basalt point base, a possible cobble hammerstone, and a chert scraper. In addition, 14 waste flakes were surface collected including two obsidian flakes. Three test pits were excavated, two of which produced cultural material. Test 1 produced a single rhyolite flake and Test 2 produced two basalt flakes. No tephra deposits were noted during reconnaissance testing.

(vi) TLM 028

The site, consisting of two loci (A, B), is situated on an esker located west of the mouth of the Tyone River on the north margin of the Susitna River. This esker parallels a bend of the Susitna River for approximately 1 km (0.6 mi). Locus A is situated at the highest elevation on the extreme northeast end of the esker, and Locus B is located approximately 750 m (2475 ft) southwest of Locus A on the level crest of the esker. The view from both loci is good in all directions although limited by the relatively low elevation of the esker.

The site is surficial, limited to a single, isolated flake collected at each locus. At Locus A, a rhyolite flake was found in a blowout. Two test pits and a shovel test did not reveal any subsurface cultural material at this locus. A basalt waste flake was surface collected at Locus B from a game trail which follows the crest of the esker. A single test pit at this locus failed to reveal any additional cultural material. Intensive surface reconnaissance along the entire length of the esker did not produce any additional surface artifacts.

(vii) TLM 031

The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. The site is situated in a system of hills and ridges surrounding several small lakes.

The site consists of a single, isolated surface artifact, a black chert end scraper on a blade. Three test pits excavated at the site failed to reveal additional cultural material. The site is located on an extensively deflated ridge, and intensive surface reconnaissance did not produce any further surface artifacts.

(viii) TLM 032

The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is located south of the southernmost point of the largest of three kettle lakes at the eastern end of the plateau. The view from the site is panoramic but somewhat restricted to the south by topography.

A total of 10 artifacts were surface collected during reconnaissance testing, including 2 quartzite end scrapers, a retouched rhyolite flake, a notched cobble exhibiting battering at one end, and a chalcedony core fragment. In addition, 5 flakes were collected with lithologies including basalt, chert and quartzite. A single test pit in the immediate vicinity of the surface scatter did not reveal subsurface artifacts. The entire area around the concentration of surface artifacts consisted of bedrock and deflated ground. All observed artifacts were collected.

(ix) TLM 036

The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is situated on a small knoll overlooking a south-facing slope leading down to the Susitna River. The knoll and ridge upon which the site is located are part of a system of discontinuous ridges exhibiting numerous bedrock and drift exposures. The view from the site is panoramic ranging from 1 km to 5 km (0.6 mi to 3 mi).

The site consists of a surface lithic scatter exposed in a blowout approximately 8 m by 12 m (26.5 ft by 40 ft) in size. A unifacially worked chert end scraper was surface collected from this blowout along with a single gray chert flake. No other cultural material was observed on the surface. A single test pit at the site did not reveal any subsurface cultural material and encountered bedrock within 10 cm (4 in).

2.4 - Known Sites in Project Area - Other Areas

(x) TLM 037

The site is located on a high plateau on the north side of the Susitna River downriver from the mouth of Kosina Creek. It is situated on one of the numerous east-west trending glacially scoured ridges. Exposed bedrock and drift characterize this plateau. The view is panoramic and includes two kettle lakes to the southwest of the site.

This is a surface site consisting of four waste flakes exposed in a blowout measuring approximately 40 m by 50 m (132 ft by 165 ft). Two of these flakes, one of gray chert and one of basalt, were surface collected, and two gray chert flakes were left in place. No diagnostic artifacts were observed. A single test pit did not reveal any subsurface cultural material. Soil deposition in the vicinity of the site is shallow; bedrock was encountered within 10 cmbs.

(xi) TLM 038

The site is located upstream from the mouth of Watana Creek on the eastern edge of a plain overlooking the creek from the west. It is situated on a small discrete lobe of the continuous edge of the plain. Access to Watana Creek is difficult or impossible in places where downcutting has resulted in cliffs and steep bedrock exposures. The view encompasses the relatively level plain west of the site and a lower alluvial terrace along with portions of Watana Creek to the north and northeast.

There is no surface indication of a site at this location. Reconnaissance level testing included two test pits and three shovel tests. Burned bone associated with charcoal was revealed in one test pit and two shovel tests. Several hundred calcined bone fragments were recovered. Most bone fragments were too small to identify, but 12 long bone fragments, 1 carpal, 1 metacarpal, and 1 tooth were identified as caribou.

Systematic testing of this site included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares and a single 40-cm by 40-cm (16-in by 16-in) test pit. An additional 22 bone fragments and 9 thermally fractured rocks were recovered and attributed to a single occupation. Four of the test squares produced cultural material, although concentration of faunal material was much less dense than in the reconnaissance test pits. No cultural lithic material other than fire-cracked rock was recovered. The cultural unit is within and above the Devil tephra.

(xii) TLM 041

The site is located on a high flat plain south of the Susitna River, southwest of the confluence of a large tributary of Fog Creek. The site is situated on a low knob on a broad, northeast-southwest, sloping, grassy plain. Despite low topographic relief, the site location affords an unobstructed panoramic view of an open plain 300-m to 400-m (1000-ft to 1320-ft) wide and approximately 1-km (0.6-mi) long.

The site was identified by an R&M geologist who collected a tuffacious rhyolite flake from the surface. Subsequent intensive surface reconnaissance and two subsurface tests failed to reveal additional cultural material. The exact location at which the flake was collected was never identified.

(xiii) TLM 044

The site is located west of Jay Creek and north of the Susitna River on a high plateau comprising glacially scoured hills and ridges. It is situated on the deflated top of a discrete knoll which affords a panoramic view of the surrounding terrain and a valley to the north which contains several lakes.

Both surface and subsurface cultural material were present at this site. Surface material consisted of five lithic scatters exposed in blowouts near the highest elevation of the knoll. A complete lanceolate point, a biface fragment, a retouched flake, a uniface fragment, 22 waste flakes and 19 bone fragments were surface collected during reconnaissance level testing. A single test pit produced 15 basalt flakes and 69 bone fragments associated with charcoal. No tephra deposits were encountered. Flake lithologies present at this site include basalt, rhyolite, chert and chalcedony.

(xiv) TLM 045

The site, consisting of two loci (A, B), is situated on the south- and east-facing slopes of a knoll northeast of TLM 044. The view from Locus A is limited by intervening topography to less than 100 m (330 ft). Locus B is situated on an east-facing slope overlooking a small valley and the view from this locus includes both the valley to the north, low marshy areas, and kettle lakes to the southwest.

Reconnaissance level testing revealed both surface and subsurface cultural material. Surface material was found in three flake scatters comprising two loci (A, B) 104 m (345 ft) apart. A complete chert point, a chalcedony microblade, a chalcedony microblade fragment, a retouched flake, and 62 bone fragments were surface collected along with 63 waste flakes. Approximately 126 surface flakes were left in place. A single test pit produced two basalt flakes and one rhyolite flake, about 290 bone fragments, 25 flakes, and 16 possible fire-cracked rocks. Faunal material included a phalanx identified as caribou, a tarsal fragment identified as possibly caribou, and a right and left maxilla identified as arctic ground squirrel (Spermophilus parryi). Lithologies represented at the site included basalt, rhyolite, chert, chalcedony and obsidian. Subsurface cultural material appeared to be associated with the contact between the Devil and Watana tephra deposits.

(xv) TLM 046

The general location and topographic setting of TLM 046 is similar to that of TLM 044 and TLM 045. TLM 046 is situated on the easternmost and highest of three knolls, the western knolls containing the other two sites. All three knolls are part of the same landform and the western slope of the highest knoll joins the ridge upon which the two lower knolls are situated. TLM 046 is located at the northern end of a north-south oriented knoll which affords the most commanding panoramic view of any of the surrounding terrain features. The view encompasses both the valley to the north with its series of interconnected lakes and lower elevations to the east and southeast with kettle lakes.

Both surface and subsurface cultural material were recovered from four flake scatters during reconniassance testing. Two projectile point bases, one of chert and one of basalt, were surface collected along with a basalt end scraper, a chert end scraper, 48 waste flakes and about 200 bone fragments. Some surface bones and 43 observed flakes were left in place. Only one of three test pits produced cultural material: 30 flakes (lithologies including basalt, rhyolite, chert and obsidian) and 8 burned bone fragments associated with charcoal. Subsurface cultural material was associated with the Watana tephra and the contact between the Watana and Oshetna tephra. A radiocarbon determination of 2340 ± 145 years: 390 B.C. (DIC-1903) was obtained from charcoal associated with subsurface cultural material.

Systematic testing included the excavation of five 1 m by 1 m test square, three of which produced cultural material. Two additional surface lithic scatters were identified at the site during systematic testing. Additional surface collection at the site included 1 point base, 75 flakes and 8 bone fragments. A total of 180 flakes were recovered from the three test squares which produced cultural material. A charcoal concentration interpreted as a hearth feature was encountered 5 cm to 10 cm (2 in to 4 in) below the surface in one of the test squares.

(xvi) TLM 047

The site is located downriver from Vee Canyon on the west side of the Susitna River. It is situated 800 m (2640 ft) west of the river at the north end of a north-/south-oriented bedrock ridge. The Susitna River valley and the river itself are visible to the north, east and south, but the view to the west is blocked by bedrock cliffs and higher terrain.

The site consists of a 3-m by 10-m (10-ft by 33-ft) surface lithic scatter exposed on the deflated crest of a bedrock ridge. Surface-collected artifacts included a chert biface fragment, a chert mircoblade fragment, and a retouched chert flake in addition to 24 rhyolite and basalt flakes. Approximately 70 rhyolite flakes were left in place. Two test pits excavated during reconnaissance level testing failed to reveal subsurface cultural material, and the site appears to be limited to the extreme northern end of the ridge.

(xvii) TLM 049

The site is located east of the mouth of the Oshetna River on the south side of the Susitna River. It is situated on the summit of a discrete knoll located on on a north-south trending continuous ridge overlooking the Susitna River. The site overlooks a broad alluvial terrace to the west, north, and east which contains two lakes, only one of which is visible from the site.

Both surface and subsurface cultural material are present at this site. A total of four test pits were excavated on the knoll, one of which produced a single basalt flake within the organic mat. Two additional surface flakes were observed, but not collected, in a blowout on the ridge top approximately 500 m (1650 ft) south of the knoll.

(xviii) TLM 052

The site, consisting of two loci (A, B) is located northwest of the mouth of Jay Creek on a southeast-northwest trending ridge. This ridge is the highest of numerous deflated ridges and knolls in this vicinity and affords an excellent vantage point overlooking the largest kettle lake in the area, an 8-hectare (20-acre) lake (Laha Lake) southeast of the site. Locus A is situated at the edge of the deflated crest of the ridge on the southern slope overlooking Laha Lake, and Locus B is located on the northeastern rounded crest of the ridge.

Both surface and subsurface cultural material were found at this site. Artifacts surface collected from the site included one basalt and two chert point bases and seven basalt and chert waste flakes. Thirty-four basalt and chert flakes were left uncollected. Most of the surface lithic material was observed at Locus A where a single test pit excavated immediately southwest of the largest concentration of flakes produced a black bashalt flake 7 cm (3 in) below the surface at the contact between the organic horizon and a gray silt (Devil tephra).

(xix) TLM 053

The site, consisting of two loci (A, B), is located northeast of the mouth of Jay Creek. Situated on a deflated ridge, the two-site loci are 240 m (792 ft) apart on opposite ends of the ridge.

Locus A contains both surface and subsurface material. A surface lithic scatter includes a chert flake bifacially retouched on the right lateral margin with a graver spur at the distal end; a whitish-gray chert flake with retouch on the left and right margins at the distal end; a large tuffacious rhyolite flake; a basalt flake; and a chalcedony flake. Test Pit 1 revealed a light brown tuffacious rhyolite flake on the contact of the glacial drift and the Devil tephra unit. Locus B consists of a single gray chert flake retouched on the dorsal surface (possibly a scraper). Locus B lacked any soil other than glacial drift and bedrock, and therefore, no subsurface testing was conducted.

(xx) TLM 054

The site is located on a kame or esker remnant east of Tsusena Creek.

No surface material was observed at the site. Two dark gray chalcedony flakes were recovered from beneath the organic mat during an initial shovel test. This shovel test was expanded into Test Pit 1, and one small bone fragment was recovered. A second test pit 5 m (16.5 ft) northeast of the first was negative.

(xxi) TLM 055

The site is located north of the northwest tip of Tsusena Butte, and west of Tsusena Creek. It is situated on a low knoll which rises approximately 2 m (6.6 ft) above the surrounding terrain. Tsusena Creek is visible from the site through present vegetation. A very wet area consisting of muskeg and marsh is present between the site and Tsusena Creek, although the immediate vicinity of the site is better drained and covered with spruce forest.

No surface artifacts were observed at the site. Two shovel tests were placed on this knoll, one of which produced a chert scraper. This shovel test was expanded into a test pit from which four additional chert flakes were recovered. Cultural material occurred above the Devil tephra in a zone of finely divided organics. During the systematic testing of site TLM 097, TLM 055 was revisited and a single 1 m (3.3 ft) test square was excavated at the site in an attempt to obtain additional diagnostic lithic material. Four burned bone fragments and five fire-cracked rocks were found associated with a dense concentration of charcoal within the same finely divided organic horizon above the Devil tephra. Three very small chert flakes were the only lithic material recovered from this test square.

(xxii) TLM 057

The site is located east of Big Lake overlooking an outlet creek to the north and the lake itself to the west.

The surface lithic scatter at the site included a chert microblade fragment, two chert flakes, and a quartzite fragment, all of which were collected. Several basalt flakes were left uncollected from the surface. Five shovel tests and a single test pit were placed on the flat knoll top but all failed to reveal subsurface material.

(xxiii) TLM 066

The site is located on the east-southeast slope of a ridgetop plateau east of Watana Creek and northeast of the mouth of Watana Creek. The site overlooks a small unnamed creek to the southeast, mountainous slopes to the northeast, and surrounding low-lying terrain in other directions. Three bifacially chipped tools were recovered from an exposed blowout surface during reconnaissance testing. These include a gray chert lanceolate projectile point found in two pieces, the base of a black chert projectile point with a reworked tip, and a gray chert ovate biface found in two pieces. One test pit excavated near the ovate biface failed to reveal subsurface cultural material.

(xxiv) TLM 067

The Sonona Creek site is situated on top of a knoll along the east side of Big Bones Ridge, west of Sonona Creek. The knoll is a prominent topographic feature, and the eastern slope drops continuously to the level of Sonona Creek. The site is above treeline and commands a view in all directions.

The site consists of three surface lithic concentrations and three rock features. The bulk of the cultural material is exposed on the surface, but in one of the two test pits excavated at the site a jasper flake was recovered from a dark organic zone. No tephra were associated with the artifact.

Feature 1 is a 3.3-m by 1-m (11-ft by 3.3-ft) linear rock pile showing definite stacking and placement of local bedrock boulders. The height of the finished wall is approximately 50 cm (20 in). Feature 2 is a smaller "windbreak," 50-cm wide by 50-cm (20-in by 20-in) high. A "window" formed by two uprights and a cap stone affords a view to the east.

Cluster 1 consists of 2 chalcedony projectile points, 1 red jasper point, 1 quartz crystal, 2 chert flakes, 1 chalcedony flake, and 1 possible tool. Cluster 2 consists of 5 black basalt flakes. Miscellaneous surface finds included 1 black basalt biface fragment, 2 rhyolite flakes, 2 chalcedony flakes, 1 chert flake, 1 polished green pebble and 1 cobble chopper.

(xxv) TLM 069

The site is located east of Jay Creek and north of the Susitna River at the top of an elongated knoll. The knoll is part of a series of glacially scoured bedrock knolls which characterize the topography in the general vicinity of the site. A small pond is located 50 m (165 ft) northeast of the site.

The site was discovered during reconnaissance testing and was later systematically tested. During reconnaissance testing, 741 flakes of various materials including chert, rhyolite, basalt, and obsidian were recovered. Two utilized obsidian flakes and one utilized chert flake were also collected. Five pieces of fire-cracked rock and 1539 burned bone fragments were collected. All but three flakes were recovered from three test pits. All bone and fire-cracked rock fragments were collected.

Systematic testing of the site included the excavation of three 1-m by 1-m (3.3-ft by 3.3-ft) test squares, three 50-cm by 50-cm (20-in by 20-in) test squares, and a series of shovel tests to help delineate the limits of the site. The cultural material recovered from this testing consisted of 1232 flakes, 4 tool fragments, 3 scrapers, 1 biface, 1 biface fragment, 1 core, 1 point, and numerous burned bone fragments. The cultural material was associated with the contact of the Oshetna tephra and the glacial drift, the contact of the Watana tephra and the Oshetna tephra within the Watana tephra, and on the contact with the decomposed organic layer and the Devil tephra. The site has at least three archaeological components, and possibly four.

2.4 - Known Sites in Project Area - Other Areas

(xxvi) TLM 074

The site is located on the rim of the southern upland terrace overlooking the Susitna River on a bend in the river northeast of the mouth of the Oshetna River.

A total of eight shovel tests were dug at the site, one of which was expanded into a test pit after recovering a large quartize flake from the contact of the Devil and Watana tephra. Another test pit was excavated on the site which revealed a concentration of charcoal.

(xxvii) TLM 076

The site, consisting of three loci (A, B, C), is located on the south side of the Susitna River east-northeast of the confluence of the Oshetna and the Susitna Rivers. The three loci are located on kame knolls and are higher than the surrounding terrain.

Locus A consists of a lithic scatter and a partially exposed hearth. The hearth contains charcoal, burned bone and fire-cracked rock. An obsidian flake was collected 50 cm (20 in) north of the hearth. Four chert flakes were collected from a blowout, and the two test pits excavated during reconnaissance testing were sterile.

Locus B consists of an obsidian point fragment and a flake, both found on the surface. No subsurface material was recovered from the test pit at Locus B. Locus C consists of one basalt flake found on the surface. No subsurface material was observed in the test pit excavated at Locus C.

(xxviii) TLM 078

The site is located on a small kame knoll 8 m (26.4 ft) above and east of Tsusena Creek, and north of Tsusena Butte.

Both surface and subsurface material were present at the site. A single basalt flake was observed on the surface. Additional lithic material was recovered in two subsurface tests. One gray chert flake associated with the humic mat was recovered in Test Pit 1 during reconnaissance testing. Test Pit 2 revealed four black basalt and two gray chert flakes associated with the Watana tephra.

2.4 - Known Sites in Project Area - Other Areas

(xxix) TLM 081

The site is located on a kame knoll southeast of Tsusena Creek and north of Tsusena Butte.

No surface artificats were observed at the site. An initial shovel test near the center of the kame revealed two brown rhyolite flakes. The shovel test was expanded into a test pit and thirty additional flakes of the same material were recovered. The artifacts appear to be associated with the Watana tephra but cryoturbation has occurred and only a tentative correlation may be made at this time.

(xxx) TLM 083

The site is located on a kame knoll east of Tsusena Creek and north of Tsusena Butte. The site is located on a feature of sufficient relative relief to afford a panoramic view of the surrounding region.

No surface artifacts were observed at the site. A single gray rhyolite flake with retouch was recovered in a shovel test which was expanded into Test Pit 1. No exact provenience is available for the flake and no further subsurface material was observed in Test Pit 1 or in the second shovel test located 2 m (6.6 ft) to the southeast.

(xxxi) TLM 084

The site is situated on top of a kame east of Tsusena Creek and north of Tsusena Butte. The site rests on the most northerly tip of a 30-m long by 22-m wide (100-ft long by 72.6-ft wide) wide northeast-southwest oriented kame, 6 m (20 ft) above the floodplain of Tsusena Creek.

One hundred eighty black basalt flakes were recovered 4-7 cm (2-3 in) below the suface at the contact between the humus and the Devil tephra in Test Pit 1. No surface artifacts were observed. Test Pit 2, 8 m (26.4 ft) southeast of Test Pit 1, was sterile.

(xxxii) TLM 085

The site is located on a small kame or esker remnant east of Tsusena Creek and north of Tsusena Butte. The site is situated on the southern end of the kame and commands an extensive view of the creek and its course to the north and downstream to the south.

No surface artifacts were observed at the site. Test Pit 1 revealed 69 gray chert flakes from a depth of 2-11 cm (1-4 in) below the surface. The flakes were found in a zone of gray to light brown tephra immediately above the glacial drift. Mixing of the soil units was present due to cryoturbation, and tentatively, the cultural material can be associated with the Watana tephra. Test Pit 2 and two additional shovel tests failed to reveal further cultural material.

(xxxiii) TLM 086

The site is located on the top of a small kame which is 15 m (50 ft) above the level of Tsusena Creek to the west and immediately north of one of its clearwater tributaries.

A single black chert flake was discovered in a surface exposure on the south slope of the kame. Subsurface testing failed to reveal any cultural material.

(xxxiv) TLM 087

The site is located on the south half of a northeast-southwest oriented kame in the kettle and kame topography which borders Tsusena Creek north of Tsusena Butte.

No surface artifacts were observed at the site. Test Pit 1, located at the highest point on the kame, produced two gray chert flakes. The context of the flakes appears to be in the Devil tephra unit. A second test pit failed to reveal further cultural material.

(xxxv) TLM 088

The site is situated on an esker southeast of Tsusena Creek within an area where the creek makes a sharp bend around the northern slopes of Tsusena Butte.

No surface artifacts were observed at the site. Test Pit 1 revealed 22 black basalt flakes associated with the Oshetna tephra. A small depression, 1-m by 80-cm by 15-cm (3.3-ft by 2.7-ft by 0.5-ft) deep was present at the site and a test pit was excavated in its center. This test revealed evidence of subsurface disturbance in that the strata were mixed and considerably different from the strata present in a test pit outside the depression. No cultural material was encountered in this test pit.

2.4 - Known Sites in Project Area - Other Areas

(xxxvi) TLM 089

The site is located on the northern ridge of Tsusena Butte east of Tsusena Creek.

The site consists of six soil exposures which contain over a hundred basalt flakes, the majority of which were left uncollected. Collected artifacts included a brown chert biface fragment and numerous rhyolite and chert flakes. Test Pit 1 revealed a hearth consisting of a thick charcoal unit with numerous faunal and lithic specimens. Identifiable faunal remains consisted of one calcined caribou 3rd phalanx, one calcined metatarsal/carpal fragment (possibly caribou), and four tooth fragments (possibly caribou). Lithic material from Test Pit 1 consists of 1 translucent flake, 6 green-gray chert flakes, 10 dark gray chert flakes, 19 tan-gray chert flakes, 36 black basalt flakes, and 498 brown chert flakes. The cultural material from Test Pit 1 is from above the Devil tephra.

(xxxvii) TLM 090

The site is located on a level bench of a north ridge of Tsusena Butte overlooking the Tsusena Creek valley.

Five black basalt flakes, one of which was collected, were found on the surface of a small exposure. Seven shovel tests placed in the vicinity of the exposure were sterile as was Test Pit 1.

(xxxviii) TLM 091

The site, consisting of two loci (A, B), is located on the southern end of a north-south trending narrow bedrock ridge, north of the highest point of Tsusena Butte. The site is situated on two sides of a dip which separates the ridge from Tsusena Butte.

Locus A consisted of ten black basalt flakes located on the surface of a bedrock-soil exposure, in a 30-cm (1-ft) square area. Three of the flakes were collected. Test Pit 1 at Locus A failed to reveal any subsurface artifacts. Locus B consisted of a black basalt point tip. No further testing was conducted at this locus.

2.4 - Known Sites in Project Area - Other Areas

(xxxix) TLM 092

The site is located on a north-south oriented bedrock ridge on the west side of the northern arm of Tsusena Lake.

The site consists of a surface lithic scatter in a soil exposure measuring 90 cm by 40 cm (3 ft by 1.3 ft) on a bedrock outcrop. A total of 3 black fine grained basalt flakes were collected from this exposure. Test Pit 1 failed to produce any subsurface cultural material.

(xl) TLM 093

The site is located southwest of the northern arm of Tsusena Lake and is situated on an exposed bedrock knob occupying an area 20 m by 35 m (66 ft by 115.5 ft) on the top of this outcrop.

Both surface and subsurface cultural material are present with three clusters of surface flakes observed in blowouts which occur among the bedrock exposures. Cluster 1 contained 15 flakes, of which 7 were collected. Cluster 2 contained 4 flakes, 3 of which (including a retouched basalt flake) were collected. Cluster 3 contained 51 flakes, of which 12 were collected. Lithologies represented on the surface were basalt, chert and rhyolite.

Subsurface testing at the site included one test pit and eight shovel tests. Test Pit 1 was excavated 2 m (6.6 ft) from Cluster 2 and revealed a total of 33 dark gray basalt flakes associated with the Watana tephra. An additional flake of similar material was recovered from the Oshetna tephra.

(xli) TLM 094

The site is located west of Tsusena Creek and north of Tsusena Butte. It is situated on the southern end of a kame which rises about 5 m (16.5 ft) above the surrounding marshy floodplain.

Twelve flakes (six of which were collected), located in a gravel exposure on the southwest end of the kame, comprise the surface artifacts at the site and are of chert and basalt. Two articulating fragments of a gray basalt biface fragment were also collected from the exposure. A test pit was excavated 1.5

(5 ft) northeast of the scatter which produced four translucent flakes from the contact of the humic zone and the Devil tephra, two light chert flakes from the Watana tephra, and one black chert flake from the contact of the Watana tephra and a gray- brown silt at 11 cm (4 in) below surface. The site may be multicomponent, but mixing of the soil units was evident due to cryoturbation, and correlations of cultural material to stratigraphic units is tentative.

(xlii) TLM 095

The site is located on the west side of Tsusena Creek north of Tsusena Butte. The site is situated on a 6-m (20-ft) high fame knoll which is part of the general kettle and kame topography of the upper Tsusena Creek drainage.

No surface artifacts were observed at the site; however, two of seven shovel tests placed at the two areas of highest elevation on the knoll revealed cultural material. Test Pit 1 at the northwest end of the knoll revealed 50 fine grained basalt flakes from within the Oshetna tepha. Test Pit 2 at the southeast end of the knoll revealed 23 fine grained basalt flakes from the Watana tephra. The site may be multicomponent.

(xliii) TLM 096

The site is located north of Tsusena Butte and west of Tsusena Creek at the western edge of a marshy alluvial plain. It is situated on the top of a low narrow ridge which trends east to west.

No surface artifacts were observed at the site. Eight shovel tests were dug at the site, two of which were expanded into test pits 1 and 2. Test Pit 1 revealed three whitish-gray chert flakes from the Devil tephra. Test Pit 2 was sterile as were the remaining six shovel tests.

(xliv) TLM 097

The site is located northwest of Tsusena Butte on the west side of Tsusena Creek. It is situated at the top of an east-facing bluff which overlooks Tsusena Creek and passes approximately 50 m (165 ft) east of the site. The field of view is panoramic with the depth of view greatest to the northeast overlooking a broad alluvial plain.

Both surface and subsurface cultural material were collected during reconnaissance level testing of the site. A gray chert lanceolate point was surface-collected from the site along with a basalt flake. Twelve shovel tests were dug along the top of the bluff, two of which revealed subsurface cultural material. These two shovel tests were expanded into test pits, one of which produced additional cultural material. This test pit produced a total of 55 flakes, one bone fragment, and one fire-cracked rock, all associated with a concentration of charcoal at the contact of the Devil tephra with the zone of finely divided organics (A horizon). Flake lithologies from this test pit include basalt and both black and gray chert.

Systematic testing of the site included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares and 24 shovel tests. All five of the test squares and four of the shovel tests produced cultural material. Diagnostic lithic material produced by subsurface testing included a basalt side-notched point base, a basalt end scraper, 4 basalt blade-like flakes, a chert end scraper, a possible backed scraper of tuffacious material, 4 retouched flakes and 2 flake core fragments. In addition, 120 fire-cracked rocks were collected along with more than 400 burned bone fragments. Flake lithologies include basalt, chert, rhyolite, tuff, siltstone, chalcedony and obsidian. Cultural material is present at the contact between the Oshetna tephra and the Watana tephra and above the Devil tephra with a minimum of two components present at this site. A side-notched point base was excavated from the Oshetna tephra in association with charcoal and a dense concentration of basalt flakes. A radiocarbon determination on charcoal from the same stratigraphic level at a nearby test, which was also associated with basalt flakes, produced a date of 3720 $\pm$ 60 C^{14} years B.P.: 1770 B.C. (DIC 2283).

(xlv) TLM 100

The site, consisting of two loci (A, B), is located at the western end of Clarence Lake, near Gilbert Creek. The site consists of 13 rectangular, square, or round depressions on terrain features slightly elevated above the lake level and lake margin of the area.

largest of these depressions, Feature 1, measures 6 m by 6.5 m (20 ft by 21.5 ft). Seven depression features, none larger than 3 m (10 ft) in diameter, are clustered 40 m (132 ft) northeast of Feature 1. All features are between 20 cm and 110 cm (8 in and 43 in) deep with fairly vertical walls.

Locus B consists of two depression features; the larger of the two measures 4 m by 4 m (13.2 ft by 13.2 ft) and the smaller measures 1.3 m by 1.1 m (4.3 ft by 3.6 ft) and is rectangular. No subsurface testing was conducted due to the number and integrity of the extant features.

(xlvi) TLM 105

The site is located on the top of a broad, flattened hill on the north shore of Clarence Lake. Clarence Lake and adjacent low-lying swampland are visible to the south, east and west. Uplands dominate the view to the north.

Two test pits and one shovel test were excavated at the site during reconnaissance testing. The two test pits collectively produced 1 black basalt and 30 white rhyolite flakes. No additional cultural material was found in the shovel test. Surface material recovered in an area of disturbed sod consisted of 12 black basalt flakes, 1 blue-gray cryptocrystalline flake, 2 white rhyolite flakes, 9 brown chert flakes, 1 quartz flake, 2 gray rhyolite flakes and 3 gray-white chert flakes. It appears that some of the lithic material was recovered from between the Oshetna and Watana tephras.

(xlvii) TLM 116

The site consists of a rock cairn located on top of a hil southeast of Tsusena Lake. The 1.3-m (4.3-ft) high cairn rests on an area of exposed bedrock. A panoramic view is available from the site with the greatest depth of view to the south and west.

No subsurface tests were placed on the site because of the rocky nature of the terrain. The rocks used in construction were generally 50 cm (20 in) long, and there was no evidence of small stones being employed for chinking or leveling. The rocks were stacked into a pyramid arrangement with an open framework. A 15-cm (6-in) long bone fragment was the only object found at the site.

2.4 - Known Sites in Project Area - Other Areas

(xlviii) TLM 117

The site is located on a north-south oriented ridge which overlooks the confluence of Deadman Creek and one of its tributaries. The ridge is one of several low, rolling ridges which border the north side of Deadman Creek and have been truncated by it. A panoramic view is available from the site.

The one test pit excavated during reconnaissance testing did not produce any cultural material. Surface lithic material consisting of 4 flakes was located on the northern half of the ridge 1 m (3.3 ft) below the centrally located high point. One black basalt flake and one gray chert flake were collected.

(xlix) TLM 118

The site is located north of the Susitna River and west of Devil Creek in an area with kettle and kame topography and deeply incised ravines. The site is situated on the summit of a knoll near a small lake and appears to be primarily oriented toward the lake, because the view to the south is obstructed by the continuation of the knoll and present vegetation.

No surface material was observed at the site, but a shovel test produced 5 flakes and 3 fire-cracked rocks. A test pit excavated next to the positive shovel test produced 26 chert flakes, 1 microblade-like flake, 1 light gray chert biface and 4 fire-cracked rocks. The cultural layer occurs between the vegetation mat and an underlying pinkish gray fine matrix which may represent the Devil tephra or an ash. Nine other shovel tests failed to reveal further artifactual material.

(l) TLM 120

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plane in a low-lying ridge and knoll system. The site occurs on a low, rounded knoll which is situated between two small streams. The field of view from the site encompasses nearby flat ground, facing ridge and knoll slopes, hilly uplands to the south and the Susitna valley to the north.

A surface lithic scatter composed of 16 basalt flakes in a 3-m by 1.5-m (10-ft by 5-ft) area was observed and collected. A test pit excavated on the northeast edge of the scatter produced 7 basalt flakes from the organic mat. Six shovel tests placed on the summit and sides of the knoll were negative.

(li) TLM 121

The site is located south of the Susitna River, southeast of the Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs in a large, flat area. A small drainage is located to the west. The field of view from the site includes surrounding ridges and knolls, intervening drainages and boggy areas, hilly uplands to the south and the Susitna valley to the north.

No surface cultural material was observed. A test pit produced 14 calcined bone fragments, 8 fragments of fire-cracked rock, and charcoal from a cultural layer immediately beneath the organic mat and above the Devil tephra. Two shovel tests were negative.

(lii) TLM 122

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plane in a low-lying ridge and knoll system. The site occurs on the southeastern end of a low ridge at a point where the side of the ridge drops abruptly to adjacent ground to the south and east. Surrounding ridges and knolls, intervening low ground, hilly uplands to the south, and the Susitna valley to the north are visible from the site.

A single surface basalt flake was observed in a small deflated area. A test pit placed adjacent to the deflated area was negative. Seven shovel tests were dug on the ridge end and other deflated areas were examined, but no additional cultural material was found.

(liii) TLM 123

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system on the crest of a ridge. View from the site is panoramic, encompassing southern uplands, surrounding ridges and knolls, and the Susitna valley, as well as boggy areas and drainages around the ridge.

Examination of a large 10-m by 15-m (33-ft by 50-ft) deflated area revealed a surface scatter of weathered bone and charcoal. In addition, 2 small rounded depressions were found. Pit 1, 3 m (10 ft) southwest of site datum, is about 1.5 m (5 ft) in diameter and 35 m (116 ft) deep. A test pit placed in the vegetation mat on the margin of the deflated area near the bone and charcoal surface scatter did not yield artifactual material. A shovel test in Pit 2 produced 2 possible birch bark fragments. Seven other shovel tests along the ridge were negative.

(liv) TLM 124

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a low ridge with a small stream nearby to the east. The field of view from the ridge crest includes surrounding ridges and knolls, adjacent low ground, hilly uplands to the south, and the Susitna valley to the north.

Two surface artifacts were collected from the ridge, including 1 basalt projectile point from a deflated area on the ridge crest and 1 modified brown chert flake found on the surface on an undeflated frost boil on the east face of the ridge near its base and approximately 90 m (300 ft) northwest of the projectile point. A test pit was excavated in the vegetation mat on the margin of the deflated area near the projectile point with negative results. Sixteen shovel tests on the ridge and examination of other soil exposure failed to reveal further artifactual material.

(lv) TLM 125

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the southwestern end of the summit of a knoll. Field of view from the site includes surrounding ridges and knolls, extensive intervening low ground, hilly uplands to the south, and the Susitna valley to the north. Present vegetation causes some local obstruction.

No surface indications of a site were observed. Of seven shovel tests, one produced a single basalt flake. Two additional basalt flakes and charcoal were found in a sandy silt with pebbles below the surface organic in a test pit placed adjacent to the positive shovel test.

(lvi) TLM 127

The site is located south of the Susitna River, southeast of Watana Creek mouth on the eastern portion of a glaciolacustrine plain on a low-lying ridge and knoll system. The site occurs on the east end of an elongated knoll. The sides of the knoll are steep to the north and east, but merge with ground of only slightly lower elevation to the south. Field of view from the site is good though limited by present forestation and encompasses other ridges and knolls, intervening low ground, hilly uplands to the south, and the Susitna valley to the north.

No surface indication of the site was observed. Of 11 shovel tests, 2 were positive, 1 producing a single basalt flake and the other revealing 3 basalt flakes. The latter was expanded into a test pit from which 4 additional basalt flakes were recovered from the surface organic mat.

Two small circular depressions were noted at the site, but no stratigraphic disturbance was noted in the test pit, which was placed on the margin of one of the depressions, and for this reason they are presumed to be of noncultural origin.

(lvii) TLM 128

The site is located on the west side of Jay Creek on a distinctive topographic feature formed by the intersection of a major ridge and a minor transverse ridge. In the zone of intersection, the crests combine to form a relatively flat area which is a local point of high relief. Field of view from the site is panoramic, including hilly upland slopes to the north and west, continuing ridge systems to the east, and lower Jay Creek valley to the south.

Both reconnaissance and systematic testing were conducted at this site. The site was initially identified by the presence of artifactual material in association with an erosional feature. This material included rhyolite and chert flakes, and a pentagonal point fragment. A test pit was placed adjacent to the erosional feature and artifactual material was recovered from 2 different stratigraphic levels. This included 6 rhyolite and 5 basalt flakes from the humic layer above the Devil tephra, in addition to an obsidian microblade fragment from a brownish silty matrix well below the Oshetna tephra. Systematic testing included the excavation of four 1-m by 1-m (3.3-ft by 3.3-ft) test squares in the vicinity of the test pit. A total of 4613 lithics and 12 bone fragments were collected and 2 cultural components were defined. Forty-two flakes were recovered in association with the Devil tephra. The remaining artifactual material was located in association with a buried soil below the Oshetna tephra within a fine olive brown silty sediment. The majority of the lithic material from the lower component was of a green chert, although black basalt and a brown translucent chert were also represented. Only 11 of the 4571 lithics from the lower component showed evidence of retouch. Most of these can be described as flakes with either unifacial or bifacial retouch on the flake margins. A biface tip of brown translucent chert and a basalt biface fragment were the only 2 artifacts where modification was not restricted to the margins.

On the western slope of the site, there is a rectangular feature which appears to be the result of a recent excavation. During initial reconnaissance, 5 shovel tests were placed on the level central area of the topographic feature the site is located on, but no further artifactual material was found.

(lviii) TLM 129

The site is located south of the Susitna River, southeast of Watana Creek mouth, on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site consists of 2 loci on 2 points of high relief on a ridge. Locus A is near the northern end of the ridge, while Locus B is about 200 m (660 ft) south of Locus A. The fields of view from both loci are panoramic, since they are among the points of highest relief in the vicinity.

At Locus A, a test pit placed adjacent to a surface lithic scatter produced flakes from within and above the Devil tephra. Thirty-eight basalt flakes were collected. A small circular depression about 80 cm (32 in) in diameter and about 15 cm (6 in) deep was noted 26 m (86 ft) to the east near the base of the slope but was not tested.

Locus B consists of a circular depression about 1.4 m (4.6 ft) in diameter and about 30 cm (12 in) deep which was not tested. Although 27 shovel tests were placed on the ridge around and between Locus A and B, and soil exposures on the ridge were examined, no additional artifactual material was found.

(lix) TLM 130

The site is located on the south side of the Susitna River, southeast of Watana Creek mouth on the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the south end of a relatively small elongated knoll between 2 drainages. Field of view from the site is limited to the east by higher ridges and knolls, but includes knolls, ridges and boggy low ground to the west, the hilly uplands to the south, and the Susitna valley to the north.

No surface artifacts were found. An initial shovel test produced 6 flakes of 5 material types and 15 bone fragments. A test pit superimposed on this shovel test produced 3 flakes of 3 material types from the Devil tephra. One brown chert end scraper, 2 flakes, and 4 unburned and 56 burned bone fragments were recovered from the contact between the Devil and Watana tephras; and 2 flakes and 85 burned bone fragments from the Watana tephra. A second shovel test on the northern end of the knoll produced no artifactual material.

Systematic testing of the site included the excavation of four 1-m by 1-m (3.3-ft by 3.3-ft) test squares. Although site stratigraphy has been affected by frost activity, the contrasting vertical distribution of lithic and faunal remains suggests that more than one component is present. The postulated upper component at the site is represented by 96 flakes of various material types and 27 small bone fragments from above the contact between the Devil and Watana tephras. The lower component is distinguished by its stratigraphic position in the Watana tephra and by the predominance of faunal remains. One thousand eighty-two bone fragments, mostly small burned pieces, and 47 flakes of similar material types as those of the upper component were recovered from the lower component.

(lx) TLM 131

The site is located south of the Susitna River, southeast of Watana Creek mouth in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a low rise in a boggy field. The view from the site includes higher ridges and knolls, intervening boggy ground, and hilly uplands to the south.

One brown chert flake was surface-collected from a deflated frost boil feature. A test pit was excavated in the vegetation mat at the margin of the frost boil near the location of the flake, but no subsurface artifactual material was found.

(lxi) TLM 132

The site is located south of the Susitna River, southeast of Watana Creek mouth in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on the south end of a knoll. Field of view from the site includes adjacent drainages, knolls to the west and northeast, and terrain rising to hilly uplands to the south, as well as Susitna valley to the north.

One gray chert flake was found in a soil exposure on the knoll, but 13 shovel tests and inspection of other soil exposures nearby failed to reveal further artifactual material.

(lxii) TLM 133

The site is located on the south side of the Susitna River, southeast of Watana Creek mouth in the eastern portion of a glaciolacustrine plain in a low-lying ridge and knoll system. The site occurs on a ridge crest in a slight saddle formed by the relatively higher ends of the ridge. Immediately to the north of the site, the ground begins to slope steeply down into the Susitna canyon. A small stream flows east of the site. Field of view from the site, which is located on one of the most prominent landforms in the vicinity, is panoramic.

A single-surface, brown chert projectile point was found on the surface of a lichen mat on a game trail. A test pit placed adjacent to the location of the point, 12 shovel tests on and around the ridge, and examination of soil exposures on the ridge failed to reveal further artifactual material.

(lxiii) TLM 134

The site is located on the southern end of a discontinuous ridge west of Jay Creek. The ridge crest descends in an irregular fashion, alternating between sloping and relatively flat areas. The southern end of the ridge is bifurcated by a small swale, and the site occurs on the east-facing side of the eastern half of the bifurcation. While the field of view to the west and northwest is obstructed by forested slopes, to the north rising hilly terrain is visible, as are the lower Jay Creek valley and mineral lick area to the south and east.

A compact surface scatter consisting of 3 articulating fragments of a green chert tool was found in a deflated area. Additional surface reconnaissance produced a possible edge-modified gravel. A shovel test near the possible modified gravel and a test pit near the location of the lithic scatter failed to reveal subsurface artifactual material.

(lxiv) TLM 135

The site is located on a discrete small linear rise associated with the southeastern terminus of a ridge which descends toward the west edge of the Jay Creek canyon. The site appears to be primarily oriented toward the south and southwest, overlooking the Jay Creek mineral lick and its approaches. In other directions, the east side of the Jay Creek valley and rising upland topography to the west and northwest are visible.

A surface lithic scatter composed of a basalt corner-notched point and 5 basalt flakes was collected from a deflated area on the crest of the linear rise. A test pit placed in the vegetation mat adjacent to the deflated area and 5 shovel tests on the feature failed to produce further artifactual material.

(lxv) TLM 136

The site is located on a small knoll west of the Jay Creek canyon. Field of view from the site is limited to the north by a large hill. The east side of the Jay Creek valley is visible from the site, as are the slopes descending into Jay Creek canyon from the west.

During surface reconnaissance, a 2.5-m by 2.5-m (8.3-ft by 8.3-ft) lithic scatter was observed in a cryoturbated soil exposure on the summit of the knoll, from which 1 basalt tool fragment, 1 possibly modified rhyolite flake, 1 basalt flake, 2 rhyolite flakes, and 3 bone fragments were collected. A test pit excavated northeast of the scatter produced cultural material from 3 stratigraphic units, including 21 flakes and 65 calcined bone fragments from the Devil tephra lower contact and the underlying silt; 22 flakes and 5 bone fragments from the Watana tephra; and 6 flakes from a clayey silt located below the Oshetna tephra.

(lxvi) TLM 138

The site is located on a short kame ridge on the west side of Jay Creek. The sides of the ridge are defined by deep drainage ravines along the south and west sides, while the Jay Creek canyon is immediately west of the site. Beyond a slightly lower terrace to the north, the terrain rises and merges with hilly uplands. The site is on a local point of high relief with a panoramic field of view.

A single-surface basalt flake was recovered from the surface of a frost-boil feature. A test pit excavated next to the location of the flake, five shovel tests placed on the ridge, and examination of other soil exposures produced no additional artifactual material.

(lxvii) TLM 139

The site is located on a broad, flat-topped ridge which parallels the west side of the Jay Creek canyon. The sides of the ridge are defined by the canyon and on the west by the ravine of a small creek. Field of view from the site includes the east side of the Jay Creek valley, the lower portion of the valley to the south, and rising irregular terrain grading into hilly uplands to the north and west.

No surface indication of the site was observed. A test pit produced 46 basalt, chert, and rhyolite flakes, and 7 calcined bone fragments from a charcoal horizon below the organic mat and above (though slightly mixed with) the Devil tephra. In addition, 48 basalt, chert and rhyolite flakes, and a quantity of faunal remains were recovered from the upper portion of a silty matrix underlying the Devil tephra. No other artifactual material was found in 2 shovel tests placed in the vicinity of the test pit.

(lxviii) TLM 140

The site is located on the southern end of a ridge-like erosional feature formed by the west wall of the Jay Creek canyon and a deeply incised tributary ravine which converges with the canyon from the west. The north end of the ridge-like feature widens and merges with gradually northward-rising, undulating terrain. The southern portion becomes constricted to a sharp crest. The site is located in an area extending from the south end to 100 m (330 ft) north on the feature.

Surface material consisting of 2 flakes was found within 50 m (165 ft) of site datum on game trails. At site datum, a basalt biface and 4 flakes of 3 material types were recovered; these also occurred on a game trail. A test pit at datum produced a basalt biface and 11 flakes of 3 material types from beneath the organic mat and above the Devil tephra. No further artifactual material was found on the surface or in 8 shovel tests in the site vicinity.

(lxix) TLM 141

The site is located on a kame terrace on the west side of Jay Creek. To the east, a tributary ravine defines the margin of the kame and subsequently joins the Jay Creek canyon. Field of view from the site is panoramic, encompassing the tributary ravine and undulating kame topography to the north and south, as well as higher terrain and an intervening marshy pond to the west.

During surface reconnaissance, 3 flakes were collected from a small soil exposure. A test pit was excavated 5 m (16.5 ft) west of the exposure and produced 50 basalt and rhyolite flakes, and 1 basalt biface fragment at the contact between the organic mat and the Devil tephra and from within the Devil tephra. Seven shovel tests in the site vicinity and examination of other exposures failed to reveal further cultural material.

(lxx) TLM 142

The site is situated on a low knoll northeast of Jay Creek mouth. Surficial geology consists of lacustrine deposits over glacial till. Other similar undulating knolls are present within a 200-m (660-ft) radius of the site and generally characterize the surrounding terrain. Several small drainages flow east and south from the site area. Northwest of the site are 3 small lakes that are hidden from view by intervening higher topography.

Surface reconnaissance produced negative results. Subsurface testing included 5 shovel tests, one of which revealed cultural remains and was expanded into Test Pit 1. The cultural unit was isolated as occurring between the Devil and Watana tephras at 4 cmbs to 10 cmbs (1 inbs to 4 inbs). Recovered cultural remains include several basalt, chert, and quartz flakes, 10 pieces of fire-cracked rock; 1 mammal tooth; 8 unburned bone fragments; and 150 burned bone fragments.

(lxxi) TLM 143

The site is located north of Jay Creek mouth on a broad undulating slope west of the creek at the rim of Jay Creek canyon, just north of a very steep cliff face above a tight bend in Jay Creek. The site lies on the edge of this canyon, and appears to be confined within 50 m of the canyon rim. Jay Creek is easily seen from the site, although it is not easily accessible because of the steepness of the canyon. In the canyon south of the site is a mineral lick; and sign of game, particularly sheep and caribou, is common.

A sparse surface scatter of lithic material was first encountered on the rim of the canyon and edge of the slope. Eighteen flakes, composed of basalt and rhyolite, were noted in areas of surface exposures (game trials, frost-boiled areas and places of active downslope movement). A single test pit was placed on the southeast end of a small kame. A dense layer of cultural material was encountered in this test pit including two projectile points: one, a complete side-notched point and the other, a lanceolate-shaped point tip. Over 1300 waste flakes, composed of basalt, rhyolite and chert, and over 800 fragments of calcined bone were recovered from the test pit as well.

Systematic testing of the site included the excavation of five 1-m by 1-m (3.3-ft by 3.3-ft) test squares. All five of the test squares produced cultural material. Three of the test squares were placed in the location of the reconnaissance test pit. These test squares produced numerous diagnostic artifacts including side-notched projectile points, end scrapers, and retouched flakes. Thousands of waste flakes and small calcined bone fragments were also recovered. In addition, large fire-cracked rocks, charcoal, and oxidized matrix suggested the presence of a hearth feature. While an exact enumeration of artifacts is not available at this time, at least 2 different components have been identified at the site. The upper component is stratigraphically positioned between a layer of finely sorted organics and an underlying fine gray silty matrix (Devil tephra), and the lower is below a yellowish brown silty unit (Watana tephra).

(lxxii) TLM 144

The site is located northeast of the mouth of Jay Creek on the west side of the creek. The site includes a prominent elongated knoll and two smaller circular knolls. The elongated knoll is the highest point of topographic relief between its location and Jay Creek and is an excellent vantage point for observing the uplands down to the Jay Creek rim in the area of a mineral lick.

Both surface and subsurface cultural material were recovered during reconnaissance testing. Three flakes were found on an exposure on the knoll crest. Additional surface reconnaissance located a basalt corner-notched projectile point on the southern slope of the knoll. A test pit was placed adjacent to the surface exposure, and two flakes and one bone fragment were collected from different stratigraphic levels. Artifactual material was also found in two of five shovel tests placed in the site area with eight additional flakes recovered.

(lxxiii) TLM 145

The site is located northeast of the confluence of Jay Creek and the Susitna River on the west side of the creek. It is situated on a ridge which extends eastward from a glaciolacustrine plain toward Jay Creek, with the end of the ridge about 100 m (330 ft) east of the site. The ridge is characterized by steep slopes, making the creek relatively inaccessible from the site. In the site vicinity, the ridge slopes at a 4- to 5-degree angle for a distance of 15 m (50 ft). Visibility is obscured by present vegetation.

Both surface and subsurface material were present at this site. Surface material consisted of a lithic scatter located on a game trail. This game trail follows the ridge crest with the surface material confined to an 8-m (26.4-ft) segment. Seven waste flakes were surface collected. Additional surface material was observed but not collected. A single test pit placed adjacent to the game trail produced 107 flakes of basalt, rhyolite, and chert in addition to 93 calcined bone fragments. Subsurface artifacts were found within a dark brown surface organic layer.

(lxxiv) TLM 146

The site is located north of the confluence of Jay Creek with the Susitna River on the west side of the creek. It is situated on a broad sloping hill that descends to a glaciolacustrine plain. Neither Jay Creek nor the Susitna River are visible from the site; however, their valleys can be seen. A narrow, shallow, clear-water stream, which originates at a kettle lake west of the site, passes south of the site and is easily accessible.

No surface cultural material was observed at the site. Seven shovel tests were dug during reconnaissance testing with one of the shovel tests producing a single basalt flake with retouch along one of its margins. This shovel test was expanded into a test pit, but no additional artifactual material was found.

(lxxv) TLM 147

The site is located north of the mouth of Jay Creek on the west side of the creek. It is situated on the eastern portion of a broad, flat terrace which extends about 200 m (660 ft) to the northwest and west, where it merges with undulating kame topography. The view from the site is only limited in a westward direction where it is partially obscured by a small kame feature.

No cultural material was observed on the surface of this site. Five shovel tests were dug, one of which contained a single rhyolite flake. Further surface reconnaissance and the excavation of a test pit, superimposed over the shovel test which contained the rhyolite flake, failed to locate any additional artifactual material. Two distinct tephras were identified at this site, although the stratigraphic position of the single flake in relationship to these tephra is unknown.

(lxxvi) TLM 148

The site is located northeast of Jay Creek mouth on the west side of the creek. It is situated on the northwest corner of a roughly triangular, broad, flat terrace, which is part of a gradually sloping, undulating glaciolacustrine plain north of the Susitna River. Jay Creek canyon, a tributary valley, and uplands to the north are visible from the site. The view to the west is obscured by spruce forest and intervening hills. A marsh and small creek 100 m (330 ft) to the west of the site provide the nearest easily accessible water.

Eight shovel tests were dug at the site during reconnaissance testing, one of which contained 20 rhyolite flakes. This shovel test was expanded into a test pit, and 11 additional rhyolite flakes were ecovered. These flakes were stratigraphically positioned in a charcoal unit beneath the organic mat, in a pinkish-gray, fine silt unit (Devil tephra), and at the contact between them.

(lxxvii) TLM 149

The site is located north of Jay Creek mouth on the west side of the creek. It is situated on a low, crescent-shaped kame knoll which is one of a series of similar kame features on an undulating terrace between Jay Creek and Laha Lake. The knoll is east of Laha Lake and north of a small unnamed creek which provides an easily accessible source of water. Visibility from the site includes similar kame features and upland topography.

No cultural material was observed on the surface of the knoll, and only 1 of 4 shovel tests placed on the knoll revealed cultural material. This shovel test was expanded into a test pit which revealed 990 small burned bone fragments and 2 small rhyolite flakes. A C-14 sample was collected from this test in association with the contact between the Watana and Oshetna tephras.

(lxxviii) TLM 150

The site is located north of the confluence of Jay Creek with the Susitna River in an area of kame ridges and knolls on an undulating terrace between Jay Creek and Laha Lake. The site is situated on a fairly linear ridge, just southwest of the central high point of the ridge. A small clear-water creek, the outlet stream from a small pond northeast of Laha Lake, flows 100 m (330 ft) to the north. From the site, there is good visibility of the rolling kames to the east and north. The view south and west is obscured by open spruce woodland and intervening topography.

No surface artifacts were located at this site during resonnaissance testing. Four basalt flakes were found in a shovel test which was expanded into a test pit. Four additional basalt flakes were encountered beneath the organic layer and protruding into the underlying Devil tephra. In addition, 5 fragments of calcined bone were found within or at the contact of the Watana tephra. The spatial distribution of material in the test pit suggests that the site contains more than one component. Eight additional hovel tests placed in the site area were negative.

(lxxix) TLM 151

The site is located north of Jay Creek mouth in an area characterized by kettle and kame topography on an undulating terrace between Jay Creek and Laha Lake. The kame feature on which this site is situated is approximately 100 m (330 ft) in length with the site located on a circular rise on the southwest end. A narrow clear-water stream, which originates at a kettle lake northwest of the site, borders the west side of the kame ridge and provides an easily accessible source of water. Visibility from the site is partially obscured in all directions by open spruce woodland forest.

No cultural material was observed on the surface of the kame ridge. Fifteen calcined bone fragments were found in a shovel test which was then expanded into a test pit. Five hundred and twenty-one bone fragments and 13 flakes representing 4 different material types were recovered from this test pit. The cultural material was found beneath a soil unit of dark brown finely sorted organics. It is possible that a pit feature is represented within this test pit. No additional subsurface testing was conducted in the 15-m by 6-m (50-ft by 20-ft) level area on which the site is situated.

(lxxx) TLM 152

The site is located northwest of the Jay Creek and Susitna River confluence, and east of Laha Lake. It is in an area that is characterized by kettle and kame topography. The site is situated on a prominent elongate kame feature overlooking 2 kettle lakes. An additional 1 hectare kettle lake is located northeast of the site, but is obscured from view by intervening terrain. The view from the site encompasses the entire margin of the lake south of the site in addition to portions of the lake to the west.

Six shovel tests were dug on the kame feature. One gray chert flake was found in one of the shovel tests which was then expanded into a test pit. The stratigraphy of the test pit revealed 3 distinct tephra units, although no other artifacts were present. Surface reconnaissance of the site area failed to locate any additional artifactual material.

(lxxxi) TLM 154

The site is located north of the mouth of Jay Creek and south of Laha Lake. It is in an area of kettle and kame topography with the site located on a kame ridge which is bordered to the south-southeast by a 2-hectare (5-acre) lake. The site is situated on the broad, flat crest of a kame ridge. Visibility from the site is obscured by intervening terrain; however, a panoramic view is available from the top of the ridge about 5 m (16.5 ft) higher in elevation than the site.

An initial shovel test revealed 12 flakes of 2 different material types. This shovel test was expanded into a test pit, and 150 additional flakes were recovered. The majority of the flakes were of a gray rhyolite, but material also included quartzite. Six subsequent shovel tests were placed in the vicinity of the test pit. A rhyolite lanceolate projectile point was found in one of these shovel tests. In addition, surface reconnaissance revealed 3 rhyolite flakes on the surface of the lichen mat.

(lxxxii) HEA 174

The site is located on top of a 30-m (100-ft) high knoll in glacially scoured terrain at the northeastern end of Deadman Lake, northeast of the point where Deadman Creek enters the lake. The view from the site is extensive and panoramic overlooking Deadman Lake to the west and Deadman Creek to the south.

The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The artifacts recovered were collected from the surface of the top, western, and southeastern slopes of the deflated knoll on which the site is located. Cultural material collected included: 1 basalt side scraper, 1 basalt blade-like flake, 1 gray quartzite lanceolate point, 2 black chert end scrapers, 1 black chert scraper fragment, 1 red-brown jasper end scraper fragment, 2 brown jasper retouched flakes, 2 gray chert retouched flakes, 2 gray rhyolite retouched flakes, 1 gray rhyolite flake, 1 gray chert flake and 2 quartz flakes.

(lxxxiii) HEA 175

The site is located at the southwest end of Butte Lake and consists of 2 loci (A and B) focused around 2 knolls within 200 m (660 ft) of the Butte Creek outlet and on a ridgeline running along the west shore of the lake. The view from the site includes all of Butte Lake and the uplands to the south, east, and west.

Reconnaissance testing and systematic testing were conducted at the site. Six shovel tests and 2 test pits were excavated during reconnaissance testing and collectively produced 1 side-notched point, 1 burinated flake, 1 point base, 2 possible microblades, 3 blade fragments, 25 chert flakes, 13 rhyolite flakes, 6 basalt flakes, and 3 microblades. Five 1-m by 1-m (3.3-ft by 3.3-ft) squares were excavated at

Locus A during systematic testing and collectively produced 2 microblade fragments, 1 basalt microblade, 1 possible basalt core tablet, 1 uniface fragment, 1 possible core chopper, 2 side-notched points, 1 chert biface fragment, 1 siltstone retouched flake, 2 retouched basalt flakes, 1 blade-like flake, 1 burinated flake, 109 chert flakes, 76 basalt flakes, 9 siltstone flakes, 4 rhyolite flakes, 2 obsidian flakes, 5 quartzite flakes, 94 flakes of undetermined material type, and 4 bone fragments. Surface artifacts included 1 projectile point base, 1 basalt biface fragment, 1 gray chert flake core, 1 rhyolite uniface fragment, and 1 cryptocrystalline core (possible).

(lxxxiv) HEA 176

The site consists of two loci (A and B) on two kame knolls at the eastern end of Deadman Lake southeast of the point where Deadman Creek enters the lake. The view from either locus is panoramic, encompassing the eastern end of Deadman Lake and the surrounding low relief terrain for 2 to 3 km (1.2 to 2 mi) in all directions.

The one test pit excavated at Locus A during reconnaissance testing produced a single red chert flake. No subsurface testing was conducted at Locus B where 1 chalcedony flake and 2 black basalt flakes were collected from the surface. Surface material collected at Locus A was recovered from 2 different clusters and collectively consisted of 1 gray rhyolite flake, 4 gray chert flakes, 1 black basalt flake and 1 white chert flake. The red chert flake from Test Pit 1 at Locus A was recovered from below the Watana tephra, which in this test was located directly on top of glacial drift with no intervening lower tephra.

(lxxxv) HEA 180

The site is situated on top of a knoll southeast of the Deadman Lake outlet and north of the confluence of Deadman Creek and a northern tributary. The knoll on which the site is located is a dominant high landform in the region providing a panoramic view from the site.

The only test pit excavated on the site during reconnaissance testing produced 2 chalcedony flakes. The remainder of the cultural material from the site was collected on the surface at 2 different scatters and consisted of the following: Scatter 1--1 gray chert flake, 2 white chert flakes, 1 black basalt flake, 2 light gray chalcedony flakes and 1 black chert flake; and Scatter 2--1 jasper microblade, 1 chert microblade, 1 dark gray chert microblade fragment, 1 brown obsidian burin spall, 1 white chert point base, 1 brown jasper flake, 1 red-brown jasper flake, 1 white chert flake, 1 pale red chert flake with retouch, 1 light red-brown chert flake, 1 red-streaked gray chert flake, 1 black-speckled white chert flake, 1 pale red rhyolite flake, 1 light red rhyolite flake, 1 gray-white rhyolite flake, 1 black-flecked chalcedony flake, 2 brown chalcedony flakes, 1 white-brown chalcedony flake, 1 white-gray chalcedony flake, 1 clear quartz flake, 1 black basalt flake, and 1 light brown siltstone flake.

(lxxxvi) HEA 183

The site is located on a deflated portion of a small low knoll northwest of the outlet stream which drains Deadman Lake. The view from the site consists of most of Deadman Lake, as well as the outlet stream.

The only artifact recovered from the site was 1 gray chert flake collected from the surface of the deflated portion of the low knoll. Because of the rocky nature of the area, no subsurface testing was possible.

(lxxxvii) HEA 184

The site is located on a blowout northwest of the outlet stream that drains Deadman Lake on the eastern shore of a small lake west of Deadman Lake. The view from the site includes all of the small lake west of the site, two thirds of Deadman Lake, and a portion of its outlet stream to the south.

The one test pit excavated at the site during reconnaissance testing did not produce any cultural material. The only artifacts revealed from the site were 2 yellow-brown chert flakes which exhibited retouch and articulated to form a large scraper.

(lxxxviii) HEA 185

The site is located on an east-west trending ridge on the west side of Deadman Lake approximately

70 m (231 ft) above the lake. In addition to Deadman Lake, 3 smaller lakes, Big Lake, and an unnamed stream are visible from the site.

Because of the rocky nature of the site, no subsurface testing was possible. Artifacts were collected from 2 loci (A and B) and collectively consisted of 2 gray chert flakes, 4 basalt flakes, 1 possible scraper preform and 1 brown chert thumbnail scraper.

(lxxxix) HEA 186

The site is located on a knoll east of Deadman Lake and is situated primarily on the eastern half of the east-west oriented knoll. The view from the site includes the braided section of Deadman Creek and several small lakes.

The one test pit placed on the site during reconnaissance testing produced 1 black basalt flake. Surface artifacts collected at the site consisted of 1 patinated gray chert biface, 1 gray chert projectile point fragment, 2 gray chert blade fragments, 1 gray chert biface fragment, 9 gray chert flakes, 1 white chert flake, 1 black chert flake, and 3 black basalt flakes.

(b) Historic Sites

(i) TLM 020

The site is located on Portage Creek and consists of an historic inscription dating to 1897, located on a bedrock exposure overlooking the creek. Four names and the date of July 2, 1897, are included in the inscription.

Other than the inscription itself, no historic or prehistoric cultural material was observed in the vicinity and no subsurface testing was conducted at the site.

(ii) TLM 056

The site, a partly collapsed log cabin, is near the base on Tsusena Butte. The cabin is situated on a gently sloping terrace 4 m (13.2 ft) above the level of the creek west of the creek margin.

The site consists of a dirt-floored, one room log cabin constructed of unpeeled spruce logs with moss chinking. The west wall of the cabin is collapsed. A door opening is present in the south wall, but the door itself is missing. Few interior furnishings were noted; however, a third of the cabin interior is visible because of the collapsed sod-covered roof. The general condition of the cabin is poor with the majority of the log members extensively rotted. There was no collection of cultural material at the site. No associated outbuildings were noted; however, a rectangular 1.3-m by 1.8-m (4.3-ft by 6-ft) depression is located southwest of the cabin. A recent tool cache was found 2 m (6.6 ft) east of the cabin under a stand of spruce trees.

(iii) TLM 071

The site was the trapping headquarters of Elmer Simco and was built in the early 1930s. The site complex is located east of Gilbert Creek, a small tributary of Kosina Creek. The cabin is situated on a low, gently sloping shoreline terrace less than 5 m (16.5 ft) above the creek.

The cabin consists of one room 3.6 m by 4.5 m (12 ft by 15 ft) and has a dirt floor. General condition of the cabin is fair to poor. The cabin contains the remains of the original furnishings and supplies used during the period between 1930 and 1950. Leakage from the roof is causing destruction of many interior items. There are three associated outbuildings at the site: an outhouse, a dog kennel, and a grass-covered structure of unknown function. Other associated features at the site include a garbage dump and a woodpile. No cultural material was collected at the site, nor was any subsurface testing conducted.

2.5 - Geoarcheology

2.5.1 - Introduction

Geoarcheology data were used for selecting survey locales and provided limiting dates for cultural resources on various terrain units associated with the last glaciation. Evaluation of various stratigraphic soil and sediment units, including three volcanic ashes, provided a basis for evaluating cultural resources found in relationship to these units. The various aspects of the geoarcheological studies are presented below.

2.5 - Geoarcheology

2.5.2 - Geoarcheologic Terrain Unit Mapping

A preliminary terrain unit map of the project area was prepared in 1980 and has undergone two revisions incorporating the results of field studies. Areas of similar geomorphologic character and surficial age are delineated--information which was useful in the selection and evaluation of survey locales.

2.5.3 - Stratigraphic Framework

Regional stratigraphic investigation was undertaken with the selection and description of 25 river bluff exposures. Organic samples were collected from four exposures and used to establish a general valley chronology including glacial and depositional history. The stratigraphy of the project area indicates a complicated glacial history with episodes of advance, stagnation, and retreat; formation and drainage of proglacial lakes; and fluvial reworking of glacial sediments. Alluvial deposition, soil development, and tephra falls are also evident.

2.5.4 - Preliminary Glacial-Geomorphologic Mapping General Comments

The investigation and mapping of glacial geomorphology in the project area have assisted in the interpretation of the complex glacial history of the project area, which is characterized by the interaction of a number of valley glaciers. The valley glaciers were variable in their patterns of advance, stagnation, and retreat, as evidenced by the location, orientation, altitude, and state of development of moraines; ice marginal meltwater channels; lake shorelines; kame-deltas; and eskers and ice flow indicators. The variation is attributed to particular characteristics of the largely independent source areas. During periods of intense glaciation, merging of valley glaciers occurred, resulting in the extension onto the valley bottom of ice lobes. Their subsequent wastage has produced extensive ice stagnation terrain in the project area.

2.5.5 - The Last Glaciation

Glaciers are interpreted to have covered much of the lowland region of the study area during the last major glaciation (late Wisconsin time) which occurred over much of Alaska between 32,000 and 13,000 years BP. The Susitna Canyon area was covered by a complex glacier system that resulted from confluent ice tongues and lobes which behaved as individual units. The distribution of glacial terrain features indicates that following the glacial maximum, lobes withdrew at different rates. Moraine morphology gives evidence for glacial retreat followed by a series of glacial readvances. Large areas of stagnant ice were present in most of the broad lowland regions during deglaciation. The stagnant ice may have influenced human movements as late as 8-10,000 years BP.

2.5.6 - Archeological Stratigraphy

Sixteen major stratigraphic units can be recognized throughout the project area. No individual archeological site contains all recognized units, but many have at least ten. In general, the stratigraphy consists of glacially scoured bedrock overlain by a series of volcanic tephra horizons interbedded with weathering horizons and buried soils. A surface organic mat overlies the older sediments. Nonvolcanic eolian sediments occur both as part of the tephra units and as separate subunits between tephra and organic horizons. In the archeological stratigraphy of the project area, the contact units are just as, if not more, important as the lithologic units. Sixteen significant intervals of time can be isolated and correlated on the basis of these contact units (Figure E.4.5).

2.5.7 - Cultural Horizons

Nine discrete cultural horizons can be identified at the present time from the regional archeological stratigraphy (Figure E.4.5). These can all be correlated throughout the region. Each horizon can be dated within limits, but the time span represented by components varies from a few hundred years to as much as 7-8000 years. Although a horizon can be identified and correlated and can be dated within limits, there is no proof that cultural materials from the same horizon at different sites are exactly equivalent in age. The volcanic ash/soil sequence provides the framework for this relatively excellent chronology.

Cultural horizons were assigned only where there was demonstrable evidence of human occupation that can be related to the regional stratigraphy. Although artifacts were found in all of the units except bedrock, only nine horizons could be firmly documented. Downslope reworking, cryoturbation, human alteration, and root disturbances all serve collectively to displace artifacts from their original contexts.

Evidence for human occupation in subunits associated with the contact units are present. Within any given site, these can be arranged in stratigraphic succession, but they were not isolated as horizons or even formal subhorizons because they cannot be correlated regionally. It is probable that many more than nine cultural horizons exist. No one site contains more than four regional cultural horizons, with the exception of site TLM 030 which contains five horizons, one of which occurs in a subunit. Most sites contain one or two regional archeologic horizons.

2.5.8 - Chronology and History

The evolution of the stratigraphic record presented in Figure E.4.5 can be broken into four major intervals which have different implications for archeology: (1) the time prior to the last glaciation, represented by Unit 15; (2) the time during the last glaciation, represented by Unit 14; (3) the time following deglaciation but prior to deposition of the first recognized tephra, represented by Unit 13; and (4) the time representing recurrent volcanic ash deposition and soil formation, represented by Units 1 to 12. Eight radiocarbon dates from regional stratigraphic studies and 12 dates associated with the volcanic ash stratigraphy permit the establishment of a reasonably good chronology for the depositional history of the project area. Deposition of the tephra sequence probably occurred within the last 5000 to 7000 years. Three distinct tephra have been identified in the study area. These units were given regional names for purposes of field identification and nomenclature. Tentative limiting dates and names given the tephra in order of increasing age are as follows: Devil (1800-2300 BP, AD 150-350 BC), Watana (2300-3200 BP, 350-1250 BC), and Oshetna (greater than 4700 BP, 2750 BC).

2.5.9 - Mammoth/Mastodon Fossil Discovery

A mammoth/mastodon fossil was found in situ in flu .al gravels at Tyone Bluff. The fossil, representing the shaft portion of a right femur, was identified by R.D. Guthrie and George S. Smith of the University of Alaska, and is the first documented occurrence for any terrestial Pleistocene mammals in southern Alaska. It yielded a radiocarbon date of 29,450 + 610 BP, and clearly implies nonglacial conditions at the time (Thorson et al. 1982). This discovery indicates that the range of mammoth should be extended about 200 km (120 mi) south of its present limit. It also suggests that mountain passes in the Alaska Range may have been deglaciated during mid-Wisconsinan time, and that portions of southern Alaska may have been suitable for human habitation during this time.

2.5.10 - Summary of Geologic History

The Susitna Valley has been repeatedly inundated with extensive valley glacier systems that coalesced to form a minor mountain ice sheet. One or more pre-Wisconsinan glaciations have been recognized.

Much of the present valley was carved to the present river level prior to middle Wisconsinan time (31,000 yr BP). The direction of drainage at that time is presently unknown.

2.5 - Geoarcheology

The valley bottom was extensively modified during the last glaciation which began some time after about 31,000 yr BP in the Fog Creek area, and some time after about 22,000 yr BP in the Tyone River region.

During deglaciation, large areas were covered with stagnant ice, and meltwater drained freely below the surface, forming complex esker systems. The direction of meltwater flow and the presence of till at river level suggests that Devil Canyon was carved prior to Holocene time. Glaciers retreated systematically over many areas leaving a number of periodically spaced massive recessional moraines.

Deglaciation of the Tyone River region was complete by at least 11,500 yr BP. Because this area was covered by a large piedmont ice lobe, other areas may have been ice free even earlier. Thus, much of the Susitna valley may have been deglaciated prior to about 12,000 yr BP. Stagnant ice may have persisted for several thousand years over much of the valley floor.

During Holocene time, the Susitna River has not greatly deepened its valley in most areas; rather it has widened the valley bottom slightly by lateral planation. Low-level alluvial terraces and tributary mouth alluvial fans have formed in widened portions of the valley. Many small streams tributary to the Susitna have greatly incised their channels during Holocene time, resulting in steep, irregular profiles characterized by waterfalls and rapids.

During the last half of Holocene time, intervals of volcanic ash deposition from distant sources alternated with intervals of weathering, soil formation, and erosion.

3 - EVALUATION OF AND IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES

3.1 - Evaluation of Selected Sites Found: Prehistory and History of the Middle Susitna River Region

3.1.1 - Introduction

Based on the results of this survey, it is probable that no single archeological site in the middle Susitna River area will provide the basis for defining the Holocene cultural chronology for the region. Because no single site has preserved the cultural spectra since late Wisconsin deglaciation, it is necessary to base the culture chronology on a series of individual sites and site components throughout the study area. The 167 archeological sites documented during the course of this survey are primarily single component sites. For the purposes of this presentation, only those sites in which the age of the site, or a component, can be documented with certainty will be used for analysis. The chronological documentation of sites and components are primarily based on two methods: (1) radiocarbon determinations and (2) relative stratigraphic placement in relationship to the three tephra. Typological considerations relating to the chronology (not site function) have been considered secondarily, because of the uncertainty associated with this kind of dating and the differing age determinations proposed by many archeologists.

The sites discussed in this application provide only brief glimpses of prehistoric cultural development in what are, in many cases, very diverse ecological settings. In all probability the sites and their various components represent different facets of the prehistoric subsistence cycle. Consequently, what are presented as "type" sites and components for particular cultural periods may in fact not "typify" the material cultural remains during specific cultural historical periods. While these limitations are recognized, it is still possible to begin to define the basic cultural chronological skeleton while realizing that during some periods it may contain a considerable amount of information, and during others, major information may be missing.

3.1.2 - Contemporary Sites: 1945 to Present

A number of contemporary cabins are scattered throughout the study area representing modern recreational use of the project area, primarily for sports hunting and fishing. Because of the contemporary nature of these structures, they have not been included, discussed, or analyzed in this report. Suffice it to say that contemporary use of the area will ultimately be documented in the archeological record.

3.1.3 - Trapping Period: 1920-1945

Four cabins which have been documented as trappers' cabins have been reported in the project area. These cultural remains document economic use of the area for fur trapping during the 1930s, and in this respect the Susitna area reflects many other areas of rural Alaska in that this was a time of relatively high fur prices during a period of international depression. The remains of four cabins dating to this period were located in the project area. However, the cabin of Elmer Simco (TLM 071) may be one of the best remaining examples from this period, because most of the household and trapping equipment are preserved intact.

3.1.4 - Exploration/Gold Rush: 1897-1920

Gold was discovered in the Cook Inlet region in 1895, shortly after which the first major western population expansion into the middle Susitna occurred. No historic sites dating to the gold rush in the middle Susitna have been discovered in the project area to date. Because Devil Canyon is not navigable, early explorers/prospectors may have been discouraged in their attempts to prospect the middle Susitna. However, an inscription near the mouth of Portage Creek documents that William Dickey and three other travelers ascended the river as far as Devil Canyon in 189[illegible] (TLM 020).

3.1.5 - Athapaskan Tradition: A.D. 1900 - A.D. 500

The middle Susitna drainage was occupied by western Ahtna Athapaskans at the time of historic contact. Through implementation of the direct historic approach, it is possible to trace through time Athapaskan occupation of the study area. Several sites in addition to those discussed below may document various periods of cultural historical development throughout this period. However, the subsequent discussion only includes sites subject to systematic testing from which age determinations can be made with certainty.

The Kosina Depression Site (TLM 0[illegible]5) was systematically tested and best exemplifies the later phase of this period. The site consisted of the remains of at least one house and several associated cache pits. Stratigraphic profiles from this site clearly indicate that the house postdates the Devil tephra, and the glass trade beads and bottle glass fragments clearly document the structure's comparatively recent age. While precise dating of the structure is not possible at this time, western trade goods may have penetrated the area as early as the late 1700s, and the site may be reasonably estimated to range in age between the late 17[illegible] and 1900.

3.1 - Evaluation of Historical Sites

A pronounced material cultural trait which occurs at TLM 065 is the high frequency of fire-cracked rock and fractured and burned caribou bone. The rock is characteristically uniform in that it originates from fist and slightly smaller-sized, smooth, water-worn cobbles. It is most probable that these cobbles were deliberately selected for stone boiling; a technique commonly employed by Native North Americans in the absence of ceramic cooking vessels. This material cultural trait, coupled with abundant fractured long bone fragments, suggests preparation of marrow "soup" and possibly bone grease in birch bark cooking containers. These site attributes are commonly associated with archeological sites throughout the Alaskan Interior and through the direct historic approach have been identified as the remains of prehistoric Athapaskan culture (Plaskett 1977).

This common association is characteristic of a number of sites located throughout the course of the archeological survey. All sites and site components which exhibit this association in a clear stratigraphic context occur above the Devil tephra and, consequently are younger than A.D. 200. In addition to the Kosina Depression Site (TLM 065) discussed above, these sites are: (1) Component I, Permafrost Creek (TLM 050) ca. A.D. 1670; (2) two and possibly three components at the Tsusena Creek site (TLM 022) which date slighly prior to and subsequent to A.D. 1500; (3) a feature at the Little Bones Ridge site (TLM 059) ca. A.D. 740; (4) Component I at the Red Scraper site (TLM 062) ca. A.D. 570; (5) Component I at the Tsusena site (TLM 097) ca. A.D. 550; and (6) TLM 130 which produced a radiocarbon date on charcoal of A.D. 530 $\pm$70. Three additional sites which have not been subject to radiometric dating but which exhibit the pronounced association of fire-cracked cobbles and fractured mammal bone, all occur stratigraphically above the Devil tephra. These are: (1) the upper Watana Creek site (TLM 038); (2) the No Name Creek site (TLM 043); and (3) Component I at the Duck Embryo North site (TLM 048). At two of these sites, No Name Creek and Duck Embryo North, evidence for heat treatment of lithics has been recognized based on the vitreous character of the lithic debitage.

While it may appear dubious to define a cultural period primarily on the basis of the association of only two cultural traits, these sites are strikingly similar when viewed collectively, and all are restricted temporally. Another striking similarity shared by these sites is the lack of diagnostic artifact types. However, this may partially reflect the comparatively small samples recovered during testing. The sites suggest intensive reliance on caribou hunting, occasionally moose hunting, intensive use of stone boiling for food preparation, and heat treatment of lithics used for tool manufacture.

The sites occur in a variety of ecological locales. Permafrost Creek, Tsusena Creek, and No Name Creek all occur adjacent to the junction of clear-water tributaries to the Susitna and are situated in the valley bottom. The upper Watana Creek site occupies an overlook with a panoramic view to the north suggestive of fall caribou hunting. Duck Embryo North is situated adjacent to a lake outlet possibly indicating exploitation of fish and waterfowl. The Tsusena site (TLM 097) is adjacent to Tsusena Creek where constricting topographic features funnel large mammal movements past the site. Sites which contain structural remains--Little Bones Ridge, Kosina Depression, and probably Jay Creek (although this site was not subject to systematic testing)--are located in elevated areas which seem to lack attractive ecological factors (such as proximity to significant bodies of fresh water, panoramic views, constricting land forms, etc.). It is possible that these more substantial sites containing features may reflect prehistoric distribution of caribou rather than other ecological variables traditionally associated with site occurrence. Such obscure site locales may also reflect social variables such as defense or ostracism.

Testing and surface features suggest that all sites dating to this time period are comparatively small and probably represent groups of not more than one or two nuclear families or a few hunters. Collectively, these sites represent a variety of functions and seasonal occupations which cannot be accurately defined based on the limited results derived from the systematic testing conducted to date. It is important to reemphasize that this discussion has been limited to only those sites which can be firmly dated, and undoubtedly numerous other sites dating to the Prehistoric Athapaskan Period exist in the project area.

All the sites dating to this period contain faunal remains, and thus, present the possibility for documenting the organic component of prehistoric Athapaskan material culture, which is currently poorly understood and represented at only a few archeological sites. The diverse types of sites situated in a variety of ecological locales may enable further research to document shifting subsistence and settlement patterns through time. Collectively, these sites are extremely significant, for they hold the potential to define Athapaskan cultural development during the past 1500 years. This has not been accomplished in Alaska or the Yukon and Northwest Territories, largely because previous research programs have not been able to locate sites conducive to answering these questions and have lacked the chronological controls essential for defining cultural development through time.

3.1.6 - Choris/Norton Tradition: ca. A.D. 500 - ca. 1500 B.C.

Three archeological sites have yielded artifactual material from stratigraphic contexts which suggest that they may be ascribed to the Choris/Norton tradition. These are Component III at the Tsusena site (TLM 097); the upper component at the Fog Creek site (TLM 030), which has been radiocarbon dated to 360 B.C. ±220 (DIC-1877); and the Left Fork site (TLM 069) which was probably occupied immediately prior to deposition of the Watana tephra. The flakes from the upper component at Fog Creek were unfortunately bagged in the field with those from the lower component, thus rendering impossible definition of the lithologic types associated with this component. However, fine grained silicious rock types are represented in this sample and were probably derived from the upper component, while the remainder of the sample is basalt and is probably derived from the lower, Northern Archaic, component. No diagnostic artifacts were recovered from Component I.

Component III at the Tsusena site (TLM 097) was not subject to radiometric dating, but it is clearly associated with the contact between the Watana and Devil tephras. This component contained 9 fire-cracked rock fragments, 15 waste flakes of rhyolite and tuff, and 65 tuffacious flakes. Although the assemblage does not provide sufficient data to define the Choris/Norton tradition within the project area, it does, when coupled with data from a number of other sites, provide data which strongly indicate the occurrence of this tradition within the middle Susitna region between ca. A.D. 500 and ca. 1500 B.C.

The period of occupation of the Left Fork site (TLM 069) remains problematic, but the preliminary data suggest that it probably occurred immediately prior to the deposition of the Watana tephra. Several artifact types suggest that the material cultural remains from this site are similar to artifacts typologically associated with the Choris/Norton period in other regions of Alaska. Bone preservation at this site suggests that it was occupied shortly before deposition of the Watana tephra, because bone preservation is comparatively rare in archeological components predating the Devil tephra in the middle Susitna region.

Three additional sites (TLM 033, TLM 034, and TLM 053), which have only been subject to reconnaissance testing, indicate cultural components between the Watana and Devil tephras; and this suggests that these sites may also be ascribed to this temporal period. In all three sites, no diagnostic artifacts were recovered; and the cultural components were defined on the basis of lithic debitage alone. It is important to note that the debitage in all three cases is fine grained cherts or rhyolite, which may be an indicator of this tradition in the middle Susitna region.

While it has not yet been possible to unquestionably document diagnostic artifacts dating to this period, several sites in addition to the Left Fork site (TLM 069) in the project area have yielded artifacts characteristic of this tradition. Bacon (1978a) suggested possible Norton influence at TLM 018, based on the occurrence of a triangular trending to pentagonal end blade. Irving (1957) reported the discovery of three obliquely pressure-flaked side blades on an overlook near the Tyone River. The artifacts reported by Irving still represent the best typological indication of the Norton/Choris tradition in the middle Susitna.

This critical interval in non-coastal Alaskan prehistory is poorly understood, and the middle Susitna River holds excellent potential for resolving the myriad of problems associated with it. Extensive field investigation of archeological components dating to this interval is essential to: (1) document the material cultural remains dating to this period; (2) elucidate settlement and subsistance patterns; and (3) resolve the problems associated with the postulated late Denali complex.

3.1.7 - Northern Archaic Tradition: ca. 1500 B.C. - ca. 3000 B.C.

Component IV at the Tsusena site (TLM 097) best documents the stratigraphic placement of the Northern Archaic Tradition within the project area. The stratigraphic position of this component is clear and is supported by a radiocarbon determination of 2070 +65 B.C. (DIC-2283). This component contained the base of a black basalt, side-notched projectile point, and black siltstone flake core along with 312 flakes of basalt and 16 of rhyolite and tuff. Because side-notched projectile points are the hallmark of the Northern Archaic Tradition, it is reasonable to ascribe it to the Northern Archaic Tradition in spite of the small sample size.

The Fog Creek Site (TLM 030) was not subject to systematic testing, but did yield reliable data pertinent to defining the Northern Archaic Tradition in the project area. Two components were recognized during reconnaissance testing of the site. The lower component contained a side-notched projectile point along with lithic debitage consisting primarily of black basalt. A radiocarbon determination for this component, which also occurs between the Watana and Oshetna tephra, is 2770 +130 B.C. (DIC-1880). While systematic testing is required to further define and clarify this site, the preliminary data are strikingly similar to that recovered from Component IV at the Tsusena Borrow C site. The Fog Creek site is significant because it not only confirms the stratigraphic placement of the Northern Archaic Tradition in the project area, but further defines the temporal span of the tradition.

Component II, which occurs between the Watana and Oshetna tephras at Tuff Creek North (TLM 027), probably reflects a Northern Archaic use of this site. Although no diagnostic artifacts were recovered, the lithic debitage is black basalt, the most common lithologic type associated with the Northern Archaic occupation at both Fog Creek and the Tsusena site (TLM 097). The stratigraphic placement of this component between the Watana and Oshetna tephra strongly supports this interpretation.

3.1 - Evaluation of Historical Sites

The lower component at TLM 143 produced side-notched points and a radiocarbon determination on charcoal of 2150 B.C. ±60 and is clearly associated with the Northern Archaic Tradition. Although no diagnostic artifacts were found in the lower component at TLM 128, a radiocarbon date (on charcoal from the paleosol on which the artifacts were recovered) of 2630 B.C. ±780 suggests that this component may also represent the Northern Archaic Tradition.

Although a number of sites in the project area have yielded side-notched projectile points and other artifact types commonly associated with the Northern Archaic Tradition, only Fog Creek, the Tsusena site, Tuff Creek North, and Jay Creek have yielded cultural horizons that can be dated with a high degree of certainty. It is probable that Component IV at the Tsusena site is not the latest occurrence of this tradition within the project area and that the lowest component at Fog Creek is probably not the earliest. Additionally, no artifacts characteristic of the Northern Archaic Tradition have been found either above the Watana or below the Oshetna tephra. These data suggest a temporal span between 1500 to 3000 B.C. for this tradition in the middle Susitna region.

These data concur with archeological data from other Alaskan archeological sites. The upper Northern Archaic component at the Dry Creek site located near Healy, Alaska, ranges in age between 2400 and 1400 B.C. (Powers and Hamilton 1978), and data from the Tangle Lakes area suggest a similar temporal span for this tradition (West 1975). These and other sites in the Alaskan interior support Workman's (1978) hypothesis that Northern Archaic Tradition spread through the Yukon Territory and northward along the Brooks Range to the Onion Portage site by 4000 B.C. and later spread into southern interior Alaska.

As demonstrated by the Fog Creek, Tsusena, and Jay Creek sites, the study area holds high potential for addressing critical questions pertinent to understanding the Northern Archaic Tradition. These are: (1) closely bracketing the temporal span during which the middle Susitna was occupied by peoples bearing this tradition; (2) the subsistance strategies and settlement patterns implemented by Northern Archaic Peoples; (3) the nature of house forms and other structures associated with this tradition; and most importantly, (4) data essential to explain the rather dramatic appearance and disappearance of this technological tradition in the archeological records. The middle Susitna is an extremely critical region for addressing these problems, because various manifestations of this tradition, which may lack diagnostic artifacts (such as side-notched projectile points) can be recognized with clarity based on their expected occurrence between the Watana and Oshetna tephras.

3.1 - Evaluation of Historical Sites

3.1.8 - American Paleoarctic Tradition: ca. 3000 B.C. - ca. 9000 B.C.

The lowest component at Tuff Creek North (TLM 027) best documents the stratigraphic placement of this tradition in the project area. At this site, Component III clearly rests on top of glacial drift and is capped by the Oshetna tephra. The Oshetna tephra was deposited prior to approximately 2700 B.C. and probably during the interval between 3000 to 5000 B.C. Although no organic material suitable for radiometric dating was recovered from this component, the artifactual material is considerably older than the Oshetna tephra. The lithics rest on and are intermixed with the upper portion of the glacial drift, and exhibit considerable weathering. Both these factors suggest that they were exposed on the surface for an extended period, possibly several thousand years, prior to the deposition of the Oshetna tephra.

The assemblage contains several blocky cores which result from the manufacture of blades, microblades and blade-like flakes. Core rotation is common, and no "type" core has been identified in the assemblage. In addition to the cores, the assemblage contains blade-like flakes, blades, microblades, and waste flakes. Some of the blades and flakes exhibit edge retouch along their margins, which is generally restricted to one surface of the specimens. No bifacial stone tools were recovered from Component III. Admittedly, the sample is small when compared to the estimated spatial extent of the site, but it does suggest striking technological similarities to the Ugashik Narrows Phase (Dumond 1977) on the Alaska Peninsula; Locality 1 at the Gallagher Flint Station (Dixon 1975); and possibly the Anangula site located on an islet (Ananuliak Is.) off Umnak Island in the Aleutians (Aigner 1978). Although radiocarbon determinations are not available from this component, it is not unreasonable to estimate the period of occupation between approximately 4000 to 5000 B.C. based on its stratigraphic occurrence below the Oshetna tephra, the advanced degree of weathering exhibited by the lithics, and typological comparison with other Alaskan archeological sites which exhibit similar technological characteristics.

Two additional sites (TLM 040 and TLM 048) appear to contain microblade components which occur below the Oshetna tephra, but the results of systematic testing at these sites are not conclusive. It appears a microblade component is represented in Component II at the Duck Embryo North site (TLM 048) which is probably derived from the contact of the glacial drift and the Oshetna tephra. However, only a single microblade was recovered along with the lithic debitage, and further work is required to clarify the age, nature, and extent of this component. At TLM 040, the Tephra site, numerous obsidian microblades and microblade fragments were recovered. Although their stratigraphic position could not be defined with certainty, there is some indication that they may have been deposited below the Oshetna tephra. Although no radiocarbon determinations are available from either of these sites, future work will probably succeed in defining their stratigraphic position and hopefully provide organics suitable for radiometric dating.

The microblades from the Duck Embryo North and Tephra sites appear to be struck from prepared cores and exhibit a uniformity not reflected in the specimens from Component III at Tuff Creek. The morphological characteristics of these microblades (from TLM 040 and 048) suggest greater technological similarity with specimens commonly associated with the Denali Complex and may be of the same age. It is not unreasonable to postulate that all these components may be ascribed to the American Paleoarctic Tradition and probably date to the interval between 3000 and 9000 B.C. It is probable that the blockier rotated blade/microblade cores postdate the prepared cores of the Denali complex, and both assemblages appear to deemphasize the manufacture of bifacial stone tools, particularly projectile points.

The potential of the project area to yield data essential to unraveling many of the complex problems associated with the American Paleoarctic Tradition is excellent. The potential of the upper Susitna basin to yield data essential to understanding the complex cultural developments associated with this tradition between the time of deglaciation (12,000 to 9000 B.C.) and ca. 3000 B.C. is excellent.

3.1.9 - Early Period: ca. 30,000 B.C.- ca. 20,000 B.C.

The midsection, or shaft, of the right femur of a proboscidean (probably Mammuthus sp.) was recovered from an exposure near the junction of the Tyone and Susitna Rivers. A single radiocarbon date run on bone collagen from the femur yielded a date of 27,500 ±610 B.C. (DIC-1819). This age determination, coupled with additional dates from the same stratigraphic section, demonstrates that at least some portions of the Upper Susitna were deglaciated during mid-Wisconsin times. The occurrence of the proboscidean fossil also documents that at least one of the passes through the Alaska Range was deglaciated during this time. These data indicate potential for the discovery of archeological sites dating to this period in the study area. However, no sites dating to this period have been recognized in the project area.

3.1.10 - Summary

Five major cultural traditions have been documented within the study area which span the past 11,000 years. These are: (1) Historic 1897 to present; (2) the Athapaskan Tradition ca.

500 A.D. to 1900 A.D.; (3) Choris/Norton Tradition A.D. 500 to 1500 B.C.; (4) Northern Archaic Tradition ca. 1500 B.C. to ca. 3000 B.C.; and (5) the American Paleoarctic Tradition ca. 3000 B.C. to 9000 B.C.? The project area was glaciated between approximately 9000 B.C and 20,000 B.C. and at least partially deglaciated between 30,000 and 20,000 B.C.

Based on the results of the reconnaissance survey and the limited systematic testing of the select archeological sites, the project area holds excellent potential for addressing many long-standing anthropological questions. Three tephras permit stratigraphic correlation between many sites and site components. This presents a uniquely significant opportunity to define the development of these archeological traditions which has not been possible elsewhere in interior or south-central Alaska. No single archeological site has been found which preserves the cultural chronology from deglaciation to historic times, but the tephra enable cultural development to be traced through time based on comparisons of a series of sites which can be clearly documented to be temporally discrete.

Because the first goal of archeology is to define cultural chronology, the work conducted thus far has been focused primarily toward this objective. Substantial progress has been made, but clearly considerable additional work is essential if this goal is to be fully realized, particularly during the Choris/Norton and American Paleoarctic Tradition periods. Systematic excavation may resolve many of the problems relevant to defining cultural chronology, and probably will provide extremely valuable data essential to interpreting the past lifeways of the cultural groups that occupied the region prior to historic contact. Better understanding of subsistence, settlement patterns, and social/cultural phenomena will result as a complementary product of developing the cultural chronology; and future research strategies should attempt to address these problems.

It is already possible to glimpse some of the larger questions which may be addressed as mitigation of adverse impact to cultural resources progresses throughout the project area. Some are: (1) defining and explaining the interrelationship between cultural succession, vulcanism and environmental change; (2) resolution of as yet unresolved questions relevant to firmly documenting, or rejecting, the occurrence of a Late Denali phase; and (3) definition and interpretation of the nature of cultural contacts or rapid technological change, which occurred during the periods of transition between cultural traditions. Future mitigation of adverse impact to cultural resources must address these and other problems. The legal requirement mandating the preservation of sites is founded on the knowledge that they hold data which may enable potential explanation of such problems. The upper Susitna River region may be one of the best locales known in Alaska to preserve such information and address these significant scientific and humanistic questions.

3.2 - Impact on Historic and Archaeological Sites

3.2.1 - Introduction

The level of adverse impact posed by the Sustina Hydroelectric Project on cultural resources is substantial. Consequently, a mitigation effort corresponding to this level of adverse impact is needed to meet mandates of federal and state cultural resource legislation. Mitigation is discussed further in Section 4.1.

The magnitude and nature of adverse impact the Susitna Hydroelectric Project will have on specific sites or groups of sites depend on the location of these cultural resources in relation to areas affected by construction, operation, maintenance, overall land modification, and ancillary development of the Sustina Hydroelectric Project and the type of activities which will occur in these areas (Table E.4.1). Three major types of adverse impacts to cultural resources have been defined; they are direct, indirect, and potential.

Sites directly impacted are those sites which are immediately affected by ground-disturbing activities associated with preconstruction, construction, or operation of the project. These include, but are not limited to, dam construction, access roads, borrow sites, camps, transmission lines, staging areas, airstrips, and reservoirs behind the Devil Canyon and Watana dams.

Indirect impacts will result from adverse effects that are secondary but clearly brought about by the project and which would not occur if the project were not undertaken. Indirect impacts will occur on sites affected by altered and/or accelerated erosional processes associated with filling of the reservoirs. Secondary land modifications such as altered drainage and accelerated erosional processes associated with dam and spillway construction, greater access to remote areas, increased number of project personnel in the area during and after construction, activities related to project maintenance, and erosion of the impoundment margins resulting from fluctuating water levels--all pose very real, though secondary, threats to cultural resources (Lenihan et al. 1981).

Potential impact is connected with ancillary development which could occur as a result of the project, but which depend on other variables which are unknown at this time. Such variables include future engineering modifications, future recreational use of the area, and increased development along access corridors and impoundment margins. Although the specific impact agent(s) that could impact sites in the potential category are not presently known, impact to sites or groups of sites can be predicted to occur as a result of expected recreational use of the area and increased development associated with this activity. Potential impact could become direct impact, indirect impact, or no impact depending on how these activities affect the areas containing cultural resources. When the location of all project facilities

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3.2.2 - Significance

To comply with federal regulations, impact analysis of cultural resources is legally required for those sites either listed in or recommended as eligible for the National Register of Historic Places. The eligibility of a site, or group of sites, for inclusion in the National Register of Historic Places is based on the site(s) significance. Therefore, it is first necessary to determine whether the site or group of sites is significant. Determination of signifance is based on the application of National Register of Historic Places criteria which define significance "in American history, architecture, archeology, and culture present in districts, sites, buildings, structures, and objects of state and local importance that possess integrity of location, design, setting, materials, workmanship, feeling, and association and/or that are associated with events that have made significant contributions to the broad patterns of history; or are associated with the lives of persons significant in our past; or that embody the distinctive characteristics of a type, period, or method of construction; or that represent the work of a master; or that possess high artistic values; or that represent a significant and distinguishable entity whose components may lack individual distinction; or have yielded or may likely yield information important in prehistory and history" (36 CFR 60).

A determination of significance must be based on adequate information. For this project, a program of reconnaissance level testing was implemented to locate and document sites. In order to generate sufficient data on which to base an evaluation of significance, systematic testing was employed. In most cases (a notable exception being historic cabins), systematic testing is necessary to assess significance. The 21 sites systematically tested all provided sufficient data to address the question of significance, and 20 of these sites appear to be eligible for inclusion in the National Register (see Table E.4.2).

Significance itself is a relative term which is used in a historic context dependent on the current state of knowledge, method and theory employed, and research questions asked. New techniques and methods have enabled archeologists to collect new and different types of data which allow new questions to be formulated and addressed. Although National Register criteria are subject to ongoing modification, significance pertaining to archeological sites generally emphasizes research potential, site integrity, and/or public appreciation.

3.2 - Impact on Sites

Although all the sites located as a result of this study are related geographically and temporally, the exact relationships await further study. Most of the sites were found associated with one or more of three tephras which provide limiting dates in a restricted geographic context and provide a unique and scientifically important opportunity to construct the first cultural chronology for the middle Sustina River valley. Armed with this information, it is possible to state that all sites (with the exception of TLM 033) found to date in the study area are likely significant and collectively hold the potential for defining the prehistory for this region of Alaska and, therefore, may be eligible for inclusion in the National Register of Historic Places. Based on all data collected to date, a preliminary cultural chronology has been developed (see Section 3.1).

Significance must be assessed on the basis of adequate data. Only 21 of the sites located and documented during the three field seasons have been systematically tested and adequate data are available from these 21. Evaluation of specific site significance for the remaining sites must await systematic testing. However, because a majority of the sites occur in relation to three tephra, it is possible to consider the collective significance of all sites for delineating the prehistory and history of the middle Susitna River valley. From this perspective, all sites located to date (with the execption of TLM 033) appear to qualify for the National Register of Historic Places.

Given this level of significance, it may be appropriate to evaluate these sites in terms of National Register eligibility as an archeological district because of the unique opportunity the known sites in this area (as well as yet undiscovered sites) have for addressing questions concerning the prehistory of a large portion of interior Alaska which is presently not well defined. If a nomination of this type is made, it should be done in concert with the State Historic Preservation Officer and the FERC.

3.2.3 - Watana Dam and Impoundment

Two historic sites and 28 archeological sites were located and documented in areas to be impacted by the Watana Dam and its impoundment. The two historic sites (TLM 079, TLM 080) will be directly impacted, as will the 28 archeological sites (TLM 017, TLM 018, TLM 026, TLM 033, TLM 039, TLM 040, TLM 042, TLM 043, TLM 048, TLM 050, TLM 058, TLM 059, TLM 060, TLM 061, TLM 062, TLM 063, TLM 064, TLM 065, TLM 072, TLM 073, TLM 075, TLM 077, TLM 102, TLM 104, TLM 115, TLM 119, TLM 126 and TLM 137).

3.2.4 - Devil Canyon Dam and Impoundment

One historic site and six archeological sites are presently known in areas to be impacted by the Devil Canyon Dam and its impoundment. The one known historic site (TLM 023) and the six archeological sites (TLM 022, TLM 024, TLM 027, TLM 029, TLM 030, TLM 034) will all be directly impacted.

3.2.5 - Proposed Borrow Sites, Associated Facilities, and Sites Disturbed by Geotechnical Testing

Seven archeological sites are presently known in the portions of the proposed borrow sites examined to date (A, B, D, E, F, G), and areas disturbed by geotechnical testing. One site will be directly impacted (TLM 035); two sites have the potential of being impacted (TLM 068, TLM 070); and it appears that four sites will not be impacted because of their distance from expected impact areas (TLM 082, HEA 177, HEA 178, HEA 179). Additional potential borrow sites have been identifed (H, I, J, K) and another expanded (F) which remain to be examined for cultural resources. Sites that fall within both an impoundment area and a potential borrow source are included under the appropriate impoundment section. Proposed borrow sites I and J are located within expected impoundment areas.

3.2.6 - Proposed Access Routes

Survey of the proposed access route was cursory, and additional survey of the proposed route and associated borrow areas is required to adequately cover the area. It is likely that numerous additional sites will be located during continued survey of the access route which is scheduled for 1983.

Five archeological sites are presently known along the selected access corridor and/or associated with proposed borrow sites associated with this corridor. All five sites will receive indirect impact (TLM 051, TLM 101, TLM 103, TLM 114, and TLM 155).

3.2.7 - Proposed Transmission Corridors

Transmission line corridors were selected very late in the project. The section from the proposed Watana dam was selected after the 1982 field season and consequently has not been surveyed. Segments of the transmission corridors from Anchorage to Willow and Healy to Fairbanks were examined at the preliminary reconnaissance level. However, continued survey is required to adequately cover these proposed corridors as well as the newly selected portion.

No sites are presently known for the portion of the transmission corridor from Anchorage to Willow. Reconnaissance level survey of the Healy to Fairbanks portion of the corridor and examination of the files in the Alaska Office of History and Archaeology document thirteen sites within the proposed corridor. Until the exact location of the route is known including access roads, tower placements, etc., all of these sites have the potential of being impacted (FAI 213, FAI 214, HEA 026, HEA 030, HEA 035, HEA 037, HEA 038, HEA 080, HEA 083, HEA 119, HEA 137, HEA 210, TLM 112). When plans for the transmission corridors are finalized and the cultural inventory complete, it will then be possible to determine the effect of this portion of the project on cultural resources.

3.2.8 - Other Portions of the Study Area

Three historic sites and 102 archaeological sites are known in this area. Two historic sites (TLM 020, TLM 071) and 24 archaeological sites (TLM 015, TLM 016, TLM 038, TLM 098, TLM 099, TLM 100, TLM 105, TLM 109, TLM 110, TLM 111, TLM 113, TLM 117, TLM 120, TLM 121, TLM 130, TLM 133, TLM 143, TLM 145, TLM 153, HEA 174, HEA 176, HEA 180, HEA 183, HEA 184) will be indirectly impacted. One historic site (TLM 056) and 74 of the archaeological sites have the potential of being adversely impacted by the project (TLM 021, TLM 025, TLM 028, TLM 031, TLM 032, TLM 036, TLM 037, TLM 041, TLM 044, LTM 045, TLM 046, TLM 047, TLM 049, TLM 052, TLM 053, TLM 054, TLM 055, TLM 057, TLM 066, TLM 069, TLM 074, TLM 076, TLM 078, TLM 081, TLM 083, TLM 084, TLM 085, TLM 086, TLM 087, TLM 088, TLM 089, TLM 090, TLM 091, TLM 092, TLM 093, TLM 094, TLM 095, TLM 096, TLM 097, TLM 106, TLM 107, TLM 108, TLM 116, TLM 118, TLM 122, TLM 123, TLM 124, TLM 125, TLM 127, TLM 128, TLM 129, TLM 131, TLM 132, TLM 134, TLM 135, TLM 136, TLM 138, TLM 139, TLM 140, TLM 141, TLM 142, TLM 144, TLM 146, TLM 147, TLM 148, TLM 149, TLM 150, TLM 151, TLM 152, TLM 154, HEA 181, HEA 182, HEA 185, HEA 211). It appears that the remaining four sites will not be impacted by the project (TLM 007, TLM 067, HEA 175, HEA 186).

Although 79 sites in this category are presently located outside expected direct and indirect areas, they could be impacted depending on future developments associated with the Susitna Hydroelectric Project. At present, they should be avoided. However, if and when it is determined that these sites will be either directly or indirectly impacted, it will then be necessary to mitigate this impact. When final plans for the project, including recreational activities, are available, it may then be possible to determine specific sites that will not be impacted by the Susitna Hydroelectric Project.

4 - MITIGATION OF IMPACT ON HISTORIC AND ARCHEOLOGICAL SITES

4.1 - Mitigation Policy and Approach

Federal regulations require that the effect of any federal project or federally licensed project on cultural resources must be assessed and mitigation measures developed to lessen or avoid the impact on those resources in, or determined to be eligible for inclusion in, the National Register of Historic Places. Mitigation measures are management tools which provide options when making decisions regarding the preservation or reduction of impact to cultural resources. Although the concept has undergone and is presently undergoing refinement, it clearly consists of three options: avoidance, preservation, and investigation (data recovery).

4.1.1 - Avoidance

Avoidance consists of any measures that avoid adverse effects of a project on cultural resources. Avoidance in and of itself may not be totally effective if not coupled with a monitoring program that will insure that a historic or archeological site protected from the immediate adverse effect (direct or indirect impact) of the project is not inadvertently damaged in the future as a result of the project (potential impact). For the Susitna Hydroelectric Project, potential damage may result from, but is not limited to, operation of the facilities, increased access to remote areas, recreational activities, private development, and the transfer of lands from federal and state governments to corporate or private parties. Therefore, avoidance must be considered in terms of long-range and short-range goals aimed at protecting cultural resources beyond the immediate construction phase of the dam and its ancillary facilities.

4.1.2 - Preservation

Preservation is any measure that results in the reduction or avoidance of impact on cultural resources through physical maintenance or protection aimed at preventing further deterioration or destruction. Preservation, as with avoidance, implies both short-term and long-term measures. Preservation may consist of stabilization and reconstruction, as well as preservation of a site by constructing a barrier around the site, patrolling and monitoring the site, public education, or the establishment of an archeological preserve. Of all the preservation options available for the Susitna Project, monitoring may have the greatest potential for long-term preservation of not only a particular site or group of sites but for cultural resources in general.

4.1.3 - Investigation (Data Recovery)

Investigation refers to a problem-orientated data recovery program aimed at collecting and conserving archeological data in a scientific manner. A program of this type means that data recovery procedures are developed for each site or group of sites, analysis of materials is undertaken, and the results are disseminated to professional and public audiences. In addition to investigation as a method of avoiding adverse impact, a site(s) could be investigated (excavated) either partially or in whole if a site(s) appears to fit the research needs of the overall cultural resource management program; if a site(s) may contain information critical to the larger mitigation program; or if a site(s) cannot be protected from indirect or potential impact such as increased off-the-road traffic, increased recreational use, an increase in the number of people in the area, or increased site visibility. It is recommended that sites actually investigated on this project be selected on the basis of systematic testing and the recommendations of the SHPO and the NPS.

4.2 - Mitigation Plan

Any mitigation plan must be based on an evaluation of project impact on the total resource, including known and undiscovered sites. Therefore, because only a portion of the area to be impacted by the Susitna Hydroelectric Project has been surveyed and investigated, any mitigation plan must include a program to examine the entire surveyable area and mitigate adverse effects on all sites on, or eligible for, the National Register of Historic Places. This program is designed to be completed in two years allowing submittal at this date to FERC prior to final review of the application. Mitigation of any adverse impact to cultural resources must await approval of the license application as well as approval by the state of Alaska to actually construct the hydroelectric facilities. Mitigation proposed here will apply to sites located and tested in the future as well as the sites presently known.

Upon completion of the cultural resource inventory and systematic testing, a detailed site-specific management plan will be prepared in consultation with FERC, the SHPO, and the appropriate land managing agencies, and filed with these agencies.

4.2.1 - Details of Plan

The highest priority for mitigating adverse impact to cultural resources associated with the Susitna Hydroelectric Project is first to complete the archeological and historical survey and thus provide a complete inventory of cultural resources. Portions of the impoundment areas, the access corridor and associated borrow pits and haul roads, as well as the transmission corridors between Healy and Fairbanks, Anchorage and Willow, and the Watana damsite and the intertie, have not been subject to thorough on- the-ground survey and subsurface testing. Therefore, completion of the reconnaissance and systematic surveys is necessary. As sites are documented during the course of the survey, they will be classified into one of the three impact categories: (1) direct impact, (2) indirect impact, and (3) potential impact (see Section 3.2 for definitions).

Sites subject to either direct or indirect impact should be investigated to assess their eligibility for inclusion in the National Register of Historic Places (Table E.4.2). To accomplish this goal, these sites will require systematic testing (for a thorough discussion of systematic testing procedures see Chapter 2 in Dixon et al. 1982a). The objective of systematic testing is to obtain sufficient data to assess the spatial limits, stratigraphy, relative age, and possible cultural affiliation of a specific archeological site. These data are essential to assess the ability of a site to yield significant scientific information, which is a necessary criterion for determining the signficance of cultural resources under the Advisory Council guidelines as stated in Procedures of the Advisory Council on Historic Preservation, 36 CFR 800. Following systematic testing, each site will need to be evaluated to determine whether it can provide data relevant to the three major goals of North American archeology: (1) establishment of cultural chronologies; (2) definition of past lifeways; and (3) explanation of cultural process. If, following systematic testing, a specific site is found to hold no potential to address any of these three fundamental scientific questions or research topics (Advisory Council on Historic Preservation 1980) it will be determined not significant and thus probably not eligible for inclusion in the National Register of Historic Places. Should a determination of nonsignificance be made, no further mitigation efforts should be required. This has already proven to be the case with one site, TLM 033.

Those sites found to hold potential to address humanistic, historical, and/or local-interest research questions should be determined significant and thus be considered eligible for inclusion in the National Register of Historic Places. The mitigation measure recommended for these sites should be preservation of information through systematic scientific excavation. This determination should be made in concert with the SHPO. The preservation of these sites through investigation (excavation) should be prioritized based upon the immediacy of the threat of adverse impact to each specific site. Thus, in general terms, those which occur in locales slated for construction should be removed through excavation prior to those within the impoundment areas. Within the impoundment areas, sites at lower elevations would receive priority above those at higher elevations. Such a prioritization should minimize potential conflicts between cultural resources and construction schedules.

4.2 - Mitigation Plan

The mitigation measure recommended for all sites falling within the potential impact category is avoidance. For those sites subject to potential adverse impact (Table E.4.2), a monitoring plan should be developed in concert with the appropriate land managing agencies (state and federal). The monitoring program should, at minimum, establish a photographic record of each site on a predetermined schedule; should any adverse impact resulting from activities of the Susitna Hydroelectric Project occur, it should be documented. Should any particular site or group of sites experience adverse impact as a result of the project, the appropriate mitigation measure for that particular circumstance should be applied. The monitoring program should be continued throughout the course of the project on an annual basis until the hydroelectric facility is operational. At such time, the monitoring program should become the responsibility of the appropriate land managing agency.

Coupled with the monitoring program will be an educational program for construction and other project personnel, which emphasizes the necessity to avoid cultural resources in and adjacent to the project area. Such a program should stress the importance of the scientific information the sites contain and should discourage looting and artifact collecting.

Analysis of the sites found in 1980 and 1981 and preliminary analysis of the sites located during the 1982 field season as well as sites on record in the Alaska Office of History and Archeology are tabulated in Tables E.4.2 and E.4.3. Of the known sites, 70 will be directly or indirectly impacted, and 84 have the potential of being impacted. Based on available data, it appears that 8 sites will not be impacted by the project. However, this is a preliminary evaluation based on the fact that these sites are some distance from expected impact areas.

Of the 167 sites presently known, 21 have already been systematically tested. Forty-nine additional sites will require systematic testing to determine their eligibility for inclusion in the National Register. Systematic testing is recommended for only those sites that have been determined to be directly or indirectly impacted by the project. For those sites on federal or state lands which will not be directly or indirectly impacted by the project, the cultural resource policies of the appropriate agency should be applied.

4.2.2 - Schedule

Both state and federal regulations mandate that all cultural resources within the project boundary be considered. Since only a portion of the total project area, the configuration of which is still undergoing modification, has been examined for archeological and historical sites, it is essential that reconnaissance level testing continue in order to document cultural resources in the immediate project area given the present level of technology. In addition, systematic testing is required to address the significance of these sites that will be directly or indirectly impacted and to determine their eligibility to the National Register. Systematic testing should, therefore, also continue for sites that will be directly or indirectly impacted.

Based on the field work completed to date, the large number of sites known (167), and the portion of the study area actually surveyed, it is anticipated that many additional sites remain to be discovered. Most of these sites will likely be subsurface in nature and found by subsurface testing techniques. Based on this information, it is anticipated that two additional field seasons of reconnaissance level survey are needed to adequately examine the entire surveyable portion of the study area for cultural resources. In addition to locating and documenting cultural resources, it will be necessary in most cases to conduct systematic testing in order to generate sufficient data on which to determine site size and content and to evaluate significance. Systematic testing requires that a grid be surveyed over the site, maps prepared, and testing units systematically excavated using standard archeological methods.

To date, only 21 of the sites have been systematically tested. Systematic testing of the 49 remaining sites and an estimated 25 additional ones, located as a result of continued survey, is estimated to take two field seasons. The time actually necessary to test "new" sites can only be estimated following completion of the cultural resource inventory. In order to complete the inventory and systematic testing prior to completion of the license application review period, it is recommended that this work take place in 1983 and 1984. Continued reconnaissnce level testing and systematic testing can take place during the same two-year period.

The following work schedule is recommended for the two-year program discussed above. Work recommended for the 1983 field season is as follows: 1) complete the reconnaissance survey of the proposed access roads, railroad, Watana and Devil Canyon damsites, construction camp areas, associated impact areas, and reservoirs, including the resurvey of defined locales that have the potential for containing sites; 2) completion of aerial reconnaissance survey and on-the-ground reconnaissance survey as necessary to complete sensitivity maps of all proposed transmission corridors and recreation facility sites as may have been defined, indicating the potential of these areas for containing archeological and historical sites; 3) completion of reconnaissance survey or any additional direct impact areas that may be defined prior to the 1983 field season; 4) completion of systematic testing of archeological and historical sites in direct impact areas for the access road and railroad, the vicinity of the construction camp areas, and the proposed Watana and Devil Canyon damsites and associated facilities. For sites located in these areas late in the 1983 field season, it may be necessary to conduct systematic testing in 1984; and 5) survey of areas selected for geotechnical testing.

Recommended work for the 1984 field season includes: 1) completion of systematic testing of sites in the reservoirs; 2) completion of reconnaissance survey along the transmission corridors, recreation facility sites, and other areas as necessary; and 3) completion of systematic testing of sites in these areas as may be necessary.

In addition to a program to find and evaluate additional sites in the project area, mitigation measures must be implemented for those sites determined to be eligible for the National Register that will be adversely affected by the project if it is approved and a decision to build the dam is made by the state of Alaska. It is estimated that mitigation will take approximately five to seven field seasons to complete, depending on the number of additional sites discovered and the number that will require investigation or preservation. The amount of time the entire process would take depends on several factors: (1) the number of additional sites found, (2) the number of personnel involved with the project, and (3) the funding level. It is possible to shorten the time frame by increasing the number of people involved. However, it should be stated that the cost of increasing personnel levels increases exponentially as logistic, supply, equipment, and additional management levels increase. If clear cutting of the impoundment areas or other subsurface disturbing activities take place, the above schedule will have to be adjusted to accommodate the expected timetable of these activities.

In summary, it is anticipated that reconnaissance testing needed to complete the inventory will take two field seasons; systematic testing needed to determine significance and eligibility to the National Register of Historic Places, two field seasons; and mitigation, five to seven field seasons, all of which could run concurrently. All estimates depend on the number of additional sites found in the untested portions of the project area.

4.2.3 - Cost

Based on available information, the preliminary cost estimates for the cultural resource program previously discussed are presented below. It should be mentioned that original estimates (1981) for completing the cultural resource inventory and the necessary systematic testing were four years and five years, respectively. The following cost estimate is based on rearranging these programs into a two-year format in order to complete the work during the license application review period and a modification of the systematic testing program based on more recent data concerning impact of the hydroelectric project on cultural resources.

It is estimated that continued reconnaissance aimed at completing the cultural resource inventory and systematic testing aimed at determining significance and eligibility to the National Register will cost $2,391,552. The survey portion of this amount is based on the approximate 10-15 percent remaining to be surveyed in the Devil Canyon impoundment, the 50 percent remaining to be surveyed in the Watana impoundment, and complete survey of the transmission corridors, access roads and railroad, and other areas as necessary. The systematic testing portion of this amount is based on the 49 sites presently requiring testing and an estimated 25 "new" sites that would likely result from continued survey. This estimate is exclusive of air logistics, food, and camp faciities for archeological personnel. It is anticipated that, for the two years of continued reconnaissance and systematic testing a staff of 45 people will be required.

The determination of the actual costs of any mitigation program for the Susitna Hydroelectric project must await completion of the cultural resources inventory systematic testing to determine which sites are in direct or indirect impact areas and eligible for inclusion in the National Register of Historic Places and the recommendations of the State Historic Preservation Officer, all of which will indicate how many sites will actually require investigation or preservation.

A preliminary cost can be estimated based on the number of sites documented to date (167); the known sites which fall within present direct and indirect impact areas (70); the number of sites which appear to qualify for inclusion in the National Register, based on systematic testing conducted to date (20 of the 21 sites tested); and an estimated 80 additional sites that could be located as a result of continued survey. If the target is 100 percent recovery of significant sites, it is estimated that a program taking into consideration the above factors would

- require approximately ten full-time personnel and 35 part-time personnel working five to seven years to complete, at an estimated cost of $8 million not including logostic support. These figures are preliminary and will be adjusted as information concerning the number of sites requiring investigation or preservation is determined.

4.2.4 - Statement of Sources and Extent of Financing

Funding for cultural resource studies is the responsibility of the Power Authority. The Archeological Conservation Act of 1974 (Public Law 93-291) authorizes that up to one per centum of the total amount of a dam project may be spent on cultural resource studies, including analysis and publication.

5 - AGENCY CONSULTATION

5.1 - Consultation Methods

For all federally funded or licensed projects, or projects on federal lands, it is necessary to obtain a federal antiquities permit. Formal application, including vitas of individuals in general and direct charge, was made to the National Park Service and the necessary permits obtained for 1980, 1981, and 1982. In addition to federal permits, state antiquity permits were obtained for state-selected land within the study area.

The State Historic Preservation Office, the State Archeologist, and archeologists with the National Park Service (Alaska) have been consulted concerning the research design and the mitigation plan. Consultation was both written and oral. Copies of the report on the 1980 and 1981 field seasons were reviewed by the Alaska SHPO and the National Park Service.

5.2 - Summary of Comments

Comments concerning the federal antiquities permit applications were in the form of stipulations to the permits by the National Park Service, Bureau of Land Management, and the U.S. Fish and Wildlife Service (no lands managed by the U.S. Fish and Wildlife Service are included in the Susitna Project area). These comments specified the conditions of the permit (see Appendix 4.A).

5.2.1- Research Design

The research design and strategy were reviewed by the Alaska SHPO, the State Archeologist, and the National Park Service and found to meet project needs and professional standards. It is their opinion that the research conducted to date is thorough and well documented and constitutes an excellent preliminary cultural resource program, but that continued reconnaissance testing of areas not covered during 1980, 1981, and 1982 must be undertaken to locate as many sites as possible given present technology and that systematic testing should continue to further evaluate sites and provide data on which to base significance, determine eligibility to the National Register, assess effect, and determine the appropriate mitigation measures. In addition, they recommended that archeological clearance continue for any activities that may impact cultural resources in the study area throughout the project. Letters addressing the research design are included at the end of this section of the application.

5.2.2 - Mitigation Plan

The Alaska State of Historic Preservation Officer and the Alaska State Archeologist concur with the proposed mitigation plan. Review of the mitigation plan by the National Park Service is pending. When received, NPS comments will be forwarded to FERC.

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TABLE E.4.1: IMPACT ON KNOWN CULTURAL RESOURCES BY AREA

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Sites	Access Route	Access Route Borrow Sites	Transmission Corridors	Other Areas	TOTAL
Direct Impact	TLM 017	TLM 022	TLM 035					
	TLM 018	TLM 023 (h)						
	TLM 026	TLM 024						
	TLM 033	TLM 027						
	TLM 039	TLM 029						
	TLM 040	TLM 030						
	TLM 042	TLM 034						
	TLM 043							
	TLM 048							
	TLM 050							
	TLM 058							
	TLM 059							
	TLM 060							
	TLM 061							
	TLM 062							
	TLM 063							
	TLM 064							
	TLM 065							
	TLM 072							
	TLM 073							
	TLM 075							
	TLM 077							
	TLM 079 (h)							
	TLM 080 (h)							
	TLM 102							
	TLM 104							
	TLM 115*							
	TLM 119*							
	TLM 126*							
	TLM 137*							38

TABLE E.4.1 (Cont'd)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Sites	Access Route	Access Route Borrow Sites	Transmission Corridors	Other Areas	TOTAL
Indirect Impact				TLM 051 TLM 101 TLM 103 TLM 114 TLM 155*		TLM 112	TLM 015 TLM 016 TLM 020 (h) TLM 038 TLM 071 (h) TLM 098 TLM 099 TLM 100 TLM 105 TLM 109 TLM 110 TLM 111 TLM 113 TLM 117 TLM 120* TLM 121* TLM 130* TLM 133* TLM 143* TLM 145* TLM 153* HEA 174 HEA 176 HEA 180 HEA 183 HEA 184	32

TABLE E.4.1 (Cont'd)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Sites	Access Route	Access Route Borrow Sites	Transmission Corridors	Other Areas	TOTAL
Potential Impact			TLM 068			FAI 213*	TLM 021	
			TLM 070			FAI 214*	TLM 025	
						HEA 026+	TLM 028	
						HEA 030+	TLM 031	
						HEA 035+	TLM 032	
						HEA 037+	TLM 036	
						HEA 038+	TLM 037	
						HEA 080+	TLM 041	
						HEA 083+	TLM 044	
						HEA 119+	TLM 045	
						HEA 137+	TLM 046	
						HEA 210*	TLM 047	
							TLM 049	
							TLM 052	
							TLM 053	
							TLM 054	
							TLM 055	
							TLM 056 (h)	
							TLM 057	
							TLM 066	
							TLM 069	
							TLM 074	
							TLM 076	
							TLM 078	
							TLM 081	
							TLM 083	
							TLM 084	
							TLM 085	
							TLM 086	

TABLE E.4.1 (Cont'd)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotechnical Sites	Access Route	Access Route Borrow Sites	Transmission Corridors	Other Areas	TOTAL
Potential Impact (Cont'd)							TLM 087	
							TLM 088	
							TLM 089	
							TLM 090	
							TLM 091	
							TLM 092	
							TLM 093	
							TLM 094	
							TLM 095	
							TLM 096	
							TLM 097	
							TLM 106	
							TLM 107	
							TLM 108	
							TLM 116	
							TLM 118*	
							TLM 122*	
							TLM 123*	
							TLM 124*	
							TLM 125*	
							TLM 127*	
							TLM 128*	
							TLM 129*	
							TLM 131*	
							TLM 132*	
							TLM 134*	
							TLM 135*	
							TLM 136*	
							TLM 138*	

TABLE E.4.1 (Cont'd)

	Watana Dam and Impoundment	Devil Canyon Dam and Impoundment	Borrow and Geotecnnical Sites	Access Route	Access Route Borrow Sites	Transmission Corridors	Other Areas	TOTAL
Potential Impact (Cont'd)							TLM 139* TLM 140* TLM 141* TLM 142* TLM 144* TLM 146* TLM 147* TLM 148* TLM 149* TLM 150* TLM 151* TLM 151* TLM 152* TLM 154* HEA 181 HEA 182 HEA 185 HA 211*	89
No Impact			TLM 082 HEA 177 HEA 178 HEA 179				TLM 077+ TLM 067 HEA 175 HEA 186	8
TOTALS	30	7	7	5	0	13	105	167

(h) - Historic Site
* - Site located during 1982 field season
\+ - On record in the Alaska Office of History and Archeology

TABLE E.4.2: SUSITNA HYDROELECTRIC PROJECT - CULTURAL RESOURCES

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 007*	O						NI	None Required	PR
TLM 015	O	R			X	1983-1984	II		SS
TLM 016	O	R			X	1983-1984	II		SS
TLM 017	W	R			X	1983-1984	DI		SS
TLM 018	W	S	X				DI	I	Kn
TLM 020	O	R	X				II	I	Kn
TLM 021	O	R					PI	A	SP
TLM 022	D	S	X				DI	I	Ty
TLM 023	D	R					DI		Ty
TLM 024	D	R			X	1983-1984	DI		Ty
TLM 025	O	R					PI	A	VS
TLM 026	W	R			X	1983-1984	DI		SSS
TLM 027	D	S	X				DI	I	Kn
TLM 028	O	R					PI	A	F
TLM 029	D	R			X	1983-1984	DI		Kn
TLM 030	D	R			X	1983-1984	DI		Kn
TLM 031	O	R					PI	A	VS
TLM 032	O	R					PI	A	VS
TLM 033	W	S		X			DI	None Required	VS
TLM 034	D	R			X	1983-1984	DI		Kn
TLM 035	B	R			X	1983-1984	DI		VS
TLM 036	O	R					PI	A	SSS
TLM 037	O	R					PI	A	VS
TLM 038	O	S	X				II	I	SS
TLM 039	W	S	X				DI	I	SS
TLM 040	W	S	X				DI	I	VS

TABLE E.4.2 (Cont'd)

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places		Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
			Yes	No					
TLM 041	O	R					PI	A	VS
TLM 042	W	S	X				DI	I	SSS
TLM 043	W	S	X				DI	I	VS
TLM 044	O	R					PI	A	SSS
TLM 045	O	R					PI	A	SP
TLM 046	O	S	X				PI	A	SP
TLM 047	O	R					PI	A	SSS
TLM 048	W	S	X				DI	I	SS
TLM 049	O	R					PI	A	SSS
TLM 050	W	S	X				DI	I	VS
TLM 051	B/AR	R			X	1983-1984	II		SS
TLM 052	O	R					PI	A	SSS
TLM 053	O	R					PI	A	SSS
TLM 054	O	R					PI	A	SS
TLM 055	O	R					PI	A	SS
TLM 056	O	R	X				PI	A	SS
TLM 057	O	R					PI	A	SS
TLM 058	W	R			X	1983-1984	DI		VS
TLM 059	W	S	X				DI	I	SS
TLM 060	W	R			X	1983-1984	DI		SS
TLM 061	W	R			X	1983-1984	DI		SS
TLM 062	W	S	X				DI	I	VS
TLM 063	W	R			X	1983-1984	DI		VS
TLM 064	W	R			X	1983-1984	DI		VS
TLM 065	W	S	X				DI	I	SSS

TABLE E.4.2 (Cont'd)

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 066	O	R					PI	A	SS
TLM 067	O	R					NI	None Required	VS
TLM 068	B	R					PI	A	SS
TLM 069	O	S	X				PI	A	SSS
TLM 070	B	R					PI	A	SS
TLM 071	O	R	X		x	1983-1984	II		SSS
TLM 072	W	R			X	1983-1984	DI		SSS
TLM 073	W	R			X	1983-1984	DI		SSS
TLM 074	O	R					PI		SSS
TLM 075	W	R			X	1983-1984	DI		SSS
TLM 076	O	R					PI		SSS
TLM 077	W	R			X	1983-1984	DI		SSS
TLM 078	O	R					PI	A	SP
TLM 079	W	R	X				DI	I	SSS
TLM 080	W	R	X				DI	I	VS
TLM 081	O	R					PI	A	SS
TLM 082	B	R					NI	None Required	SS
TLM 083	O	R					PI	A	SP
TLM 084	O	R					PI	A	SP
TLM 085	O	R					PI	A	SP
TLM 086	O	R					PI	A	SS
TLM 087	O	R					PI	A	SP
TLM 088	O	R					PI	A	[illegible]
TLM 089	O	R					PI	A	SS
TLM 090	O	R					PI	A	SS

TABLE E.4.2 (Cont'd)

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 091	O	R					PI	A	SS
TLM 092	O	R					PI	A	SS
TLM 093	O	R					PI	A	SS or PR
TLM 094	O	R					PI	A	SS
TLM 095	O	R					PI	A	SS
TLM 096	O	R					PI	A	SS
TLM 097	O	S	X				PI	A	SS
TLM 098	O	R			X	1983-1984	II		SP
TLM 099	O	R			X	1983-1984	II		SP
TLM 100	O	R			X	1983-1984	II		SSS
TLM 101	AR	R			X	1983-1984	II		SS
TLM 102	W	R			X	1983-1984	DI		VS
TLM 103	AR	R			X	1983-1984	II		SS
TLM 104	W	R			X	1983-1984	DI		VS
TLM 105	O	R			X	1983-1984	II		SS
TLM 106	O	R					PI	A	SS
TLM 107	O	R					PI	A	SS
TLM 108	O	R					PI	A	SS
TLM 109	O	R			X	1983-1984	II		SS
TLM 110	O	R			X	1983-1984	II		SS
TLM 111	O	R			X	1983-1984	II		SS
TLM 112	T	R			X	1983-1984	II		SS
TLM 113	O	R			X	1983-1984	II		SS
TLM 114	AR	R			X	1983-1984	II		SS
TLM 115	W	R			X	1983-1984	DI		SSS

TABLE E.4.2 (Cont'd)

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 116	O	R					PI	A	SS
TLM 117	O	R			X	1983-1984	II		SP
TLM 118	O	R					PI	A	Ty
TLM 119	W	R			X	1983-1984	DI		VS
TLM 120	O	R			X	1983-1984	II		VS
TLM 121	O	R			X	1983-1984	II		VS
TLM 122	O	R					PI	A	VS
TLM 123	O	R					PI	A	VS
TLM 124	O	R					PI	A	VS
TLM 125	O	R					PI	A	VS
TLM 126	W	R			X	1983-1984	DI		VS
TLM 127	O	R					PI	A	VS
TLM 128	O	S	X				PI		SSS
TLM 129	O	R					PI	A	VS
TLM 130	O	S	X				II	I	VS
TLM 131	O	R					PI	A	VS
TLM 132	O	R					PI	A	VS
TLM 133	O	R			X	1983-1984	II		VS
TLM 134	O	R					PI	A	SSS
TLM 135	O	R					PI	A	SSS
TLM 136	O	R					PI	A	SSS
TLM 137	W	R			X	1983-1984	DI		SSS
TLM 138	O	R					PI	A	SSS
TLM 139	O	R					PI	A	SSS
TLM 140	O	r					pi	a	SSS

TABLE E.4.2 (Cont'd)

			Appears to Be Eligible for Inclusion in the National Register of Historic Places						
AHRS #	Location	Testing Level	Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
TLM 141	O	R					PI	A	SSS
TLM 142	O	R					PI	A	SSS
TLM 143	O	S	X				II	I	SSS
TLM 144	O	R					PI	A	SSS
TLM 145	O	R			X	1983-1984	II		SSS
TLM 146	O	R					PI	A	SSS
TLM 147	O	R					PI	A	SSS
TLM 148	O	R					PI	A	SSS
TLM 149	O	R					PI	A	SSS
TLM 150	O	R					PI	A	SSS
TLM 151	O	R					PI	A	SSS
TLM 152	O	R					PI	A	SSS
TLM 153	O				X	1983-1984	II		SS
TLM 154	O	R					PI	A	SSS
TLM 155	AR				X	1983-1984	II		SP
HEA 026*	T						PI	A	U
HEA 030*	T						PI	A	U
HEA 035*	T						PI	A	U
HEA 037*	T						PI	A	U
HEA 038*	T						PI	A	U
HEA 080*	T						PI	A	U
HEA 083*	T						PI	A	U
HEA 119*	T						PI	A	U
HEA 137*	T						PI	A	U
HEA 174	O	R			X	1983-1984	II		F

TABLE E.4.2 (Cont'd)

AHRS #	Location	Testing Level	Appears to Be Eligible for Inclusion in the National Register of Historic Places: Yes	No	Further Testing Required	Proposed Testing Schedule	Expected Impact	Recommended Mitigation	Land Status
HEA 175	O	S	X				II (1981) NI (1982	None Required	F
HEA 176	O	R			X	1983-1984	II		F
HEA 177	B	R					NI	None Required	F
HEA 178	B	R					NI	None Required	F
HEA 179	B	R					NI	None Required	F
HEA 180	O	R			X	1983-1984	II		F
HEA 181	O	R					PI	A	F
HEA 182	O	R					PI	A	F
HEA 183	O	R			X	1983-1984	II		F
HEA 184	O	R			X	1983-1984	II		F
HEA 185	O	R					PI	A	F
HEA 186	O	R					NI	None Required	F
HEA 210	T	R					PI	A	U
HEA 211	O	R					PI	A	F
FAI 213	T	R					PI	A	U
FAI 214	T	R					PI	A	U

* Reported in the files of the Alaska Office of History and Archeology.
** Sites should be tested on a priority basis within the framework of the overall cultural resource program.

Abbreviations for Table E.4.2

Location:

AR - Access Route
ARB - Access Route Borrow
B - Borrow and Geotechnical Sites
D - Devil Canyon Dam and Impoundment
O - Other Areas
T - Transmission Route
W - Watana Dam and Impoundment

Expected Impact:

DI - Direct Impact
II - Indirect Impact
PI - Potential Impact
NI - No Impact by the project as presently known

Testing Level:

R - Reconnaissance
S - Systematic Testing

Significance:

X - The site has received testing and determined to be significant and is likely to be eligible for inclusion in the National Register.

Recommended Mitigation:

A - Avoidance
I - Investigation
P - Preservation

Land Status:

SS - State Selected
SSS - State Selected Suspended
SP - State Patented
VS - Village Selection
Abbreviations for village selections:
- Ch - Chickaloon
- Kn - Knik
- Ty - Tyonek

F - Federal
PR - Private
U - Unknown

TABLE E.4.3: SUMMARY OF IMPACT BY LOCATION

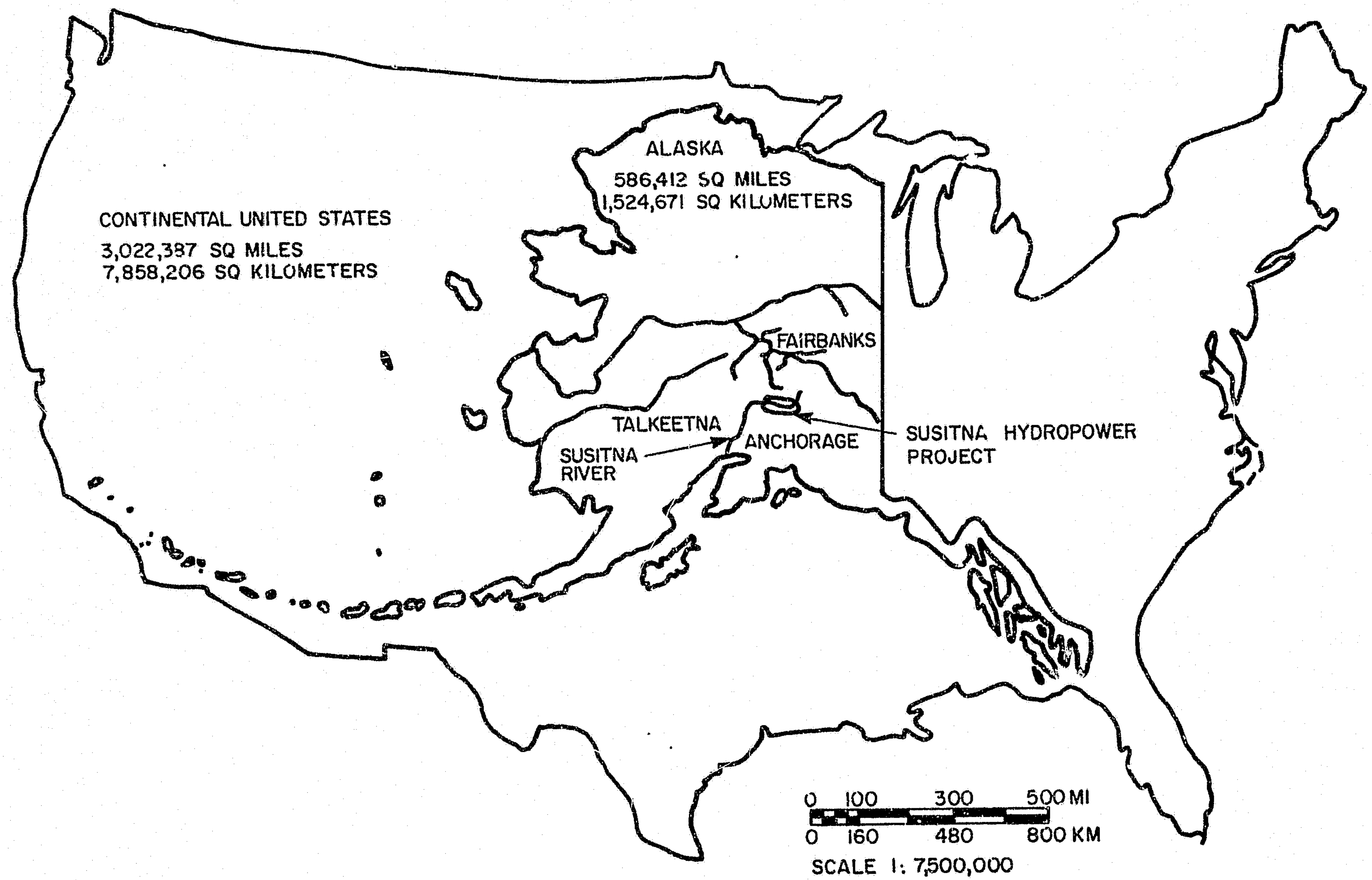
	W	D	B	AR	ARB	T	O	TOTAL
DI	30	7	1	0	0	0	0	38
II	0	0	0	5	0	1	26	32
PI	0	0	2	0	0	12	75	89
NI	0	0	4	0	0	0	4	8
TOTAL	30	7	7	5	0	13	105	167

Abbreviations:

DI - Direct Impact
II - Indirect Impact
PI - Potential Impact
NI - No Impact by the project as presently known

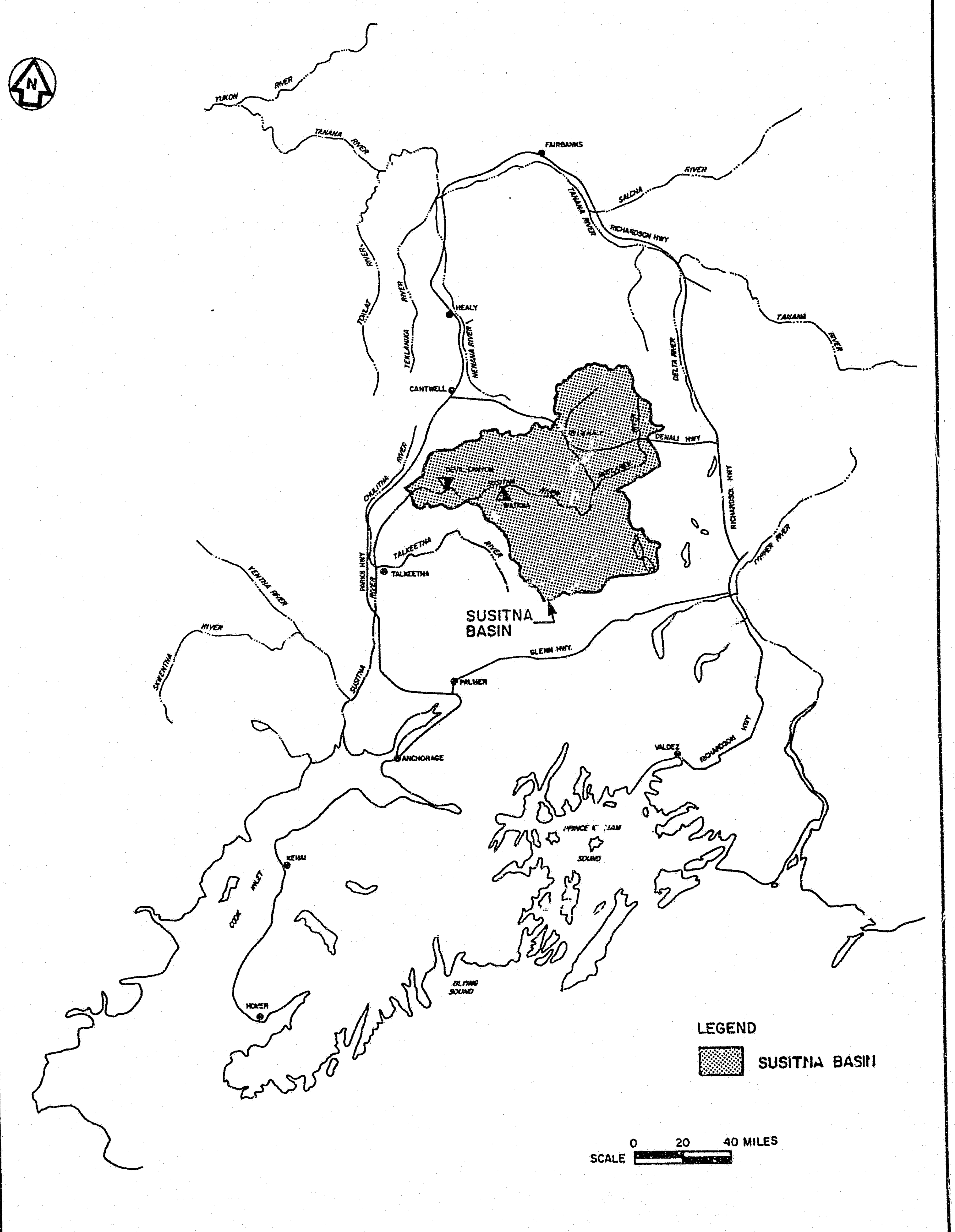
W - Watana Dam and Impoundment
D - Devil Canyon Dam and Impoundment
B - Borrow and Geotechnical Sites
AR - Access Route
ARB - Access Route Borrow (proposed)
T - Transmission Route
O - Other Areas within the study area

* Proposed access road borrow areas in which cultural resources have been identified have subsequently been eliminated as potential borrow sources.



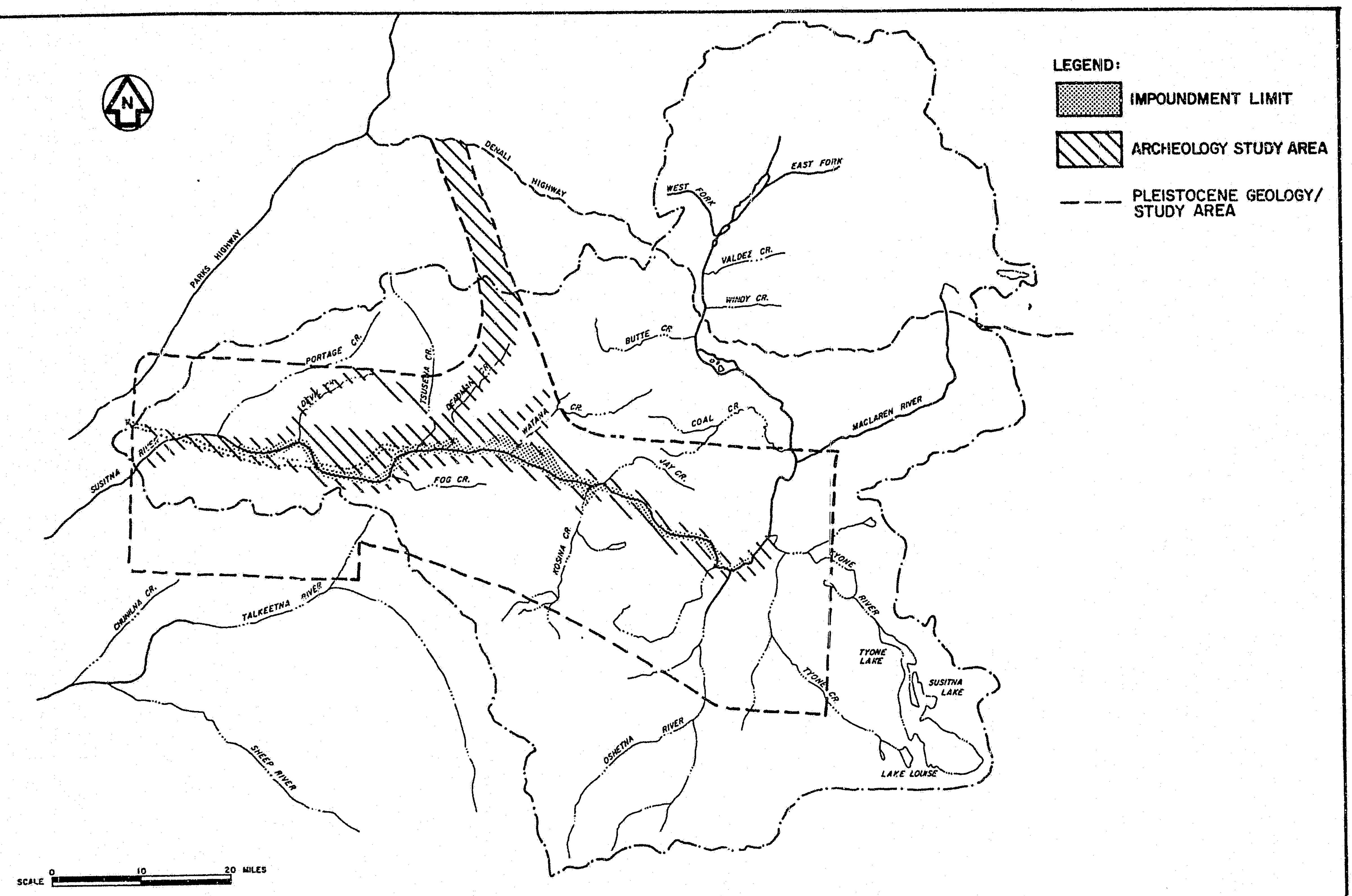
LOCATION OF SUSITNA HYDROELECTRIC PROJECT

FIGURE E.4.1



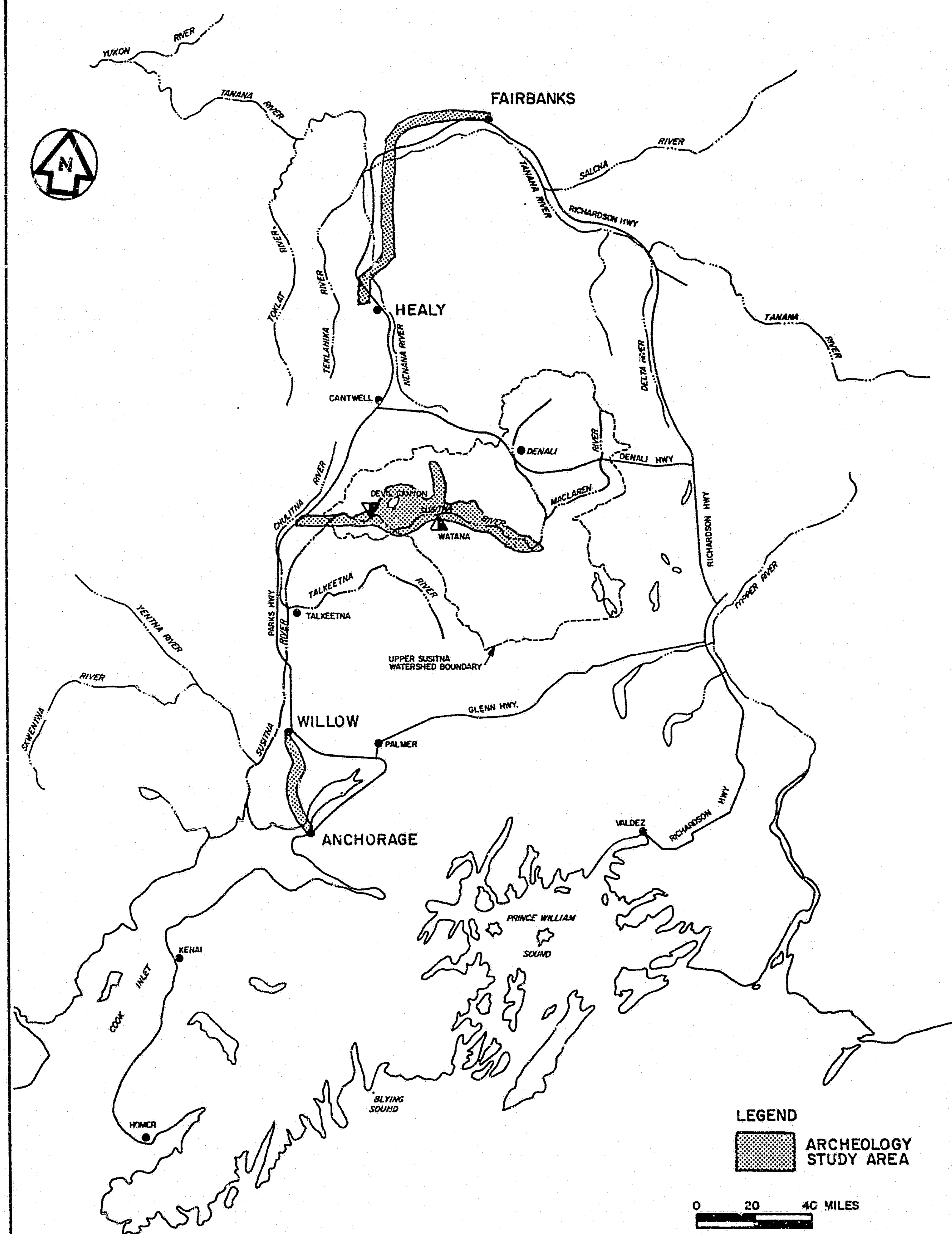
LOCATION OF SUSITNA RIVER BASIN ABOVE GOLD CREEK

FIGURE E.4.2



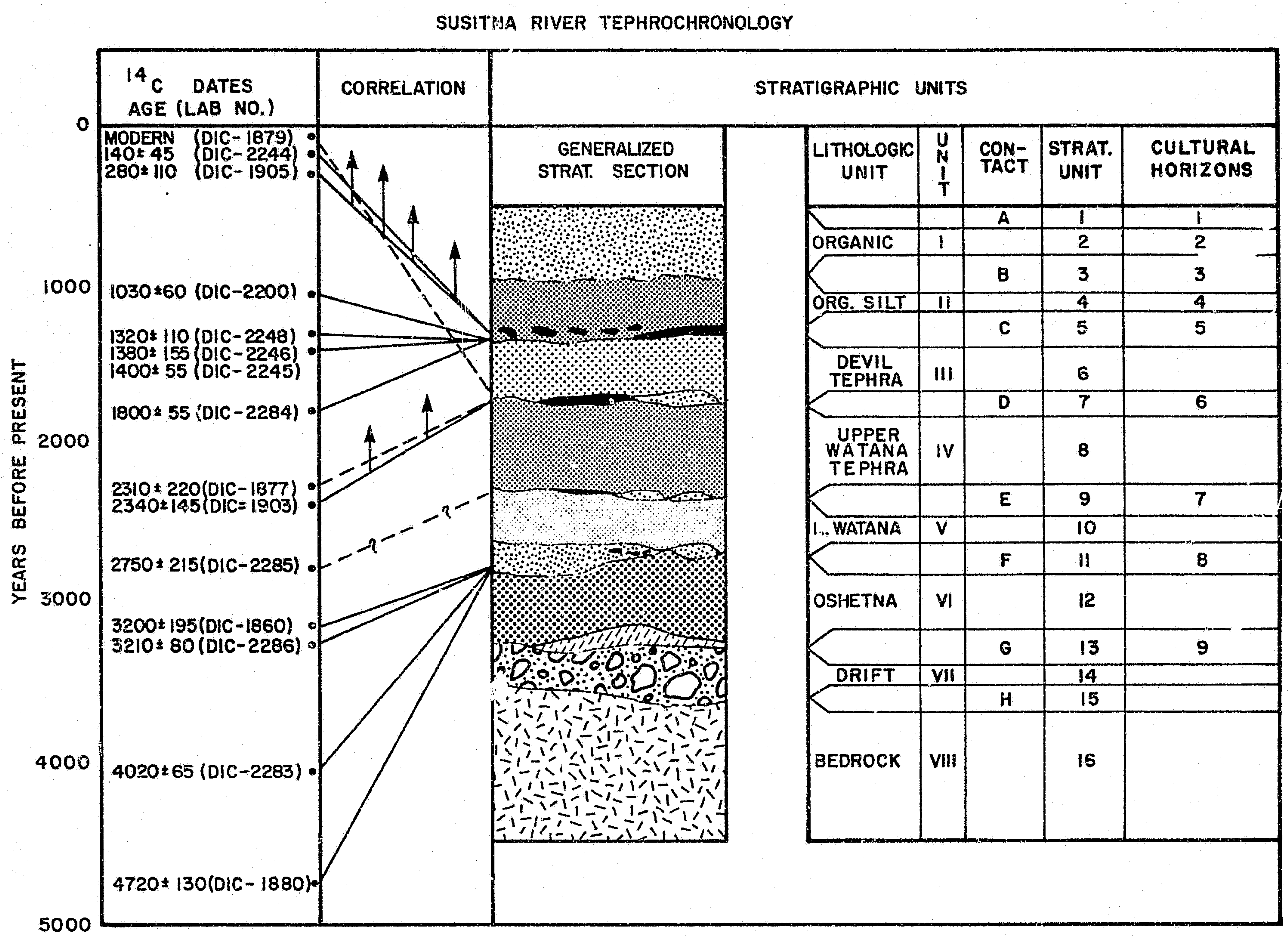
STUDY AREA FOR CULTURAL RESOURCES AND ASSOCIATED ACTIVITIES - SUSITNA RIVER

FIGURE E.4.3



STUDY AREA FOR CULTURAL RESOURCES - TRANSMISSION CORRIDORS

FIGURE E.4.4



SUSITNA RIVER
STRATIGRAPHIC UNITS AND TEPHROCHRONOLOGY

FIGURE E.4.5

APPENDIX E4A

Antiquities Permit Stipulations

8. (CONTINUED) SPECIAL CONDITIONS ARE CHECKED (X) AS APPROPRIATE TO THIS PERMIT

a. [X] This permit shall not be exclusive in character, and there is hereby reserved unto the landowners the right to use, lease or permit the use of said land or any part thereof for any purpose.

b. [X] Other institutions may be engaged in archeological research in the general area covered by this permit, and in case there should be conflict with respect to a site not specifically designated in a permit, the parties concerned shall reach agreement between themselves as to which shall work the site.

c. [X] The Department of the Interior, including its bureaus and employees and the landowners and their grantees, shall be held blameless for any and all events, deeds or mishaps, regardless of whether or not they arise from operations under this permit.

d. [X] Such guidance and protection as is consistent with the duties of the Department of the Interior official in charge of the area will be afforded the permit holder and his party.

e. [X] Transportation in Department of the Interior vehicles cannot be furnished, except in cases where no extra expense to the Department is involved.

f. [X] All costs shall be borne by the permittee.

g. [X] The exploration or excavation of any Indian grave or burial ground on Indian lands and reservations under the jurisdiction of the Department of the Interior is restricted solely to qualified archeologists. No grave or burial ground abandoned less than 200 years may be investigated without permission of the governing council of the Indians concerned, which supplemental authority must be promptly recorded with the superintendent or other official in charge of the designated area.

h. [X] All excavated areas shall be restored by filling in the excavations and otherwise leaving the area in as near to original condition as is practicable.

i. [X] The permittee shall conduct all operations in such a manner as to prevent the erosion of the land, pollution of the water resources, and damage to the watershed, and to do all things necessary to prevent or reduce to the fullest extent the scarring of the lands.

j. [X] Any findings of mined or processed precious metals or other treasure or treasure trove in the area covered by this permit are the exclusive property of the landowners, and shall not be disturbed or removed from the site without specific written permission from the Department of the Interior.

k. [X] Before undertaking any work on lands administered by the Bureau of Land Management, clearance should be obtained from the Office of the State Director at 701 C St. PO Box 13, Anchorage, AK 99513, and from the BLM District Officer in direct charge of the area concerned at all District Offices in Alaska - see attached sheet.

l. [X] Before undertaking any work on lands administered by the Fish and Wildlife Service, clearance should be obtained from the Office of the Regional Director at 1011 E. Tudor Rd., Anchorage, AK 99503, and the Refuge Manager in charge at the appropriate Fish & Wildlife refuge. Possession or use of firearms in such areas is prohibited.

m. [ ] Before undertaking any work on lands administered by the Bureau of Reclamation, clearance should be obtained from the official in charge of the area.

n. [ ] Before undertaking any work on lands administered by the National Park Service, clearance should be obtained from the superintendent in charge of the area.

o. [ ] Before undertaking any work on Indian tribal lands or on individually owned trust or restricted Indian lands, clearance should be obtained from the Bureau of Indian Affairs official having immediate jurisdiction over the property at ______

[X] Other special conditions continued on attached sheet(s).

1. Work under this permit is limited to consultation services (general survey investigations, limited surface collections and testing for site evaluative purposes only) when requested by the Bureau of Land Management (BLM). Extensive testing, emergency excavation, and/or salvage may not be undertaken under this permit except with the written approval of the appropriate BLM District Manager.

2. Academic research projects may not be conducted under the authority of this permit. Such projects will require separate research permits.

3. The permittee shall contact the appropriate BLM District Manager prior to the beginning of each of his field operations to inform the BLM of specific work to be conducted. At this time, the BLM District Manager may impose additional stipulations as deemed necessary to provide for the protection and management of the resources of the area.

4. Collections of cultural artifacts and other related material acquired under the provisions of this permit remain the property of the United States Government and may be recalled at any time for the use of the BLM or other agencies of the Federal Government.

5. The following individuals are authorized to be in direct charge of field work conducted under this permit:

George S. Smith, C. Eugene West, David C. Plaskett, Brian Gannon, Robert C. Betts.

6. The person in direct charge of field work, or a qualified designee, shall be on site at all times when work is in progress. Failure to comply with permit stipulations will result in removal of subject's name from the approved list of persons-in-direct charge.

7. During the course of the work conducted under this permit, the BLM District Manager or his representative shall have access to the study area of this permit, and during or after completion of this work, shall have the right to inspect all artifacts or other material removed from these sites.

8. The following information shall be submitted to the District Manager as a part of the preliminary report or as a part of a separate report within 30 days of the end of each completed project:

a. identification of the specific Federal Antiquities permit under which work was performed;

b. identification of the project and the BLM Serial case file (if any) for which the report is being written;

c. the names of individuals utilized in activities under this permit, the commencement and termination dates of investigations, and the disposition of original notes and records;

d. a description of survey methods and the intensity of the survey;

e. a definition of "site" and "site types" as used in this study;

f. a statement of the work done under the permit;

g. the significance of identified cultural resources and their potential for contributing data concerning archeological problems of the project area, including descriptions and maps exhibiting their relationship to the proposed project. Sites which may merit nomination to the National Register of Historic Places will be so identified;

h. a completed Site Inventory Form for each site found (BLM #8110-1 thru-5 or toehr approved form) with appropriate maps indicating the location of each site;

i. a catalog and evaluation of all objects collected; and

j. a recommended program of study to realistically mitigate direct and indirect adverse effects on cultural resources which will result from the project, including possible research designs. It is recommended in the event that archeological resources are to be affected by the originally planned project that every attempt be made to alter the areas of surface disturbance to avoid these resources. When mitigating actions must include excavation, the request for clearance will report in detail the reasons why avoidance cannot be accomplished.

10. A copy of all published journal articles (reprints) and other published or unpublished reports and manuscripts resulting from the work conducted under this permit shall be filed with the District Manager.

11. Upon request, all field notes, records, photographs, and other data related to this permit shall be made accessible to the BLM and/or the Departmental Consulting Archeologist for review.

12. If any evidence of human remains is encountered during the course of test excavations, all work shall cease and the responsible BLM Officer shall immediately be notified. Work shall not recommence until permission to do so is obtained from the responsible BLM Officer.

13. No lithic replicative experimentation shall be conducted at any archeological site or aboriginal quarry source covered by this permit.

14. Stakes and/or flagging used to identify sites, shall be removed upon completion of the project.

15. Vehicular activity shall be restricted to existing roads and trails unless otherwise authorized by the District Manager. Care should be exercised to avoid directly or indirectly increasing access or potential vandalism to cultural resource sites.

16. Disturbed areas shall be kept to a minimum size consistent with the purpose of the study.

17. Permittee shall take adequate precautions to prevent livestock from injury in any pit or trench.

18. All test pits shall be backfilled.

19. Living trees shall not be cut or otherwise damaged.

20. Camp sites shall be at least 300 yards from water.

21. Proper precaution shall be taken at all times to prevent and suppress fires. The permittee shall be held responsible for suppression costs for any fores on public lands caused through negligence of the permittee or his authorized representatives. No debris burning shall be allowed without specific permission from the District Manager.

22. Improvements ushc as fencing or reservoirs or other improvements within the permit area shall not be disturbed or where disturbance is necessary, prior approval must be obtained from the District Manager. Any improvement disturbance shall be left in the original or better condition as is determined by the District Manager.

23. The permittee shall be responsible for cleaning up all camp and work sites before leaving the area. Caution shall be taken to adequately prevent littering and pollution on the public lands under permit or the adjoining properties. Refuse shall be carried out and deposited un approved disposal areas.

24. The BLM reserves the right to request the Departmental Consulting Archeologist to terminate this permit at any time.

25. The resumes of all crew chiefs must be submitted to the State Office, BLM, and to the office of the Departmental Consulting Archeologist, if any changes in personnel are anticipated.

26. The permittee shall contact the appropriate BLM District Manager prior to beginning each of his filed operations (with follow-up written notification) to inform the BLM of specific work to be conducted. Such notification should take place at the earliest stage of a project requiring a consulting services survey. At the time of notifcation, the permittee shall also bring with him written concurrence from the appropriate Native Corporation, when the project will involve land selected under the ANCSA.

27. All artifactual material collected or excavated under this permit from lands selected under the provision of ANCSA shall remain the property of the United States Government until such times as interim conveyance of the particular parcel of land is completed. Upon conveyance, ownership of artifactual material collected or excavated, from land conveyed under ANCSA, between the time of "withdrawl for selection" and "conveyance" corporation. Ownership of artifactual material can be transferred at an earlier date if proper facilities for housing and storing the collection by the Native group are available. Requests for transfer of ownership of artifacts should be made to the Bureau of Land Management, Alaska State Director.

GLOSSARY

Bifacial knives - a knife flaked on both sides

Bone collagen - fibrous protein in bones which holds cells and tissue together

Burin - a stone artifact defined on the morphological characteristic of a blow(s) struck along one or more edges. Generally believed to be used in working antler, ivory and bone

Burin spalls - thin, curved, and sharp-edged pieces of rock

Calcareous concretionary - material of limestone origin which has grown together

Chert point - a small piece from a compact and siliceous rock; flint is a variety of chert

Chert flake - small piece of compact rock such as flint or silica

Cobble spall - a thin, curved piece of rock 64-256 mm in diameter

Cryoturbation - frost heaving

Cryptocrystalline flake - material so fine-grained that individual components cannot be seen without a magnifying lens

Debitage - waste material from the manufacture of tools

Distal end - the end farthest from the point of attachment

Eskers - stratified accumulations of gravel, sand, and stone, usually occurring in long ridges

Humic zone - the organic layer of soil, composed of material derived from decomposing plants

Kame ridges - a ridge of sand or gravel deposited in contact with glacier ice

Kettle lake - a bowl-shaped lake resulting from the melting of a huge mass of ice

Lanceolate - tapering to a point; shaped like a spear

Lithic - sediments and rocks in which rock fragments are more important proportionally than feldspar grains

Lithologies - the physical characteristics of a rock

Moraine - drift material deposited chiefly by direct glacial action

Rhyolite flakes - small pieces of dense homogeneous rock

Tephras - solid volcanic ash

Tuffacious flake - small pieces from compacted volcanic rock

SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E CHAPTER 5

SOCIO-ECONOMIC IMPACTS

SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E CHAPTER 5

SOCIOECONOMIC IMPACTS

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1 - INTRODUCTION

A systematic approach was used for the socioeconomic impact analysis and assessment. It involved defining impact areas, describing and analyzing baseline socioeconomic conditions, developing and comparing projections of socioeconomic conditions with and without development of the dams, and developing a foundation for an impact management program.

Considerable effort was devoted to identifying and analyzing factors that will significantly influence the magnitude and geographic distribution of project-induced changes. A socioeconomic impact model was developed and computerized to project forecasts and analyze the effects of changing key factors.

Key factors include project schedules; leave, shift and shift rotation schedules; the locally available supply of labor; housing and related facilities at the construction sites; and worker access to the sites. The estimated project-induced changes provided in the following sections are based on one of several possible specifications for these key factors. With this specification, it is projected that socioeconomic impacts will generally be insignificant for the Railbelt Region of Alaska. On the whole, the project-induced changes will probably be viewed as positive by most of the parties-at-interest.

However, there will be project-induced changes in communities located near the construction sites that are not in alignment with these communities' attitudes toward change. For example, the population of Cantwell is projected to double, and possibly more than quadruple, by 1990, the peak year of construction activity, and the population of Trapper Creek is projected to more than double by 1990. The potential changes associated with these rapid population increases are not generally desired in Cantwell nor Trapper Creek.

Some of these project-induced changes could be brought into better alignment (mitigated) by adjusting several of the key factors during project design and labor negotiations phases. In addition, specific mitigation measures could be used to reduce the cost or disruption of project-induced changes to the communities.

An impact management program is recommended as a vehicle to help optimize project-induced changes for small communities located near the construction sites and to minimize adverse impacts on workers. It involves updating and using the results of the impact assessment, in combination with a monitoring program and with the input of parties-at-interest, to develop and implement, and evaluate the results of, an anticipatory mitigation program.

This report on socioeconomic impacts was prepared in accordance with the Federal Energy Regulatory Commission's (FERC) rules and regulations for preparation of Chapter 5 of Exhibit E. At the direction of the Power Authority, supplementary information not required by these rules and regulations was developed. Some of this supplementary information is provided in several sections of this report to provide for a better understanding of the socioeconomic impacts. Additional information is provided in Frank Orth & Associates, Inc. (1982).

2 - BASELINE DESCRIPTION

2.1 - Identification of Socioeconomic Impact Areas

The selection of impact areas was heavily influenced by the following factors: anticipated worker transportation time, mode and route; physical barriers: population concentrations and the indigenous labor force; political jurisdictions; and amenities in communities. The identification and rationale for selection of impact areas are described below.

2.1.1 - Local Impact Area

After considering the above factors, it was tentatively concluded that most of the significant permanent and temporary project-induced population changes and associated impacts would occur in the Matanuska-Susitna (Mat-Su) Borough and nearby communities such as Cantwell. Accordingly, the Mat-Su Borough, including the lands in and around the project site, and nearby communities are designated as the Local Impact Area for the purposes of this analysis.

The Mat-Su Borough is the smallest statistical area for which relevant time-series economic and socioeconomic data are available; and it is large enough for the organization of social life for the pursuit of one or several common interests and for providing the necessary infrastructure. Hence, the most reliable quantitative estimates of impacts are for the borough rather than communities in or near the borough.

Project-induced population changes could be large, relative to future population levels without the project, in several communities in and near the Mat-Su Borough. These significant changes are addressed quantitatively to the extent allowed by available data. A strong effort was made to provide as much geographical detail for impacts as possible because it is the small communities and clusters of population that will be most affected by the project.

2.1.2 - Regional Impact Area

The Regional Impact Area, referred to as the Railbelt, was conceived to include most of the impacts that would spill out of the Local Impact Area. It includes the Anchorage, Kenai-Cook Inlet, Seward, Valdez-Chitina-Whittier, Mat-Su Borough, Southeast Fairbanks, and Fairbanks-North Star Census Divisions (see Figure E.5.1). Project-induced employment changes could be significant in the six Census Divisions that surround the Mat-Su Borough, particularly Anchorage and Fairbanks. Some of the physical inputs and many of the labor inputs will be drawn from the Anchorage and Fairbanks Census Divisions.

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2.2 - Employment, Population, Income, and Other Trends

For analytical purposes, the Regional Impact Area is divided into three subareas: Anchorage, Fairbanks and Valdez. The Anchorage, Kenai-Cook Inlet, Seward and Mat-Su Census Divisions comprise the Anchorage subarea; the Fairbanks North Star and Southeast Fairbanks Census Divisions comprise the Fairbanks subarea; and the Valdez-Chitina-Whittier Census Division comprises the Valdez subarea.

2.1.3 - State

Socioeconomic changes that could occur outside the Regional Impact Area and within the state of Alaska, combined with changes that could occur in the Regional Impact Area, provide an approximation of statewide changes. Because there are likely to be few significant statewide impacts, sections of this report pertaining to statewide impacts are intentionally brief.

2.2 - Description of Employment, Population, Personal Income and Other Trends in the Impact Areas

The information in this section was drawn from an extensive review of relevant reports and conversations with local authorities. Major sources of baseline information are included in the References at the end of this chapter. The literature review, interviews, analysis, and population-related projections were conducted by Frank Orth & Associates, Inc., personnel.

2.2.1 - Local

Recent trends in the population, employment, and per capita income of the Mat-Su Borough are displayed in Figure E.5.2. In general, the Local Impact Area can be described as a rural area with limited public facilities and services and a limited role for local government. The southern part of the area is growing rapidly and becoming more suburban as a result of its proximity to Anchorage. The northern part of the Local Impact Area comprises very small communities which have also been growing in the past few years, but at a more modest pace.

(a) Employment

Virtually all employment in the Mat-Su Borough, as reflected in Table E.5.1, is in the government, services, and support sectors. Total employment by place of employment has risen steadily from 1145 in 1970 to 3078 in 1979, an increase of 169 percent. Employment in the first three quarters of 1980 averaged 3224. The borough has consistently had high unemployment rates (20 percent in 1970 and 13.8 percent in 1979) because employment opportunities have not kept pace with the growth of the labor force. The rate is often the highest in the state; in addition, the borough is more dependent on seasonal employment than are larger population centers, such as Anchorage (Alaska Department of Labor, various issues).

Employment opportunities in the communities closest to the damsites (Talkeetna, Trapper Creek, the railroad communities north of Talkeetna, and Cantwell) are limited. Lack of local jobs force many residents to leave the area for periods of time to work on the North Slope, in Wasilla or Anchorage and Fairbanks. Retail businesses associated with tourists, some government agencies, guiding, and arts/crafts businesses provide the majority of available jobs in these communities.

(b) Population

Population in the Mat-Su Borough has grown rapidly since 1970, largely reflecting construction of the trans-Alaska pipeline and the evolution of borough areas into bedroom communities for the municipality of Anchorage. From 1970 to 1980 the population of the borough grew by 175 percent. Table E.5.2 shows population in the borough by community as well as the population of some communities just outside the borough's borders. Palmer and Wasilla stand out as the largest communities, with 1981 populations of approximately 2567 and 2168, respectively (Matanuska-Susitna Borough Planning Department 1981).

Approximately 90 percent of the borough's estimated 1981 population of 22,339 resides within a 20-mile (32 km) radius of Wasilla. The bulk of the remainder is distributed along the Parks Highway and railroad corridor. Several hundred inhabitants are scattered throughout the borough's wilderness regions accessible primarily by water or air; these inhabitants include a few borough residents of the middle Susitna basin in the vicinity of the impoundments.

U.S. census data indicated the following demographic profile for the Mat-Su Borough:

- 51% Male and 49% Female.
- 97% Caucasian, 2% American Native, 1% Black.

The Mat-Su Borough, like other areas of the state, is expected to experience growth in the mid-1980s. As a result of the tendency of Anchorage employees to move into the Mat-Su area, strong growth is also projected to continue into the 1990s, with the borough population growing at an average annual rate of six percent. In the Base Case (which describes conditions without the Susitna project), population of the borough is expected to reach almost 43,000 in 1990, over 69,000 in the year 2000, and 88,000 by 2005.

The incorporated communities of Palmer, Wasilla, and Houston are expected to grow many times over their present levels to populations by 2005 (without the Susitna project) of 7581, 12,053, and 5909, respectively. Houston, Big Lake, and Wasilla are expected to receive a large increase in population after 1990 as completion of the Knik Arm crossing brings these communities within a half-hour's drive of Anchorage.

Trapper Creek, presently a community of about 225, is projected to double in population size by the year 2000 to approximately 475 people, growing at a four percent average annual rate. In the Base Case, its population is expected to reach 577 by 2005. Growth in Trapper Creek, in absence of the Susitna project, will be constrained by the amount of private land available and, more importantly, by the lack of employment opportunities. The Talkeetna area, currently containing about 640 inhabitants, is expected to grow at an annual rate of 5 percent a year and reach population levels of around 1000 in 1990, 1642 in 2000, and 2106 in 2005.

The U.S. Census Bureau listed the population of Cantwell at 62 in 1970 and 95 in 1980. However, a recent census conducted by a local group of residents in conjunction with the post office listed the population of Cantwell in 1980 and 1982 as 182 and 183, respectively (Community of Cantwell, Inc. 1982). Approximately half of the population consists of native Americans. Residents have indicated that the population of Cantwell grew rapidly after construction of the Parks Highway in the 1970s and has now leveled off. Based upon an assumption of two percent average annual growth, it is expected that Cantwell's population will equal approximately 214 in 1990 and 260 in the year 2000.

(c) Sociocultural Setting

Much of the information in this section was taken from Stephen R. Braund & Associates, Inc. (March 1982).

Talkeetna and Trapper Creek have experienced considerable population influx in recent years, noteworthy in that they are too remote from Anchorage to serve as bedroom communities and offer limited economic opportunities. Most residents in the area share the desire to live in a non-industrial, relatively rural setting.

2.2 - Employment, Population, Income, and Other Trends

Talkeetna, located 114 miles (182 km) north of Anchorage, is the former site of an Indian village. It became a mining community after the discovery of gold in 1886, serving as a basis of operations for prospectors operating in the Yentna Mining District. Some miners spent the winter trapping, which was a significant part of the local economy until the 1940s. Construction of the Alaska railroad spurred growth by increasing access to the area by miners, travelers, and trappers. Upon construction of the Talkeetna airfield and FAA facility in 1940, young families began moving into the area to work for the government.

Talkeetna became the center for mountaineering expeditions to Mt. McKinley in the 1950s. In 1965, construction of the Parks Highway and Talkeetna Spur Road gave Talkeetna road access for the first time. Recreational use of the area increased, as did land sales and home construction for a growing population of young families.

Trapper Creek was settled after 1950, initially by homesteaders. Upon construction of the Parks Highway and the operation of the state's Open-to-Entry (OTE) land disposal program during 1968-1973, a new group of residents moved to the area, some acquiring 5-acre (2 ha) parcels for recreational use, others seeking a year-round life in the wilderness.

In both communities, the newer residents are more negative about future change and development, feeling that it will be in conflict with their rural, relatively self-sufficient life-style. In contrast, the older residents are accustomed to change and do not feel threatened by growth.

There has been some friction between newer and older settlers in the Talkeetna area, with some older residents skeptical of the motivations of newer settlers and claiming that the new, young counterculture type of resident relies on food stamps and other government assistance rather than seeking a true subsistence lifestyle. Over time, however, social relations between the groups have improved.

Cantwell is an unincorporated community in which approximately half of its residents are Native Americans belonging to the Ahtna regional corporation. The non-native portion of the community has increased significantly since the completion of the Parks Highway in the mid-1970s and social conflict has emerged. A report on the sociocultural studies performed for the Alaska Power Authority on communities near the damsites contained the following statement on the capacity of the existing social structure to deal with the stress of growth:

"Changes may also be close to exceeding the carrying capacity of local social systems; sufficient numbers of persons may be residing in the communities (Cantwell and McKinley, a small community near McKinley National Park) or attempting to settle there that the capacity of the existing forms of social organization, amity, and decision-making may be exceeded. Differences among values and requirements of residents may be more extreme than at any previous point in recent history, leading residents to fear for the future of community life, to be pondering the creation of community government, and to be reassessing their own attachment to the immediate area" (Stephen R. Braund & Associates, Inc. March 1982).

A recent example of the division in Cantwell has been the limited involvement of the Native community in the recently formed Community of Cantwell, Inc. (an organization developed to act as a vehicle for the receipt of state grants for the community) and opposition by the Native community to dealings between state agencies and Community of Cantwell, Inc. (CIC). Currently, state dealings with the community are fragmented. In order to ensure representation of the whole community, both the Alaska Power Authority and the Alaska Department of Community and Regional Affairs have separate representatives who deal with either the Native or non-native portions of the population, through the Native village council and CIC, respectively.

(d) Income

Trends in per capita personal income are shown in Table E.5.3. Personal income rose substantially in the Mat-Su Borough in the 1970s and stabilized as the trans-Alaska pipeline was completed. Personal income rose from $3,957 per capita in 1970 to $9,032 per capita in 1977 and declined to $8,878 in 1979. The increase between 1970 and 1979 was therefore 124 percent. However, using the Anchorage Consumer Price Index - Urban as a measure of inflation, personal income in 1979 was 19 percent higher than that of 1970 in real terms. The mean household income for Mat-Su Borough in 1980 was $30,627, despite one of the highest unemployment rates in the state (U.S. Department of Commerce, Bureau of Economic Analysis).

(e) Housing

Table E.5.4 shows 1981 housing stock estimates and vacancy rates for major areas of the Mat-Su Borough. A recent survey by the borough showed total housing stock of 8582 units, of which 79.4 percent (6814 units) were occupied (Matanuska-

Susitna Borough Planning Department 1981). Most of the units were in the Palmer-Wasilla area. An earlier survey showed that single-family houses predominate in the borough, representing 83 percent of the total; mobile homes and multifamily units accounted for 11 percent and five percent, respectively (Policy Analysts May 1980). Population per household for selected communities in the borough averaged 3.07 according to 1980 census data. This is considerably higher than the national and state averages.

Housing vacancy rates fluctuate rapidly, with a five percent rate seen by local authorities to be healthy and growth-promoting. During the summer of 1981, vacancy rates in the incorporated cities ranged from 6.7 percent to 10 percent; more remote communities such as Talkeetna and Trapper Creek experienced very low vacancy rates of between one and two percent (Matanuska-Susitna Borough Planning Department 1981).

In 1981, there were 78,962 acres (31,585 ha) of unimproved subdivided land in the Mat-Su Borough (Matanuska-Susitna Borough Land Management Division December 22, 1982). Based upon a rough average of 1 acre (0.4 ha) per home, this amount of private land will be more than sufficient to provide for the increased number of households, under the Base Case. Currently, zoning efforts are under way in the incorporated communities in the borough. There are no zoning regulations that would affect settlement in the areas around Talkeetna and Trapper Creek. The project sites lie in a large area termed the Talkeetna Mountain Special Use District, which is affected by borough regulations that restrict settlement to recreational use.

In 1982, there were 96 housing units in the Cantwell area, of which 69 were occupied (Community of Cantwell, Inc. 1982). Some of the vacant units in Cantwell do not have dependable sources of water or electricity, and thus could be termed marginal, year-round housing. To an extent, settlement in Cantwell has been limited by the availability of land for development. Non-native private land is scarce in Cantwell and the plots that are available are relatively expensive. Approximately 25 plots of subdivided land are currently available for sale. In addition, Ahtna, Inc., the Native corporation which represents the Indians living in Cantwell, owns almost 54,000 acres (21,600 ha) of land in and around the community. Of this amount, approximately 10,000 (4000 ha) are already patented; the remainder are in interim conveyance (Alaska Department of Community and Regional Affairs October 22, 1982).

(f) Local Government Structure

(i) Matanuska-Susitna Borough

The Matanuska-Susitna Borough was incorporated as a second class borough on January 1, 1964. At the time of incorporation, the borough automatically assumed three areawide powers: taxation; education; and planning, plotting, and zoning. In 1966, the citizens of the borough voted to add parks and recreation to the borough's powers. The borough operates solid waste disposal sites and libraries on a non-areawide basis (outside the incorporated cities). In addition, the borough administers six fire service areas and sixteen road service areas.

The Mat-Su Borough has a Mayor-Manager-Assembly form of government. The borough administration, working under the direction of the manager, currently comprises five departments: finance, public works, assessment, planning, and engineering. The Mat-Su Borough School District administration operates schools throughout the borough and is directly responsible to the Borough Assembly.

(ii) Communities in the Mat-Su Borough

There are three incorporated communities within the Mat-Su Borough: Palmer, Wasilla, and Houston.

Palmer is a first-class, home-rule city, and as such has all legislative powers not prohibited by law or charter. The city of Palmer has a Mayor-Manager-City Council form of government, with a part-time mayor and full-time city manager. The city operates a police station, water and sewer system, library, fire station, and garbage collection service.

The city of Wasilla is a second-class city, and has a part-time mayor and city council with a full-time city clerk. The second-class city of Houston has a part-time Mayor-City Council form of government, with a part-time city clerk.

The Mat-Su Borough also contains several unincorporated communities within its 23,000 square miles (59,800 square kilometers). These include the communities of Talkeetna, Trapper Creek, Big Lake, and Willow. Most of these are located by roads, but the borough also contains bush communities, such as Skwentna and the "railroad communities" north of Talkeetna. Much of the borough is mountainous and very sparsely populated, and thus does not lend itself to the development of community organization.

In 1981, residents of the Talkeetna area voted against incorporation as a first-class, home-rule city. Both Talkeetna and Trapper Creek have informal community councils which have been active in requesting information on the Susitna project and its probable impacts on these communities.

(iii) Cantwell

Cantwell is an unincorporated community in an unorganized borough, located about 10 road miles (16 km) north of the Mat-Su Borough's northern boundary. Recently, residents of the community formed a non-profit corporation called Community of Cantwell, Inc. It was set up as an entity suitable for receipt of state grants for the community.

(iv) Native Corporations

In 1971, the Alaska Native Claims Settlement Act (ANCSA) was passed, creating thirteen Alaska Native regional corporations. The corporations were granted $962.5 million and 44 million acres (18 million ha) of land. Each Alaskan Native is a shareholder of one of these corporations. The regional corporations are conventional private corporations, with the exception of a prohibition on the sale of stock until 1991. The corporations are not political institutions, but as a result of their large landholdings, they are becoming major political forces in Alaska.

In the event that sufficient land is not available within a regional corporation's designated area, the corporation is allowed to select lands in nearby areas within its own region. There have been great difficulties in adequately fulfilling the land entitlements of the Cook Inlet Region, Inc., (CIRI) because of the populated nature of the Cook Inlet region. In 1976, Congress authorized the Cook Inlet land swap, under which CIRI shifted much of its land entitlement (areas of land from which it is entitled to select its land holdings) into other regions, with the consent of the relevant regional corporations.

Part of this land swap included land in the Mat-Su Borough, especially around the middle Susitna River. The shareholders of this corporation do not live in the local impact area.

Cook Inlet Region, Inc., has, since that time, selected much of the land in the middle and upper Susitna Basin, including land in and around the damsites. Another regional corporation, Ahtna, Inc., owns approximately 54,000 acres (21,600 ha) of land around the Cantwell and Denali Highway areas. Approximately 72 members of Ahtna, Inc., live in Cantwell (which in 1971 was identified by the U.S. Department of the Interior as a Native village). Further information on the land holdings and selections on Native corporations is found in Chapter 9 on Land Status.

Both the CIRI and Ahtna regions have separate nonprofit organizations, which manage the social, educational, health and welfare problems of the natives in their regions, called the Cook Inlet Native Association and Copper River Native Association, respectively.

(g) Public Facilities and Services

This section describes existing public services at the community and borough level, to the detail appropriate to the degree of probable impact of the Susitna project. The services addressed include water supply, sewage treatment, solid waste disposal, transportation, police and fire protection, health care services, education, and recreational facilities. Table E.5.5 summarizes the facilities available by community.

Most of the communities in the local impact area have little in the way of public services. Almost all public facilities and services within the Mat-Su Borough will need to be expanded considerably to provide current per capita levels of service to a population that will be growing rapidly over the next twenty years, independent of the Susitna project. In several areas, expansion is already being planned to accommodate this anticipated growth.

(i) Water Supply and Sewage Treatment

The cities of Palmer and Wasilla have water supply and chlorination treatment systems with peak capabilities of 1,368,000 gallons per day (gpd) (5,198,400 liters per day) and 864,000 gpd (3,283,200 liters per day), respectively. Other areas are provided with water on an individual basis by wells or by a community water system that serves a specific subdivision. Most areas of the borough have sufficient water availability. In the Trapper Creek area, potable water is sometimes difficult to locate, because of permafrost conditions and dissolved minerals (Matanuska-Susitna Borough Engineering Department 1983).

Palmer has a city-wide sewage facility in the form of a two-cell lagoon. It currently processes 300,000 gallons per day (1,140,000 liters per day) of sewage with an average 30-day detention time. City officials estimate that the present facilities can handle up to 500,000 gallons per day (1,900,000 liters per day) (Palmer City Manager October 15, 1981). It is estimated that this level will be reached by 1989. At that point, the system's capacity will need to be augmented by adding at least a third cell. In the Base Case, it is expected that growth in Wasilla will result in a requirement for construction of a centralized sewage treatment facility (currently, residents use individual septic tanks).

Residents of other areas rely on septic tanks. Since in most parts of the local impact areas inhabitants live on plots of 1 acre (0.4 ha) or more, it is probable that residents will continue to rely on individual septic tanks. Community sewage systems become feasible only in areas of greater population density. Currently, the waste from septic tanks is trucked to Anchorage for disposal by private companies. Mat-Su Borough voters have authorized construction of a treatment plant in the borough. Some subdivisions and trailer parks are served by small public sewage systems.

(ii) Solid Waste

The Mat-Su Borough has non-areawide solid waste management authority (i.e., outside incorporated communities) and operates nine landfills comprising 217 acres (87 ha). In 1981, landfill capacity equaled about 1600 acre-feet (1,973,600 cubic meters). Each of the incorporated communities contracts with the borough for use of the closest landfills.

The borough intends to close most of these sites by 1987 and set up transfer stations. Final disposal will then take place at an 80-acre (32-ha) central site, near Palmer (Arctic Environmental Engineers 1977).

Residents of the Cantwell area use a landfill site that is not maintained by any public authority and that is on privately owned land.

The city of Palmer operates a collection and disposal system for city residents. In Cantwell and in the rest of the Mat-Su Borough, it is the responsibiliy of individuals to transport their waste to the various landfills.

(iii) Transportation

- Road and Highway

The Alaska Department of Transportation and Public Facilities is responsible for maintenance of the highways that run through the local impact area. The department currently operates year-round maintenance stations at Cantwell, Chulitna, Talkeetna and Willow. Road equipment works to the north and south of each station twenty-four hours a day (Alaska Department of Transportation and Public Facilities September 23, 1982).

The Parks Highway is the principal surface transport route for the local impact area, linking it to both Fairbanks and Anchorage. The Parks Highway was built with a large amount of excess capacity relative to the traffic levels at the time of construction. Present levels constitute approximately ten percent of capacity, and without the Susitna project, the highway should have excess capacity through the year 2000 (Alaska Department of Transportation and Public Facilities, September 22, 1982). Two bottlenecks exist with the north-bound traffic on the Parks Highway at Anchorage and at Wasilla. A five-lane expansion of the Parks Highway in the Wasilla area (currently in the design stage with construction scheduled for 1983) by the Alaska Department of Transportation and Public Facilities is expected to relieve congestion there (Alaska Department of Transportation and Public Facilities September 21, 1982).

During the summer months, the 160-mile (256-km) Class 2 gravel Denali Highway connects the Parks and Richardson Highways. In the winter, snow is not plowed on the Denali Highway, and it is, therefore, closed to traffic. Cantwell is located at the junction of the Denali and Parks highways. Many of the homes in Cantwell are adjacent to the Denali Highway.

Average daily traffic (ADT) data from the State Department of Highways, collected during 1981, report the following average annual daily traffic counts on the Parks Highway connecting Anchorage with the Denali Highway turn-off at Cantwell [Mile 210 (km 336) from Anchorage]: Mile 35.95 (km 57.85) - 1,367 vehicles; Mile 150.58 (km 242.33) - 610 vehicles. On the Denali Highway between Cantwell and Fish Creek [Mile 6.9 (km 11.1) from Cantwell], ADT was reported to be 120 vehicles. Also, on the Denali Highway at Mile 93 (km 149), Maclaren River (the project access road lies in this segment), ADT of 50 vehicles was reported.

The Department of Transportation did not provide information as to the vehicle mix within these counts. However, it can be assumed that the nature of the Parks Highway as the main connecting link between Anchorage and Fairbanks produces a moderate amount of routine truck traffic. The Denali Highway, on the other hand, is traveled primarily by tourists and hunters in passenger vehicles.

Most local roads in the area are not paved. In the Mat-Su Borough, there is currently a high demand for improved maintenance of existing roads and expansion of maintenance to rural roads not currently maintained by the borough. In Cantwell, which is not part of an incorporated borough, local roads are largely unmaintained.

As the Mat-Su Borough population grows (with or without the Susitna project), the skeletal framework of the transport system will need to be filled in and built up to meet the increased demands. Incrementally, as new subdivisions are created, additional roads will be required. In addition, upgrading of some roads will be necessary and collector roads will be required to allow traffic to go to and from communities without entering Wasilla (Matanuska-Susitna Borough Service Area Coodinator December 1981).

- Rail

The Alaska Railroad runs 470 miles (756 km) from Seward and Anchorage to Fairbanks. It is federally owned and operated, but transfer of the railroad to state ownership is now being discussed. Many major communities in the impact area are connected by the Alaska Railroad, which also provides access to a number of small communities which have no road access. Annual freight traffic volume varies between 1.8 and 2.3 million tons (1.6 and 2.1 million tonnes), and it is estimated that the system is working at only 20 percent capacity (Alaska Railroad January 1981). Daily Anchorage-Fairbanks and Anchorage-Whittier passenger service is provided during the summer months, with service being reduced to twice weekly during the winter. The passenger train will stop at any location for embarking or disembarking passengers.

- Air

As shown in Table E.5.5, many communities have active airstrips designed for light propeller aircraft. Floatplanes are also common in areas with lakes. Most public airports in the Mat-Su Borough and Cantwell are expected to be sufficient in their present or planned capacity to accommodate the additional needs of a growing population. There is, however, need for a new air facility to serve Wasilla. The existing facility is not easily expanded because of the terrain and lack of available land.

(iv) Police

Police protection in the Mat-Su Borough and Cantwell is provided by the Alaska State Troopers. There are 17 troopers stationed in Palmer, 3 in Trapper Creek, 1 in Cantwell, and 2 in Paxson. In addition, 5 other troopers are responsible for fish and wildlife protection and enforcement. The city of Palmer has police powers and maintains a force of eight officers and several civilian support personnel. There are 3 detention and correctional facilities in the Mat-Su

Borough, and another prison is currently planned. Borough correctional facilities serve the whole Anchorage region.

(v) Fire

There are nine operating fire service areas in the Mat-Su Borough. Costs of fire protection are funded by special millage rates on assessed valuations within the service areas. With the goal of achieving a rating of 8 from the Insurance Service Organization (ISO), the maximum rating for areas without community water systems, the borough's fire chiefs in 1981 prepared a fire protection plan which proposes 12 additional stations and the purchase of new equipment for existing stations. All of the fire service areas within the borough rely on volunteer staffing.

Residents of the Mat-Su Borough not within the boundaries of a fire service area rely on their own resources and neighbor's volunteer assistance for fire protection.

Cantwell has recently formed a fire service area and is in the process of procuring equipment and constructing a fire hall. This station will rely on volunteer firefighters. Financial arrangements pertaining to the fire service area are discussed in Section 2.2.1 (h), Fiscal Conditions of Local Governments.

(vi) Health Care

The 23-bed Valley Hospital, built in Palmer in 1954, provides acute and long-term care to residents of the Mat-Su Borough with a staff of 8 doctors. There is a satellite facility in Wasilla. An expansion of the hospital is currently underway; it will add 7 beds and additional space for equipment to the Valley facility and will enable the hospital to serve a borough population of up to 30,000. Another addition of 30 beds could be built at a later date (Valley Hospital October 14, 1982). The majority of the funds for this project were obtained directly or indirectly from the state.

Standards for acute public health care focus on the capability of hospital facilities and staff to accommodate the expected number of patients without building over-capacity that will then add to hospital costs. While rule-of-thumb bed multipliers of between 2.1 and 5.8 beds per 1000 population are often used in the literature, it has become appropriate to base the number of beds on a measure of the long-term average daily census of patients using the hospital divided by the desirable occupancy rate. In Alaska, the recommended occupancy rates are 80 percent for urban hospitals and 55 percent for rural hospitals. The formulas used to project the requirements for hospital beds are displayed in Appendix 5.B.

Ambulance service in the borough is provided through the Palmer Fire Center on a 24-hour basis. Each fire hall in the Mat-Su Borough, including the ones at Trapper Creek and Talkeetna, has an ambulance for emergency service and individuals who have received Emergency Medical Training (EMT).

Public health centers are located in Palmer and Wasilla. There are also facilities in Wasilla which provide individual and group therapy, family and marital counseling, and alcohol and drug consultation. The Palmer Pioneer Home provides long-term nursing and non-nursing care for the elderly.

Cantwell has no medical care in the community, with the exception of an ambulance and several EMTs. The closest medical expertise is a doctor's assistant in Healy; most residents go to Anchorage or Fairbanks for medical care. There is a local chapter of Alcoholics Anonymous in Cantwell, as well.

(vii) Education

The Mat-Su Borough operates 17 schools: 12 elementary schools, 2 junior high schools and 3 high schools. At the beginning of the 1981-1982 school year, enrollment totalled 4515 students. Plans call for expansion of existing facilities and construction of 3 new schools: an elementary school serving 400 pupils in Wasilla; a permanent elementary school in Trapper Creek for up to 150 students; and a secondary school initially accommodating 300 in the Houston area.

The communities of Trapper Creek and Talkeetna each have elementary schools. Junior and senior high school students from both communities attend Susitna Valley High School. The capacities and 1981 enrollments of these schools are displayed in Table E.5.6.

The school at Cantwell is part of the Railbelt School District. It provides education for students in kindergarten through 12th grade. Current enrollment is 33 students. The school has capacity for about 60 students.

(viii) Recreational Facilities

Opportunities for outdoor recreation abound in the Matanuska-Susitna Borough and in the Cantwell area. The largest attraction in the region is Mount McKinley National Park and the surrounding Denali National Park and Preserve. Entrance to the park is off the Parks Highway, 26 miles (42 km) north of Cantwell.

Denali State Park, located within the Mat-Su Borough, will eventually offer a variety of summer and winter recreational activities. Nancy Lake Recreation area south of Willow, the Lake Louise area in the southeastern part of the borough, and the Big Lake area between Willow and Wasilla are other popular recreational sites.

There are relatively few local public recreational facilities in the borough, but plans call for future development of playgrounds and neighborhood parks in conjunction with school complexes (Matanuska-Susitna Borough School District October 1981).

(h) Fiscal Conditions of Local Governments

Information on current levels of revenues and expenditures was derived from examination of the budgets of the Mat-Su Borough and the incorporated communities and conversations with key public officials.

(i) Mat-Su Borough

- Revenues

There are generally four major fund categories in the budget:

- The General Fund

  The general fund constitititutes about 36 percent of total revenues and has several fund sources. Property taxes contribute approximately 37 percent of general fund revenues and are raised by a mill rate of 6.7 per 1000 assessed valuation. Another 20 percent of the borough general fund revenues is contributed by municipal assistance funds from the state. Other major sources of general fund revenues are state-shared and federally shared revenues.

- Service Areas Fund

  According to the 1981-82 annual budget there are 6 fire service areas, 16 road service areas, and 2 special service areas. The borough has the power to levy taxes in these areas to raise revenues to provide the services. About 30 percent of the service areas fund comes from property taxes. The balance, or 70 percent, is provided by state-shared funds and municipal assistance revenues. The service areas fund accounts for only 3 percent of total borough revenues.

- Land Management Fund

  Like the service areas fund, the land management fund contributes only three percent to the borough budget. The sources of these funds include state grants, recording and land management fees, and others.

- Education Operating Fund

  This fund constitutes well over half the borough budget. It is estimated that as much as 58 percent of the total budget is made up of the education fund. The state is the major contributor primarily through the Foundation Program. In 1981/1982, the Foundation Program was estimated to provide $14.37 million to the school district.

\- Expenditures

Expenditures for 1981 were estimated at $16.7 million in the general fund area, $4.4 million for the service areas fund, and $1.1 million for land management. The biggest expenditure item for the borough is the school district fund. In turn, the largest expenditure items for the school district are regular instruction, which accounts for 33 percent, support services (18 percent), and operations and maintenance (19 percent). The balance of expenditures is divided among vocational education, special education, and miscellaneous services.

The 1981 budget figures for the borough show unequal revenues and expenditures. Deficits have not been a problem, especially in the recent past (Matanuska-Susitna Borough Finance Director December 1982). Apparently, state grants have been responsible for bridging the gap. Whether or not deficits become a problem in the future may depend on whether the state continues to provide this cushion when the want or need arises.

(ii) Talkeetna

Talkeetna is currently unincorporated and has no powers to levy taxes. Talkeetna receives services from the borough based on three service areas. These include a fire service area, Talkeetna flood control area, and the greater Talkeetna road service area. Total revenues in 1981 for the three service areas were, respectively, $26,142, $1,106 and $45,820. The major sources were local taxes, except in the case of road service where the entire $45,820 came from state general revenues. Expenditures were $20,176 for fire service, $576 for flood control, and $45,820 for road service.

(iii) Trapper Creek

Trapper Creek, as an unincorporated community, has no direct fiscal responsibilities and depends entirely on the borough for services.

(iv) Cantwell

Cantwell is an unincorporated community in an unorganized borough and as such has no local government.

The community, through the Community of Cantwell, Inc., applied for three grants for 1982: a one-time per capita grant of $89,000; a grant for establishment of a fire hall for $87,000 from the Department of Community and Regional Affairs; and a Public Safe Water grant from the Department of Environmental Conservation (Community of Cantwell, Inc. September 1982). The only revenue upon which the community can depend on an annual basis is state-shared revenue; this usually amounts to between $25,000 to $32,000 per community (Alaska Department of Community and Regional Affairs November 1, 1982). It is expected that about $3000 to $5000 will be needed on an annual basis for operations and maintenance of the fire hall, and the community is planning a variety of fund-raising measures to raise that revenue.

In addition, there is a native village council in Cantwell which has, in the past, also served as a vehicle for accepting per capita and other state grants for the community. Two such grants were channeled through the council: one to install a powerline from a local generator to households in the community, and the other for materials used to construct the community hall.

Residents of Cantwell belong to the Railbelt School District, which is a Rural Education Attendance Area that has no taxing authority and is responsible directly to the state legislature. The school district budget for the 1982-83 school year was estimated at $3,786,770, of which approximately 7 percent is earmarked for operating expenses of the school at Cantwell. Approximately 87 percent of the school district's revenue comes from the state government; 4 percent from local sources; and 8 percent from the federal government (Railbelt School District Superintendent September 30, 1982).

(i) Electric Power

The Matanuska-Susitna Borough is serviced by power from the Matanuska Electric Association (MEA), a cooperative located in Palmer. In 1980, the MEA served 12,969 customers in 3,360 square miles (8740 square kilometers) of south-central Alaska. Wholesale power is purchased primarily from Chugach Electric Association's (CEA) natural gas-fired turbines at Beluga and Bernice Lake, as well as from the Alaska Power Administration's Eklutna hydroplant and a small hydroelectric operation at Cooper Lake located on the Kenai Peninsula. The MEA sold about 250 million kilowatt hours (250 Gwhr) of electricity in 1981. The MEA currently has an "all requirements" contract with the CEA. Under this agreement, CEA will sell all the power MEA needs, to the extent it can.

The community of Cantwell currently does not have access to electric power. Residents rely on individual generators. The community has been seeking a commercial source of power for several years.

2.2.2 - Regional

Recent trends in the population, employment, and per capita income of the regional impact area are displayed graphically in Figure E.5.3.

(a) Employment

Table E.5.7 presents data on nonagricultural employment for the Railbelt. Employment increased by 39 percent between 1970 and 1975, and by an additional 14 percent between 1975 and 1979. Construction, service and support sectors represent large percentages of employment in the region. Employment in the Anchorage Region accounted for 69 percent of Railbelt employment in 1979.

For 1970, 1975, and 1979, labor force and unemployment were as listed below.

	1970	1975	1979
Railbelt			
Labor Force	79,347	110,283	126,110
Unemployment	9.9%	6.1%	9.0%
Anchorage			
Labor Force	51,398	65,938	78,822
Unemployment	8.3%	5.9%	7.1%
Fairbanks and Southeast Fairbanks			
Labor Force	18,003	27,030	22,589
Unemployment	10.4%	4.7%	12.2%

(b) Population

Population in the regional impact area rose from 204,523 in 1970 to 284,166 in 1980. The Railbelt contains over 70 percent of the state's population, the majority centered in the greater Anchorage area. Within the greater Anchorage area, there has been a gradual shift in the relative shares of population that live within the municipality and in nearby areas. The Kenai and Mat-Su Borough census divisions have grown more rapidly than the city itself, and now account for 10.3 and 8.2 percent of the Anchorage region, respectively.

Population in the Railbelt is expected to rise from 284,166 in 1980 to 483,686 in 2000. The population growth rate is projected to be greater during the 1980s than the 1990s. This growth is expected to result from natural resource development projects in various parts of the state.

The population in the Fairbanks region is projected to be about 77,600 in 1988. Population growth after 1988 will average about 1.5 percent.

The Anchorage region will experience a pattern similar to the Railbelt as a whole--relatively rapid growth during the mid 1980s and then an average annual growth rate of about 2 percent during the 1990s. The Anchorage region population of 375,000 in the year 2000 will account for 75 percent of the Railbelt's population.

(c) Income

In the Railbelt, personal income on a per capita basis rose from $4,940 in 1970 to $11,243 in 1976 and has remained close to that level since. In 1978, average per capita income in the region equaled $11,522. In real terms, per capita income rose by 36 percent between 1970 and 1978.

(d) Housing

The Railbelt contained approximately 98,350 households and 119,555 housing units in 1981. Anchorage and Fairbanks represented the largest concentrations of housing in the region.

As shown in Table E.5.8, the municipality of Anchorage contained 65,771 civilian housing units, of which 46 percent were single-family units, 12 percent mobile homes, and 42 percent were in multifamily buildings. Between 1975 and 1981, the civilian housing stock in the city increased by 35 percent. Most of this growth occurred during the construction boom associated with the TAPS pipeline. The vacancy rate in Anchorage has in recent years fluctuated from a low of one percent in 1975 to a high of about 11 percent in

1980. In July of 1982, a survey done for the municipality indicated a census-defined vacancy rate of 5.8 percent.

In the municipality of Fairbanks, housing stock in 1978 stood at 7,351 (see Table E.5.9). Multifamily units accounted for 43 percent of the total. Vacancy rates have risen in the post-pipeline period, but not as dramatically as in Anchorage. The overall vacancy rate rose from a low of 0.4 percent in 1976 to 9.1 percent in 1980.

2.2.3 - State

Recent trends in the population, employment, and per capita income of the state are displayed graphically in Figure E.5.4.

(a) Employment

Alaska's economy has historically been dependent upon development of its natural resources, primarily fisheries, minerals and timber. As a result, employment has been oriented towards these consumptive and extractive industries. The military has played a major role since World War II. In recent years, employment in state and local government has increased dramatically. In addition, employment in service and support sectors of the Alaska economy is increasing, reflecting the maturation of the state's economy.

Impact of the trans-Alaska pipeline is evident in the employment figures shown in Table E.5.10. Between 1970 and 1975, a pipeline-induced growth spurt caused employment to increase by 75 percent. From 1975 to 1980, however, total employment increased by only 2.9 percent. In 1981, Alaskan employment equaled 194,000; the annual average unemployment rate in that year was 9.2 percent.

(b) Population

The population of Alaska has risen steadily since the 1940s; yet this largest state of the United States is still the least populous with an estimated 1980 population of 400,031. Alaska's population grew by 32 percent between 1970 and 1980, jumping by 50,000 between 1975 and 1976 alone. Most of the population is in the South-central - Fairbanks region (the Railbelt), and half of the states' citizens reside in Anchorage.

(c) Income

The average per capita personal income in the state rose from $4,638 in 1970 to $10,254 in 1976. Since completion of the pipeline, however, the pace of increase has slowed. Per capita income in Alaska averaged $11,150 in 1979. The real increase in per capita personal income during the nine-year period was 27 percent.

3 - EVALUATION OF THE IMPACT OF THE PROJECT

Tables E.5.11 through E.5.18 present an overview of impacts of the project on the Mat-Su Borough as a whole, on particular communities in the local impact area, and on the region. Emphasis is placed on 1990 and 1999, the two peak years of construction. As these tables show, it is anticipated that the impacts of the project on socioeconomic conditions will be greatest in the communities of Trapper Creek, Talkeetna, and Cantwell, because of their proximity to the site and their relatively small size.

Impacts of the project were evaluated by comparing the projected conditions without the project to expected project-induced changes. The future without the Susitna hydro development was projected in order to perform two objectives: to put the changes expected to result from the project into perspective, and to estimate when threshold levels of public facilities and services (i.e., levels of population at which additional facilities are required) would be reached as a result of the cumulative impacts of other projects plus the Susitna project.

3.1 - Impact of In-migration of People on Governmental Facilities and Services

3.1.1 - Introduction

In the sections below, the expected impacts of the project on key public facilities and services in the local impact area are discussed. Information is given on the impacts of both the population influx associated with the direct construction work force and the in-migrating population associated with support workers (i.e., workers employed by private suppliers of equipment or materials for the project and workers employed by service industries whose increase in business is related to increased demands for goods and services by construction workers). The population influx includes workers and their dependents on all portions of the project (including workers on the access road, rail sidings, damsites, transmission lines, etc.).

In general, the impacts of the project on local facilities and services will be mitigated by the provision of worker housing and extensive facilities and services at the work sites. Thus, the impacts on the nearby communities will be limited in the main to the effects related to the direct and support workers who choose to relocate their permanent residence and families to these communities. In addition, there will be a limited economic contraction on most parts of the local impact area as construction of each phase of the project terminates because of the buffering effect of the expected continued increase of the population that will occur as a result of other projects and continued suburbanization of the Mat-Su Borough.

3.1 - Impact of In-migration

3.1.2 - Methodology

The projections of population influx associated with the project rely greatly on several important assumptions regarding work force characteristics, distribution of workers' settlement, and policy decisions related to the project. Population influx estimates were calculated by using the following assumptions:

(a) Base Case Population Projections

Population projections for the different impact areas were conducted using percentage growth measures that were developed by examining growth trends over the past 15 years and modifying them to reflect the probability of growth in the future. These projections relied to a large extent on projections of growth in the Railbelt region and in the state by the Institute for Social and Economic Research at the University of Alaska (Goldsmith and Hyskey May 1980).

(b) Population Influx Associated with the Direct Work Force

It was assumed that 90 percent of the direct workers who in-migrate into the region will be accompanied by dependents. Since housing will be provided onsite, there will be little incentive for most single workers who come from outside the Railbelt region to establish residence in a nearby community. On the other hand, in-migrating direct workers with families who cannot obtain family housing onsite will be more likely to desire housing for their dependents in the region. It should also be noted that a large percentage of the work force for this project will be skilled tradesmen, and such workers are more likely to have families than unskilled construction laborers.

An assumption of 2.11 dependents per accompanied construction worker was used to calculate the population influx associated with the direct work force. This figure is an average derived from a survey of construction projects throughout the United States that was performed for the U.S. Corps of Engineers (U.S. Army Corps of Engineers June 1981). The resultant population-per-household figures differ from the household size projected for the state of Alaska; the specific construction worker measure was used, since construction workers have been observed to have characteristics slightly different from the population as a whole. No specific data on characteristics of construction workers in Alaska are available at this time.

Further explanation of the methodology used to determine the number and distribution of in-migrating direct workers can be found in Section 3.3 and Appendix 5.A.

(c) Population Influx Associated with the Support Work Force

In order to calculate the population influx associated with the support work force, the population-per-household measures that were projected for the state under the Base Case (declining at a constant rate from 2.829 in 1988 to 2.657 in the year 2000) were multiplied by the estimated number of in-migrating support workers. It was assumed that these workers would have the same general demographic characteristics as present residents.

The population-per-household measures were derived from a study done by the Institute of Social and Economic Research (ISER) to project electricity demand in the Railbelt. In the ISER model, the average number of people per household is estimated to decline by 20 percent over the next 20 years and is consistent with the projected decline in the national level of number of persons per household (Goldsmith and Hyskey May 1980).

Further explanation of the methodology used to determine the number and distribution of in-migrating support workers can be found in Section 3.3.

(d) Public Facilities and Services

Public facility and service impacts have been estimated using the following approach: (1) Appropriate per capita standards were developed, based upon an extensive literature review and the input of local officials; (2) the adequacy of existing facilities and services were assessed; and (3) estimates of future needs related to natural growth and to project-induced population influx have been compared with present and planned capacity. Details of the methodology used can be found in Appendix 5.B. Important items of methodological literature reviewed in the course of this work include Anderson and Chalmers (1977), Burchell and Listokin (1978), Leistritz and Murdock (1981), and Stenehjem and Metzger (1980).

3.1.3 - Watana Construction Phase

(a) Local

(i) Mat-Su Borough

In most areas of the Mat-Su Borough, the population influx related to the project will only add slightly to the substantial increases in need for public facilities and services that will result from the population growth projected under the Base Case. In contrast, the large proportional increase of population into the borough communities of Trapper Creek and Talkeetna will have larger impacts on the needs for public facilities and services. These impacts are discussed in detail in the sections that follow.

- Magnitude of Population Influx

Population influx into the Mat-Su Borough is shown in Table E.5.19. As a result of construction of the project, the population of the Mat-Su Borough is expected to increase by a cumulative total of up to 5356 in 1990, including new onsite and offsite residents. It is forecast that about 1390 people will resettle in communities in the borough (offsite) by 1990. Of this offsite in-migrant population, approximately 1025 people (74 percent) will be direct workers and their families, and about 365 (26 percent) will be support workers and their dependents. The new offsite population would represent an increase of 3.2 percent over base case projection of population in 1990, and would result in a total borough population of 44,353 in that year (excluding the work camp/work village). Over 90 percent of the project-induced population influx will occur between 1986 and 1990, and over 40 percent in 1987 alone.

The Susitna project will be only one of several factors contributing to the borough's projected rapid rate of growth during the 1985-1990 period. With construction of the project, population in the borough will increase by about 15,721 between 1985 and 1990, of which approximately 11,760 will be related to baseline growth and 5356 will be project-related. Spillover growth from Anchorage is expected to be one of the most important factors behind this growth.

3.1 - Impact of In-migration

The population influx into the incorporated communities is expected to be small; between 1985 and 1990, the project will result in an increase of approximately 50 people in Palmer, 45 in Houston, and about 60 in Wasilla. Over 50 percent of the in-migrant population in the borough is expected to settle in the Trapper Creek-Talkeetna area, and the remainder will probaly establish homes in the area around Willow and Montana creeks and the suburban area surrounding Palmer and Wasilla.

Between 1990 and 1993, the population in the borough related to the project will decline along with the decline in work force at the Watana site. Overall, however, the population of the borough is expected to continue to increase during this period.

- Water Supply and Sewage Treatment

The water supply and sewage treatment needs of the project and of the work force and families living at the Watana site will be provided for by the project contractors. There will be no impact on public facilities in Mat-Su Borough.

The population influx associated with in-migrant workers who establish residences in the borough will have only a slight impact on the public water and sewage systems. In Palmer, water consumption at the peak of construction at the Watana site (1990) would rise by 1.2 percent over the base case projection of 608,000 gallons per day (2,310,400 liters per day). Water usage requirements were projected using an average daily water consumption of 120 gallons per day per (456 liters per day) capita in 1981, rising to 150 gallons per day (570 liters per day) in 2000.

Population influx into Palmer will result in an average increase in sewage treatment requirements of 6000 gallons per day (22,800 liters per day), which is 1.1 percent above the 1990 baseline projection level. The population influx during 1985-1990 will occur at a time when existing facilities are already reaching their limits, and a third sewage treatment cell will be required (with or without the project). These projections were based upon a standard of 120 gallons per day (456 liters per day) per capita.

3.1 - Impact of In-migration

- Solid Waste.

The solid waste requirements of personnel and dependents living at the construction work sites will be taken care of at the camp and village, and will have no significant impacts on public facilities in the Mat-Su Borough.

It is estimated that the population influx into the borough communities associated with the project will increase the annual landfill needs of the borough by a cumulative amount of 1.27 acres (0.51 ha) between 1985 and 1993. This represents a two percent increase over the baseline projection for that period. This population increase may contribute to a slight advance in requirements for additional landfill acreage, which is expected to be needed under base case conditions around 1994-1995.

- Law Enforcement

The State Trooper force in Trapper Creek will need to be enlarged by one trooper as result of the project to reflect the growing population in the northern part of the borough (around Trapper Creek and Talkeetna). Police protection provided by the project and by the Cantwell State Trooper station can be expected to handle the population at the project site (although the onsite population will be located in the Mat-Su Borough, the Cantwell station will be the closest station by road).

An average rural standard of one officer per thousand population was used to project law enforcement requirements in the northern part of the borough; for the base case police requirements shown in Table E.5.11, a standard of 1.5 policemen per thousand population was used in the southern part of the borough and 1.0 policeman per thousand in the rural northern part.

- Fire Protection

The project facilities and work camp/family village will be protected by firefighting equipment and personnel at the work sites; there will be little impact on existing service areas.

Fire protection planning in rural areas such as the Mat-Su Borough is more dependent on the distance of facilities from population centers than on the size of population. Since in-migrants are expected to settle into existing housing or housing on land that is already subdivided, there will be little impact on fire protection facilities in most communities. Firefighters will continue to be, for the most part, volunteers.

- Health Care

The work camp/family village at the construction site will provide facilities for health care, including a 20-bed hospital. It is expected that there will be little impact by the construction-site population on the Mat-Su Borough's health facilities, with the exception of cases of major illness or accidents which cannot adequately be handled by the site hospital.

The population influx into Mat-Su Borough communities associated with the project is expected to raise the number of hospital beds needed in 1990 by about one. Under the base case, a new hospital is projected to be needed by 1990. The population influx associated with the project may accelerate this development by a year. Appendix 5.B contains an explanation of the formula used to project hospital requirements in rural areas of Alaska.

There has been some social impact research conducted which suggests that rapid growth in a community and the stress associated with rapid change can result in increases in the incidence of many "people problems" such as divorce, alcoholism, child abuse, and suicide. In most parts of the borough, growth related to the Susitna project will only represent a fraction of the growth and change that are expected to take place. Thus, impacts of the project on social services in the southern part of the borough are expected to be minimal. In the areas surrounding Trapper Creek and Talkeetna, the need for social services may become more pronounced.

- Education

School-age children at the construction site will be educated at facilities that will be built as part of the project facilities but will probably be operated as part of the Mat-Su Borough school district. It is estimated that by 1990 there will be approximately 300 schoolchildren living at the family village. Based upon Mat-Su Borough School District planning standards described in Appendix 5.B, there would be a need for approximately 13-14 teachers.

There will be an approximate increase of 200 primary school children and 160 secondary school children accompanying in-migrants into communities in the Mat-Su Borough between 1985 and 1990. It is estimated that there will be a need for 8 additional primary school classrooms and teachers and 8 secondary classrooms and teachers, in addition to the 216 primary school and 230 secondary school classrooms which will be needed to accommodate growth between 1981 and 1990, under the base case.

The number of school-age children associated with direct construction workers was projected using an average 0.86 schoolchild per accompanied in-migrant worker. Projections of base case enrollment and enrollment associated with the in-migrant support work force used an estimated ratio of school-age children to population of 22.8 percent through 1987, rising to 25 percent of population in 2000. These ratios are based upon the Mat-Su Borough's planning standards.

- Public Recreation Facilities

Chapter 7, Recreational Resources, provides a description of the recreation plan that will be part of the project design. This plan includes provision of recreational facilities at the work camps and family village as well as the development of new recreational opportunities for the public. The intent of the recreation plan is to satisfy recreational demand created by hydroelectric development and to offer compensation for recreational opportunities lost as a result of the development. Chapter 7 also describes the impacts of the project (both positive and negative) on existing recreational resources in the Upper Susitna Basin.

3.1 - Impact of In-migration

The project-induced population influx into borough communities will represent 3.2 percent of borough population in 1990. This additional population will have a slight impact on the requirements for public recreational facilities in the borough, such as parks, athletic fields, etc.

- Transportation

The Susitna Hydroelectric Project includes the construction of a road into an area that currently has no auto access. If a policy decision is made to allow public access to this road upon completion of the project, the result will be a major addition to the local transportation system. In addition, a portion of the Denali Highway will be cleared of snow in the winter as part of the project construction effort, and this will provide additional road access to nearby residents during the winter.

Almost all of the project-related supplies and equipment will be transported by rail to Cantwell, and then by truck to the Watana work site. The rail system is currently underutilized and the increased revenues are expected to benefit the railroad.

An increase in vehicular traffic on the Parks Highway, the Denali Highway and nearby roads will result to the extent that workers commuting to and from the site drive to pick-up points. In general, the Parks Highway is currently only 10 percent utilized, and this increase in traffic is not expected to have any adverse impacts. The current congested portion of the highway near Wasilla should be relieved by the expansion of the highway in that area that is now underway. The project could add to congestion on weekends during the summer, unless the scheduling of commuting workers is conducted so as to avoid those periods.

Projected traffic estimates have been developed which assume the following: a single-status camp is provided for laborers and most of the semi-skilled/skilled workers; a village with family housing facilities is provided for some of the semi-skilled/skilled workers and all of the engineering/administrative workers who desire it; there are recreational and other facilities at the work

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Tables E.5.20 and E.5.21 show the daily estimated traffic volumes for the Denali Highway and for the project access road. Appendix 5.D lists the specific assumptions which underlie these estimates. Projected increases were not estimated for the Parks Highway, since the Department of Transportation is confident that the addition of project-related traffic to projected traffic without the project will in no way exceed the design capacity of the highway.

These estimates are for the peak year (1990) and the peak season (July-August), and they include traffic projections for traffic that is not related to the project. They indicate that the heaviest average daily traffic volumes which can be anticipated, assuming one vehicle per commuting worker, are: 794 passenger vehicles and 90 heavy and light trucks on the Denali Highway Cantwell to Fish Creek segment; 604 passenger vehicles and 90 heavy and light trucks on the Denali Highway Fish Creek to Maclaren River segment; and 654 passenger vehicles and 90 heavy and light trucks on the access road. Should a Project Transportation Program be instituted, these volumes will be lower to the extent such a program provides for pooling (more workers per vehicle) and/or alternate transportation means for workers and materials.

Compared to these project-generated peak volumes, the Department of Transportation has projected average daily traffic volumes (ADT) on the Denali Highway Cantwell to Fish Creek segment to be 320 vehicles, and on the Fish Creek to Maclaren River segment (access road to the project lies in this segment) to be 130 vehicles. These projections are exclusive of any project-related traffic.

Project-generated increases in vehicular traffic on the Parks Highway and Denali Highway will entail additional maintenance requirements by the Maintenance and Operations Division of the Alaska Department of Transportation, especially during the months of heavy snowfall. Currently, the Denali Highway is not cleared of snow during the winter months and is allowed to close in the fall. During summer months, graders work the gravel surface of the highway on a daily basis.

Initially, maintenance of the access road will be the Contractor's responsibility. If and when the Department of Transportation and Public Facilities assumes responsibility for maintenance of the project access road, the Division will be required to service it as well. Regardless of the servicing entity, state funds will undoubtedly provide for an access road maintenance program both during and after project construction. The final maintenance plan has yet to be determined.

(ii) Trapper Creek

The small, remote, and unincorporated nature of the community contributes to a low current level of available public facilities and services. A major impact of the increase in population in Trapper Creek may be an increased need for services that are currently not available, such as fire protection and closer proximity to medical care.

- Magnitude of Population Influx

Trapper Creek will experience the largest relative population impacts of all the communities in the Mat-Su Borough by virtue of its location in the northern part of the borough on the Parks Highway. The population impact is displayed by year in Table E.5.22.

Between 1985 and 1990, it is projected that under the base case the population of this small community will increase by about 75 people, bringing the 1990 population to 320. With construction of the Watana portion of the project, population in the area around Trapper Creek is expected to reach almost 800 by 1990. This would be an increase of 150 percent over the community's projected population without the project in that year. The largest single annual increase in population is expected to occur in 1987.

3.1 - Impact of In-migration

Direct workers and their families will account for about 50 percent of the in-migrant population related to the project. Trapper Creek is projected to receive a relatively large increase in support employees and population as result of the community's location on the Parks Highway, its relatively large expected influx of direct construction workers, and the limited number of retail and service businesses currently located in the area.

Trapper Creek will experience a lull period between 1991 and 1995, during which time approximately 225 project-related individuals are expected to leave (47 percent of the population that is projected to have in-migrated as result of the project). Growth expected under the baseline protection will only partially compensate for this decline.

- Water, Sewage, and Solid Waste

In Trapper Creek, water and sewage needs are met by individual wells and septic tanks, and solid waste is disposed at a nearby landfill run by the borough.

Few impacts from the increased population are expected. One resident has mentioned that it is possible the added population will exacerbate present problems of insufficient ground water during dry spells. Mat-Su Borough officials have indicated that the water supply should be sufficient for a population increase of that magnitude, though suitable ground water sources may take some effort to locate because of the geology of that area (dissolved manganese and permafrost conditions).

Rapid growth can have the potential for hastily built housing developments that do not meet health standards for wells, septic tanks, and/or solid waste disposal. It is anticipated that borough and state oversight of growth in the Trapper Creek area could prevent such problems from occurring. This need for supervision could affect officials in the Mat-Su Borough or the Alaska Department of Environmental Conservation.

- Transportation

Increased vehicle traffic on the Parks Highway is expected. The addition of housing units may result in the need for additional roads to serve them; in the Mat-Su Borough, this is the responsibility of subdivision developers.

- Police Protection

The Susitna project and the accompanying increase in the population of the northern part of the borough may induce an enlargement of the State Trooper substation at Trapper Creek, thus resulting in increased police presence in the community.

- Fire Protection

Trapper Creek currently has no active fire protection facilities. The present small size of the community has limited its ability to support a fire service area. There is an existing building that could be used if a new service area were developed.

The population influx into Trapper Creek will exacerbate the need for active fire facilities in the community. It is possible that the additional population added to the natural growth over the 1983-1990 period could result in additional ability of the residents to support a fire service area. A well which could supply the necessary water for a fire station may take some exploration to locate, but Mat-Su Borough officials believe that sufficient water is available.

- Health Care

With the exception of an ambulance, no formal health care facilities are currently available in Trapper Creek. Residents of the area with medical training help out on an informal basis (without pay) when needed, and health care facilities in Wasilla and Palmer are utilized.

Growth of the community resulting from both baseline forecast growth and project-related in-migration is expected put a strain on this informal system of medical care. The community may want to request the establishment of a Public Health Service office in the future.

In addition, the stress associated with rapid change may result in increased need for provision of some social services in Trapper Creek and surrounding areas.

- Education

The 6-classroom elementary school currently under construction in Trapper Creek will have an initial capacity of 100 students, and could be expanded to accommodate up to 200 students.

The project-related population increase will include an increase in student enrollment at the elementary school of between 65 and 85 students by 1990, over the base case projection of about 80 in that year. The result will be a need for expansion of the school in the late 1980s and addition of 3 or 4 teachers.

In addition, about 60 junior and senior high school students living with project-related families in Trapper Creek are expected to be added to the enrollment of Susitna Valley High School by 1990.

(iii) Talkeetna

- Magnitude of Population Influx

Between 1983 and 1990, an estimated population influx into Talkeetna of 335 people is expected to occur as a result of the project (see Table E.5.23 for annual population projections). This will represent a 34 percent increase over the baseline forecast level of 1000. Of these 335 new residents, 80 percent are projected to comprise direct construction workers and their families, and 20 percent will be support workers and their dependents.

- Water and Sewage

Talkeetna is served by independent wells and septic tanks; there is a potential for problems in the "downtown" area because of the small size of the lots on which houses are built and the proximity of wells to septic tanks. This would not be a problem in the outlying areas around Talkeetna where the plots of land are usually larger.

3.1 - Impact of In-migration

It is not possible to predict with certainty where new residents in Talkeetna will settle. To the extent that project-related in-migrant population settles in the town itself, this group of people will contribute to the need for central water and sewage systems. It is possible that quickly constructed housing will need to be closely supervised to ensure compliance with health standards regarding wells and septic tanks. This need for supervision could affect officials in the Mat-Su Borough or the Alaska Department of Environmental Conservation.

- Solid Waste

The peak population influx into Talkeetna associated with the project will occur just around the time that the borough's landfill near Talkeetna is scheduled to be closed (1987-1989). A new landfill or a transfer station will be needed at that time. The additional population is not expected to have any adverse impacts.

- Transportation

A large amount of the supplies and equipment for construction of the dams will be transported by railroad. This is not expected to have any adverse effects on rail service for Talkeetna residents.

As the population increases and new housing is constructed, there will be increased need for construction and maintenance of roads in Talkeetna and the surrounding area. However, baseline forecast growth is expected to cause a large part of this increased need. Construction of new roads to service subdivisions will be the responsibility of individual developers, and maintenance of local roads will be administered by the borough through the Talkeetna Road Service Area.

- Police Protection

As Talkeetna grows, there may be a community desire for a police presence closer than the Trapper Creek station. The additional 34 percent population influx associated with the project between 1985 and 1990 and the proximity of the work camp to the community may further reinforce this tendency. Incorporation of the community would be a prerequisite to the establishment of a local police force. (In 1981, the community turned down a ballot measure to incorporate. It is difficult to predict the point at which incorporation will occur.)

- Fire Protection

Increased population is not expected to affect the firefighting facilities in the area; these are planned on the basis of distance between the station and population centers and on the availability of pumped water. The planned addition of equipment to the Talkeetna fire station should be sufficient to serve the community until such time as a community water system is put in place. Adequate water is available to keep the storage tank and pumper truck full.

- Health Care

Residents of Talkeetna currently use the health care facilities in Anchorage and the southern part of the borough. The population influx related to the project, along with base case projected growth, may result in sufficient demand to warrant some provision of medical care in the community by a private doctor.

In addition, the stress associated with rapid change may result in increased need for provision of some social services in and around Talkeetna.

- Education

The population influx associated with the project will include approximately 48 primary school-age children by 1990, just as the enrollment in the elementary school in Talkeetna is projected to exceed its capacity of 120 (the predicted base case enrollment in the school in 1990 is 126). Additional classroom space and approximately two teachers will be required.

There will be an additional 41 secondary students from Talkeetna attending Susitna Valley High School by 1990 as a result of the project. Together with the additional enrollment at that school of 58 students from Trapper Creek families, the project-induced increase in enrollment is expected to equal about 100 students. This will increase total enrollment at Susitna Valley from the base case projection of 200 to over 300 in 1990. The school has a capacity of 180 students. Under the base case, additional classroom space is expected to be needed around 1988-89. With the project, enrollment is projected to exceed present capacity one year earlier. At the height of the Watana peak, project-induced enrollment will result in the need for 5 more teachers and classrooms than will be needed under the base case.

(iv) Cantwell

- Magnitude of Population Influx

One component of the project-related population influx into Cantwell will be the workers at the rail siding, for whom bachelor quarters will be provided by the project. It is also anticipated that many workers at the damsites will want to establish homes in the Cantwell area, if the housing is available.

The size of the population influx into Cantwell will be heavily influenced by the development of housing in the community by private individuals and by mitigation measures that could be developed and implemented. To the extent that housing and land for housing is not sufficient, it is probable that many of these people will settle in other areas or will have their families remain at their present homes. This is an especially important consideration in the Cantwell area, because of the limited amount of non-native private land and the question surrounding future plans for Native-owned land (see Section 3.4). It remains to be seen whether Ahtna, Inc., will find it desirable and economically feasible to develop its land for housing. As result of this uncertainty, two scenarios of impacts have been projected. The population projections, under both scenarios, are displayed in Table E.5.24.

Under Case A, projections of population influx were based upon a housing supply-constraint model, in which it was assumed that the influx of population would be limited to the number that could be accommodated by existing vacant housing and land that will most probably be available for use by housing, mobile homes, or trailers. No further land would be expected to become available. The majority of workers who wished to settle there but could not find housing would either (1) not move their families at all or (2) would find housing in other parts of the local impact area.

The Case B impact projections assume that land and housing will be available at an acceptable cost to accommodate all in-migrant workers that desire to settle in Cantwell. It is thus a demand-side model which uses assumptions on worker activity based upon the experience of communities near other large projects in remote areas (U.S. Army Corps of Engineers June 1981 and Denver Research Institute February 1982). It is highly uncertain how much housing will become available and at how rapid a pace. In addition, if a local commercial source of electric power does not become available (currently residents rely on individual generators) the cost of power may further discourage workers and their families from settling in Cantwell. Thus, it is best to consider Case B as a presentation of an upper range of possible impacts, rather than as a likely scenario.

Both scenarios include the planned provision of housing for workers at the rail siding area, and these workers are included in the projections in Table E.5.24. The housing for project workers at Cantwell will be bachelor quarters. Any in-migrant workers who wish to bring their families will need to obtain housing for their families.

Under both scenarios, it is expected that there will be a large influx of population into Cantwell during 1985 and 1986. Under Case B, the population of the community would triple; under Case A, the population of Cantwell would be double the population level expected without the project. Under both cases, it is likely that the proportion of non-native Americans in the community will rise sharply.

In Case B, approximately 455 people are expected to desire to settle into the community by 1986 (under the housing supply-constraint conditions of Case A, it is estimated that only 230 people would move into Cantwell during that period). Of this total, about 300 (66 percent) will be related to the direct construction work force working at the railhead and to a small number of workers at the Watana site who choose to settle their families at Cantwell. The remainder will comprise support workers and their families. The influx would represent an increase of almost 200 percent over the size of population that was projected for Cantwell in 1986 under the base case (200). This dramatic increase would occur very quickly over a period of 18 months.

After 1986, there will be a sharp decline in the number of workers needed at the railhead. However, as the work force at the Watana site increases, there will be an influx of families of a portion of those workers that will more than offset the decline related to the railhead. It is projected that the number of project-related people in Cantwell could rise to a peak level of between 255 (low case) and up to 1000 (high case) in 1990. Approximately 90 percent of this cumulative in-migrant population will be related to the direct work force in the high case. Under the high case projections, population in Cantwell in 1990 (1214) will be approximately 4.5 times as large as would be the case without the project.

Several factors affected the assumptions that underlie the projected number of project workers that are expected to want to settle in the Cantwell area, if there is housing available. First, Cantwell is the closest community, by road, to the proposed work site, but it can only be considered a daily commute under good weather conditions (usually May - September). It is estimated that under optimal conditions it would be an 80-minute drive from Cantwell to Watana; under poor conditions, it could take up to 3 hours or more. The distance could be expected to discourage project worker in-migration into Cantwell. On the other hand, the lengthy project construction period (9 years for the Watana portion alone), and the limited availability of family housing at the site is expected to result in a larger demand for housing than would be expected in a community that is so far away from the work site.

3.1 - Impact of In-migration

The population projections upon which the impacts of the project are based assume that the community will obtain some form of power supply by 1985 (residents of the community currently rely on individual generators) and that the lack of power will thus not be a deterrent to future in-migrant settlement. Power may be provided by purchase of a community generator, or possibly by provision of a substation related to the planned Anchorage-Fairbanks transmission intertie.

- Water Supply, Sewage Treatment, and Solid Waste Disposal

The residents of Cantwell rely upon individual wells and septic tanks for their water supply and sewage treatment needs. Under Case A conditions, the population influx related to the project is not expected to affect water and sewage in Cantwell.

Under Case B, the community will begin to approach a size at which a community water system becomes feasible. The need for a centralized water system will depend on the pattern of housing development. If housing continues to be built on plots of 1 acre (0.4 ha) or more, individual wells will continue to prevail.

The additional population in Cantwell and debris from the railroad siding can be expected to intensify the need for a new community landfill quickly. Currently, the need for a new landfill for Cantwell residents is considered to be a top priority.

- Transportation

The traffic on the Parks Highway and Denali Highway will increase substantially as a result of the commuting of project workers and the transport of supplies from the railhead to the Watana site. This will require an increase in maintenance and maintenance staff by the state to continue current levels of service. In addition, local roads will need to be built to serve any additional subdivisions. This will be the responsibility of individual developers.

The Denali Highway will need to be upgraded to handle the increased traffic from an estimated

30-35 trucks a day and use by commuting workers. The additional traffic will exacerbate the dust problems that nearby residents experience in the summer, unless that portion of the highway is paved.

Additional snow clearing equipment and manpower will be required to service the Denali Highway and project access road during the winter months. Also, Highway Maintenance Division equipment will be maintaining these two road surfaces during the spring and summer months. The access road gravel surface will require near constant grading because of heavy truck traffic. The extent of maintenance impacts of servicing the Denali Highway section of the route will depend on the nature of road surface ultimately determined for this portion.

A substantial increase in traffic caused by the Susitna project is expected at the Cantwell intersection of the Parks and Denali Highways. Anticipated traffic patterns in this area will need to be studied to determine necessary navigational and traffic control aids.

There are currently one state trooper and one Fish and Game officer stationed at the Cantwell station. The increased population at the community and at the damsites will result in an increased need for police protection of approximately five to six officers (based upon rural standards of about one officer per thousand population). Provision of police protection at the Watana site by the project management may mitigate the need for additional state troopers at Cantwell somewhat.

- Fire Protection

Increased population is not expected to affect the firefighting facilities in Cantwell; these are planned on the basis of distance between the station and population centers and on the availability of pumped water. The planned fire hall and equipment should be sufficient to serve the community as it grows. Adequate water is available from wells, creeks and lakes to serve the station.

3.1 - Impact of In-migration

- Health Care

With the exception of an ambulance, no formal health care facilities or social service organizations are currently available in or near Cantwell. Growth of the community may result in an increased need for emergency medical care. Growth may also help to attract some private medical care to the area.

In addition, the stress associated with rapid change may result in increased need for provision of some types of social services within the community.

- Education

It is estimated that between 50 and 80 schoolchildren would be added to the enrollment of the school in Cantwell as result of the project between 1985 and 1986. By the peak of construction at the Watana site in 1990, the project-related number of schoolchildren in Cantwell is expected to equal between 70 and 150, depending upon the number of workers at the damsite who have their families settle at Cantwell.

Total enrollment at the Cantwell school (including both enrollment expected under the base case and the addition induced by the project) will thus equal about 125 in 1986 and between 110 and 190 in 1990. This would be beyond the capabilities of the existing school, and an addition to the school would need to be constructed to accommodate the increase in enrollment. The present school at Cantwell has capacity for about 55 to 60 children and can handle as many as 75 on a short-term basis. The increase in enrollment would also result in requirements for approximately 10 additional teachers, based upon an average teacher-to-student ratio of 15:1.

(b) Regional

The population of the Railbelt is expected to increase to approximately 400,000 by 1990, of which only 1867 in-migrants (or 0.5 percent) will be related to the project. This represents such a small percent of current and projected population in the region, that impacts on facilities and services outside the local impact area are expected to be negligible.

3.1.4 - Watana Operation Phase and Devil Canyon Construction Phase

(a) Local

(i) Mat-Su Borough

- Magnitude of Population Influx

As shown in Table E.5.19, project-induced population is not expected to increase significantly in the late 1990s as the construction activity at Devil Canyon intensifies (an increase of about 155 people over a 5-year period). It is probable that the available work force in the Railbelt, including those who worked on the construction of the Watana dam, will be able to fill the new direct jobs. Some secondary population influx will occur as income from this portion of the project is spent.

Since the population of the borough will continue to grow as a result of natural growth factors implicit in the base case population projections, the relative impact of the project-induced, offsite population will be smaller. In 1999, the project-induced population (including many people who moved into the area during the earlier Watana period and stayed) of 1047 people will account for only 1.6 percent of total borough population.

- Water Supply and Sewage Treatment

No further impacts on the water or sewage systems in the Mat-Su Borough are expected.

- Solid Waste Disposal

The cumulative landfill acreage need of the borough will increase about 2.2 acres (0.9 ha) during the 1994-2002 period, or 1.2 percent as a result of the project-related population living offsite in borough communities. The borough may need to provide additional acreage for its central landfill around 1994-1955, with or without the Susitna project.

- Police Protection

The need for policemen in the Mat-Su Borough, outside Palmer, is expected to continue to increase in the 1990s under the base case, as the population continues to grow. At the peak of Devil Canyon construction in 1999, it is expected that there will be need for about 76 officers, compared to a projected need for 75 police under the base case.

- Fire Protection

The project facilities and work camp/work village will be protected by firefighting equipment and services at the work site; there will be little impact on existing fire service areas during this period.

- Health Care

No adverse impact on the borough's health care facilities are expected during this period as a result of the project.

- Education

There will be limited additions in enrollment in the Mat-Su Borough School District as a result of the Devil Canyon portion of the project. Between 1993 and 1999, enrollment in the school district is expected to increase from about 12,065 to 16,740. Of this total enrollment in 1999, project-related in-migrant households are expected to account for 288 students, or just 1.7 percent.

- Transportation

The Devil Canyon phase of the project will include construction of a rail spur from Gold Creek to the damsite. No additional impacts on the transportation systems in the borough are expected during this period.

(ii) Trapper Creek

- Magnitude of Population Influx

In Trapper Creek, it is expected that as activity at Devil Canyon begins, population will increase from about 625 in 1994 to 770 in 1999 (see Table E.5.22). This represents an average annual growth rate of 2.4 percent. Project-related population will represent about 40 percent of total population in Trapper Creek in 1999.

- Impacts on Public Facilities and Services

No further important impacts on public facilities and services in the community are expected. Any increases in infrastructure which occur during the Watana period as a result of the population influx related to the project are expected to be sufficient to accommodate the community's population during the Devil Canyon phase.

(iii) Talkeetna

- Magnitude of Population Influx

Project-related population in Talkeetna will rise gradually from about 222 in 1995 to 257 in 1999. Most of the population growth in Talkeetna during this period will be unrelated to the Susitna project. At the peak of construction at Devil Canyon it is expected that project-related population will account for 14 percent of population in the community.

- Impact on Public Facilities and Services

While it is likely that infrastructure needs in Talkeetna will continue to increase in the 1990s, these requiremetts will be related to the continued increase in population unrelated to the project.

(iv) Cantwell

- Magnitude of Population Influx

Upon completion of the Watana portion of the Susitna project, between 90 (low impact scenario) and 215 (high impact scenario) people are expected to move out of the Cantwell area. No further in-migration of project-related population is expected during the Devil Canyon construction phase.

- Impact on Public Facilities and Services

The decline in population in Cantwell associated with the completion of Watana construction will have most relevance to capacity utilization of the school. It is expected that the number of project-related students enrolled in the school will decline by about 30 upon completion of the Watana portion of the project. To the extent that the school was enlarged to accommodate the peak number of students, there may be some overcapacity. It is expected that potential problems can be avoided through careful planning and communication about the project (see Section 4 on mitigation measures).

(b) Regional

As a result of the limited population influx into the Railbelt and the large projected base case population, no measurable impacts on public facilities and services in the region outside the local impact area are expected during the Devil Canyon phase.

3.1.5 - Watana and Devil Canyon - Operation Phase

There will be some expected departure of population from the local impact area as construction of the second dam is completed. However the effects of this decline in population on public facilities are expected to be minimal, with the possible exception of schools in Trapper Creek and Cantwell. Planning, communication with local authorities, and other mitigation measures are expected to prevent overcapacity problems. Because of the limited public facilities currently in place in the communities closest to the project and the small size of these communities even with the projected peak amount of project-related population influx, it is not expected that excess capacity will have been built.

During the operation phase of the project, all project workers and their families will be living at the onsite village, where housing and other community facilities will be available. No impacts on public facilities and services in the local and regional impact areas are expected during this period.

3.2 - On-site Manpower Requirements and Payroll, by Year and Month

3.2.1 - Manpower Requirements

Tables E.5.25 - E.5.27 show the projected total annual number and origin of onsite construction and operations manpower for the Watana and Devil Canyon dams from 1985-2005. These estimates include all manpower required for the construction of the access road and camp/village, power facilities, and transmission facilities, and all management and administrative personnel. Manpower for offsite activities such as procurement, manufacturing, shipping, and a portion of the engineering staff are not included in these estimates.

For the construction work force, manpower is divided into laborers, semiskilled/skilled workers, and engineering/administrative employees. As shown in Table E.5.25, the peak demand for labor occurs in 1990 with an estimated construction work force of 3498.

The Watana dam will be constructed in two phases with an ultimate generating capacity of 1020 MW. The first installment of 680 MW will be completed by January 1994, at which time operations manpower will total 70 persons. The additional generating capacity will be available in July 1994 and will result in a total operations work force of 145 workers.

Analysis of construction manpower requirements for the 600-MW Devil Canyon dam is based on main access construction beginning in 1992 and site facilities construction beginning in 1994. This dam would come on-line in 2002. The total onsite operations work force for both dams will equal 170 during 2002 and thereafter. During part of 1992 and all of 1993, construction activities related to both dams would be occurring.

It is apparent from Figure E.5.5 that the first phase of the Watana dam requires a significantly greater number of workers than both the second phase of Watana and Devil Canyon combined. This difference can be attributed to the additional labor requirements in the initial years for construction of the work camp and village, the access road, and to the more labor-intensive nature of a gravel-fill dam (Watana) than a concrete thin arch dam (Devil Canyon). Significant decreases in work force requirements (relative to the preceding years) will occur between 1991 and 1996.

3.2.2 - Seasonality of Manpower Requirements

The demand for manpower will vary during any given year. As Figure E.5.6 shows, at least 80 percent of the peak demand for labor in a given year will be required during mid-March to mid-

September. Labor requirements rise from about 30 percent to 80 percent of the peak during February to mid-March, and fall from 80 percent to about 30 percent of the peak during mid-September to the beginning of December. Labor requirements will be about 30 percent of the peak during December and January.

Table E.5.28 shows the construction and operations manpower requirements by month and year. The figures in this table were derived by applying the seasonal labor curve in Figure E.5.6 to the manpower requirements shown in Table E.5.25. Each construction labor category was expanded seasonally, and then factored to the slightly different trade mix ratios which occur between 1985 to 1994 and 1995 to 2002. After adjustment, all labor categories were combined into Table E.5.28.

It is clear from Table E.5.28 that a significant number of workers will not be employed on the project for several months each year. During months when the quantity of labor demanded is low, it is likely that a significant portion of the peak annual work force will return to their permanent residences. Those workers who maintain permanent residences outside the region will leave the region during these periods. Some workers might also travel to another job for which they have already been hired. Some workers who do not already have non-project-related jobs during this low demand period may seek employment while based at their permanent residences while others might not seek work for a period of time.

During these extended times off the job, workers are not likely to receive substantial amounts of compensation. It is possible that workers will be given travel allowances when they leave their jobs on the project. These allowances would help pay their travel expenses to their homes and perhaps back to the job. It is also possible, but in general less likely, that workers would be given monetary inducements (other than travel allowances) to return to their jobs. Inducements would most probably be reserved for the most highly valued workers.

(a) Project Effects on Unemployment

The effects of the project on unemployment rates and levels in the region and communities of the region are difficult to predict. One would think that the increased availability of jobs would lower both unemployment rates and levels, but this might not be the case for the following reason.

It must be kept in mind that it is not solely the number of jobs available that determines unemployment. The number of job seekers relative to the number of jobs available is the main determinant of unemployment. It is possible that a larger than required number of workers could come to the points of hire for this project from outside the region. This would be probable if there were relatively few job opportunities outside the region or if the wages for jobs on this project were considerably higher than job wages elsewhere. This phenomenon would tend to increase rates and levels of unemployment, perhaps above the rates and levels that existed prior to the project.

Recent experience has indicated that the number of persons looking for work in Alaska is capable of growing faster than the number of new jobs. For example, in recent summers thousands of job seekers have come to Alaska looking for work in construction, professional and technical, and other occupations. While one would expect the unemployment rate to decline considerably during the summer months as more jobs become available, this has not been the case.

In addition, recent economic expansion has tended to increase unemployment rates and levels over previous similar economic expansions. During recent periods when more jobs have been available, unemployment rates have been higher than previous similar periods of job expansion, and the total number of unemployed persons has increased rather than decreased.

In summary, the influence on unemployment of manpower demand for this project is uncertain, but it is possible that the project will tend to exacerbate rather than ameliorate unemployment rates and levels in any season of the year. The outcome largely depends upon the extent of in-migration of job seekers. This phenomenon will be monitored and included as part of the Impact Management Program (see Section 4).

3.2.3 - Payroll

Payroll is important because it is the source of impacts resulting from direct on-site construction and operations work force expenditures. Based on the above onsite construction and operations manpower requirements the total yearly project payrolls from 1985 - 2002 were derived and are shown in Table E.5.29. These totals were derived by matching wages to the respective trades which comprise the labor categories indicated in the monthly manpower requirements in Table E.5.28. It was assumed that for laborers and semiskilled/ skilled workers there are 1825 worker hours per year (54 hours per week and an average of 29 weeks per year) and for administrative, engineering and operations/maintenance personnel 2496 working hours per year (48 hours per week and 52 weeks per year).

Wage rates for laborers and semiskilled/skilled workers were obtained from the Alaska Department of Labor (ADOL). These wage rates are routinely collected by ADOL through industry surveys, and are the worker's base rate of pay exclusive of any fringe benefits and prior to standard deductions. Wage rates for engineering/administrative and operations/maintenance personnel were obtained from Acres American, Inc. and are the workers' Alaskan base rate of pay exclusive of any fringe benefits and prior to standard deductions. In all manpower labor categories, wage rates used in computing on-site payroll do not include such added benefits as travel allowances, housing allowances, and other highly variable items.

The construction payroll in 1990, the peak year of construction, totals $81.055 million. Annual operations payroll ranges from $2.7 million in 1993 to $6.7 million in 2002 (in 1982 dollars). Table E.5.29 shows payroll by year and month. The manpower figures which were used to generate total hours paid have been adjusted for the slight annual difference in construction trade mix. Base figures indicate that in 1990, 22 percent of the onsite workforce will be laborers, 53 percent semiskilled/skilled, and 25 percent administrative/engineering. In 1999, this mix is projected to alter to 20 percent laborers, 48 percent semi- skilled/skilled, and 32 percent administrative/engineering. Payroll calculations were made on the basis of these two different ratios. Years 1985 through 1994 were calculated at the 1990 trade mix, and years 1995 through 2002 at the 1999 trade mix.

3.3 - Residency and Movement of Project Construction Personnel

The principal objectives of this section are to provide a statement of and rationale for the assumption used to project the residency and movement of workers and the resultant population influxes and effluxes, and to provide the results of these projections. This is done by discussing probable geographic sources of direct manpower, residency and movement of direct manpower, support employment generated by the direct construction work force, and dependents associated with in-migrating manpower. In this context, support employment includes (1) workers employed by private suppliers of equipment or materials for the project and (2) workers employed by service industries whose increase in business is related to increased demands for goods and services by construction workers.

Estimations for several elements of the work force are made, including: (1) number of workers that would reside in the region at the beginning of construction at Watana; (2) number of workers that would relocate their residences within or to the region; and (3) number of workers that will maintain their residences outside the region. Estimates of population influxes and effluxes are also included.

These estimations are made for the census divisions, cities/communities of the region, and Cantwell. Estimates are produced separately for Cantwell because slightly different assumptions were necessary due to railhead construction and operation at Cantwell.

Assumptions and methods used in the analysis are discussed throughout this section, and important communications with knowledgeable persons are referenced where appropriate. Sources that were reviewed and that contributed substantially to the development of assumptions and methods include U.S. Army Corps of Engineers (1981); Denver Research Institute (1982); Metz (July 1981); Metz September (1981); Holmes & Naver (1981); and University of Alberta (1980). Further elaboration of the approach to the impact assessment is provided in Appendix 5.A.

3.3.1 - Region

(a) General Geographic Sources of Manpower

Most of the manpower for the project will be supplied from within the region. The percentage of jobs that could be filled by the regionally available work force varies with each labor category. In general, a greater portion of laborers than engineers and administrators will be supplied from the region.

As shown in Table E.5.26, it is estimated that 85 percent of the laborers will be supplied from the region, 5 percent from other areas of state, and 10 percent from out-of-state; 80 percent of semi-skilled/skilled workers will be supplied from the region, 5 percent from other areas of the state, and 15 percent from out-of-state; and 65 percent of the workers in the engineering/administrative category will come from the region, 5 percent from other areas of the state, and 30 percent will be from out-of-state.

The percentages are estimates. These estimates were made through analysis of unemployment data for laborers, semi-skilled/skilled workers (mostly crafts or trades), and administrative and engineering personnel. Labor required for the project was compared to labor available in the region's census divisions. Preliminary percentages were developed based on this comparison.

Next, local union officials, Alaska Department of Labor economists, and construction contractors were consulted. Insights obtained from discussions with these persons, listed in the References, helped with the estimations of the future availability of workers in the region and census divisions. Based on these insights, the preliminary percentages were modified to reflect probable future conditions.

(b) Detailed Geographic Sources of Manpower

The first row in Table E.5.30 displays the projection of construction workers that will come from the region, based upon the percentages listed above. Here it can be seen that by 1990, the peak year, about 2842 residents of the region will be employed as onsite construction workers.

Geographic sources of manpower were projected in detail for census divisions of the region and selected cities/communities of the Mat-Su Borough. The projections are shown in Table E.5.30. These figures represent the cumulative number of residents, by place of residence prior to the start of construction in 1985, who will become onsite construction workers (that is, these figures show the current residence of workers who will obtain employment on the project).

These projections were made by assuming that project employment would be distributed among census divisions based, in part, upon each census division's average share of the total construction employment in the region during 1979-1981. These shares, hereinafter called residence factors, were adjusted to reflect the census division's proximity to the construction sites relative to other census divisions. The residence factors are:

Anchorage:	55.9%
Mat-Su:	6.7%
Kenai-Cook Inlet:	11.1%
Seward:	0.2%
Fairbanks:	23.8%
S.E. Fairbanks:	0.2%
Valdez-Chitina-Whittier:	2.1%

Project employment was projected for selected Mat-Su Borough cities/communities based upon each city/community's recent average share of total population in the Borough. Trends in population shares were also taken into account in making initial estimations of city/community shares of the Borough's project employment. Population data were used in lieu of employment data because employment data is not available for most cities/communities.

As above, these shares, hereinafter called residence factors, were adjusted to reflect a city/ community's proximity to the construction sites relative to other cities/communities. The residence factors are:

Palmer:	10%
Wasilla:	8%
Houston:	5%
Trapper Creek:	1%
Talkeeetna:	4%
Other areas:	72%

Even after adjusting the residence factors for proximity to the construction sites, several of the figures in Table E.5.30 are relatively small, particularly for the smaller cities and communities. It is considered likely that the large number of construction workers in Anchorage and Fairbanks and the presence of the union hiring halls in those cities will result in a majority of workers on the Susitna project being residents of the large cities. This could result in limited employment of people from the smaller communities closer to the project, in the absence of mitigation measures. It is possible that more persons in the small communities will obtain onsite construction jobs than indicated, especially if there is an effective local hire program.

(c) Residency and Movement of Regional and Non-Regional Manpower

It is expected that manpower living in the region before 1985 and becoming employed on the project during or after 1985 will move their permanent residences closer to the construction sites during the project. It is also expected that some of the workers who permanently reside outside the region prior to 1985, the start of construction, will move their permanent residences to the region during the project. Quantification of these changes in residences is the subject of this section.

For relocation of regional manpower within the region, it was assumed that workers would migrate from all census divisions of the region to the local impact area (Mat-Su Borough and Cantwell). However, since the number of workers residing in the Seward, Southeast Fairbanks and Valdez-Chitina-Whittier census divisions prior to 1985 was insignificant relative to the other census divisions, the amount of relocation from these census divisions was not quantified.

It was assumed that, in any given project year, about 10 percent of the workers who would otherwise have resided in the census division in which they lived in 1984, would instead move their residences closer to the construction sites. Put another way, in any given year, about 90 percent of the project workers who will be living in the Anchorage, Kenai-Cook Inlet, and Fairbanks census divisions in 1984 and subsequently become employed on the project, would keep their permanent residences in these census divisions after 1984.

The rationale for this assumption is that currently there is substantial movement from urban areas, particularly Anchorage, to rural areas, particularly the Mat-Su Borough. In addition, it is believed that many Alaskans would prefer to live in more rural areas if there were employment opportunities nearby.

This assumption was operationalized by lowering the original residence factors for the Anchorage, Kenai-Cook Inlet, and Fairbanks census divisions, and raising the residence factors for the Mat-Su Borough and Cantwell. The residence factors were changed so as to approximate the 10 percent value discussed above. For workers in the engineering/administrative category, it should be noted that some of the "movers" were distributed to communities located closer to the site, while most were distributed to the onsite village.

Of the workers who in-migrate into the local impact area, approximately 45 percent are projected to settle in Cantwell and 55 percent in the Mat-Su Borough (with the exception of the workers on the railhead, who will be living in housing provided by the project in Cantwell). Workers that move from the Anchorage, Kenai-Cook Inlet, and Fairbanks census divisions into the Mat-Su Borough will settle in cities and communities as follows:

Palmer:	4%	of workers that migrate to the Borough.
Wasilla:	5%	
Houston:	4%	
Trapper Creek:	25%	
Talkeetna:	25%	
Other Areas:	37%	

Here, it was assumed that workers would in general choose to have their permanent residences closer to the construction sites than the larger population centers of Wasilla and Palmer. It was assumed tht these workers would be willing to trade off some conveniences for a shorter commuting time.

In years where manpower requirements decline from the previous year, it is likely that some of the workers who relocated will no longer be employed on the project. This lack of project employment could be temporary or permanent between 1991 and 2002, and permanent after 2002 (to the extent that these workers do not fill the operations jobs). It was assumed that all of the workers who relocated within the region would remain at their new permanent residences. This assumption was made because these workers are the ones who wanted to move to more rural areas prior to 1985, but did not because of the lack of jobs. Their strong desire to live in this rural area will give them extra incentive to make it feasible to remain. If there is any out-migration by this group, it is likely that they will move to cities such as Anchorage, Fairbanks, and Wasilla where it is likely that more jobs will be available.

Workers who live outside the region prior to 1985 will also choose to relocate to the region. It was assumed that 50 percent of the laborers and semi-skilled/skilled workers who come to work on the project from outside the region will choose to relocate to the region. This percentage of relocation is higher than has been experienced on many other projects because there will be a rather stable demand for this kind of labor during 1988-1992. This will provide an extra incentive for workers to relocate. In addition, there will be no onsite accommodations for laborers' dependents, and few accommodations for semiskilled/skilled workers' dependents. This will create an incentive for workers who have dependents to relocate their residences to the region.

For workers in the engineering/administrative category, it was assumed that 15 percent would settle in the region. A lower percentage of engineers and administrators (relative to laborers and semiskilled/skilled workers) will relocate to communities of the region because accommodations will be available for many of these workers and their dependents at the construction sites.

Workers in all three of the labor categories were distributed among census divisions of the region according to geographic source-specific residence factors. For workers coming from out-of-state, the following factors were used during 1985-1986:

Anchorage:	27%
Mat-Su and Cantwell:	50%
Kenai-Cook Inlet:	2%
Seward:	0%
Fairbanks:	21%
SE Fairbanks:	0%
Valdex-Chitina-Whittier:	0%

These factors were increased slightly for Mat-Su and Cantwell, and decreased slightly for Anchorage and Fairbanks during 1987-2002. It was assumed that some workers would temporarily settle in the larger cities, then settle in the more rural areas as they get to know the area better.

For workers coming from other areas of Alaska but outside the region, the following factors were used during 1985-1986:

Anchorage:	20%
Mat-Su and Cantwell:	60%
Kenai-Cook Inlet:	5%
Seward:	0%
Fairbanks:	15%
SE Fairbanks:	0%
Valdez-Chitina-Whittier:	0%

Residence factors for rural areas for these workers are higher than those for the workers coming from out-of-state because it was assumed that the Alaska workers coming from outside the region would know the area better and be more apt to settle in the less populated areas.

As above, the residence factors were increased slightly for Mat-Su and Cantwell, and decreased slightly for Anchorage and Fairbanks during 1987-2002. It was assumed that some workers would temporarily settle in the larger cities, then settle in the more rural areas as they get to know the area better.

It is expected that workers moving from outside the region to communities of the Mat-Su Borough will choose to settle in roughly the same pattern as those workers that move from the Anchorage, Kenai-Cook Inlet and Fairbanks census divisions into the Mat-Su Borough. Accordingly, the workers that come from out of the region will settle in cities and communities as follows:

Palmer:	4%	of workers that migrate to the Borough.
Wasilla:	5%	
Houston:	4%	
Trapper Creek:	25%	
Talkeetna:	25%	
Other Areas:	37%	

3.3 - Residency and Movement of Project Construction Personnel

Here it was assumed that workers would in general choose to live closer to the construction sites than the larger population centers of Wasilla and Palmer. It was assumed that these workers would be willing to trade off some conveniences for a shorter commuting time.

In years where manpower requirements decline from the previous year, it is likely that some of the workers who relocated from outside the region will no longer be employed on the project. This lack of project employment could be temporary or permanent between 1991 and 2002, and permanent after 2002 (to the extent that these workers do not fill the operations jobs).

It is assumed that 50 percent of the workers who lose their employment on the project will leave their place of relocation and return to their original place of residence or go elsewhere in search of new employment. On large projects in the lower 48 states, an average of about 30-40 percent of the workers who have completed their employment on projects choose to remain in the area. The percentage is projected to be higher for this project because it is expected that workers will stay in the area after construction on Watana ends, hoping to obtain employment on the construction of the Devil Canyon dam during 1994 - 2002. It is not possible to forecast at present where these workers will find employment while they are not employed on the project. It is assumed that there will be jobs available on other smaller construction jobs in or near the area, and that other miscellaneous jobs will be available.

After 2002, it is expected that a large number of these workers will choose to remain in the area because by that time they will know about job opportunities in the area and will have an attachment to the area.

Table E.5.31 shows the results of applying the above assumptions. It shows in-migration to and out-migration from communities, cities and census divisions by workers who: (1) lived in the region prior to obtaining employment on the project and subsequently relocated within the region; and (2) workers who relocated to the region from elsewhere. These figures represent the cumulative number of construction workers, by labor category, year, and, implicitly, project phase, that would in-migrate and out-migrate.

Table E5.32 shows the distribution of construction and operations workers by place of permanent residence. The first column shows the cumulative number of workers who will maintain permanent residences in the Railbelt region or Cantwell. These workers will reside temporarily at the work camps while on-the-job. The second column includes workers that will reside permanently outside of the Railbelt region and Cantwell, or permanently at the villages. The third column shows the total number of workers that will permanently reside at the villages.

It is apparent from Table E.5.32 that most of the workforce will reside permanently in the region or Cantwell during all construction years except for 2002. The table also shows that workers who maintain permanent residences are small in number when compared to those that maintain permanent residences in the region or Cantwell.

Residency of Support Employment

Support employment was estimated by applying location and time-sepcific aggregate multipliers to the on-site construction workforce that maintains residences in the region outside of the village. The following multipliers were applied to this on-site workforce:

Census Division	Multiplier (Time Period)
Anchorage	2.1 (1983-84); 2.2 (1985-87); 2.3 (1988-96); 2.4 (1997-2005)
Mat-Su	1.8 (1983-87); 1.9 (1988-2005)
Kenai-Cook Inlet	1.4 (1983-89); 1.5 (1990-99); 1.6 (2000-2005)
Seward	1.3 (1983-99); 1.4 (2005-2005)
Fairbanks	1.5 (1983-89); 1.6 (1990-99); 1.7 (2000-2005)
SE Fairbanks	1.2 (1983-99); 1.3 (2000-2005)
Valdez-Chitina-Whittier	1.3 (1983-99); 1.4 (2000-2005)

The value of each multiplier was adjusted upward slightly to account for the effect of expenditures made by workers who reside temporarily at the camp or village and take occasional excursions in the region and travel to their residences outside the region. The value of each location-specific multiplier was assumed to increase with time because of import substitution and other factors that reflect a maturing and growing economy, and time lags in expenditures made by the work force.

Results obtained from applying the multipliers are shown in Table E.5.33. These figures represent the cumulative number of onsite construction and support workers by place of residence.

(d) Relocating Workers and Associated Population Influx and Efflux

Population influx and efflux will result from in-migration of onsite construction and support workers and their dependents. The numbers of in- and out-migrating onsite construction workers were previously shown in Table E.5.31. The number of in-migrating support workers was determined by estimating the percent of total support jobs accruing to a place that would be filled by in-migrants. The following percentages were used:

Anchorage:	25%
Kenai-Cook Inlet:	15%
Seward:	0%
Fairbanks:	15%
SE Fairbanks:	20%
Valdez-Chitina-Whittier:	30%

Mat-Su Borough:

Palmer:	10%
Wasilla:	10%
Houston:	10%
Trapper Creek:	70%
Talkeetna:	25%
Other Areas:	10%

These percentages resulted from an analysis of the amount of labor potentially available at each place. Unemployment data, labor force participation rates, and underemployment information were utilized in this analysis. These percentages were then applied to the support employment estimates, by place, to obtain the number of in-migrating support workers in each location.

3.3 - Residency and Movement of Construction Personnel

The total number of in- and out-migrating onsite and support workers is shown in Table E.5.34. During the peak of construction activities in 1990, 675 in-migrant direct and support workers will reside in the region. Of this total, 63 will be direct onsite construction workers and the remainder, 612, will be support workers. As manpower requirements fall during 1991-1995, about one half of these in-migrants will remain in the area. It is likely that some of these persons will become employed during the construction of the Devil Canyon dam.

During 1996-1999, workers will again in-migrate to the region. This is shown in Table E.5.34. This in-migration will halt in 1999, and after 1999 there will be some out-migration.

As construction activity is completed in 2002, the percentage of in-migrant workers who remain after construction ends in 2002 is 12 percent. For the Mat-Su Borough, this figure is much higher--60 percent--because the majority of the in-migration to the borough consists of workers originating from the Anchorage, Fairbanks, and Kenai-Cook Inlet Census Divisions; as discussed earlier, it is assumed that all of the direct workers that move to the borough from these Census Divisions will view their moves as permanent and will remain in the borough after their employment on the project has ended.

Within the Mat-Su Borough, the settlement of in-migrants is expected to be different from the distribution of the existing population. It is expected that more than one half of the in-migrants will establish their residences in the area around the communities of Talkeetna and Trapper Creek. A significant amount of settlement will also occur in "other" areas of the borough; this corresponds to areas outside incorporated cities, such as Montana Creek, Caswell and Willow. By the peak of construction activity, it is expected that about 117 onsite construction and secondary workers will have settled in Talkeetna, 168 in Trapper Creek, and 200 in the incorporated cities and other areas of the borough. Migration estimates for all years are shown in Table E.5.34.

Table E.5.35 shows estimates of total population influx and efflux by Census Division and for selected Mat-Su Borough cities and communities. These projections are based on the assumptions that, for the direct construction work force, 90 percent of the workers who relocate from within or to the region will be accompanied by dependents, and that those dependents will average 2.11 per worker (see Table E.5.36 for estimates of population influx and efflux associated solely with the in-migrant onsite construction work force, and see Section 3.1 for a discussion of the rationale for these assumptions).

For estimating population influx and efflux associated with the support work force, the Alaska state average number of persons per household figure was used. Cumulative population influx into the region during the two peak periods equals 1867 and 691, respectively. Almost all of the net population influx associated with the direct onsite construction and support work forces in 1990 will relocate to the Anchorage subarea of the region (the Mat-Su Borough, and the Anchorage, Kenai-Cook Inlet, and Seward Census Divisions). The city of Fairbanks is expected to have a small net out-migration of population as result of the project.

It is expected that the Kenai-Cook Inlet, Anchorage, and Fairbanks Census Divisions will experience slight out-migrations of population during various stages of construction activity, since out-migration to the Mat-Su Borough exceeds in-migration from outside the region. The totals increase as the construction activities end because a portion of the in-migrant workers and their families are expected to return to areas outside the region.

During the peak construction year at Watana, the total project-induced population increase to the Mat-Su Borough totals 1389. This accounts for 74 percent of the total population influx into the region. Of this total, 837 were expected to remain in the borough after 2002.

In 1990, Talkeetna, Trapper Creek, and other areas of the borough will experience 89 percent of the total population influx to the borough: Trapper Creek, 31 percent; Talkeetna, 24 percent; and other areas 34, percent. These projections represent considerable population increases relative to the baseline forecasts for each of these areas. Conversely, Palmer, Wasilla and Houston will experience only moderate increases in population. At the end of construction, total population increases to Trapper Creek, Talkeetna and other areas are projected to equal 212, 209, and 308, respectively.

Numbers and categories of school-age children accompanying in-migrant workers were also projected. For the direct workers that relocate, the number of school-age children accompanying these workers was estimated using a ratio of 0.89 schoolchildren per in-migrant worker accompanied by dependents. This ratio is an average of the ratios observed in other large projects in the lower 48 states.

For the in-migrant population associated with the support workers, it was assumed that a certain percentage of the population would be school-age children. This percentage was arrived at by analyzing recent experience in the Mat-Su Borough. Under the base case for the Mat-Su Borough, the standards that the school district uses for planning were used in this study as well. The borough's short-term plan (through 1987) uses an estimate of 22.8 percent. For long-range planning purposes, an estimate of 25 percent is used. For the purposes of this study, the ratio is assumed to rise gradually from 22.8 percent in 1987 to 25 percent in 2000 and then hold constant at that level through 2005.

School-age children were divided into primary and secondary categories by assuming that the current ratios of primary school students (54 percent of total) and secondary school students (46 percent of total) will remain constant. It was beyond the scope of this analysis to forecast changes in distribution by school and grade.

3.3.2 - Cantwell

(a) The Impact Scenarios

Project-induced employment and population effects in Cantwell were estimated for two cases, the high and moderate impact cases. In the low case (Case A), it is assumed that lack (or high cost) of land and/or housing limits the number of workers at the damsites or in support jobs in Cantwell, who settle in Cantwell. In the high case (Case B), it is B, it is assumed that land and housing will be available at an acceptable cost to accommodate all in-migrating direct and support workers who desire it. It is best to consider Case B as a presentation of an upper range of possible impacts, rather than as a likely scenario. In both scenarios, it is assumed that single-status housing will be available for construction workers at the railhead during 1985-86, and for the railhead operations workers during 1987-1993.

(b) Origin of Work Force

It was estimated that approximately 20 percent of the labor force in Cantwell (which was estimated to equal one half of the population) would receive direct employment on the project without vacating positions that would need to be filled by in-migrants. The remainder of the construction operations workers at the railhead will in-migrate from outside the community.

In addition, approximately 45 percent of the workers who work at the damsites and in-migrate into communities in the local impact area (comprising the Mat-Su Borough and Cantwell) will establish residences in Cantwell, if housing is available. These in-migrants are expected to come from the Railbelt region, other areas of Alaska, and outside Alaska in the same proportions as described in Section 3.3.1 (a).

(i) Resident Employment on the Project

The first column of Table E.5.30 shows the estimated total number of residents now living in Cantwell who will become employed on the project. These figures represent about 11 percent of Cantwell's current population.

(ii) Relocating Workers

The second column of Table E.5.30 shows the estimated total number of construction workers who will relocate to Cantwell during 1985-2002, for Cases A and B (these figures are cumulative). In the first two years, most of the in-migrating workers will be employed at the railhead and in later years most will be employed at the damsites. Railhead workers will be able to live in the bachelor housing provided by the project or in private housing if they desire to have their families with them. All workers employed at the damsite will need to obtain private housing if they wish to live in Cantwell.

(c) Support Work Force

The support work force was calculated by applying an aggregate multiplier of 0.5 to the number of direct project workers living at Cantwell in a given year. This multiplier is slightly higher than the currently estimated multiplier for this small community. It was adjusted upward to account for the effect of expenditures of workers at the damsite who pass through Cantwell while commuting or taking excursions. Approximately 10 percent of the Cantwell labor force is assumed to fill a portion of this project-induced support employment. One half of the spouses that accompany the direct in-migrant work force to residences in Cantwell are also expected to fill a portion of the secondary positions. The remainder of the secondary jobs created will be filled by in-migrants.

(d) Population Influx Associated with the Project

The assumptions used to project the population influx and school-age children associated with in-migrant direct and support workers are discussed in Section 3.1.

Table E.5.37 displays the projected population influx into Cantwell associated with the project, by year, for both Cases A and B. As the table shows, under the high impact scenario (Case B), the project-induced population influx into Cantwell will equal approximately 430 in 1985, rising to almost 1000 in 1990, and then declining to 785 upon completion of the Watana portion of the project. Approximately 90 percent of the population influx will be associated with the direct work force. Approximately 745 project-related people will remain in Cantwell at the end of the project.

Population influx in the low case (Case A) follows a somewhat different pattern. Under Case A, 90 percent of the population influx is expected to occur in the first year of rail siding construction (1985). The construction work force at the railhead, and associated dependents, will account for almost all of that population influx. As some of these workers move out of the area upon completion of the railhead, workers associated with the Watana damsite are expected to move into the private housing they vacate. The project-related population in Cantwell is not expected to increase much further as the project reaches the peak of construction, because of the lack of sufficient housing. After 1990, project-related population will decline by about one third. Approximately 155 project-related personnel are expected to remain in Cantwell at the completion of project construction in 2002 under this scenario.

3.4 - Adequacy of Available Housing in Impact Areas

3.4.1 - Watana - Construction Phase

(a) Local

In the sections below, the adequacy of available housing is analyzed by comparing projected future housing availability in the local and regional impact areas with the demand for housing related to the project. Housing facilities will be provided at the work camps and family villages for all workers desiring housing and for the families of administrative/engineering personnel (workers will not be allowed to bring in their own housing, in the form of trailers or mobile homes, to the work site). In addition, there will be housing provided for construction and operation workers at the railhead in Cantwell. Thus, the probable impacts of the project on housing conditions in the local impact area will be limited to direct and support workers who choose to move their permanent place of residence into the communities.

Projections of future housing stock in the local impact area were developed based upon the following methodology: The projected growth in the number of households, under the base case, was calculated by dividing population projections of each community by population-per-household measures which were assumed to decline gradually over time to converge with national and state averages. As discussed in Section 3.1, the population-per-household measures were derived from the study done by ISER to project electricity demand in the Railbelt. In the ISER model, the average number of people per household is estimated to decline by 20 percent over the next 20 years and is consistent with the project decline in the national level of number of persons per household (Goldsmith 1980).

For Cantwell and most areas of the borough, housing stock was assumed to increase in direct proportion to growth in the number of households. The exception was the area in the Mat-Su Borough outside the incorporated communities, for which it was assumed that the vacancy rate (a very high 25 percent in 1981) would fall in time and, therefore, that the housing stock would increase at a slower rate than the number of households.

(i) <u>Matanuska-Susitna Borough</u>

As indicated above, housing will be provided at the project site for all construction workers and for the families of administrative/engineering personnel. The majority of construction workers on the project are expected to use the onsite housing facilities. These workers will not be in-migrating into established communities and, therefore, will have no impact on the housing market in the Mat-Su Borough.

3.4 - Adequacy of Available Housing

There will be an impact on the availability of housing in the borough to the extent that workers decide to establish permanent residence in any of the nearby communities. The impact of the in-migrating workers (including support workers as well as direct employees) on the housing market in the borough is displayed in Table E.5.38. The Watana construction period will be characterized by an influx of workers and their families between 1983 and 1990, and a gradual emigration of people from the area after 1990.

A total of approximately 485 project-induced households are expected to settle in the Mat-Su Borough between 1985 and 1990, the height of construction activity at the Watana site. Of this number, it is estimated that 355 will be households of direct workers on the project and that 130 will be indirectly related to the project. There will be a projected 2336 vacant housing units in the borough in 1990, or almost five times as many units as in-migrant households. Thus the in-migration is not likely to cause any dislocations in the borough's housing market as a whole. The number of in-migrating workers and their families may be larger than the above figures indicate if (1) a substantial number of construction workers from outside the state in-migrate in the hope of obtaining employment soon after they arrive, or (2) if lack of housing in the Cantwell area forces those in-migrants who would have liked to live in Cantwell to find housing in the Mat-Su Borough.

The period between 1990 and 1993 will see an estimated 28 percent decline in the overall demand for housing by project-related households, as the number of workers needed at the Watana site declines and some leave the area. However, as a result of baseline forecast growth (i.e., growth unrelated to the project) the overall number of households will continue to increase during this period. The decline in Susitna project-related households could be somewhat larger during this period if it appears that the Devil Canyon dam is going to be postponed.

The figures above represent an overview of the Mat-Su Borough housing market. Specific impacts can be judged best by looking at the community level. The majority of housing demand by project-related in-migrants will be concentrated in the northern part of the borough. Vacancy rates in that area have historically been very low and demand is expected to exceed supply, causing rapid construction and some inflation in land and housing prices. This will be discussed in greater detail in the following sections.

(ii) Trapper Creek

The availability of vacant housing in Trapper Creek has been extremely limited. For instance, in 1981, Trapper Creek contained roughly 68 households and 69 housing units. Very low vacancy rates are expected to be the norm in the future, as additional housing is built only to satisfy definite needs. As Table E.5.38 shows, it is projected that the number of households and housing units in Trapper Creek will reach about 107 and 108, respectively, in 1990 (without the Susitna project).

In contrast, it is xpected that an additional 168 workers related to the project (88 direct and 80 support) would be desirous of settling their households in Trapper Creek, if the housing were available. Housing demand in the area would thus increase by 157 percent. This figure could be somewhat higher if unemployed workers come into the area in the hope of obtaining employment on the project; however, the lack of housing available for rent will probably preclude a large number of unemployed job-seekers from settling in this area.

It is possible that speculative activity prior to the construction peak period will result in additional housing units being available to meet part of the increase in demand. Some families may reside temporarily in cabins or rooms owned by lodges in the area, and part of the housing needs may be met quickly by purchase of mobile homes and trailers to be used on individual lots or in trailer parks. Mobile homes and trailers are a common form of housing among experienced construction workers who travel.

While there is not a large quantity of private land in the Trapper Creek area, there is a sufficient amount to support the expected population influx. It is probable that this large increase in demand for housing will lead to increases in land and housing prices.

(iii) Talkeenta

As in Trapper Creek, the availability of vacant housing in the area of Talkeetna has been extremely limited. In 1981, the housing stock consisted of 196 units, of which only two were vacant. It is expected that this trend of low vacancy rates will continue.

The population influx related to the Watana construction phase will result in additional demand for housing by about 88 direct and 29 support households (more if there is an influx of job-seekers) coming into the area between 1983 and 1990. Under baseline forecast conditions, only about six vacant housing units are expected to be available to accommodate these new families.

The expected shortfall in housing supply may be made up by speculative advance construction, temporary residence in local lodges/hotels, the use of mobile homes and trailers, and rapid construction. There appears to be sufficient private land to accommodate this influx. To the extent that the housing supply cannot meet demand, it is likely that some in-migrant families will find housing elsewhere in the northern part of the borough.

(iv) Cantwell

In 1982, there were 27 vacant housing units in Cantwell. Many of these were somewhat remote or could be considered marginal as year-round housing. The number of vacant housing units is not expected to increase under the base case.

Housing will be provided for workers at the railhead, but not for families of those workers. The demand for housing is expected to increase by approximately 135 households between 1984 and 1986, as result of the project (approximately 53 households of railhead construction workers, 27 other households directly related to the project, and an estimated 55 families of secondary workers). Under Case A, the supply-constraint scenario, it is projected that housing will be available for only 40 percent of these households (55), which will include all of the families of railhead workers who in-migrate. Under Case B, the demand-side scenario, it is expected that housing will be available for the households of all workers who want to in-migrate through entrepreneurial activity on the part of Ahtna, Inc., and other private concerns with land holdings in the area.

Land availability is currently a significant constraint to growth in Cantwell. Most of the privately owned land in the Cantwell area is owned by the Ahtna Native corporation. Development of this land for housing for in-migrant households related to the Susitna project will be subject to Ahtna, Inc.'s appraisal of the economic feasibility of this development (Ahtna, Inc. October 1982).

It should be stressed that all the housing that will be required by project workers will be supplied by the project contractor at the railhead in Cantwell and at the damsites. Housing development by Ahtna, Inc., is not necessary to the project. Housing development is likely, however, to affect the decisions of project workers regarding the establishment of residences outside the camps. Housing development is also a significant variable affecting the amount of growth that Cantwell will experience as a result of the project.

Upon completion of the railhead, the number of construction workers living in Cantwell will decline, but this decline will be more than offset by the incoming families of additional workers stationed at the Watana site. By 1990, approximately 330 project-related households are expected to be living in Cantwell under the Case B scenario (301 direct households and 32 support households).

Housing shortages in the first few months of 1985 are likely. It is possible that speculative activity prior to the construction peak period will result in additional housing units being available to meet a portion of the increase in demand. Part of the housing needs may be met quickly by purchase of mobile homes and trailers to be used upon individual lots or trailer parks. The railhead construction workers who bring families will be more likely to seek rental housing or mobile homes/trailers because of their shorter stay in the area. Entrepreneurial capabilities and attitudes toward risk will be important factors influencing the amount and rate at which housing becomes available. Some families may reside temporarily in rooms owned by the lodges in the area, although in the summer these families will be competing for room with the tourists to whom these lodges currently cater. It is likely that this large increase in demand for housing will lead to increases in land and housing prices.

(b) Regional

No significant impacts are expected on housing conditions in the Railbelt outside the Matanuska-Susitna Borough. At the peak of construction of the Watana portion of the project (1990), the cumulative number of in-migrant households into the region and Cantwell is expected to total approximately 1010 of which 365 will be households of direct workers on the project and 645 will be support households. This represents only 0.7 percent of the projected number of households in the Railbelt and Cantwell in 1990. Based upon the assumptions that (1) the housing stock keeps pace with baseline forecast housing demand and (2) vacancy rates average about 5 percent, the estimated number of vacant housing units in the Railbelt and Cantwell in 1990 of 8600 will be far more than sufficient to accommodate the in-migrants.

3.4.2 - Watana Operation Phase and Devil Canyon Construction Phase

(a) Local

Table E.5.39 displays the impact of the project on housing demand in the local impact area during the Devil Canyon construction phase.

(i) Mat-Su Borough

As during the first phase of construction, direct workers on the project will have onsite housing provided by the contractor, and there will be housing available for the families of the administrative/engineering personnel. To the extent that direct or support workers choose to establish residences in borough communities, local housing will be affected.

As construction activity on the Devil Canyon portion of the project begins, another 48 project-related households are expected to move into the Mat-Su Borough between 1995 and 1999. Most of these households will be related to in-migrant support workers, as it is probable that there will be enough direct workers for the project among local residents and the workers who had stayed after construction of the Watana facility was completed. Existing housing is expected to be more than adequate to accommodate these workers.

(ii) Trapper Creek

During the Devil Canyon construction phase, approximately 34 additional families are expected to move into Trapper Creek between 1995 and 1999, bringing to 111 the number of project-related households in 1999 (about 40 percent of all households in the community in that year). As this will be below the earlier Watana peak number of households, adequate housing is expected to be available. After 1999, project-related households are again expected to move out of the area. Approximately 73 of these families will remain in the community at the completion of construction.

(iii) Talkeetna

Between 1995 and 1999, approximately 12 households related to the project are expected to move into Talkeetna, bringing the cumulative number of families living in the community (related to the project) in 1999 to 89, and the total number of households to 670. Adequate housing is expected to be available. At the end of construction of the project, about 72 project-related households are expected to remain in Talkeetna.

(iv) Cantwell

Upon completion of the Watana portion of the project, it is expected that approximately 70 project-related households will gradually move out of the area, and this could result in an oversupply of housing in the community, along with a decline in the value of homes and real estate. The projected decline in housing demand would equal 17 percent of total households in the community. No additional households are expected to move into Cantwell during the Devil Canyon phase of the project. Under Case B, approximately 264 project-related households will be living in the community in 1999, representing an increase of 91 percent over the number of households projected to be in the community under the base case.

(b) Regional

No measurable impacts on housing in the Railbelt are expected during this phase of construction. In 1999, the peak year of Devil Canyon construction, a cumulative total of 610 project-related households will have moved into the region and stayed, representing 0.3 percent of the total number of households in the area. Adequate housing is expected to be available.

3.4.3 - Watana and Devil Canyon Operation Phases

As construction of the Devil Canyon facilities is completed, it is expected that some households of project-related workers will leave the area. Trapper Creek will be most affected by this decline in housing demand. In that community, approximately 38 households are expected to leave the area between 1999 and 2003. An oversupply of housing could result.

The combined operation phase of the project will require a direct work force of about 170. All of these workers and their families will have housing at the site. There will be no impacts on housing conditions in communities in the area.

About 290 of the original 500 households which moved into communities in the Mat-Su Borough are expected to remain in the region. The decline in number of households is not expected to have a significant impact on housing, as the population of the borough will grow rapidly anyway and the decline will occur over a 13-year period (1990-2003).

3.5 - Displacement and Influences on Residences and Business

The potential for displacement of residences and businesses by project facilities and for changing business activity are discussed in this section. As can be seen from the following discussion, displacement impacts will be very small. Other influences on business activity as result of the project will be far more important.

3.5.1 - Residences

Although some cabins used intermittently by hunters, trappers, and recreationists will be displaced by the project, no permanent residences are expected to be inundated or otherwise displaced. Some residents of the middle and upper basin may voluntarily leave the area for other wilderness regions in response to increased construction and recreational activities.

3.5 - Displacement and Influences on Residences and Businesses

The transmission line is currently routed to avoid all known residences and other improvements; however, there are a few privately owned parcels of land that may have improvements on them. The status of these lands and potential improvements on them will be updated by ongoing studies. If there are any displaced residences, displacement would occur during the construction phase of Watana.

3.5.2 - Businesses

There are no known businesses that will be physically displaced by the reservoirs, the transmission lines, the rail spur, or other project-related structures or activities. However, there are businesses that will be impacted in other ways by the project.

Through its impact on the distribution of fish and wildlife and through increases of access to the area, the project may affect certain aspects of business activity. The possible effects are discussed below in regard to natural resource-dependent businesses.

(a) Natural Resource-Dependent Businesses

During the construction phase of each dam, guides are expected to adjust to changes in abundance and location of fish and game species. When both dams are in operation, guides may benefit from increased access to wilderness areas.

Adjustment by guides may take the form of conducting more activity in alternative areas to which they have already been assigned. In the past, guides could register to operate in any or all of Alaska's 26 Game Management Units (GMUs). Since 1976, however, the state has decided to limit guiding operations to three GMUs for each guide. Those already registered in additional units are allowed to maintain their rights to those units, but new guides must register for only three units. In 1980, there were 194 different guides eligible to operate in Unit 13. Only seven of these were registered as operating only in this unit. Statewide, there were about 340 guides.

Therefore, while close to 60 percent of all guides were eligible to operate in this GMU, most of them had alternative eligibility elsewhere. Harvest statistics from 1976 through 1979 show that GMU 13 accounts for 20 percent of statewide moose harvest. Hunting activity as measured by number of hunters shows a similar distribution. If guiding is proportional to hunting activity level, these statistics show that some 80 percent of guiding activity occurs outside of GMU 13. It is possible that other areas could be used more intensively by the guides who will be impacted in GMU 13. The potential impact of this intensified use on existing guides in other areas is not currently known.

Lodges catering to hunters and fishermen could find new opportunities to offer access to activities such as cross-country skiing or to provide facilities for business conferences.

Guiding and lodging businesses operate in the area, as do commercial trappers. Hunting, and river and lake fishing are the mainstay of guiding and some lodge businesses, while furbearing animals support trapping operations.

As discussed in Section 4 of Chapter 3, the net impacts on fish and game (with mitigation) will be small. The distribution of these resources, however, is likely to change. This change may make it necessary for guide businesses to move part of their operations elsewhere. The move may involve the stategic relocation of some physical assets, such as cabins. The project itself, however, is not expected to inundate any such assets or other improvements.

Reduction in the remote nature of the area is expected to have some impact on guiding businesses. If the area becomes readily accessible, guides will lose part of their revenue because some of the residents will not need guiding services. In addition, the area may become less preferred by foreigners. The extent of such impacts is not now predictable.

Trappers will be affected by loss of habitat for furbearers, but will benefit from increased access. The amount and location of harvestable salmon could change, but long-term impacts on the activities of Cook Inlet commercial fishermen, recreational fishermen, and other user groups are expected to be small relative to recent activity levels of these groups. Some estimates of economic and related impacts on commercial fish are reported in Section 3.7.1.

Impacts on recreation will include possible changes in hunting and fishing areas and the loss of sections of the Susitna River to white-water kayaking, but general recreational use is expected to increase as a result of improved access when both dams are in operation.

One active mining site, No. 1 Moose Creek, will be totally inundated. The project may be beneficial to other mining activities by improving access, which will allow existing claims to be worked more profitably and facilitate discovery of new deposits. Most of these benefits would begin to accrue when both dams are in operation and if miners are permitted to use access routes created by construction and operation activities.

It should be noted that Cook Inlet Region, Inc., a regional Native corporation, and a few of its villages have claimed a substantial amount of land in the proposed project development area. Currently there are very few if any Natives that live in the project area. The major impact of the project on this corporation and its villages would be to provide them a possible economic windfall: the claimed land could be traded more advantageously than if the project were not developed; or, the claimed land, if conveyed, would probably be worth more with the development of the dams than without the development of the dams.

(b) General Businesses

Business activity will increase along the Parks Highway between Anchorage and Fairbanks during the mid-to-late 1980s as a result of railhead construction and operation at Cantwell, construction of the access road and camp, and construction of the dam and related facilities at Watana. In general, it is expected that the construction, transportation, wholesale and retail trade, real estate, and services sectors will benefit. Businesses that are contracted to provide specific goods or services such as fuel, communications, housekeeping, trucking, helicopter or airplane support will benefit. Existing support sector businesses such as restaurants, service stations, lodging establishments, retail food stores, etc., will expand and new businesses will be started. Table E.5.40 shows the estimated number of support jobs that will be created by the project in the Railbelt region, and the Mat-Su Borough and Cantwell.

The project is expected to have a significant impact on business activity in Cantwell, a significant but lesser impact on Trapper Creek, and still less of an impact on Talkeetna, Houston, Wasilla, Fairbanks, Anchorage, and Palmer. Cantwell's businesses will have increased sales because a relatively large population will relocate there and because it is the community along the access route located nearest to the construction site. Native Alaskans in

Cantwell, shareholders of Ahtna, Inc., will stand to benefit substantially from this increased business. Many of these Natives lack employment during some or most of the year.

The new residents will have spending patterns similar to those residents now living in Cantwell, and the workers hwo pass through Cantwell are expected to concentrate their expenditures on food, beverages, lodging and related items. Each of the other cities or communities mentioned above, except for Palmer, will experience the same types of impacts as Cantwell, but the impacts will be less pronounced. Because Palmer is not on the Parks Highway and, therefore, not subject to pass-through workers, it will not receive business stimulus from this source.

Members of the Cook Inlet region will own most of the land adjacent to the rail spur that is built from Gold Creek to Devil Canyon. There may be opportunity for the provision of a railroad operations support.

Currently, Ahtna, Inc., and the Native village of Knik provide camp operation services to the Susitna studies personnel located at the Watana site. Both Ahtna and CIRI believe there will be opportunities for construction and camp operation contracts as a result of the project.

During 1985-1990, there could be temporary shortages of goods and services in some of the smaller communities where workers pass through and/or settle. For example, the community of Cantwell will experience significant pass-through and settlement in 1985-1986. Currently, most residents get their food and household items in Anchorage. Unless businesspersons plan and prepare for providing considerably more products in stores in Cantwell, there could be frequent temporary shortages of these products.

Another possibility is that the smaller communities could have excess retail capacity in the early-to-mid 1990s and from 2000 onward. This would be the case if these communities make permanent rather than temporary business adjustments to the demands of the peak work force and associated relocating workers.

(c) Employment

The estimated number of support jobs created by the project in the Railbelt region and the Mat-Su Borough is shown in Table E.5.40. Most of the jobs in the Mat-Su Borough will be located in Trapper Creek, Talkeetna, and unincorporated areas of the borough. It is estimated that current residents of the borough will fill about 55 percent of the jobs created in the borough. These support sector jobs will have a significant impact on the unincorporated communities and areas because employment is seasonal or sporadic and the unemployment rate at any time of the year is probably quite high. Because many of these jobs will be filled by second job holders (spouses and young people) in the base population and dependents of in-migrating workers, they will create beneficial economic impacts because they will add to family income without adding significantly to the population.

The Susitna project will create a significant number of jobs for the region and the Mat-Su Borough. These are shown in Table E.5.41 along with projections of jobs in the Base Case for the region and the Mat-Su Borough. It is apparent from this table that, during the construction phases, the number of jobs created in the region by the project is significant when compared to the Base Case projections of jobs for the region. During construction, the project will increase the total number of jobs available in the region by two to three percent.

3.6 - Fiscal Impact Analysis: Evaluation of Incremental Local Government Expenditures and Revenues

3.6.1 - Watana - Construction Phase

(a) Local

(i) Mat-Su Borough

The expenditures by the Mat-Su Borough with and without the project have been projected on a per capita basis in January 1982 real dollars. It was assumed that current per capita expenditures would be applicable to the future. Other major assumptions regarding revenue projections include: (1) that there will be real growth in property values; (2) future increases will be realized in the mill rates; and that (3) certain per capita receipts of state shared funds, federally shared funds, and municipal assistance funds will be forthcoming. A list of these and other assumptions, rationale for assumptions, and methodology used in making the projections is contained in Appendix 5.C. Additional information regarding methodology may be found in Frank Orth & Associates, Inc. (1982).

3.6 - Fiscal Impact Analysis

Currently, and in recent history, the borough has spent more than has been raised conventionally. Thus, the per capita spending levels used in these projections assume that the borough will be able to continue meeting local needs/wants through state grants. To the extent that the borough may be unable to obtain state grants at the same levels as in the past, the projected level of disparity between revenues from conventional sources and expenditures may not be realized.

The project's impacts on the borough budget as a whole will be minimal. Most of the growth in revenues and expenditures will be related to the baseline population conditions.

The impacts will be largest in the school district and service areas funds. In absolute terms, the education fund will experience the highest increases both in expenditures and revenues. On the other hand, the service areas fund will experience the highest impact relative to the baseline conditions especially in the revenues. Table E.5.42 isolates the area services fund revenue projections for selected years. The impact on the general fund will be small as will the impact on the land management fund. The impact on the general fund will in part be related to the education and service areas portion of funds that are traditionally channeled through this fund.

Revenue impacts of the four funds are discussed first. This is followed by a similar analysis of the expenditures for each fund. This is not to say that the funds are independent of each other. For example, the general fund revenues have elements of education funds as well as funds that are collected as non-areawide taxes for services in the service areas. Discussion of individual funds is therefore limited to identifying impact types. An attempt to aggregate over the four funds would lead to some double counting of revenues and is, therefore, avoided.

Using the figures in Table E.5.43, comparisons between the future with the project and a future without the project (base case) are highlighted, as are comparisons between expenditures and revenues.

3.6 - Fiscal Impact Analysis

All the impacts mentioned are based on total population influx estimates including the population associated with both the direct construction workers and secondary workers. In 1985 and 1990, the direct population influx will account for 78 percent of total population influx. This proportion will increase to 93 percent in 1994 as some of the secondary workers leave after completion of Watana. At the height of Devil Canyon construction in 1999, this proportion is expected to drop again to 86 percent as some indirect and induced populations are attracted by the new level of activity.

- Revenues

All of the four major revenue funds of the borough, including general funds, service areas funds, land management, and school district funds, will grow between now and the end of the Watana dam construction period. All four funds will approximately double from current levels by the year 1990 and will have more than doubled by 1994. This growth will occur with or without the project.

During this period, the greatest project impact in terms of deviation from the baseline projections will occur in the service areas fund. It is projected that the 1990 service areas revenues ($3.4 million) will exceed the baseline revenue projections ($2.7 million) by about 26 percent as result of the population influx during construction at Watana. Even as early as 1985, the service areas fund will have an incremental impact over the base case of 6 percent, while the other funds will be relatively unaffected by preconstruction activity.

The education fund, which in absolute magnitude is greater than the other three funds combined, will experience incremental impacts of the project amounting to less than one percentage point in 1985. The impact in 1990 is projected to be 6.2 percent. In 1994, the education fund revenues with the project exceed the education fund base case by four percent (approximately $2.5 million). The general fund revenues and land management fund revenues will receive relatively little impact.

- Expenditures

Relative to the baseline, increases in expenditures due to the project are expected to be smaller than increases in revenues. In absolute terms, however, revenues and expenditures will rise by approximately the same amount for two of the funds (the general fund and the land management fund).

It is estimated that the population influx into the borough will reach 1389 in 1990 at the height of Watana construction. Related to this population will be an estimated 359 school-age children for whom school facilities and services will be required. In addition, there will be an estimated 300 school-age children at the onsite village for whom the borough will be partially responsible. This will cause an additional expenditure of $4.0 million (for education) over the baseline estimate of $61.1 million. These monies will go toward providing such services as general instruction, operation and maintenance, and other support services. Table E.5.44 contains school-age children projections with and without the project.

The service areas fund is responsible for such services as ambulance, sanitary landfill, library, and road maintainance. As the population grows, demand for these services is expected to follow. The construction of the project will bring several hundred people into some of the communities such as Talkeetna and Trapper Creek. It is estimated that this population influx will cause additional spending for service equal to about $200,000 in 1990.

It must be pointed out, however, that in all four major fund categories, expenditures are expected to be higher than revenues. The incremental expenditures owing to the project generally do not exceed $200,000 in 1985 for any fund. Expenditures of the education fund in 1990 are projected to increase by $4 million, for a 6.5 percent increase over a base case estimate of $61.1 million. This is the highest absolute impact on any fund expenditure or revenue item that year.

- Comparing Expenditures to Revenues

Impacts on both revenues and expenditures are projected to be small relative to the base case. With or without the project, there will be deficits in the borough budget. As can be seen below, the project itself will not greatly contribute to the worsening of these deficits.

1990 Project-Related Pressures on the Borough Budget (in million dollars)

Fund	Increase in Spending	Increase in Revenues	Increase in Deficits
General Fund	1.0	1.1	0.1
School Fund	3.1	4.0	0.9
Service Areas	0.7	0.2	-0.5
Land Management	0.1	0.0	-0.1

It is expected, however, that the borough will have to increase service substantially in the service areas such as Talkeetna and Trapper Creek as a result of the project.

A substantial portion of the service area revenues comes from the state-shared funds and municipal assistance funds. Consequently, there are likely to be time lags between the time these services are initially required and the arrival of funds. A portion of the borough general fund comes from the state in the form of school debt service reimbursement. Recent legislation has increased this funding level to cover 90 percent (up from 80 percent) of the school bond debt service and has reduced the reimbursement lag time so that state funds can be available within the same fiscal year as the expenditures.

Implicit in the projections is the assumption that the property taxes will grow because of both an expanding tax base and increased mill rates, and may constitute more than the 30 percent share of the service areas fund revenues. If this were to happen, the problem of time lags could become even more acute. There is usually a time lag between the time property is assessed and put on tax rolls and the receipt of tax dollars. In the meantime new services may be required, but they face a funds shortfall. Although this has not been a big problem according to the borough budget director, it could be in the future when the spending levels become larger with increased populations (Matanuska-Susitna Borough Finance Director October 1982).

(ii) Talkeetna

Talkeetna is not incorporated and therefore cannot collect taxes. As a result, the fiscal pressures and benefits of the project on Talkeetna will be felt in the borough budget. In 1981, the borough collected $73,000 (in 1982 dollars) on behalf of the community of Talkeetna. In 1990, revenue collections without the project could amount to $169,000. With the project, the corresponding figure would be $188,000, causing an incremental increase in revenue of $19,000.

(iii) Cantwell

Cantwell has no local government and is located in an unorganized borough. Thus, the only currently existing local entities that will experience fiscal impacts from the project will include the non-profit group, Community of Cantwell, Inc., and the Railbelt School District.

The only annual revenue source upon which the Community of Cantwell, Inc., can depend is state-revenue sharing; this usually averages between $25,000 and $32,000 per year for unincorporated communities, and is not based upon the size of population. Thus, it is not expected that the increase in population in Cantwell will be reflected in an increase in these revenues.

The fiscal impact of the project on Cantwell is uncertain, as the result of the range of population impacts that could occur. Because of the unincorporated nature of the community, expenditures will not necessarily need to increase under Case A, the low-impact scenario. A peak population influx of approximately 200 people is not expected to have a large impact on the planned fire station, with the exception of an increased need for volunteer firefighters. However, if the community felt that additional expenditures were needed for community facilities (such as a new solid waste disposal area) because of the population influx related to the project, it is probable that the additional revenue would be sought by way of state grants. At some point in the future, Cantwell may decide to incorporate in order to widen its revenue base and provide more facilities and services for the residents there.

Under Case B, the high-impact scenario, approximately 1000 project-related people could move into the community by the peak of Watana construction. The possibility of incorporation of the community and the need to finance additional community facilities and services would increase greatly.

The Railbelt school district will be faced with an increase in both expenditures and revenues as a result of the population influx associated with the project.

It is estimated that expansion of the Cantwell school will be needed, and the financing for this expansion would need to be requested from the state legislature. The school district expects there would be a one-year lag between a request for revenue for a capital project of this type and the receipt of authorization. Another 2 years would be required for planning and construction.

Operating expenses at the school would also increase to reflect the 250 percent increase in enrollment. The addition of between 7 and 10 teachers would result in an increase in expenditures for teachers' salaries, alone, of $252,000 to $350,000 in 1982 real dollars. Other operating expenses could also be expected to increase proportionately. Total expenses could be expected to reach approximately $1,430,000 by 1990.

The increase in enrollment will also result in additional revenues for the school district. Based upon the present average revenue of $8,683 per schoolchild, 1990 revenues for the school district could be expected to rise by approximately $1,300,000 under the high-impact scenario.

(b) Regional

The project is not expected to have significant regional impacts during this or subsequent phases of development. For further discussion of this, refer to Frank Orth & Associates, Inc. (April 1982).

3.6.2 - Watana - Operation Phase; Devil Canyon - Construction Phase

(a) Local

(i) Mat-Su Borough

Overall, the borough revenues and expenditures will continue to grow during this period, which is expected to last from 1994 to 2002. The following is an analysis of revenues and expenditures at selected intervals during this period.

- Revenues

  - General Fund

    It was assumed that the state would continue to fund the school district through the foundation program, pupil transportation revenues, and other grants. Traditional revenues from these sources have been directly or indirectly based on the school-age population. For this reason, the Susitna project, by increasing the number of school-age children in the borough's responsibility, will lead to increased revenues.

    By 1994, general fund revenues will have grown from a 1981 level of $15.7 million to a baseline projection of $33.1 million. These revenues could, however, reach a higher level of $33.8 million with the Susitna project. The incremental impact is an approximate 2.1 percent increase over the baseline forecast. In 1999, the corresponding forecast for the general fund revenues are $41 million and $41.9 million and show an incremental impact over the base case of 2.2 percent. This trend of diminishing relative impacts continues and is reflected in the projections for the year 2002 when the project impact over and beyond the base case forecast will be 1.9 percent. The incremental dollar amount is estimated at $0.9 million.

  - Service Area Fund

    At the start of the Watana operation phase and the early stages of Devil Canyon construction (1994), the service areas fund revenues will have grown to $3.9 million compared to a baseline forecast of $3.1 million. The incremental impact relative to the base case will equal about 25.8 percent (compared to the 1990 impact of 25.9 percent). The absolute magnitude of the impact itself would be $0.8 million.

By 1999, the absolute magnitude of the project-related increase is projected to equal one million dollars. Relative to the baseline forecast for that year, this translates to a 27 percent increment. At the completion of the Devil Canyon construction phase in 2002, the incremental impact of the project would be 23.8 percent based on a base case forecast of $4.2 million in revenues and a project scenario revenue level of $5.2 million.

. Land Management Fund

Land management fund revenues are the smallest of the four funds considered. During this phase of development, the greatest impact on land management revenues is projected to occur in 1999. This will be a 3.4 percent impact but will be negligible ($0.1 million) in absolute magnitude.

. School District Fund

The baseline forecast for this phase shows that school funds will grow from $62.1 million in 1994 to $80.9 million in 1999 and $93.4 million in 2002. The corresponding incremental impacts of the project are estimated at 4.0 percent, 3.2 percent, and 1.8 percent, respectively. In no case does the absolute increment exceed $2.6 million.

- Expenditures

. General Fund

Incremental impacts in the general fund expenditures are projected to be no higher than 1.7 percent of the base case in 1994. The baseline expenditure for that year is $40.1 million. In 1999, expenditures will have grown to $51.2 million in the base case and $51.9 million, assuming the project scenario, and will, therefore, experience an incremental impact of 1.4 percent. The reduction in relative incremental impacts is also shown in the 2002 projections where the impacts amount to 1.0 percent.

- Service Area Fund

With the project, the service areas fund expenditures are projected to experience somewhat higher percentage incremental impacts than will the general fund expenditures. Service areas expenditures will be increased by $0.2 million in each of the years 1994 and 1999, leading to corresponding percentage impacts of 1.7 percent and 1.3 percent. These estimates are based on baseline projections of $11.7 million and $15.9 million, respectively.

- Land Management Fund

Actual changes in the base case expenditures resulting from the project are forecast to be very limited.

- School District Expenditures

As in the Watana construction phase, the number of school-age children at the onsite village school is expected to remain constant at about 300. Workers are expected to take advantage of the availability of housing at the work village throughout the Devil Canyon construction period so that the number of school-age children at this village will remain high, although the total construction work force will be lower than in the earlier period. However, the number of school-age children associated with the project in the rest of the borough will be somewhat lower (see Table E.5.44). For this reason the project impacts on the school budget will be lower than those to be experienced in the earlier period.

Incremental impacts on the school district expenditures are, however, forecast to be greater than those of the other borough funds both relative to the base case and also in absolute terms. In 1994, impacts on expenditures are projected to be 4.5 percent of the $76.1 million baseline. The corresponding impact levels for the years 1999 and 2002 are, respectively, 3.8 percent and 1.9 percent. Of the three years considered, 1999 will experience the largest absolute impact at $3.5 million.

- Comparing Expenditures to Revenues

As in the Watana construction phase, revenues and expenditures will grow during the second phase of development. This growth is depicted in the projections that assume construction and operation of the project as well as in the base case. Over time, a widening gap between expenditures and revenues is forecast and will occur with or without the project. In general, the growing deficit situation is not forecast to be worsened nor alleviated by development of the project. However, examination of individual funds (see below) reveals that school district deficits get slightly worse while general funds and service areas funds tend to experience some improvement with the project. The amount of relief or additional burden, however, is dwarfed by the overall size of the deficits involved.

1990 Project-Related Pressures on the Borough Budget
(in million dollars)

Fund	Incremental Spending	Incremental Revenues	Incremental Deficits
General Fund	0.9	0.7	-0.2
School Fund	2.6	3.5	0.9
Service Areas	1.0	0.2	-0.8
Land Management	0.1	0.1	0.0

(ii) Talkeetna

Revenue collections on behalf of Talkeetna are projected to grow in the base case from $169,000 in 1990 to $233,000 in 1994 and to $365,000 in 1999. The corresponding growth with the project is forecast to be from $188,000 in 1990 to $246,000 in 1994 and again to $382,000 by the year 1999. The incremental project impacts in 1994 and 1999 are, therefore, $13,000 and $17,000 compared to $19,000 in 1990. These increments will contribute to growth of the service areas fund revenues.

(iii) Cantwell

As the Watana construction phase is completed, it is expected that between 70 and 215 project-related residents will leave Cantwell (athough the population and school enrollment in Cantwell are expected to remain more than three times as large as would be the case under the base case). This would be reflected in a decline in any per capita revenues that the community receives and a lessened ability to support any new infrastructure that has been developed.

The school district will also be faced with a decline in both revenues and expenditures as the enrollment in the school declines by about 30 children. Over-capacity in the school, and any resulting financial burden, may be avoided by careful planning.

3.6.3 - Watana and Devil Canyon - Operation Phases

(a) Local

(i) Mat-Su Borough

There will be few residual fiscal impacts after completion of Devil Canyon construction. The service areas and the school district will continue to serve some of the population influx together with the operations personnel at the dams who remain in the borough. The number of school-age children associated with the project will decline. Those at the construction village will be reduced by at least half, leaving the children of operations personnel. Most of the project-related school-age children in the general population will move out of the borough with their families. Adjustments in services by the borough during the earlier periods will be adequate to handle requirements by the residual population.

(ii) Talkeetna

In the base case, the borough is projected to collect \$468,000 on behalf of Talkeetna in 2002. With the project, the corresponding collections are expected to be \$482,000. The incremental impacts because of the project in this year, will, therefore, be both lower in absolute magnitude and more relative to the baseline than the 1990 forecasts.

3.7 - Local and Regional Impacts on Fish and Wildlife User Groups

The purpose of this section is to indicate how the project will affect users of fish, game and furbearers. Amounts and locations of impacts as these relate to users are provided where possible.

The section is organized in three main parts. These parts discuss potential impacts on users of fish, game and furbearers, respectively. An overview of adverse impacts on these users is provided below.

Many persons use fish, game and furbearers that could be affected by the project. Some of these persons, particularly those in the "railroad communities" north of Talkeetna, have reported that up to one-half of their food has come from locally caught fish and game, and home gardens (Braund 1982). Interviews with persons in the railroad and other nearby communities indicate that the availability of fish and game is important to their lifestyle as well as to their physical sustenance. If any users are adversely impacted by the project, they will most likely be these types of users.

Without mitigation, persons who use salmon, moose and pine marten will be most affected. It is projected that up to 6000 spawning salmon could be lost annually from several sloughs between Devil Canyon and Talkeetna. It is also projected that a significant number of moose and pine marten could be lost from the middle Susitna basin, primarily south of the Susitna River in the case of moose, and in the impoundment areas and transmission corridor in the case of pine marten. In addition, the geographic distributions of salmon, moose and pine marten will be altered.

With mitigation, it is projected that potential salmon losses in the slouths between Devil Canyon and Talkeetna will be negligible; there will be no decrease in moose populations; and that the distribution of moose will change. It is projected that moose will tend to congregate in browse-enhanced tracts during the winter and hunting seasons. In addition, although no large changes in salmon distributions are projected, it is possible that salmon distribution among sloughs could change. There is no way to mitigate most of the loss of pine marten.

While the biophysical effects of the project, with mitigation, will be negligible to most users, this might not be the case for all users. Changes in salmon, moose and pine marten distributions will disrupt the use patterns of local users.

The largest impact of the project on fish and wildlife users will be from easier and, therefore, increased access to fish and wildlife. Existing as well as potential users will have easier access. This will increase competition for fish and wildlife among existing users and new users. Potential conflicts could be reduced through effective management.

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3.7 - Impacts on Fish and Wildlife User Groups

3.7.1 - Fish

(a) Methodology

The impacts to Alaska's fishery resources which would result from construction of the Susitna dams depend upon loss of habitat rather than specific loss of fish. The river habitat can be viewed as a production ground capable of producing a number of fish each year. The exact numbers produced depend upon many aquatic and environmental conditions which vary over time.

Data are available which provide salmon escapement levels for several points along the Susitna River for 1981 and 1982. To the extent that these two years are representative of the long run salmon productivity of the Susitna River, they can be used to estimate potential losses from dam construction. Compared to long term averages, both 1981 and 1982 salmon returns were high. Information from Chapter 3 suggests that that potential impacts to the salmon resouces downstream from Talkeetna resulting from dam construction would be "limited". Therefore, this section has focused on how the potential impacts above Talkeetna would impact users of the fisheries resources.

Assuming a worst case, the maximum loss to the salmon resource would be 100 percent of the slough spawning escapement above Talkeetna. This provides an estimate of the maximum potential loss which would occur annually, given the 1981 and 1982 escapement levels. Harvest-to-escapement ratios for Cook Inlet were estimated by ADF&G in 1975 (Friese 1975). These ratios can be used to estimate total potential salmon losses which would result from loss of spawning salmon above Talkeetna.

In Chapter 3, another estimate of potential losses to salmon escapement is provided for salmon utilizing slough habitats for spawning in the Talkeetna-to-Devil Canyon stretch of river. These sloughs may not be accessible during the spawning season as a result of dam construction. The potential loss of the number of salmon utilizing the slough habitat for spawning, therefore, is another estimate of the potential loss to the salmon resource. Both of these estimates are developed in this section. Specific impacts on fishery resources are discussed, to the extent possible, in the section immediately following. In later sections, users of the resources are discussed in the categories of commercial and noncommercial use.

(b) The Commercial Fishery

A basic assumption has been made that the commercial fishery for salmon produced in the Susitna system occurs only in upper Cook Inlet. This assumption is based upon an ADF&G/Su Hydro 1982 report (ADF&G 1982h). The report states that commercial fisheries in lower Cook Inlet are primarily terminal, occurring in small bays. Therefore, few salmon migrating to Upper Cook Inlet are intercepted in the lower inlet area.

The upper Cook Inlet is divided into two management divisions: the Central District and the Northern District. A map showing the boundaries of the management area of Cook Inlet is shown in Figure E.3.7 in Chapter 3. The most important regulatory distinction between the two areas is that both set and drift gillnets are allowed in the Central District, whereas only set gillnets are allowed in the Northern District.

Table E.5.45 shows the average annual commercial catch and value from the fishery in the upper Cook Inlet. The most important species, from the standpoint of economic value, is sockeye salmon. The average annual sockeye ex-vessel value for the ten-year period from 1973 to 1982 was $10,717,244. The average annual catch was 9,173,314 pounds. The second most important species in terms of value is chum salmon. The average annual chum catch was 4,940,850 pounds, giving an average annual ex-vessel value of $3,145,970. The other species in descending order of economic value in the upper Cook Inlet are coho, pinks, and chinooks. The actual catch and value fluctuate for each species from year to year, but the ten-year average provides a reasonable indication of recent trends (Commercial Fisheries Entry Commission 1982a).

The Cook Inlet commercial catch can be attributed only in part to salmon production from the Susitna system. The fishery is on mixed stocks with the contribution by individual river systems being indeterminant. The exception is sockeye salmon; estimates for the upper Cook Inlet commercial fisheries in 1979 and 1980 fisheries show stock contribution to the sockeye harvest by the Susitna River was 22.7 percent and 19.2 percent respectively (Friese 1975). The commercial data provided for Cook Inlet refers to the entire commercial catch rather than the specific proportion of the catch attributable to salmon production from the Susitna system.

The number of participants in the commercial salmon fishery is limited to the number of permits issued. The numbers of drift gillnet and set gillnet permits for Cook Inlet for the years 1975 to 1981 are shown in Table E.5.46. A small number of the set net permits, perhaps 10 percent, are from outside the upper Cook Inlet fishery. The total number of permits used in 1981 was 1161 (ADF&G 1982b). With an average of 2.5 people per set net site, the total number of fishermen in upper Cook Inlet would be approximately 2500 people. The catch distribution between the different gear types varies by species due to the different areas fished. Chinooks are taken mostly in the set net fishery, whereas chum salmon are taken mostly in the drift net fishery. The other species are taken on a more even basis. In general, the set net fishery takes more of the coho and pink catch, while the drift net fishery takes more of the sockeye catch.

(i) Specific Impacts

The specific impacts to the different fish species that would result from construction of the Susitna dams have been determined in a preliminary manner. For the salmon resources, for example, there are point estimates for the 1981 and 1982 escapements of fish passing upriver from Talkeetna. This upstream reach of the river, from Talkeetna to Devil Canyon, where many of the impacts are likely to occur. It would be erroneous to assume that two point estimates provide a total representation of the actual productive capacity of the river. Similarly, it could be misleading to assign values to potential losses based only on these estimates, since the final evaluation of all impacts of construction of the Susitna dams has not been completed.

Given the above qualifications, the following discussion may be useful as an example of order of magnitude of potential project impacts on the commercial fisheries. The slough habitat from Talkeetna to Devil Canyon has been identified as the most likely area for adverse impact from project operation. The largest potential impact above Talkeetna would be to chum salmon, since this species utilizes sloughs, in addition to the tributary and mainstream Susitna River, for spawning. In 1981, an estimated 20,835 chums passed upriver past the Talkeetna Station. Using this figure of 20,835 fish and assuming a worst case (Case 1) that the dams would result in a 100 percent loss, a loss to the total Cook Inlet chum run of 45,837 fish would be indicated. This assumes a catch escapement ratio of 2.2:1. Applying an ex-vessel prive to this number of fish, a potential ex-vessel value of $214,517 would have been lost to the commercial fishery in 1981 (see Table E.5.47).

This estimate should not be interpreted as a precise figure since it is based upon preliminary biological data. It does, however, provide a point estimate for the potential post-project loss to the upper Cook Inlet commercial fishery for chum salmon based on a number of assumptions. Table E.5.47 shows a similar set of calculations for sockeye, pink, chum and coho losses which would have occurred during 1981 and 1982, assuming as a worst case there would be a post-project loss of 100 percent above Talkeetna.

The potential losses estimated for chum salmon are the highest of the four species included: $214,517 for 1981 and $467,568 for 1982. Similar estimates for coho, pink and sockeye can be seen in Table E.5.47. As noted in Chapter 3, the sockeye spawning in the sloughs seem to be wanderers and not a reproductively viable population. Chinook salmon were not included in estimates of potential losses since Susitna chinook are projected to receive very limited impacts from the project. It should also be noted that the calculations are based upon a catch-to-escapement ratio of 2.2:1 for coho, chum, and sockeye; and 3.8:1 for pinks.

Case 2 provides a second estimate of potential losses to the Cook Inlet commercial fishery. The number of spawning salmon which utilize the slough habitat from Talkeetna to Devil Canyon are estimated in Section 2 of Chapter 3. Assuming a post-project total loss of production from this habitat, the potential losses to the commercial fishery were estimated for 1981 and 1982. These estimates for Case 2 are shown in Table E.5.48, and are considerably smaller than the potential losses from Case 1. If the biological impacts represented by Case 2 are the more accurate estimates, then the potential losses to the commercial fishery shown in Table E.5.48 would provide the better estimate.

The two estimates, provided in Cases 1 and 2, should be interpreted as a range of potential impacts to the commercial fishery from dam construction.

(c) Non-Commercial Use - The Sport Fishery

Statewide sport harvest data indicate that potential impacts to the sport fishery which would occur if the Susitna dams were constructed would be in three main areas. One area would be the impoundment area of the proposed dams and the areas downstream. A second area of potential impact would be upstream from the impoundment areas in the mainstream Susitna and possibly into some of the tributaries such as the Lake Louise-Lake Susitna-Tyone Lake areas. The third would consist of areas which could be reached from the access road, between the Denali Highway and the Watana site.

The biological impact areas and quantified levels of impact to resident and migratory fishery resources that would result from the Susitna dams construction have not been determined for all of these areas. Data on specific angler use of the Susitna and tributaries above the Talkeetna confluence are virtually nonexistent. There are, however, data describing use patterns on the lower Susitna and main tributaries which will be presented in summary.

The East Susitna Drainage-West Cook Inlet-West Susitna Drainage areas consists of some of the major sport fishing areas of the state. These include the Deshka River, Alexander Creek, Talachulitna River, Willow Creek, Montana Creek, Clear Creek, Sheep Creek, and others. In these areas, there were over 97,000 angler days fished in 1981 (Mills 1981).

A summary of the sport fish catch by major species and total number of angler days expended in the lower Susitna drainage is shown in Table E.5.48. Many of the areas included in this table may be out of the area of impact from the Susitna dams, but they do indicate levels of angler activity.

Guiding is a support service to sport fishing. There are at least two guide businesses which operate in the mainstream Susitna upriver from the Talkeetna confluence to the proposed damsites. They guide fishermen to areas such as Portage Creek and some of the Slough areas of the Susitna River. The two businesses which have been identified are Mahays Riverboat Service and the Talkeetna Riverboat Service, both operating out of Talkeetna. To the knowledge of the study team, there are no Native-owned fish guiding service businesses currently operating in the impact area.

(d) Non-Commercial Use - Subsistence Fishing

The subsistence catch of fish produced by the Susitna system discussed in this section refers only to the catch from Cook Inlet. The Cook Inlet subsistence catch has been recorded for several years by the Alaska Department of Fish and Game. Other personal use fishing does occur in the Susitna River system, but data are not available with which to evaluate the magnitude of the catch of that fishery. Subsistence fishing within the Susitna Basin is not a recognized fishery by ADF&G.

3.7 - Impacts on Fish and Wildlife User Groups

As was the case for the commercial catch, the subsistence catch of salmon in Cook Inlet is on mixed stocks. Therefore, the entire subsistence catch cannot be attributed to Susitna-produced fish. However, since these are the only data available to show subsistence use patterns, they are presented here.

The subsistence catch of salmon in Cook Inlet, by species and year for the period 1969 to 1981, is shown in Table E.5.49. During this period, the number of permits increased from 330 to 1178, with most of the increase occurring from 1979 to 1981. It should be noted that the change in numbers of permits over this period is due, at least in part, to regulatory changes. The catch of salmon has followed the same pattern as the number of permits, increasing rapidly after 1978 to the largest catch in 1980 of 16,973. Overall, sockeye and coho contribute most to the total catch. In 1980 and 1981, however, the chinook catch was very significant, with over 2000 fish taken each year, representing 13 to 14 percent of the total catch (ADF&G 1982c).

Although the residents of English Bay, Port Grahm and Tyonek qualify for subsistence permits, to date, the community of Tyonek has accounted for most of the subsistence catch in Cook Inlet. Since that community is predominantly Native, most of the catch is by Native subsistence fishermen.

The value of the Cook Inlet subsistence catch is unknown. The value of the subsistence catch as a food source to rural Alaskans could perhaps be determined using a shadow price. The ex-vessel price of the salmon, a valuation sometimes used for subsistence, is not an appropriate measure since it can be assumed that subsistence fish are for consumption as food. Ex-vessel prices paid for salmon are for a production input to a commercial fish processing business. A more appropriate measure of value for subsistence fish as food to rural Alaskans would be retail cost of salmon delivered to the point of subsistence capture, or the price of an equally desirable, alternative food source. There may also be social, cultural or religious values associated with the capture, preparation and use of salmon. If this is the case, then these additional factors are also important and should be considered in the determination of the value of the subsistence catch.

3.7.2 - Game

Chapter 3 of Exhibit E contains estimates of impacts of the Susitna project on the game animals found in the area. These impacts, especially with mitigation, are small. However, changes in the distribution of important species like caribou and moose

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3.7.2 - Game

Chapter 3 of Exhibit E contains estimates of impacts of the Susitna project on the game animals found in the area. These impacts, especially with mitigation, are small. However, changes in the distribution of important species like caribou and moose are expected to result in impacts to some of the users of these resources. In addition, increased access is likely to lead to competition of the resources between current and new users.

Discussion of the impacts on game users requires that the user groups be identified first. Two major groups are involved and include commercial and non-commercial users. For each group of users, the use patterns are described. An examination of the probable interface of the project conditions and existing use patterns is presented in order to identify probable types of project impacts on these users. The identified types of impact are then discussed in the context of the users' ability to adjust to new conditions, including using alternative geographic areas or engaging in other activities. Due to inadequate data, the discussion is necessarily qualitative and is intended to provide a basis for future monitoring of the identified impact types.

(a) Commercial Users

There is no direct commercial exploitation of big game. Most game animals are hunted for recreation, trophies, and food, rather than for commercial purposes. In the following discussion, a description of indirect commercial use by various secondary industries that to some degree depend on big game resources is presented.

(i) Guides and Guide Services

Guiding is a common part of hunting in Alaska. Non-residents have been required to hire guides if they are hunting certain species. Recent legislation makes it mandatory for nonresidents to use guides for all species in the future. Since the services offered by some guides cover the whole spectrum of the hunter support activities, this section describes the support industry as a whole.

Guides who make at least part of their annual income from big game hunting activity may be divided into three groups: assistant guides, registered guides, and master guides. Assistant guides cannot execute contracts with clients, but must work for a registered guide.

Registered guides are full licensed operators and may own exclusive guide areas or operate in joint areas with other guides. Exclusive guide areas are recognized as assets and may be transferred for a fee from one guide to another as long as the transfer is recorded at the Game Licensing and Control Board.

A master guide is a registered guide who has been in business for a considerable time and is nominated by two of his contemporaries.

In 1980, there were 194 different guides eligible to operate in Unit 13, where the proposed project is located. Only seven of these were registered as operating only in this unit. Statewide, there were about 340 guides. Each guide may be licensed to operate in three different units; therefore, many have alternative areas for business. Some can still operate in all the state's 26 units, if they were licensed to do so before the new regulation came into effect.

Services offered by guides and service charges vary from guide to guide. In some cases, in addition to guiding, a full range of services may include, but not be limited to:

- Transportation;
- Lodging;
- Cooks;
- Boat Transportation; and
- Camping equipment.

To provide this range of services, considerable investment is required.

Guiding businesses are expected to be indirectly impacted. If the project reduces the number of available harvestable animals, it is conceivable that this would reduce hunting opportunities. Regulations, such as permit hunts that limit the number of hunters for a given season, could result. In areas where the permit hunt systems already exist, the number of available permits may be reduced. This scenario translates into reduced business volume for the guiding industry. Furthermore, if increased access leads to reduction in the remote nature of the area, guiding in the area would be impacted. Access related impacts would be possible, even if the number of animals to be unaffected by the project. Impacts would be more pronounced if guides were unable to compensate for reduced business volume by raising price or moving to substitute hunting areas. As discussed in Section 3.5, alternative areas exist but it is not known what the impact of intensified activity would be in those areas.

Possible impacts depends at least in part on: (1) the reduction in animal populations; (2) changes in hunting regulations in response to reduced animal populations; (3) the relationship of animal abundance to hunting quality; (4) increased access that reduces the remote nature of the area; and (5) changes in animal population distribution. The first of these is expected to be small, since no net losses are expected for the important species of moose and caribou, especially if mitigation measures are implemented (see Section 4 of Chapter 3). Therefore, any changes in regulations are more likely as a result of increased access and animal population distribution rather than due to reduction in total abundance.

The quality of hunting may change in specific areas due to the redistribution of animals. This could impact the guiding industy if no alternative areas are available. Increased access, however, will probably be the more likely cause of impact to the guiding industry in the region by changing the remote nature of the area. Increased access during construction, coupled with noise and other construction-related disturbances, may result in a need for adjustment on the part of those guides that currently use the area.

It is not known whether, instead of serving relatively few high paying clients who place a high value on the wilderness experience, the guides would serve a higher volume of clientele that would pay less on a per capita basis. If such an adjustment is possible, the guiding industry may be able to avoid adverse impacts.

Determination of the impact of reduction in remoteness will require monitoring. Increased acces may mean that hunters who would otherwise need guides would no longer require this service in the area. According to state law, all nonresidents must use guides. This part of the new market would, therefore, not be affected except for the hunter's attitude toward loss of remoteness. These attitudes will need to be monitored as construction begins. User interviews could be conducted to make this determination.

(ii) Lodge Operators

In Terrestrial Environmental Specialists (1982) three different lodges in the project area were identified. The include the Stephan Lake Lodge, the High Lake Lodge, and the Tsusena Lake Lodge. All are currently well maintained and are used for private and guided fishing and hunting as well as a research base for the Susitna project.

The lodge on Tsusena Lake is now used by the owners for private hunting, fishing and recreation. The High Lake Lodge was leased to Acres American Incorporated during the past two summers for work on the Susitna Hydro project studies.

The Stephan Lake Lodge, operated commercially as a base for guided hunting and fishing, has 10 structures. The current operator also maintains seven cabins which are used as outreach bases for hunting and fishing in the more remote areas. The Lodge offers full services, including guided hunting and fishing, and handles six to eight hunters and about 30 fishing recreationists each year (Bailey 1982, Personal Communication).

For the most part, the services offered are packaged deals. These include:

- Air transporation to and from the lodge and hunting grounds;

- Lodging during the hunt. The lodge itself is used and so are the cabins. When necessary, tent camps are set up if hunting is to be done in areas removed from the lodge and the cabin locations; and

- Guided hunting and fishing. For hunting, available species include bear, moose, and sheep. This particular operation does not provide guided hunting for caribou or goat.

Guiding charges by this operation are as follows: A bear hunt typically costs $5000, a moose hunt $4000, a combination hunt for moose and bear, $7500.

In addition to the lodges directly in the project area, there are several other lodges on the highway system between Anchorage and Fairbanks and between Paxson and Cantwell which cater to visitors to the Susitna Basin. Listed below are 18 lodges which are located between Wasilla and Healy on the Parks Highway and between Paxson and Cantwell on the Denali Highway.

Location	Comment
Wasilla to Houston	
Klondike Inn	
Willow to Healy	
Pioneer Lodge	
Sheep Creek Lodge	
Montana Creek Lodge	
Big Su Lodge	Talkeetna vicinity
Talkeetna Roadhouse	Talkeetna vicinity
Swiss Alaska Inn	Talkeetna vicinity
Chulitna River Lodge	
Jack River Inn	In Cantwell
Jere-A-Tad Lodge	North of Cantwell
North Face Lodge	
Healy Roadhouse	In Healy
Paxson to Cantwell	
Paxson Lodge	In Paxson
Tangle River Inn	
Southeast Susitna Lodge	
Susitna Lodge currently leased by Denali Mining Co.	Not open to public.
Gracious House	Guided and unguided hunting, cabins and bunkhouse
Adventures Unlimited	Near Butte Lake

The impact of the proposed project on lodge operators would be indirect. None of the lodges identified are expected to be physically affected by the presence of the project. However, it is possible that some of the grounds used for camping will be inundated. Adjustment to this type of impact may take the form of utilizing alternative areas and providing other activities. The level of economic impact may depend on whether these lodges can serve a different type of clientele. Instead of foreign clients who seek wilderness hunting and fishing experiences, the lodges may cater to more in-state residents as the area becomes more accessible.

Future service may be provided to photographers and other non-consumptive users staying for fewer days at a time, in place of hunters who may stay for weeks at a time. By catering to more people and charging less instead of serving fewer wilderness-seeking clients at relatively high prices, the lodges may avoid losing income. In this respect, lodge operations are different from the guiding businesses. Guiding, by its nature, tends to depend on availablility of areas that are unfamiliar to the general public, while lodges, for the most part, care about the occupancy. Lodge businesses, therefore, are unlikely to suffer due to increased access, but may instead benefit from the influx of more people. Thus, through changes in their modes of operation, the lodge operators might be able to successfully adjust to changing conditions.

(b) Non-Commercial Use of Game Resources

(i) Management and Regulations

To provide an overview of the various responsibilities for the management of game resources in Alaska, the following brief narrative is given.

The Board of Game has the overall mandate to create all the regulations governing the taking of game. The regulations may be developed for various purposes. Some of the regulations now in effect relate to open and closed seasons and areas, the setting of quotas for harvest, and designation of management areas. Figure E.5.7 illustrates the location of the Game Management Units (GMUs). The proposed location of the Susitna Project is in GMU 13 (see Figure E.5.8

for details). The Board also promotes research and the training of people for game management. To assist the Board in the performance of its duties, advisory committees may be established in various parts of the state with powers to hold public meetings and to establish emergency closures of hunting seasons when necessary.

The Commissioner of Fish and Game, through the Division of Game, fulfills his duties to "... manage, maintain, improve, and extend the ... game ... resources of the state." (Alaska Statute Undated). The Division meets this responsibility in various ways, including assessing game populations, identifying and protecting important habitats, and preparing reports for the public and to inform the Board. This Division may recommend regulations to the Board of Game. Through cooperative efforts with the Division of Wildlife Protection, the Division of Game also participates in the enforcement of hunting regulations.

The public can participate in many ways. Through the election of public officials, the public determines the overall legislation regarding the management of game. The public can also petition the Board of Game to influence the formation of regulations.

- The Hunter

Big game hunters in Alaska may be classified into two groups: recreational hunters and subsistence hunters. Recreational hunters, including trophy seekers, may be Alaska residents, other citizens of the U.S., or foreigners. The second group is made up of exclusively Alaska residents who under subsistence criteria have qualified to use game resources. The following discussion focusses on these two groups. Researchers, for experimental purposes, take game animals. However, because this use constitutes small removals, the project is not expected to affect research users.

It may be pointed out that, except for the use of caribou, harvest statistics do not distinguish between the types of use. For this reason, subsistence use of game resources in the project area has not been determined.

Resident hunters hunt for trophy and meat; nonresidents and foreigners primarily for trophies. Subsistence users have the main goal of bringing home food meat. This includes the objectives of (1) obtaining high quality goods at a relatively low price; (2) fulfilling certain cultural traditions and obligations to their community or family; and others.

Currently, subsistence use has priority over other uses with the provision that it shall not interfere with resource conservation efforts. The issue of subsistence use is a controversial one in Alaska, and a proposal to eliminate subsistence priorities appeared on the ballot in 1982 and was defeated.

The extent of subsistence utilization of the resources in the project area is not known. However, some idea of the significance of subsistence use of caribou may be gained from examination of the number of hunting permits that are reserved for this purpose. During the 1981-82 hunting season, 53 permits out of a total of 1600 were issued to subsistence users. Of the 53, 36 had successful hunts in which caribou were taken. Examination of the residence status of all qualifiers who received these permits reveals that less than 15 resided in the communities of Cantwell, Talkeetna, and Trapper Creek. Of the 1750 drawings permits for caribou hunting in GMUs 13 and 14 for the 1982-83 season, 450 were reserved for subsistence. This constitutes a large increase in the allocation of subsistence permits. The results of the season's success will not be know until later this year or some time in 1984.

(ii) Resources and Use Patterns

The following discussion deals with all noncommercial use of game resources. This approach is necessary because the harvest statistics do not distinguish between recreational use and subsistence use.

The big game resources identified as having the most potential to be impacted include caribou, moose, black and brown bear, Dall sheep, wolf, and wolverine. The following section is devoted to describing the use patterns relating to several of these resources. It is difficult to assess the economic importance of individual species because of the complicated nature of the regulations. Available information from a few of the guides in the area shows the relative fees charged for the various species. However, there is no information on the business volume nor the percentage of this volume that is represented by each species. Moreover, hunts are sometimes conducted as combination hunts and charges made on that basis. The relative importance of the project area in providing hunting and guiding opportunities may be inferred from examination of harvest from GMU 13 relative to statewide harvest. In 1978-79, harvests from this unit represented the following proportions of statewide harvest:

Moose	14.5%
Caribou	9.0%
Wolf	9.0%
Brown bear	8.0%
Black bear	5.0%

Some detailed information available regarding caribou and moose is presented below. Further analysis of the other species could be provided at a later date if more detailed statistics are received from other contractors.

- Caribou

The Nelchina herd is highly migratory. It is known to have utilized the Nelchina Basin ranging from the Wrangell and Mentasta Mountains in the east through the Lake Louise flats to Talkeetna Mountains and Chunilna Hills in the west (see Figure E.5.8). For purposes of discussing possible impacts of the project, data on this herd as a whole will be treated as being relevant. However, special attention could be given at a later date to Game Management Subunits 13A, 13B, 13E, 14A, 16A and 16B. Subunit 13E contains most of the proposed impoundment area while 13A and 13B are adjacent to the area. Areas 14A, 14B, 16A and 16B are to the southwest, but nevertheless constitute areas which in the past have been used by the herd.

. Resource Status

Population estimates over the past 20 years show that the herd numbers were greatest in the early 1960s. The 1962 population estimate was recorded at some 71,000 animals. The herd declined to a recorded low of 7690 animals in 1973; since that time, the herd has partially recovered. The current ADF&G management plan calls for maintenance of the herd at about 20,000 adults. The population levels of the 1950s and 1960s are thought to have been excessive and to have overutilized the habitat.

. The Experience Sought and Hunter Residence

Hunting for caribou provides both recreation and food meat. The Nelchina herd is conveniently located near the largest population concentration in the state. Accordingly, residents of Anchorage and Fairbanks represent a major proportin of the total number of people who hunt this herd.

. Transporation To and From Hunting Grounds

Acces to the hunting areas is by various means. However, the three most frequently reported transport means are air transportation, off-road vehicles (ORVs), and a combination of highway and foot access. Statistics for the period 1973-74 to 1980, in which hunters listed the "primary" method of transportation to the hunting areas, show an evolutin of access means preference. In the very early 1970s, highway vehicles were the most frequently reported means of access. This was followed closely by ORV transport and air transportation. Later, ORVs took over the lead and air transport followed. More recently, air transport has been most frequently reported, while ORVs and highway vehicles follow.

The proposed Denali access road is likely to alter the distribution of harvest if it is opened to the public. The Susitna Nenana subherd would be impacted. Thus, localized increases in hunting pressure on some subherds are possible. The road has the potential to isolate a range that could support up to 10 percent of the Nelchina herd. This may result in less caribou for hunters in the mountains between the Parks Highway and the access road, north of the Susinta River. However, the total harvest in GMU 13 is not likely to change because of the project, as long as the current permit hunt system remains in effect.

- Hunting Pressure

Hunter participation in harvest of the Nelchina herd has historically been greater than that of recent years. The drop in participation from historic levels has not been voluntary, but has been accomplished by regulatory reform. The limited resource size and the carrying capacity of the range together with increasing demand to hunt in the area led to management measures that reduced and limited hunter participation. By 1980, participation as measured by numbers of hunters had dropped to under 30 percent of the 1970-71 level. In 1980, an estimated 982 hunters, compared to 3710 in 1970-71, were involved in hunting for Nelchina caribou. The reduction in total hunting pressure is even greater than indicated by this comparison if one considers that in some areas of GMU 13 the bag limit is currently one caribou, whereas in the early 1970s and before, some hunters took as many as three animals during each regulatory year.

Current levels of hunting pressure are controlled by use of permits. The number of permits is determined, at least in part, by the estimated caribou population and management objectives for maintaining a certain level of population size. The current population size of about 20,000 is well below peak historic levels.

- Supply and Demand for Hunting Opportunity

There has been a widening gap between the supply of drawing permits issued and the total number of applicants for this hunting opportunity. As shown below, the number of applicants for these permits doubled between 1978 and 1979 and continued to grow during the following year, while the number of available permits grew from 1000 to 1300 over the same period. Demand for hunting opportunity outstripped the supply by a factor of

3 to 1 in 1978 and 5 to 1 in 1980. It is possible that the number of applicants is a low estimate of demand. The number applying would probably grow faster if the number of available permits was higher. Knowledge that the probability of obtaining a permit is low may be stopping some would-be applicants.

Caribou Permit Hunt In G.M.U.'s 13 & 14

Year	No. Permits	Applicants	Harvest
1978	1000	2775	529
1979	1300	5600	630
1980	1300	6841	621

Controlled hunting pressure in the form of a limited number of hunters each year and a bag limit, have apparently helped the recovery of the resource while at the same time ensuring a steady success rate for individual hunters.

- Success Rate

Success rate, as measured by the reported number of animals taken per participating hunter, fluctuated rather widely during the period from 1970-71 to 1980. In the 1970-71 season a total of some 3710 hunters took 3790 animals; the success rate was 1.02 animals per hunter. As many as 1415 hunters were unsuccessful that year. This apparent contradiction is explained by the fact that some hunters took as many as three animals each. In 1973, the rate dropped to 32 percent, indicating one kill for every 3 hunters. Success, however, has improved and stayed above 60 percent since the institution of permit hunts in 1977. The success rate was approximately 63 percent in 1980. Through limits on the number of hunters, the institution of permit hunts is (at least in part) responsible for stabilization of the success rates. The other factor affecting success rates may have been increased herd numbers which themselves benefited from the permit hunt system. However, since hunting pressure has been controlled through different regulatory regimes over the years, success rates do not indicate the relative quality of hunting.

3.7 - Impacts on Fish and Wildlife User Groups

- Moose

For purposes of impact analysis, moose populations in the Susitna River Basin have been divided into two groups and studied as upstream and downstream moose. Big game studies conducted by ADF&G revealed that upstream moose consist of 13 subpopulations that conduct a significant amount of their year-round activities in and around the proposed impoundment area. They are associated with the numerous creeks and rivers that are tributaries and subtributaries of the Susitna River (ADF&G 1982d).

Downstream moose include those subpopulations that have their home ranges to the south of the proposed Devil Canyon damsite. They traverse areas to the north and south of Talkeetna, utilizing both sides (east and west) of the Susitna. These areas constitute one of the most important wintering habitats for moose in the state (ADF&G 1982e).

. Resource Status

Population characteristics of moose in the study area are discussed in Section 4.2.1 of Chapter 3. Moose populations were on the increase during the 1950s in GMU 13. Throughout the 1960s and the first half of the 1970s, moose populations declined because of poor winter conditions. Since 1975, moose populations appear to have stabilized. During the fall of 1980, ADF&G sampled portions of the study area in GMU 13 and made a gross estimate of 4027 animals as the population of upstream moose in parts of subunits 13A, 13B, and 13E. Figure E.5.9 shows the study area utilized in these and prior studies. However, the 1980 study concentrated most of the survey effort in count areas (CA) 6, 7, and 14 (see Figure E.5.10). Data for moose in CA 7 and CA 14 historically exhibited sex and age composition characteristics similar to those of moose in the whole of GMU 13. Both the upstream and downstream moose contribute to guided and unguided hunting for recreation, antler trophies, and meat.

. Experience Sought and Hunter Residency

Most nonresidents take moose for antler trophies, while residents take moose for meat in addition to the recreation activity involved.

3.7 - Impacts on Fish and Wildlife User Groups

Resident hunters who seek moose in GMU 13 are most frequently residents of Anchorage, Fairbanks, Palmer and Whittier. The rank order of participation in GMU 14 is Anchorage, Palmer, Wasilla, Whittier and others. Anchorage, Whittier, Fairbanks and Eagle River residents are prominent in moose hunting in GMU 16. In each case, Anchorage resident account for 50 percent or more of total resident participation.

. Transportation To and From Hunting Grounds

The most frequently used transport means for moose hunters in GMU 13 are: highway vehicle, off-road vehicles, air transport and boat. Frequently, these methods are used in combination with one another and with others such as snow machines. Transport data used for this discussion are derived from harvest ticket reports, which allow for reporting a combination of travel means. The use of highway vehicles is the most common method of transport to the general area. Within the area, however, other forms are more common.

. Hunting Pressure

Hunting pressure in terms of number of hunters participating in GMU 13 has varied over the past 12 years and so has the success rate. In 1971, 4881 hunters participated to take a total of 1814 moose for a success rate of 37 percent. The corresponding activity for 1981 was 3105 hunters who experienced a success rate of 25.6 percent. Table E.5.50 contains hunting pressure and total harvest of moose in GMU 13 since 1970.

Hunting pressure is controlled by regulation in various ways. At least three basin methods are available and are used alone or in combination to achieve management objectives in specific situations. As contained in the Alaska hunting regulations pamphlet number 23, these methods were applied with varying intensity in GMUs 13, 14, and 16 and elsewhere. These methods are: (1) limiting the season; (2) harvest quota (usually optional use of permits); and (3) direct limitations on effort (optional).

Hunting seasons and other regulations are set and supervised by the Board of Game and its advisory committees; this is done for each GMU, subunit, or for specific areas within a subunit. The Game Division of ADF&G advises the board and participates in the enforcement of regulations. Harvest quotas are set directly by specifying that only a certain number of animals may be taken during a given season.

Direct effort limitations are also applied; this is done mostly by issuing a limited number of hunting permits, which are either competed for (drawing permits) or are given out on a first-come, first-served basis (registration permits). For the 1982-83 moose hunting season, a total of 655 permits (of which 65 were registration permits) were planned in a total of six subunits or areas in GMU 14. There were 180 permits for two locations in GMU 16 of which 30 were of the registration type. The method of direct effort limitation was not used in GMU 13. Instead, moose size limitations were used; only bulls with an antler spread of at least 36 inches (90 cm) could be harvested. Regardless of the method used, only one animal was allowed per hunter. This is an indirect way of limiting total harvest and effective hunting effort.

Since 1972, various regulations were used in areas of GMU 13 which have helped to radically reduce the total harvest. The "bulls only" rule combined with shorter harvest seasons and a bag limit of one moose have been responsible for the decline in harvest. As can be seen in Table E.5.51, the total number of hunters has itself stayed well over 2200, while total harvest fell from 1814 in 1971 to 712 in 1972 and has since remained below 900 each year.

- Success Rate

The reported success rate of hunters has fluctuated between 19 percent and 36 percent since 1972. The average success rate from 1972 through 1981 was 26.8 percent and ranged from a low of 19 percent in 1980 to a high of 36 percent in 1979. The 1981 success rate was, therefore, above average for the past 10 years. It is however, in contrast to the rates depicted during the late 1960s, when success was generally above 30 percent. In 1960, the success rate approached 50 percent. Changes in moose populations and regulations which limit the number of hunters or the season are important factors in the determination of success rates. Since these factors have changed over the years, the success rates do not readily indicate relative hunting quality.

- Importance of Regulations

In addition to changes in recreational quality which might lead recreationists to choose other areas, the project could also prompt stricter regulations and further reduce opportunities to hunt in the area. For some species, the regulations are already very strict compared to years past. The project may lead to further tightening of current regulations. Regulations on the hunting of moose (whose numbers in the region have been increasing) may be relaxed in the near future, but if these prove unsatisfactory and mitigation measures do not compensate for moose losses in the impoundment area, further restrictions may be required.

Some idea of the current supply of hunting opportunity in the project area may be gained by examining the hunting regulations pertaining to GMUs 13, 14, and 16. For example, there are more opportunities to hunt for black bear than brown bear.. This is reflected in the per hunter bag limit of three black bears each year compared to one brown bear every four years. Similarly, whereas there is no bag limit for wolf in GMU 13 nor for wolverine in GMUs 13 and 14, there are rather stringent rules on the hunting of caribou, moose, and Dall sheep for the 1982-83 hunting season. This pattern reflects both the condition of the resource and the regulatory philosophy.

If the expected inundation of black bear habitat leads to significant reduction in harvestable numbers, changes in regulations aimed at protecting the remaining population may be instituted. If this happens, the opportunity to hunt for black bear may no longer be as liberal. Thus, the impacts of the project on the hunter and on current levels of use could occur by reducing the quality of hunting and through changes in regulations aimed at protecting populations of individual species.

- Impacts on the Hunter

There are several factors that influence the number of hunters who will visit any given site. One of the most important is the quality of hunting to be expected at the site. As stated above, the regulatory regime governing the taking of game is also important. Both of these factors could be affected by changes in animal populations. The impacts of the Susitna project on the hunter are therefore expected to stem from both alterations in the quality of available sites and regulator limitations on participation. The hunter who prefers remote areas may also be impacted by increased access that will be created by the presence of the project.

The access issue is complication by consideration of land ownership. Ownership and its implications for access rights to hunting sites may make discussion of project impacts on the hunter a secondary issue. The future structure of land ownership and stewardship in the project area may play a more significant role in determining access to hunting areas than will the presence of the project. Upon permanent conveyance of selected Native landholdings, these lands will become private property. It is difficult to say how these lands would then be used.

3.7.3 - Furbearers

The major furbearer species in the impact area include lynx, beaver, mink, muskrat, pine marten, red fox, river otters, short-tail weasels (ermine), and least weasels. Wolves and wolverine are also often trapped for their fur, but for purposes of this study these species have been classified as game.

Trapping, and some hunting, of furbearers for the purpose of selling pelts is the major human use of these species. While some trapping is done on a part-time basis by individuals who have recreational cabins, it is difficult to distinguish between commercial and noncommercial trapping activity, since these individuals sometimes keep the furs for their own use and sometimes sell them to supplement their income. No statistics are kept which distinguish between commerical and noncommerical trapping activity. As a result, this discussion will concentrate on the trapper group as a whole.

The commercial trapping of specific species increases and decreases in cycles, in accordance with the abundance of the species and, to some extent, the price of pelts. Trapping intensity is also affected by the amount of access that exists in an area. Access can be provided by trails and clearings as well as by roads.

Available data on the activity of trappers operating in the impact area and the size of harvests are of limited usefulness because of several factors explained below. Thus, this section will focus on a general description of the trappers operating in the vicinity of the project and the economic value of the species they harvest.

In general, it is expected that the major impact on trapping could be an increase in access to a remote area that is not currently heavily trapped (trappers could use the access road or the cleared right-of-ways of the transmission lines to gain access to the area upon completion of the project). This is expected to result in an increase in the number of trappers, though it will not necessarily be a beneficial effect for the trappers who are currently operating in the middle and upper Susitna Basin.

The benefits of increased access for trappers could be moderated or negated by the following possible developments:

- As the regional corporations Ahtna, Inc. and Cook Inlet Region Inc., take title to the lands they have selected in and around the project area, much of the land on which trapping occurs will become private land. These private landholders may very well restrict trappers from operating on their land, irrespective of the project.

- The state can take steps to either restrict public use of the road to the dam sites, or to restrict project workers and related users of the road from engaging in trapping. There may also be regulation of the transmission lines to ensure that other users of these relatively clear areas are discouraged.

3.7 - Impacts on Fish and Wildlife User Groups

(a) Data Limitations

The impact area of the project as it relates to game and furbearers (see Chapter 3) crosses the boundaries of several Game Management Units, as defined by the Alaska Department of Fish and Game. Thus, it is difficult to relate estimates of harvests in particular GMUs with harvests in the impact area. Furthermore, it is difficult to determine harvests of furbearers within a particular GMU from available statistics, due to the types of data collected and the difficulty of obtaining data by the origin of the fur.

Records are kept by the state on trapper exports of furs, dealer purchases of furs, and dealer exports. Table E.5.51 displays data on trapper exports and dealer purchases, by species, for 1977 through 1980. In addition, sealing reports, which include all pelts obtained from a particular locale, are compiled for three furbearer species: lynx, river otter and beaver.

It is believed that these data underestimate actual harvests in GMU 13 to such a degree that the statistics are not useful in this context, for several reasons. First, the basis for the first three types of records is the residence of the individual trapper or dealer reporting, not the actual origin of the furs. In the case of GMU 13, many of the trappers who operate there are actually residents of other areas such as Anchorage and the surrounding suburbs. The pelts that they obtain are thus not included in the statistics on GMU 13. In addition, expc t data are likely to underestimate actual harvests signif antly because a certain percentage of pelts are used in-state or sold to tourists in the form of garments and thus are not included in the statistics.

(b) Trapping Activity

In general, it appears that there is not currently a large number of trappers operating in the areas in which furbearer populations are expected to be affected. This seems to be due to the relative inaccessibility of the area.

The 1980-1981 trapper questionnaire prepared by the Alaska Department of Fish and Game estimated that five individuals trapped in the Cantwell-Denali area and six trappers operated around Talkeetna-Petersville (this includes an area far larger than the impact area). Approximately 35 percent of the trappers responding to the overall survey (which included all Game Management Units in the south-central region) indicated that they had not trapped during the 1980-81 season, and many of these indicated they had not done so because of the mild winter and lack of snow (ADF&G 1981). Oral interviews with residents of the local impact area, as part of the land use portion of this study, indicated that early trappers were also few in number but covered far more extensive areas in their trapping. In the 1940s and 1950s, many long-time trappers switched over to the more lucrative activity of guiding big game hunts (Jubenville 1981).

It is estimated that there are a large number of residents of the local impact area who do some trapping on a part-time basis and keep the pelts for their own use or sell a few to supplement their income in the winter months. There are no data available on the size of this user group; however, very few of these residents trap in the areas around the project site in which furbearer habitat will be affected. Land use investigations of the project area showed that approximately six to eight part-time trappers worked out of cabins along Clarence Lake, Deadman Lake, Portage Creek, Indian River, and some other large lakes in the middle Susitna Basin in 1981-1982.

Winter trapping currently is focused in areas near Stephan Lake, Tsusena Creek, and Clarence Lake. Trap lines in the south-central district average 25 miles (41 km) in length, and are ususally travelled by snowmobile. There are also some traps set by trappers working out of aircraft in the eastern portions of the Susitna valley. These have become economically feasible as a result of the value of lynx, wolves, wolverine and other high-priced pelts.

(c) Aquatic Species

(i) Baseline

Beaver and muskrat are present in some tributaries and lakes in the middle basin with beaver being increasingly more abundant downstream from Devil Canyon. No beaver are known to live in the Watana impoundment area, nor in the portion of the Susitna River between Watana and Devil Canyon. The beaver population on the Susitna River between Portage Creek and Talkeetna is estimated at 70. There are also approximately 65 beaver along Deadman Creek, which is located near the proposed access road from the Denali highway to the Watana site.

Muskrat pushups were seen at 27 of the 103 lakes surveyed in the middle basin (see Chapter 3). No sign of muskrat has been observed on the Susitna River between Devil Canyon and Talkeetna by the project team.

Values for beaver pelts in 1982 were in the range of $10-$55. Muskrat pelts were valued at between $1.00 and $4.50 for pelts of animals that were trapped (H.E. Goldberg & Co. 1982), and between $.50 and $2.00 for slight shot pelts (at breakup, muskrats are harvested by hunters shooting from boats). Historically, beaver and muskrat in alpine areas, such as the project sites, are seldom pursued by trappers due to the relative cost of obtaining the furs versus their market value. Exports of beaver pelts are not currently high, reflecting the relatively low price. It is believed that trapping of beavers downstream from Devil Canyon has not declined as much as exports. Often, trappers continue to operate but delay sale of the pelts until the price rises (ADF&G 1982f).

The meat of both muskrat and beaver is used as well as the fur. The meat is used for bait, for dog food, and for human consumption.

River otter and mink are common in areas of the middle basin of the Susitna, but trapping effort of these species has not been great. Otter are relatively difficult to trap and the pelt values have not usually been high enough to justify the effort. Mink are abundant near some lakes and streams and all major tributary creeks; otters are common in the middle Susitna River basin. In this area, mink are only trapped incidentally while seeking other species. 1982 market prices per pelt ranged from $20.00 to $70.00 dollars for otter, and $10.00 to $50.00 for mink (H.E. Goldberg & Co. 1982).

(ii) Impacts of the Project

According to Section 4 of Chapter 3, approximately 75 beaver will be lost in the project area as a result of construction of the project. This will be partially offset by an increase in beaver populations downstream from Devil Canyon in sloughs not managed for salmon mitigation. Approximately 5 to 10 muskrat will be lost during construction of both projects. These declines are not expected to have a significant impact on trappers in the impact area.

From the perspective of economic impacts to commercial trappers, the increase in access into the middle basin is expected to more than compensate for the decline in animal population caused by the impoundments and borrow sites. Downstream from Devil Canyon, the improved habitat for beaver resulting from the alteration in stream flows can be expected to result in more profitable trapping.

Mink and otter will remain on lakes and ponds of the project area, but approximately 21 percent of river and stream habitat upstream from Gold Creek will be lost. Partially offsetting this, changes in water level and flow may improve habitat for mink and otter near Devil Canyon and downstream from it. The impacts on current trappers are not expected to be significant, owing to the small amount of trapping of these species in the project area.

(d) Pine Marten

(i) Baseline

Pine marten (sable) are abundant in the vicinity of the proposed impoundments and have been historically important to trappers. It is estimated that there are 150 pine marten present in the area to be flooded by the Watana impoundment and 55 in the Devil Canyon area. The value of marten from south-central and interior Alaska in 1982 ranged from $10 to $50 per pelt (H.E. Goldberg & Co. 1982).

(ii) Impacts

As discussed in Section 4 of Chapter 3, the impacts of the project on the pine marten are expected to be of the greatest magnitude of all furbearers because of this species high dependence upon forested habitats along the Susitna River and its tributaries and the inundation of habitat of that type by the impoundments. Habitat supporting up to 130 marten will be lost in the reservoirs and transmission corridor. This represents approximately 11.5 percent of the marten population in the middle Susitna basin. In those areas, the harvest of marten by trappers could decline accordingly. It is expected that the increased access to areas supporting marten will be beneficial to trappers, to the extent that this access is allowed.

(e) Lynx

Lynx have been scarce in south-central Alaska in recent years but there are indications that the population of this species will be increasing over the next couple of years. The population of lynx generally is prone to large fluctuations which are related to the size of the snowshoe hare population, a major food source. Lynx are very rare at present in the middle basin.

The wholesale value of a lynx pelt in the spring of 1982 ranged from $100 to $500 depending upon the size and quality of the fur (H.E. Goldberg & Co. 1982). It is believed this high value has induced additional trapping pressure of lynx in the region and has increased the economic feasibility of running trap lines with aircraft (Gipson, September 1982).

Until 1980, there were prohibitions against the export of lynx pelts that were part of an international effort to preserve this species. No such controls currently exist. The present scarcity and high value of lynx in south-central Alaska may be resulting in an underreporting of the harvest of this species by trappers due both to concerns about future reinstatement of controls and to sensitivity regarding their current income.

(f) Fox

The fox population in the impact area has been low since the 1970s. Project research indicated that only one trapper operated in the Tyone-Susitna and Devil Canyon areas in 1979-1980, and that in 1980-1981 and 1981-1982 there were two and three trappers, respectively, seeking fox pelts. Very few fox were actually taken in each of these years; thus, impacts of the project on trappers of fox would be minimal.

(g) Secondary Industries

There are several categories of businesses that are directly or indirectly affected by the fortunes of the trapping industry in Alaska. These include enterprises which sell equipment, clothing and food to trappers; individuals who build and/or lease cabins; tanning establishments; fur dealers; and garment manufacturers, among others. Due to the relatively small percentage of Alaskan trappers who operate in the impact area (less than 0.5 percent), impacts of the project on these secondary industries are not expected to be significant.

4 - MITIGATION

4.1 - Introduction

FERC regulations do not explicitly define mitigation policy or goals for socioeconomic impacts. Nevertheless, the responsibility exists to mitigate significant adverse impacts.

This section describes measures to mitigate the direct impacts of the project. Section 4.2 discusses the background and approach to mitigation and Section 4.3 is a summary of communities' attitudes toward changes. Section 4.4 presents a mitigation program based upon mitigation objectives and community attitudes.

4.2 - Background and Approach

The order of mitigation priorities presented by the Council on Environmental Quality include (1) avoiding impacts, (2) minimizing impacts, (3) rectifying impacts, (4) reducing or eliminating impacts over time, and (5) compensating for impacts. The objective of mitigation is to avoid or minimize impacts that are perceived to be costly, disruptive, or otherwise undesirable. Mitigation measures are proposed when the private sector (market mechanism), existing local and state government mechanisms, and social assimilation mechanisms (social service organizations, churches, etc.) do not have the capacity, capability or responsiblity to adequately mitigate adverse impacts.

It is important to recognize that the labeling of a project-induced change as adverse is often a normative decision. Each individual within a community will have his own view about the impact of a change, and individuals change their view with the passage of time. Likewise, communities develop opinions regarding change, by concensus or other means, and this opinion, or label, is also subject to change with time. Section 4.3 discusses current attitudes in the affected communities.

The process used to develop the mitigation program is:

(1) To examine recent attitudes toward changes in potentially impacted communities;

(2) To use recent attitudes to label changes as adverse or beneficial;

(3) To determine significant adverse changes;

(4) To develop mitigation objectives;

(5) To identify measures to avoid significant adverse project-induced impacts;

(6) To identify measures to minimize, rectify, reduce or eliminate, and/or compensate for any remaining significant adverse project-induced impacts; and

(7) To develop an impact management program.

The Power Authority proposes several significant mitigation measures in Section 4.4. These measures will be refined during the design period. Some of the factors that will be taken into account during the refinement process include:

- The evolution of citizens' attitudes;

- The development of communities located near to the construction sites;

- Refinements in baseline and with-project socioeconomic forecasts; and

- Development of information on the use of fish and wildlife resources.

The Power Authority recognizes that mitigation planning for socioeconomic impacts is especially dynamic and will be able, through its impact management program, to identify and mitigate many adverse impacts before they occur. This program is elaborated further in Section 4.5.

4.3 - Attitudes Toward Changes

According to a survey done in mid-1980 (Policy Analysts 1980), persons in Palmer, Wasilla, and Houston are generally in favor of development projects. These communities want more economic development (particularly jobs) and a more diversified and stable economic base. In Cantwell, public response to economic development (and to the Susitna Project, specifically) has also been generally positive. However, these indications should be taken as tentative because these persons probably had not fully absorbed and reflected upon the information made available to them when they expressed their views. In addition, most of the residents of Cantwell are not aware of the large impacts that could result in or near Cantwell if Ahtna, Inc. leases or sells land for development of housing and related facilities.

Persons in Cantwell were more guarded than persons in other communities about their general support for the potential project-induced changes. Several of these persons wanted more jobs for residents of Cantwell and more sales for local businesses, but were concerned about project-induced traffic, price increases for goods, services, housing and land, needs for additional education facilities and services, and impacts on the environment such as potential losses of fish and wildlife.

4.4 - Mitigation Objectives and Measures

Residents of Trapper Creek and Talkeetna have indicated that rapid and uncontrolled change is not desired. Some of the residents of each community would like no changes and others in each community would like to have controlled economic development. Those in favor of controlled development want to proceed with caution and learn more about what could happen to their communities as a result of the project before committing to a growth plan. Several residents were concerned about potential losses of fish and wildlife, potential loss of the wilderness or remote character of the middle Susitna basin, and the preservation of fish and wildlife. Additional information about these and other small communities' attitudes toward changes is provided in Braund (1982).

Project-induced changes in Anchorage and Fairbanks are expected to be slight. Therefore, these residents' attitudes toward change are not covered here.

4.4 - Mitigation Objectives and Measures

The following mitigation objectives are largely based upon the attitudes presented in Section 4.3:

- Avoid large and rapid population influxes into nearby communities such as Cantwell, Trapper Creek, and Talkeetna. This will result in avoiding substantial shortages of housing and community facilities and services, cost of living increases, and changes in lifestyle/way-of-life;

- Avoid large traffic increases on the Denali and Parks Highways, especially during the summer months;

- Avoid large loss of wilderness and remote attributes of the middle Susitna basin, including the avoidance of losses of fish and wildlife resources;

- Avoid frequent interactions between workers and fish and wildlife, including involuntary interactions such as injury to animals by vehicles and consumptive use of fish and wildlife by workers; and

- Minimize, reduce or eliminate over time, or compensate for, significant adverse impacts caused by construction worker-related population influxes and effluxes.

Two categories of mitigation are available during design and construction of the project. The first category (see Section 4.4.1) contains mitigation measures that help avoid significant adverse impacts. These measures are usually part of project design and construction procedures and include, by design or default, the negotiations between project contractors and entities that represent elements of the work force.

4.4 - Mitigation Objectives and Measures

The second category (see Section 4.4.2) contains measures that help communities or other bodies cope with project-induced disruptions that occur during or remain after project design. The Power Authority will first seek to avoid significant adverse impacts, and then it will seek to minimize, reduce or eliminate over time any remaining significant adverse impacts. The last recourse will be compensation for impacts.

4.4.1 - Mitigation Measures That Would Help Avoid Significant Adverse Project-Induced Impacts

Factors such as timing of manpower demand; leave, shift, and shift rotation schedules; housing and related facilities at the construction site; and a transportation program for workers can be managed, subject to the results of labor negotiations, to produce different magnitudes and geographic distributions of project-induced changes and impacts. Each specification of these factors will produce unique magnitudes and geographic distributions of project-induced impacts. Some specifications will cause impacts to be largely avoided in some places.

(a) Timing of Manpower Demand

To the limited extent, it is economically and technically feasible the Power Authority will schedule construction with consideration for minimizing seasonal and annual peaks in the work force and maintain more steady levels of employment. This will help avoid or reduce the magnitudes and rates of forecasted project-induced population and related changes in communities located nearest to the project site. It could also help reduce average daily traffic during the summer months on the Denali and Parks Highways.

(b) Leave, Shift, and Shift Rotation Schedules

Different leave, shift, and shift rotation schedules will result in different amounts and patterns of residence relocation and commuting by workers. These amounts and patterns can be predicted accurately enough to be helpful to mitigation planning.

Prior to negotiations with representatives of elements of the work force, schedules which appear to be most consistent with preferred impacts on communities and workers and which would result in an acceptable cost to the project will be defined by the Power Authority. This definition will be made through simultaneous analysis of this and other mitigation measures discussed below. To the extent possible, the Power Authority will negotiate labor contracts to conform to schedules that help avoid significant adverse impacts on communities and workers.

(c) Housing and Related Facilities

The availability, siting, type, quality, and administration (including camp policies, rules and regulations) of housing and related facilities will greatly affect workers' residence preferences. Experience at other projects that are comparable to this project has shown that there is a tendency for many workers, especially those with families, to relocate to nearby communities if housing is not available at the construction site. Because communities located near the Susitna construction sites do not have the capacity nor the desire to have their populations increase several-fold in a two or three year period, it would be appropriate to provide acceptable housing for the workers at the Susitna construction sites.

It has been observed at projects similar to the Susitna Project (semi-remote or remote construction sites, variable and frequently unfavorable weather conditions making commuting difficult, and nearby communities that are small and have little infrastructure) that, if adequate worker housing and related facilities are available at the construction site and if the leave and other schedules are developed appropriately, workers will tend to maintain their existing family residences and reside at the worksite during shifts. This has resulted in minimizing resettlement by workers in communities located near construction sites.

As a measure to avoid large population influxes into nearby communities, the Power Authority will provide single status accommodations at the construction sites for shift workers, and family accommodations and related facilities for workers who will be at the worksite on a more permanent basis. These arrangements, together with appropriate leave and other schedules, will reduce resettlement by workers in nearby communities. Detailed planning for the siting, type, quality, and administration of housing and related facilities for workers will begin in 1983 and continue through the design period.

(d) Transportation Program for Workers

The impacts discussed in Section 3 were forecasted under the assumption that there would be no transportaton program available to the work force. Workers would be responsible for getting to and from the construction site on their own, and would be permitted to come and go as they desire from the worksite. Parking would be provided for the workers near the site.

4.4 - Mitigation Objectives and Measures

The absence of a transportaton program has the general effect of increasing population influxes into small communities located nearest to the site. A carefully planned transportation program would reduce these influxes and would influence both the geographic distribution and magnitude of other project-induced changes from what they would be in the absence of such a program. For example, the largest departure from the community impacts discussed in Section 3 would occur if most workers were to travel by organized air transportation to the construction sites from the larger cities such as Anchorage and Fairbanks. In this case, impacts on the small communities located nearest to the construction sites would probably be substantially less then the currently forecasted levels. Smaller departures from forecasted communities impacts would occur if other modes of transportation (as elaborated below) were emphasized in a transportation program.

A multimode and flexible transportation program would best serve the interests of the communities and the workers. A program that includes a combination of private (personal) and organized ground (bus and, possibly, van) transportation will allow those workers living in communities along the Parks Highway, including the cities of Fairbanks and Anchorage, easier access to the construction site.

Workers could be encouraged through incentives to use organized transportation; it has been observed on other projects that more local workers are hired and that workers are less tired, more alert and punctual, and miss fewer work hours and days if organized transportation is used. This will be particularly true for this project because buses can cope better with the weather than most private vehicles and reduced traffic will result in fewer collisions with other vehicles and wildlife. The project-induced traffic estimates presented in Section 3.1 would be significantly reduced by an organized ground (or air) transportation program.

The ground transportation can be structured to influence the geographic distribution of project-induced changes. The configuration and location of park-and-ride lots as well as pickup sites are key variables.

Organized air service will also influence the geographic distribution and magnitude of project-induced changes. Air transportation from Anchorage and Fairbanks will encourage workers who want to relocate to settle near or in these cities. It will also tend to draw more of the labor force already living in or near these cities to work on the project.

4.4 - Mitigation Objectives and Measures

Anchorage and Fairbanks are the most able cities in Alaska to absorb population influxes. For example, Anchorage is currently experiencing an influx of about 1000 persons per month. It is projected that during 1985-1990, the net project-related population influx into Anchorage will equal 663 (this takes into account people moving from Anchorage to the local impact area as well as people moving into Anchorage. Thus, it is unlikely that Anchorage would be significantly impacted, even if more than the forecasted amount of persons were to relocate to Anchorage.

Commuter air service to the project site would reduce impacts on nearby communities and increase the number of workers who would maintain or relocate their residences to major communities of the Railbelt. Air service levels should be flexible because it may be desirable to change air service if project-induced changes do not occur as anticipated. For example, during the peak construction years, it might be appropriate to consider changing air service if project-related populations are causing unanticipated significant adverse impacts. This could occur if traffic and, perhaps, settlement become too great in and near small communities during the peak (summer) periods. Effective air service will route workers, particularly those who arrive from out of the region and do not want to settle temporarily or permanently in the more remote parts of the region, to the larger communities that can most easily provide housing and other services and away from the smaller communities.

There are several transportation options under consideration. These range from limited intervention to substantial air service and bus service arranged and partially funded by, but not provided by, the Power Authority. In any option, the Power Authority plans to fund a Transportation Coordinator position.

Likely impacts of these options on communities and workers will be determined during the design phase. Socioeconomic mitigation objectives will be considered in the selection of a transportation option.

(e) Summary

The Power Authority, through its plans for housing and related support facilities at the construction sites, its commitment to support a transportation program that helps avoid adverse impacts in communities and on workers, and its commitment to develop leave, shift, and shift rotation schedules to help meet socioeconomic mitigation objectives, will aid in meeting the following mitigation objectives:

4.4 - Mitigation Objectives and Measures

- Avoid large and rapid population influxes into nearby communities such as Cantwell, Trapper Creek, and Talkeetna.

- Avoid large traffic increases on the Denali and Parks Highways, especially during the summer months;

- Avoid large loss of wilderness and remote attributes of the middle Susitna basin, including the avoidance of losses of fish and wildlife resources; and

- Avoid frequent interactions between workers and fish and wildlife, including involuntary interactions such as injury to animals by vehicles and consumptive use of fish and wildlife by workers.

During the design phase, a transportation option will be selected and onsite housing plans will be refined. This will be done in coordination with planning of leave, shift, and shift rotation schedules and timing of manpower demand. This coordination will help ensure that the most cost-effective means of achieving socioeconomic objectives are chosen. The overall goals are to meet socioeconomic mitigation and other project objectives that are not in conflict with one another, make trade-offs where objectives are in conflict, impose a minimum of constraints upon workers, and implement the plans at an acceptable cost.

4.4.2 - Mitigation of Significant Adverse Impacts That Remain in Communities

After the mitigation measures discussed above have been designed for implementation, the Power Authority will evaluate whether the private sector, local and state government mechanisms, and social assimilation mechanisms will be able to adequately meet changing demands; and determine additional mitigation measures required to reduce project-induced changes that are not adequately reduced by private, government, and social entities. These measures will be place-specific and the probable effects of each measure will be estimated. The cost of implementing each measure will be estimated and each measure will be evaluated for cost-effectiveness. This process will allow the Power Authority to implement mitigation measures with knowledge of their probable effects and costs.

There are several means by which the private sector, local and state governments, social service organizations, and if appropriate, the Power Authority and Contractor can reduce adverse disruptions and budget impacts. These include project-community interaction, provision of additional community facilities and/or services, subdivision development, temporary offsite housing, assistance to social organizations, house financing, and others. Within each of these categories, technical and financial assistance may be available.

The Power Authority is now committed to implementing project-community interaction. Communication among the Power Authority, local and state agencies, and impacted communities through a public participation program and other means is a necessity. Information about anticipated project-induced changes will be communicated to communities, agencies, and other appropriate entities in a timely manner, and these entities' attitudes toward and concerns about these changes will be communicated back to the Power Authority in a timely manner. Timeliness is important, because one goal of the mitigation program is to anticipate and prescribe mitigation measures in advance of the predicted impacts rather than to react to impacts. Communication among entities is discussed further in the presentation of the Impact Management Program below.

4.5 - Impact Management Program

8.5

The goal of the impact management program is to reduce adverse socio-economic impacts caused by the project. This will be done by:

- Developing and providing impact information to communities, individuals, and agencies in a timely manner. This information is intended to assist them in planning for and adjusting to project-induced changes. It is also provided so that attitudes and concerns can be discussed, and planning can be based upon the best available information;

- Refining and implementing cost-effective mitigation measures to reduce adverse impacts that cannot be adequately handled by existing private, government, and social mechanisms;

- Evaluating the effectiveness of mitigation measures; and

- Making adjustments to these measures, or adding or deleting measures to achieve desired mitigation objectives.

4.5.1 - Developing Impact Information

Updated impact assessments will be made as project features, manpower needs and schedules become more defined. Both the baseline and the with-project projections will be updated with new data and information. Current natural resource development, state government spending scenarios, and employment data will be among the most important information used in updating the base case. Project characteristics such as manpower requirements and loading schedules will be among the most important information used in the updates of the with-project projections.

If substantial uncertainty exists in key assumptions or parameters, projects may be based upon a multiple scenario model. With this type of model, ranges of impacts, rather than point estiamtes, can be determined and provided as input to community planning.

The update of the base case will include an expanded data base for nearby communities such as Cantwell, Trapper Creek, and Talkeetna which will be developed during 1983 and 1984. The new base case will contribute to determining which changes are project-induced. One anticipated use of the expanded data base will be in determining the relative importance of fish and wildlife in local residents' household income, and locations of fish and wildlife harvest and capture.

The initial update of the with-project projections will take into account the refined plans for onsite housing and related facilities, the selected worker transportation option, and tentative leave, shift and shift rotation schedules. The initial impact assessment, based upon the updated base case and with-project projections, will be the starting point for refinement of measures to assist communities with the mitigation of adverse impacts.

Economic and social conditions, including availabilities of housing, facilities, and services, will be monitored in affected communities during construction. Monitoring activities will be more extensive in the nearby communities. The monitoring program will include a determination of seasonal effects of the project.

In addition, the work force will be monitored starting in the first year of construction. Factors such as workers' permanent residence before and during construction, numbers of workers with dependents, and numbers of dependents per worker will be monitored. Information for these types of factors will help in the determination of project-induced impacts.

4.5.2 - Providing Impact and Other Information

The Power Authority has developed a special public participation program for this project. Information has been and will continue to be provided to communities, individuals, agencies, and other parties through public meetings and workshops, newsletters, press releases, teleconferences, briefing packets, and other means.

These parties will have opportunities to express attitudes and concerns about impacts and mitigation measures through the public meetings and workshops, teleconferences, writing to the Power Authority, or by special direct consultation with the Power Authority.

4.5.3 - Refining and Implementing Mitigation Measures

During the design phase, the mitigation measures discussed in Section 4.4.1 (those designed to avoid adverse socioeconomic impacts) will be refined. This will be done by an interdisciplinary task force in a multi-objective context. Additional impact projections assessing the effect of different transportation and onsite housing options will be developed.

Once the mitigation measures are refined, implementation measures of the type discussed in Section 4.4.2 will be considered and refined. The intent will be to anticipate adverse impacts and make adjustments before the anticipated impacts occur.

The monitoring programs will provide information that will allow for evaluation of the performance of mitigation measures on mitigation objectives. Mitigation measures will be adjusted, and measures will be adjusted, and measures will be added and deleted as required throughout construction to meet the mitigation objectives.

Before and during construction activities, the Power Authority will interact with the communities, the private sector, state and local government institutions, and human service organizations. Representatives of state and local government institutions and other appropriate entities will be requested to review and comment upon annual mitigation reports, including recommended mitigation measures for future implementation.

5 - MITIGATION MEASURES RECOMMENDED BY AGENCIES

Written comments regarding the November 15, 1982 draft Exhibit E are contained in Chapter 11. In Chapter 11 a response is provided for each comment. Some responses refer the reader to sections of Chapter 5 where appropriate changes have been made. Other responses fully address issues raised with no reference to Chapter 5.

Several agency comments contained recommendations for mitigation. The main purpose of this section is to summarize these recommendations, and identify the section of Chapter 5 that address these recommendations. A secondary purpose is to summarize important agency suggestions for further work that relate to mitigation.

5.1 - Alaska Department of Natural Resources (DNR)

Source: Letter to Mr. Eric Yould from Esther Wunnicke, January 13, 1983.

- A location with more physical amenities, such as in the Fog Lakes area south of the Susitna River on privately owned land, is recommended for the permanent townsite. The DNR feels that the tendency for workers to reside onsite (Exhibit E emphasizes that a high amenity site will minimize adverse impacts to nearby communities) depends on the quality of housing and other amenities.

  This mitigation recommendation is discussed in Section 4.4.1(c) and Section 4.5.

- A more comprehensive approach to ensuring "that the local unemployed get a chance at project-related jobs" is reommended. DNR feels that "it will be necessary to develop a clearly defined and legal program" to encourage local hire.

  This mitigation recommendation is discussed in the Power Authority's written response to DNR's letter.

5.2 - Alaska Department of Fish and Game (ADF&G)

Source: Letter to Mr. Eric Yould from Mr. Don Collinsworth (including Appendix C), January 13, 1983.

- The ADF&G would like "some indication as to what can be done to resolve the impacts" (to resource users).

  Idications are provided in Section 4.4.1 and Section 4.5.

5.3 - U.S. Fish and Wildlife Service (FWS)

Source: Letter to Mr. Eric Yould from Mr. Keith Bayher (including attachment), undated (received by the Power Authority on January 14, 1983.

5.3 - U.S. Fish and Wildlife Service (FWS)

- The FWS states that "avoidance of adverse impacts should be given priority as a mitigation measure", and gives examples such as "mode, timing, and routing of construction access; schedule of work; type and siting of the construction camp/village;...".

  This recommendation is discussed in Sections 4.2, 4.4 and 4.5.

- The FWS stresses the need for an effective monitoring program and "believe the program should provide for participation by representatives of appropriate State, Federal, and local agencies and be financed by the project. This panel should have the authority to recommend modification of how activities are conducted to assure that mitigation is effective".

  This recommendation is discussed in Sections 4.1 and 4.5.

- The FWS would like construction camp alternatives such as siting, type of camp, and administration considered as means to minimize adverse impacts to fish and wildlife resources and their use.

  This recommendation is discussssed in Sections 4.4.1(c) and 4.5.1.

5.4 - Summary of Agencies' Suggestions for Further Studies That Relate To Mitigation

The FWS suggests that the base case (baseline projections) be updated. They feel that the data base should be broadened for the update. The FWS also expressed the opinion that the size of impacts, and therefore the mitigation requirements, are directly related to the base case. This suggestion is addressed in Section 4.5.1.

The FWS states that "to evaluate impacts to users of fish and wildlife resources, the impacts to resources must first be assessed. In that many of these resource impacts have not been sufficiently quantified, one could not expect an acceptably quantified socioeconomic analysis. This could only have lead to a highly general mitigation plan, which is what we find here." In addition, both the FWS and the ADF&G suggest that more data and information about current and recent use of fish and wildlife resources in the project area could be collected.

These agencies imply that this collection effort could occur simultaneous to the on-going studies of the impact of the project on fish and wildlife resources. These agencies feel that incomplete analyses of impacts on fish and wildlife users are preventing full evaluation of socioeconomic issues. Protection of, or minimizing adverse impacts on, existing users of fish and wildlife resources seems to be of concern.

5.4 - Summary of Agencies' Suggestions

Measures designed to protect or minimize adverse impacts on existing users are discussed in Section 4. These measures will help avoid large losses of the wilderness and remote attributes of the middle Susitna basin, and frequent interactions between workers and fish and wildlife, including involuntary interactions such as injury to animals by vehicles and consumptive use of fish and wildlife by workers.

However, if it becomes apparent that existing users of fish and wildlife deserve further protection, then it would be appropriate to consider collecting and analyzing the types of data and information discussed in several of the FWS and the ADF&G comments. This would contribute to the development of more in-depth measures to mitigate potential disruptions and other potential adverse impacts on fish and wildlife users.

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TABLE E.5.1: MATANUSKA-SUSITNA BOROUGH ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

	1970		1975		1979		Percent of Impact Area 3		
	Total	%	Total	%	Total	%	1970 %	1975 %	1979 %
TOTAL(a) - Nonagricultural Industries	1,145	100.0	2,020	100.0	3,078	100.0	1.8	1.8	2.7
Mining	*	-	*	-	11	0.3	*	*	0.0
Construction	120	10.5	188	9.3	184	6.0	2.3	1.1	2.2
Manufacturing	*	-	30	1.5	40	1.3	*	1.2	1.1
Transportation - Communication & Utilities	114	9.6	218	10.8	316	10.2	1.9	1.8	2.6
Wholesale Trade			44	2.2	49	1.6	-	0.8	1.0
Retail Trade	174	15.2	271	13.4	696	22.6	1.4	1.7	3.8
Finance-Insurance & Retail Estate	22	1.9	62	3.1	129	4.2	0.8	1.3	2.1
Services	179	15.6	288	14.3	447	14.5	2.0	1.4	2.3
Federal Government	106	9.3	124	6.1	97	3.1	0.9	1.0	0.8
State and Local Government	376	32.8	758	37.5	1,101	35.8	3.2	4.3	5.2
Miscellaneous	*	-	*	-	21	0.7	*	*	1.8

* Data unavailable due to disclosure policy.

(a) Figures may not total correctly because of averaging and disclosure limitations on data.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK (various issues).

TABLE E.5.2: COMMUNITY POPULATION: MATANUSKA-SUSITNA BOROUGH, 1939, 1950, 1960, 1970, 1976, 1980, 1981

Community	1939	1950	1960	1970	1976[(a)]	1980[(b)]	1981[(a)]
Talkeetna	136	106	76	182	328	265	640
Willow	NA[(c)]	NA	78	38	(323)	134	NA
Wasilla	96	97	112	300	1566	1548	2168
Palmer	150	890	1181	1140	1643	2143	2567
Montana	NA	NA	39	33	76	40	NA
Big Lake	NA	NA	74	36	721	412	2408
Chickaloon	NA	NA	43	22	62	20	NA
Eska Sutton	14	54	215	89	496	NA	NA
Houston	NA	NA	NA	69	375	325	600

COMMUNITY POPULATION: OTHER COMMUNITIES NOT IN MATANUSKA-SUSITNA BOROUGH

Community	1950	1960	1970	1976	1980[(b)]	1982[(d)]
Nenana	242	286	382	493	471	NA
Healy	NA	NA	79	503	333	NA
Cantwell	NA	85	62	NA	182	183
Paxson	NA	NA	20	NA	30	NA
Glennallen	142	169	363	NA	488	NA
Copper Center	90	151	206	NA	213	NA
Gakona	50	33	88	NA	85	NA
Gulkana	65	51	53	NA	111	NA

(a) Mat-Su Borough Survey. The methodology for these surveys differs from U.S. Census data and hence the 1976 and 1981 figures are not comparable to Census data.

(b) Alaska Department of Labor, Administrative Services Division. January 1, 1981. Alaska 1980 Population: A Preliminary Overview. Juneau, AK.

(c) NA = Not Available.

(d) Community Census, September 1982.

Source: For all other data, U.S. Department of Commerce, Bureau of the Census.

TABLE E.5.3: PER CAPITA PERSONAL INCOME IN THE MAT-SU BOROUGH IN CURRENT AND 1970 DOLLARS

	Per Capita Personal Income	
Year	Current Dollars	In 1970 Dollars[(a)]
1970	3,957	3,957
1971	4,279	4,150
1972	4,539	4,286
1973	4,970	4,526
1974	6,068	5,011
1975	8,092	5,855
1976	8,542	5,718
1977	9,032	5,666
1978	8,939	5,231
1979	8,878	4,704

(a) Discounted using the Anchorage Consumer Price Index - Urban (CPI-U) as a measure of inflation.

Source: U.S. Department of Commerce, Bureau of Economic Analysis.

TABLE E.5.4: HOUSING STOCK ESTIMATES AND VACANCY RATES IN LOCAL IMPACT AREA

Area	Number of Units	Percent of Total	Vacancy Rate (%)
Talkeetna	196	2.3	1.0
Houston	229	2.7	9.6
Big Lake Special Area	1,750	20.4	49.9
Wasilla	718	8.4	6.7
Suburban[a]	3,801	44.3	6.8
Palmer	872	10.2	10.2
Other Areas in Mat-Su[b]	1,016	11.8	52.8
Cantwell	96	1.1	28.1
Total Local Impact Area	8,678	100.0	20.7

(a) Includes an area that is outside of Palmer and Wasilla's city limits and extends west to Houston and east to Sutton.

(b) Includes an estimated 69 housing units in Trapper Creek.

Source: Matanuska-Susitna Borough Planning Department, Population and Housing Survey, October 1981; and Cantwell Population and Housing Census, September 1982.

TABLE E.5.5

COMMUNITY FACILITIES SUMMARY

	Schools																								Government				
	Elementary	Secondary	Higher	Water	Sewer	Solid Waste Disposal	State Trooper Post	Local Police	Court System	Fire Hall	Health Center	Long Term Care Fac.	Mental Health Facility	General Hospital	Roads	Railroad	Public Transportation	Airstrip	Library	Community Building	Post Office	Park System	Power	Telephone Service	Communication/Media	Home Rule	First Class	Second Class	Unincorporated	Unified Home Rule
Nenana	*	*		*	*	*	*			*	*				*	*		*		*	*	*	*	*	*		*			
Cantwell	*	*				*	*								*	*		*		*	*			*	*				*	
Trapper Creek	*					*	*								*						*		*	*	*				*	
Talkeetna	*					*				*					*	*		*	*	*	*	*	*	*	*				*	
Willow	*					*									*	*		*	*	*	*		*	*	*				*	
Houston						*				*					*	*							*	*	*			*		
Palmer	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*	*				
Wasilla	*	*	*	*		*				*	*		*		*	*		*	*	*	*	*	*	*	*			*		
Paxson						*									*			*					*	*	*				*	
Glennallen	*	*				*	*		*	*	*	*		*	*			*	*	*	*		*	*	*				*	
Copper Center	*		*			*				*	*				*			*		*	*		*	*	*				*	
Gakona						*									*			*		*	*		*	*	*				*	
Healy	*	*		*	*	*	*				*				*	*		*			*		*	*	*				*	
Gulkana				*	*	*					*				*					*			*	*	*				*	
Valdez	*	*		*	*	*	*	*	*	*	*	*	*	*	*			*	*	*	*	*	*	*	*	*				
Anchorage	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*					*
Fairbanks	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*				

TABLE E.5.6: CHARACTERISTICS OF PUBLIC SCHOOLS: MATANUSKA-SUSITNA BOROUGH SCHOOL DISTRICT 1981

School	School Type	School Grade	Capacity	Enrollment	Condition/Plans for Expansion
Big Lake	E	1-6	350	177	No plans.
Butte	E	1-6	500	300	No plans.
Glacier View	E/J	1-8	60	50	Currently consists of portables. Plan to build two classrooms.
Iditarod	E	Pre-6	550	460	Recently burned down. Plan to have back in operation by 1/82.
Sherrod	E	Pre,3-6	450	454	No plans.
Skwentna	E/J/S	4-12	15	16	No plans.
Snowshoe	E	1-6	500	409	New facility.
Swanson	E	1,2	350	231	No plans.
Talkeetna	E	1-6	120	65	No plans.
Trapper Creek	E	1-6	30	40	Presently four portable facilities have submitted a grant proposal for facility consisting of four classrooms and a gym/multipurpose room.

TABLE E.5.6 (Cont'd)

School	School Type	School Grade	Capacity	Enrollment	Condition/Plans for Expansion
Wasilla Elementary	E	1	120	90	Very old facility with half of building condemned. Have plans for a new facility in 1984.
Willow Elementary	E	1-6	91	96	Expansion considered in the five year building plan.
Palmer	J	7-8	500	332	No plans.
Wasilla	J	7-8	600	353	Recently completed addition to facility.
Palmer	S	9-12	900	619	No plans.
Susitna Valley	J/S	7-12	180	122	Plans for additions for the and and vocational studies.
Wasilla	S	9-12	1,200	715	Recently completed addition to the facility.
Matanuska-Susitna Community College	CC	NA	NA	1,500	NA

E = Elementary; J = Junior; S = Senior; CC = Community College

Source: Matanuska-Susitna Borough School District

TABLE E.5.7: REGIONAL NONAGRICULTURAL EMPLOYMENT

	1970		1975		1979		Percent of State		
	Total	%	Total	%	Total	%	1970 %	1975 %	1979 %
TOTAL[a] - Nonagricultural Industries	62,690	100.0	113,818	100.0	113,204	100.0	67.8	70.4	68.0
Mining	1,610	2.6	2,243	2.0	2,822	2.5	53.7	59.2	48.9
Construction	5,264	8.4	16,359	14.4	8,257	7.3	76.3	63.6	81.8
Manufacturing	1,850	3.0	2,596	2.3	3,705	3.3	23.7	26.9	28.9
Transportation - Communication & Utilities	6,021	9.6	12,094	10.6	12,062	10.7	66.2	73.4	72.2
Wholesale Trade	-	-	5,366	4.7	5,083	4.5	-	90.8	92.2
Retail Trade	12,111	19.3	15,965	14.0	18,309	16.2	79.2	78.6	76.7
Finance-Insurance & Retail Estate	2,520	4.0	4,696	4.1	6,139	5.4	81.3	77.9	76.4
Services	8,868	14.1	20,995	18.4	19,674	17.4	77.8	83.5	69.4
Federal Government	12,372	19.7	13,022	11.4	12,728	11.2	72.4	71.2	71.0
State and Local Government	11,585	18.5	17,799	15.6	21,130	18.7	62.6	60.9	57.7
Miscellaneous	52	0.1	217	0.2	712	0.6	26.0	19.0	98.9

(a) Sums of individual entries may not equal total due to averaging and disclosure limitations on data.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK (various issues).

TABLE E.5.8: 1981 CIVILIAN HOUSING STOCK IN THE MUNICIPALITY OF ANCHORAGE, B. TYPE

Type of Unit	Number of Units	Percent of Total
Single Family	30,097	45.8
Duplex	6,040	9.2
3-4 Units	6,211	9.4
5-19 Units	9,356	14.2
20+ Units	6,036	9.2
Mobile Homes	8,031	12.2
In Parks	6,146	9.3
On Lots	1,885	2.9
TOTAL	65,771	100.0

Source: Municipality of Anchorage Planning Department.

TABLE E.5.9: HOUSING STOCK IN FAIRBANKS AND THE FAIRBANKS-NORTH STAR BOROUGH, BY TYPE, OCTOBER 1978

	Fairbanks-North Star Borough	Municipality of Fairbanks
Single Family	6,849	3,312
Duplex	960	714
Multifamily	3,832	3,187
Mobile Homes	2,097	138
TOTAL	13,738	7,351

Source: Fairbanks-North Star Borough Community Information Center. Community Information Quarterly. Summer 1980. Volume III, Number 2. p. 70.

TABLE E.5.10: STATE ANNUAL NONAGRICULTURAL EMPLOYMENT BY SECTOR

	1970		1975		1979	
	Total	%	Total	%	Total	%
TOTAL[(a)] - Nonagricultural Industries	92,400	100.0	161,689	100.0	166,406	100.0
Mining	3,000	3.2	3,790	2.3	5,773	3.5
Construction	6,900	7.5	25,735	15.9	10,092	6.1
Manufacturing	7,800	8.4	9,639	6.0	12,818	7.7
Transportation - Communication & Utilities	9,100	9.8	16,473	10.2	16,704	10.0
Wholesale Trade	3,200	3.5	5,908	3.7	5,511	3.3
Retail Trade	12,100	13.1	20,300	12.6	23,877	14.3
Finance-Insurance & Retail Estate	3,100	3.3	6,030	3.7	8,035	4.8
Services	11,400	12.3	25,136	15.5	28,345	17.0
Federal Government	17,100	18.5	18,288	11.3	17,915	10.8
State and Local Government	18,500	20.0	29,247	18.1	36,617	22.0
Miscellaneous	200	0.2	1,143	0.7	720	0.4

[a]Figures may not total correctly because of averaging.

Source: Alaska Department of Labor. Statistical Quarterly. Juneau, AK (various issues).

TABLE E.5.11: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON MATANUSKA-SUSITNA BOROUGH

Socioeconomic Variable	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	22,285	42,964	44,353[a]	1,389[a]	3.2[a]	66,338	67,385[a]	1,047[a]	1.6[a]
Employment[b]	NA	4,002	6,914	10,880	3,966	57.4	9,505	11,691	2,186	23.0
Housing Demand (no. of units)	8,582	6,810	14,417	14,903	486	3.4	24,670	25,036	366	1.5
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Solid Waste Disposal (acres per year)	617	2.5	6.7	7.0	0.3	4.0	13.6	13.8	0.2	1.3
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	20	20	48	49	1	2.1	75	76	1	1.3
Education										
(primary students)	3,136	2,388	5,406	5,608	202	3.7	8,884	9,011	157	1.4
(secondary students)	3,280	2,141	4,605	4,764	159	3.5	7,568	7,674	131	1.7
Hospital Beds	23	20	60	61	1	1.7	109	110	1	0.9
Community[c] Parks (acres)	0	-	80	82	2	2.4	133	135	2	1.5

NA = Not Applicable

(a) Population increase refers to population influx in Mat-Su Borough communities, and does not include population residing only at work camp/village.
(b) By place of employment.
(c) Community parks generally contain facilities such as tennis courts, ball diamonds, play apparatus, basketball courts, nature walks, and swimming pools.

Source: Forecast by Frank Orth & Associates, Inc.

TABLE E.5.12: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE CITY OF PALMER

Socioeconomic Variable	Present Conditions: 1981 Capacity	Present Conditions: 1981 Amount/ Usage	Watana Construction Peak: 1990 Baseline Forecast	Watana Construction Peak: 1990 Forecast with Project	Watana Construction Peak: Impact of Project	Watana Construction Peak: % Increase Over Baseline Forecast	Devil Canyon Construction Peak: 1999 Baseline Forecast	Devil Canyon Construction Peak: 1999 Forecast With Project	Devil Canyon Construction Peak: Impact of Project	Devil Canyon Construction Peak: % Increase Over Baseline Forecast
Population	NA	2,567	4,525	4,574	49	1.1	6,167	6,206	39	0.6
Employment (a)	NA	(b)	(b)	(b)	29	(b)	(b)	(b)	13	(b)
Housing Demand (no. of units)	872	783	1,551	1,568	17	1.1	2,299	2,313	14	0.6
Water (gallons per day)	1,368,000	300,000	608,000	615,000	7,000	1.2	918,500	923,500	5,500	0.6
Sewage Treatment (gallons per day)	500,000	300,000	543,000	549,000	6,000	1.1	740,000	745,000	5,000	0.7
Police	8	8	8	8	0	0.0	9	9	0	0.0
Education (primary students)	800 (c)	685 (c)	569	576	7	1.2	826	832	6	0.7
(secondary students)	1,400 (c)	951 (c)	485	491	6	1.2	704	709	5	0.7
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) By place of employment.
(b) Data not available.
(c) School service areas do not correspond exactly to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Palmer.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.13: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE CITY OF WASILLA

	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
Socioeconomic Variable	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	2,168	4,157	4,216	59	1.4	7,969	8,017	48	0.6
Employment[a]	NA	(b)	(b)	(b)	28	(b)	(b)	(b)	13	(b)
Housing Demand (no. of units)	718	670	1,404	1,424	20	1.4	2,965	2,982	17	0.6
Water (gallons per day)	864,000	(b)	559,000	567,000	8,000	1.4	1,186,000	1,193,000	7,000	0.6
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	1,170	959[c]	523	531	8	1.5	1,067	1,075	8	0.7
(secondary students)	1,800[c]	1,068[c]	446	453	7	1.6	909	914	5	0.6
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) By place of employment.
(b) Data not available.
(c) School service areas do not correspond exactly to city limits. 1981 enrollment may include a service area that extends beyond city boundaries, whereas projections for 1990 and 1999 refer only to school children living in Wasilla.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.14: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE CITY OF HOUSTON

Socioeconomic Variable	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	600	1,415	1,459	44	3.1	3,335	3,372	37	1.1
Employment[a]	NA	(b)	(b)	(b)	9	(b)	(b)	(b)	7	(b)
Housing Demand (no. of units)	229	207	508	523	15	3.0	1,249	1,262	13	1.0
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education (primary students)	0[c]	0[c]	178	184	6	3.4	447	453	6	1.3
(secondary students)	0[c]	0[c]	152	157	5	3.3	380	384	4	1.1
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) By place of employment.
(b) Data not available.
(c) School service areas do not correspond to city limits. Children in Houston currently attend schools outside of the city. A secondary school initially accommodating 300 students is planned.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.15: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE COMMUNITY OF TRAPPER CREEK

Socioeconomic Variable	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	225	320	795	475	148.4	456	770	314	68.9
Employment[a]	NA	(b)	(b)	(b)	113	(b)	(b)	(b)	48	(b)
Housing Demand (no. of units)	69	68	107	275	168	157.0	169	279	111	65.1
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	30[c]	40[d]	78	143-163	65-85	109.0	116	161-181	45-65	56.0
(secondary students)	0[c]	0[d]	34	92	58	170.6	52	92	40	76.9
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) By place of employment.
(b) Data not available.
(c) Planned capacity of 100 with room for expansion to 200.
(d) School service areas do not correspond exactly to community delineations. The Trapper Creek elementary school serves a wide area outside of the community. Secondary school-age children from Trapper Creek attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.16: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE COMMUNITY OF TALKEETNA

Socioeconomic Variable	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
	1981 Capacity	1981 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	640	1,000	1,335	335	33.5	1,563	1,820	257	16.4
Employment[a]	NA	(b)	(b)	(b)	114	(b)	(b)	(b)	48	(b)
Housing Demand (no. of units)	196	194	334	451	117	35.0	581	670	89	15.3
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Education										
(primary students)	120[c]	73[c]	126	164	48	30.2	209	240	39	14.8
(secondary students)	0[c]	0[c]	107	138	41	29.0	178	204	31	14.6
Hospital Beds	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NA = Not Applicable

(a) By place of employment.
(b) Data not available.
(c) School service areas do not correspond exactly to community delineations. Secondary school-age children attend Susitna Valley High School.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.17: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE COMMUNITY OF CANTWELL (HIGH CASE IMPACTS)

	Present Conditions		Watana Construction Peak				Devil Canyon Construction Peak			
Socioeconomic Variable	1982 Capacity	1982 Amount/ Usage	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	NA	183	214	1,214	1,000	467.2	256	543	796	310.9
Employment[a]	NA	-[b]	-[b]	-[b]	190	-[b]	-[b]	-[b]	120	-[b]
Housing Demand (no. of units)	96	69	78	411	333	426.9	93	361	264	283.8
Water (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sewage Treatment (gallons per day)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Police	NA	1	1	6	5	500.0	1	4	3	300.0
Education (no. of school children)	60	33	39	189	150	246.2	46	108	118	134.8

NA = Not Applicable

(a) By place of employment
(b) Data not available

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.18: SUMMARIZED IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON THE REGION(a)

		Watana Construction Peak				Devil Canyon Construction Peak			
Socioeconomic Variable	1980 Amount	1990 Baseline Forecast	1990 Forecast with Project	Impact of Project	% Increase Over Baseline Forecast	1999 Baseline Forecast	1999 Forecast With Project	Impact of Project	% Increase Over Baseline Forecast
Population	284,166	397,999	399,866	1,867	0.5	473,191	473,882	691	0.1
Employment	114,112(b)	200,112	206,128	6,016	3.0	232,311	235,466	3,155	1.4
Households	96,899	138,938	139,613	675	0.5	171,895	172,156	261	0.2

(a) Includes the following census divisions: Anchorage, Kenai Peninsula, Mat-Su Borough, Fairbanks-North Star Borough, S.E. Fairbanks and Valdez-Chitina-Whittier.

(b) Average employment during the first nine months of 1980.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5..9: IMPACT OF THE PROJECT ON POPULATION IN MAT-SU BOROUGH, 1985-2002

Year	Base Cost Population	Project-Induced Offsite Population Influx	Total Offsite Population	Onsite Population Influx	Total Population
1985	31,202	110	31,312	1,017	32,329
1986	33,950	146	34,096	1,243	35,339
1987	36,894	721	37,615	1,971	39,586
1988	39,323	985	40,308	2,601	42,909
1989	41,543	1,107	42,650	2,982	45,632
1990	42,964	1,389	44,353	3,967	48,050
1991	45,263	1,337	46,600	3,472	50,072
1992	47,112	1,210	48,322	2,772	51,094
1993	49,734	1,013	50,747	1,724	52,471
1994	51,988	937	52,925	1,333	54,258
1995	54,607	891	55,498	1,055	56,553
1996	57,191	924	58,115	1,340	59,455
1997	60,272	975	61,247	1,765	63,012
1998	63,000	1,032	64,032	2,090	66,122
1999	66,338	1,047	67,385	2,183	69,568
2000	69,334	1,021	70,355	1,868	72,223
2001	72,731	930	73,661	1,185	74,846
2002	76,295	837	77,132	386	77,518

Source: Projections by Frank Orth & Associates, Inc.

TABLE E.5.20: DAILY ESTIMATED TRAFFIC VOLUMES DURING PEAK CONSTRUCTION YEAR AND SEASON: ONE WAY TRIPS DAILY BASIS

Description	Case A[a]	Case B[b]
Cantwell Commuters: Access Road and Denali Highway	86	50
Commute to Permanent Residence by Other Region Residents: Access Road and Denali Highway Traffic	358	208
Worker and Resident Dependent Excursions During Work Week: Access Road Traffic	350	350
Worker and Resident Dependent Excursions During Work Week: Denali Highway Traffic	30[c]	30[c]
Government and Agency Personnel	10	10
Heavy Trucks	70	70
Support Materials	20	20

(a) Assumes each commuting worker uses a private vehicle - one vehicle per worker.

(b) Assumes the application of a 1.72 commuter worker to private vehicle ratio. This ratio represents selected results of a study that examined worker/vehicle ratios in major eastern U.S. power plants under construction in 1978 and 1979 (Metz. July 1981. Traffic Quarterly. Vol. 35, No. 3.)

(c) Assumes that 10% of this total user category will travel some portion of the Denali Highway during excursions.

NOTE: These traffic volumes incorporate all of the assumptions listed in Appendix 5.D.

TABLE E.5.21: TOTAL AVERAGE DAILY TRAFFIC ON ACCESS ROAD AND DENALI HIGHWAY DURING PEAK CONSTRUCTION YEAR AND SEASON

During Peaking Construction Year and Season

	Case A[a]	Case B[b]
Denali Highway		
Cantwell to Fish Creek:		
DOT non-project related traffic projection	320	320
Project related passenger vehicles	489[c]	303[c]
Project support materials vehicles	20	20
Project heavy trucks	70	70
Total	899	713
Fish Creek to Maclaren River:		
DOT non-project related traffic projections	130	130
Project related passenger vehicles	489[c]	303[c]
Project support materials vehicles	20	20
Project heavy trucks	70	70
Total	709	523
Access Road		
Project related passenger vehicles	804[c]	618[c]
Project support materials vehicles	20	20
Project heavy trucks	70	70
Total	894	708

(a) Case A: a heaviest volume case which assumes that commuters are using one vehicle per worker.

(b) Case B: applies a 1.72 worker per vehicle formula to the number of commuting workers in private vehicles.

(c) See Appendix 5.D for underlying assumptions.

NOTES:

1. On any given day, there could be high variability in the non-project related ADT, especially Saturday and Sunday as opposed to Monday through Friday.

2. The Alaska State Department of Transportation has projected 1990 Average Daily Traffic (ADT) on the Denali Highway independent of the Susitna Project. In the Cantwell to Fish Creek segment, ADT is projected to be 320 vehicles. In the Fish Creek to Maclaren River segment (access road to the project will lie in this segment), ADT is projected to be 130 vehicles. These figures then are additive to project-generated traffic.

TABLE E.5.22: IMPACT OF THE PROJECT ON POPULATION IN TRAPPER CREEK, 1985 - 2002

Year	Base Case Population	Project-Induced Population Influx	Total Population With Project
1985	263	32	295
1986	274	43	317
1987	285	241	526
1988	296	337	633
1989	308	378	686
1990	320	475	795
1991	333	451	784
1992	346	387	733
1993	360	288	648
1994	375	250	625
1995	390	227	617
1996	406	247	653
1997	422	278	700
1998	439	306	745
1999	456	314	770
2000	474	302	776
2001	493	256	749
2002	513	212	725

Source: Projections by Frank Orth and Associates, Inc.

TABLE E.5.23: IMPACT OF THE PROJECT ON POPULATION IN TALKEETNA, 1985 - 2002

Year	Base Case Population	Project-Induced Population Influx	Total Population With Project
1985	780	25	805
1986	820	33	853
1987	862	174	1036
1988	906	237	1143
1989	952	267	1219
1990	1000	335	1335
1991	1051	323	1374
1992	1104	294	1398
1993	1160	250	1410
1994	1219	233	1452
1995	1281	222	1503
1996	1347	229	1576
1997	1415	240	1655
1998	1487	253	1740
1999	1563	257	1820
2000	1642	251	1893
2001	1726	230	1956
2002	1814	209	2023

Source: Projections by Frank Orth and Associates, Inc.

TABLE E.5.24: IMPACT OF THE PROJECT ON POPULATION IN CANTWELL, 1985 - 2002

Year	Base Case Population	Project-Induced Population Influx Case A	Project-Induced Population Influx Case B	Total Population With Project Case A	Total Population With Project Case B
1985	194	230	430	424	624
1986	198	230	455	428	653
1987	202	165	638	367	840
1988	206	178	774	384	980
1989	210	184	843	394	1053
1990	214	198	1000	412	1214
1991	219	197	984	416	1203
1992	223	194	961	417	1184
1993	228	190	920	418	1148
1994	232	130	794	362	1026
1995	237	129	785	366	1022
1996	241	129	785	370	1026
1997	246	129	793	375	1039
1998	251	130	796	381	1047
1999	256	130	788	386	1044
2000	261	130	767	391	1028
2001	267	128	744	395	1011
2002	272	125	744	397	1016

Source: Projections by Frank Orth and Associates, Inc.

TABLE E.5.24: IMPACT OF THE PROJECT ON POPULATION IN CANTWELL, 1985 - 2002

Year	Base Case Population	Project-Induced Population Influx Case A	Project-Induced Population Influx Case B	Total Population With Project Case A	Total Population With Project Case B
1985	194	230	430	424	624
1986	198	230	455	428	653
1987	202	165	638	367	840
1988	206	178	774	384	980
1989	210	184	843	394	1053
1990	214	198	1000	412	1214
1991	219	197	984	416	1203
1992	223	194	961	417	1184
1993	228	190	920	418	1148
1994	232	130	794	362	1026
1995	237	129	785	366	1022
1996	241	129	785	370	1026
1997	246	129	793	375	1039
1998	251	130	796	381	1047
1999	256	130	788	386	1044
2000	261	130	767	391	1028
2001	267	128	744	395	1011
2002	272	125	744	397	1016

Source: Projections by Frank Orth and Associates, Inc.

TABLE E.5.25: ONSITE CONSTRUCTION AND OPERATIONS MANPOWER REQUIREMENTS, 1985-2005[a]

Construction	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Laborers	562	843	1279	1693	1897	2369	2202	1723	894	549	338	539	844	1076	1144	1002	507	105			
Semi-Skilled/Skilled	148	323	355	448	502	627	583	422	220	136	92	148	230	295	312	308	234	24			
Administrative/Engineering	390	184	268	359	402	502	467	355	185	115	71	115	176	229	243	187	159	22			
Subtotal Construction	1100	1350	1902	2500	2801	3498	3252	2500	1299	800	501	802	1250	1600	1699	1497	900	151			
Operations & Maintenance (All Labor Categories)									70	145	145	145	145	145	145	145	145	170	170	170	170
TOTAL	1100	1350	1902	2500	2801	3498	3252	2500	1369	945	646	947	1395	1745	1844	1642	1045	321	170	170	170

(a) Supplied by Acres American Incorporated.

TABLE E.5.26: ONSITE CONSTRUCTION WORK FORCE: REGIONAL, ALASKA NON-REGIONAL, AND OUT-OF-STATE, 1985-2002

REGIONAL	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Laborers (85%)	478	717	1087	1439	1612	2014	1872	1465	760	467	287	458	717	915	972	852	431	89
Semi-Skilled/Skilled (80%)	118	258	284	359	402	502	466	337	176	109	74	118	184	236	250	246	187	19
Administrative/Engineering (65%)	254	120	174	233	261	326	304	231	120	75	46	75	114	148	158	122	103	14
Subtotal Construction	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
ALASKA NON-REGIONAL																		
Laborers (5%)	28	42	64	85	95	118	110	86	45	27	17	27	42	54	57	50	25	5
Semi-Skilled/Skilled (5%)	7	16	18	22	25	31	29	21	11	7	5	7	11	15	16	15	12	1
Administrative/Engineering (5%)	20	9	13	18	20	25	23	18	9	6	4	6	9	11	12	9	8	1
Subtotal Alaska Non-Regional	55	67	95	125	140	175	163	125	65	40	25	40	62	80	85	75	45	7
OUT OF STATE																		
Laborers (10%)	56	84	128	169	190	237	220	172	89	55	34	54	84	108	114	100	51	11
Semi-Skilled/Skilled (15%)	22	48	53	67	75	94	87	63	33	20	14	22	34	44	47	46	35	4
Administrative/Engineering (30%)	117	55	80	108	121	151	140	107	56	35	21	35	53	69	73	56	48	7
Subtotal Out-of-State	195	188	262	344	386	482	448	342	178	110	69	111	172	221	234	202	134	21
Total Non-Regional	250	255	357	469	526	656	610	467	243	150	94	151	234	301	319	277	179	28
TOTAL	1100	1350	1902	2500	2801	3498	3252	2500	1299	800	501	802	1250	1600	1699	1497	900	151

TABLE E.5.27: OPERATIONS WORK FORCE: 1993-2005

YEAR	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Activity													
Watana (680 MW)	30	60	60	60	60	60	60	60	60	60	60	60	60
Watana (340 MW)		45	45	45	45	45	45	45	45	45	45	45	45
Devil Canyon (600 MW)										25	25	25	25
Disptach Control	40	40	40	40	40	40	40	40	40	40	40	40	40
TOTAL	70	145	145	145	145	145	145	145	145	170	170	170	170

Source: Acres American Incorporated.

TABLE E.5.28: ONSITE CONSTRUCTION AND OPERATIONS MANPOWER REQUIREMENTS - 1985 TO 2002

	1905	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CONSTRUCTION																		
January	330	405	571	750	840	1050	976	750	390	240	151	239	376	479	510	449	270	45
February	341	419	590	775	868	1085	1008	775	402	248	156	247	388	495	527	464	279	47
March	473	581	818	1075	1205	1504	1398	1075	558	344	217	343	539	686	730	643	387	65
April	726	891	1255	1650	1849	2309	2146	1650	857	528	333	527	827	1054	1121	988	594	100
May	792	972	1370	1800	2017	2519	2341	1800	935	576	363	575	902	1149	1223	1077	648	109
June	957	1175	1655	2175	2437	3044	2829	2175	1130	696	439	694	1090	1389	1478	1302	783	131
July	1089	1337	1883	2475	2773	3463	3219	2475	1285	792	499	790	1241	1581	1681	1481	891	149
August	1100	1350	1902	2500	2801	3498	3252	2500	1298	800	504	798	1253	1596	1698	1496	900	151
September	990	1215	1712	2250	2521	3149	2927	2250	1169	720	454	718	1128	1437	1529	1347	810	136
October	759	932	1312	1725	1933	2414	2244	1725	896	552	348	551	865	1102	1172	1033	621	104
November	561	689	970	1275	1429	1784	1658	1275	662	408	257	407	639	844	866	763	459	77
December	385	473	666	875	980	1224	1138	875	454	280	177	279	439	559	594	524	315	53
PEAK CONST./YR	1100	1350	1902	2500	2802	3498	3251	2500	1299	800	504	798	1253	1596	1698	1496	899	151
OPERATIONS/MAINT.																		
SUBTOTAL - YEAR									70	145	145	145	145	145	145	145	145	170
TOTAL	1100	1350	1902	2500	2802	3498	3251	2500	1369	945	649	943	1398	1741	1843	1641	1044	321

NOTE: Annual manpower requirements and trade mixes for peak years provided by Acres American, Inc.

Source: Frank Orth & Associates, Inc.

TABLE E.5.29: ONSITE CONSTRUCTION AND OPERATIONS MANPOWER - TOTAL PAYROLL, 1985 to 2002

(IN THOUSANDS OF 1982 DOLLARS)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CONSTRUCTION																		
January	989	1214	1710	2248	2519	3146	2924	2248	1183	719	470	745	1169	1490	1585	1396	839	141
February	1022	1254	1767	2323	2603	3251	3021	2323	1222	743	486	770	1208	1539	1637	1443	867	146
March	1418	1740	2451	3222	3610	4509	4191	3223	1695	1031	674	1068	1676	2135	2271	2001	1203	202
April	2177	2671	3763	4945	5541	6921	6433	4946	2602	1583	1035	1639	2572	3277	3486	3072	1847	310
May	2374	2913	4105	5395	6045	7550	7018	5396	2839	1727	1129	1787	2806	3575	3803	3351	2015	338
June	2869	3520	4960	6519	7305	9123	8479	6520	3430	2086	1364	2160	3391	4320	4596	4049	2434	409
July	3265	4006	5644	7418	8312	10381	9649	7419	3903	2374	1552	2458	3858	4916	5229	4608	2770	465
August	3298	4046	5701	7493	8396	10486	9747	7494	3943	2398	1567	2483	3897	4965	5282	4654	2798	470
September	2968	3642	5131	6744	7556	9437	8772	6745	3548	2158	1411	2234	3507	4469	4754	4189	2518	423
October	2275	2792	3934	5170	5793	7235	6725	5171	2720	1655	1082	1713	2689	3426	3645	3211	1931	324
November	1682	2064	2908	3822	4282	5348	4971	3822	2011	1223	799	1266	1988	2532	2694	2374	1427	239
December	1154	1416	1995	2623	2939	3670	3411	2623	1380	839	549	869	1364	1738	1849	1629	979	164
TOTAL/YR	25492	31279	44070	57922	64901	81055	75341	57930	30477	18537	12116	19191	30125	38382	40831	35977	21628	3630
OPERATIONS/MAINT.																		
TOTAL/YR									2759	5715	5715	5715	5715	5715	5715	5715	5715	6699
TOTAL PAYROLL	25492	31279	44070	57922	64901	81055	75341	57930	33236	24252	17831	24906	35840	44097	46546	41692	27343	10329

NOTE: Annual manpower requirements and trade mixes for peak years provided by Acres American, Inc.

Source: Frank Orth & Associates, Inc.

TABLE E.5.30: ONSITE CONSTRUCTION WORK FORCE: CUMULATIVE PROJECT EMPLOYMENT AND RESIDENCE OF INDIVIDUALS CURRENTLY RESIDING IN THE REGION

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	850	1094	1545	2031	2276	2842	2642	2033	1056	650	407	651	1016	1299	1380	1220	722	122
Anchorage Subarea	640	835	1171	1537	1722	2150	1999	1536	798	491	308	493	769	984	1045	926	552	92
Anchorage	493	650	906	1188	1332	1663	1546	1186	616	379	238	381	595	761	809	718	431	71
Mat-Su	56	71	101	133	149	186	173	133	69	43	27	43	66	85	90	79	47	8
Kenai-Cook Inlet	91	113	162	214	240	299	278	215	112	69	43	68	107	137	145	127	74	13
Seward	2	2	3	4	5	6	5	4	2	1	1	1	2	3	3	2	1	0
Fairbanks	191	236	341	450	504	630	585	452	235	145	90	144	225	287	305	267	154	27
SE Fairbanks	2	2	3	4	4	5	5	4	2	1	1	1	2	2	3	2	1	0
Valdez-Chitina-Whittier	17	20	29	39	43	54	50	39	20	12	8	12	19	25	26	23	13	2
Mat-Su Communities																		
Palmer	6	7	10	13	15	18	17	13	7	4	3	4	7	8	9	9	5	1
Wasilla	4	6	8	11	12	15	14	11	6	3	2	3	5	7	7	6	4	1
Houston	2	2	3	4	4	6	5	4	2	1	1	1	2	3	3	2	1	0
Trapper Creek	1	1	1	1	1	2	2	1	1	0	0	0	1	1	1	1	0	0
Talkeetna	2	3	4	5	6	7	7	5	3	2	1	2	3	3	4	3	2	0
Other	41	52	74	98	110	137	127	98	51	31	20	31	49	63	66	59	34	6

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.31: ONSITE CONSTRUCTION WORK FORCE: CUMULATIVE IN-MIGRATION AND PLACE OF RELOCATION IN THE REGION

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	64	85	36	46	51	63	49	26	-10	-25	-33	-33	-33	-23	-20	-26	-43	-66
Anchorage Subarea	49	65	85	112	125	156	145	127	98	87	80	80	80	88	90	86	72	54
Anchorage	19	26	-92	-123	-139	-176	-179	-184	-192	-195	-197	-197	-197	-194	-194	-195	-199	-204
Mat-Su	27	36	189	251	282	354	346	334	315	308	303	303	303	309	310	307	298	286
Kenai-Cook Inlet	2	3	-12	-16	-18	-22	-23	-24	-25	-26	-27	-27	-27	-26	-26	-26	-27	-28
Seward	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairbanks	15	20	-49	-66	-74	-93	-96	-101	-108	-111	-113	-113	-113	-111	-110	-111	-115	-120
SE Fairbanks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valdez-Chitina-Whittier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mat-Su Communities																		
Palmer	1	1	8	10	11	14	14	13	13	12	12	12	12	12	12	12	12	11
Wasilla	1	2	9	13	14	18	17	17	16	15	15	15	15	15	16	15	15	14
Houston	1	1	8	10	11	14	14	13	13	12	12	12	12	12	12	12	12	11
Trapper Creek	7	9	47	63	70	88	87	84	79	77	76	76	76	77	78	77	74	71
Talkeetna	7	9	47	63	70	88	87	84	79	77	76	76	76	77	78	77	74	71
Other	10	13	70	93	104	131	128	124	117	114	112	112	112	114	115	113	110	106

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.32: RESIDENCE OF CONSTRUCTION AND OPERATION WORKERS ON AND OFFSITE

	Construction Workers Residing in Railbelt or Cantwell (a)	Construction Workers Residing at Work Camps and Family Village at Damsites (b)	Operations Workers Residing Permanently at Family Village at Damsite	Total Work Force
1985	952	148	0	1100
1986	1226	124	0	1350
1987	1556	346	0	1902
1988	2043	457	0	2500
1989	2292	509	0	2801
1990	2862	636	0	3498
1991	2650	602	0	3252
1992	2011	489	0	2500
1993	1004	295	70	1369
1994	606	194	145	945
1995	317	184	145	646
1996	565	237	145	947
1997	937	313	145	1395
1998	1229	371	145	1745
1999	1313	386	145	1844
2000	1131	366	145	1642
2001	694	206	145	1045
2002	116	35	170	321

(a) Includes present residents and in-migrants. These workers will reside permanently in the Railbelt or Cantwell and temporarily at the work camps while on-the-job.

(b) Some of these workers will reside temporarily at the work camps and permanently at residences located outside of the Railbelt and Cantwell, while others will reside permanently at the village.

Source: Frank Orth & Associates

TABLE E.5.33: TOTAL REGIONAL EMPLOYMENT: ONSITE CONSTRUCTION, AND SUPPORT BY PLACE OF RESIDENCE[(a)]

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	1536	2052	2632	3601	4050	5073	4736	3481	1483	701	206	705	1492	2089	2260	2060	1045	241
Anchorage Subarea	1243	1678	2217	3052	3432	4300	3982	2922	1243	588	172	592	1259	1764	1908	1727	891	198
Anchorage	991	1347	1557	2140	2405	3010	2771	2037	872	416	123	419	896	1251	1353	1222	629	154
Mat-Su	136	180	473	665	749	943	869	633	263	121	34	122	258	366	397	354	177	27
Kenai-Cook Inlet	114	147	183	242	272	342	337	249	105	49	14	49	103	144	156	148	72	16
Seward	2	3	3	5	5	7	6	4	2	1	0	1	2	3	3	3	1	0
Fairbanks	272	349	379	501	563	705	692	513	220	105	31	105	214	299	323	305	151	40
SE Fairbanks	2	2	3	4	4	5	5	4	2	1	0	1	2	2	2	2	1	0
Valdez-Chitina-Whittier	19	24	33	44	49	62	57	42	18	8	2	8	17	24	26	25	12	3
Mat-Su Communities																		
Palmer	12	16	32	44	50	62	57	42	18	8	2	8	18	25	27	24	12	3
Wasilla	10	13	29	41	47	59	54	40	16	7	2	7	16	23	24	22	10	1
Houston	4	5	10	13	15	19	19	13	5	2	1	2	5	7	8	7	4	0
Trapper Creek	14	20	120	168	190	239	220	160	66	30	8	31	65	93	100	90	46	6
Talkeetna	17	23	121	169	191	240	221	161	67	31	9	31	66	93	101	91	46	6
Other	84	112	185	259	292	368	338	246	102	47	13	47	101	143	155	138	71	10

(a) Excludes employment of workers living in Cantwell and employment of workers who maintain permanent residence at the village or outside the region.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.34: TOTAL IN-MIGRATION AND OUT-MIGRATION IN THE REGION: ONSITE CONSTRUCTION AND SUPPORT[(a)]

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	230	310	340	480	539	675	621	446	169	60	-9	52	152	237	261	232	88	-42
Anchorage Subarea	200	270	367	517	581	728	674	515	263	165	102	158	251	329	351	322	193	80
Anchorage	155	210	121	179	201	250	213	104	-68	-136	-179	-138	-66	-12	3	-17	-107	-182
Mat-Su	38	51	251	344	387	486	468	423	352	324	308	320	339	360	366	356	323	289
Kenai-Cook Inlet	7	9	-5	-6	-6	-7	-6	-11	-20	-24	-26	-24	-21	-19	-18	-18	-23	-27
Seward	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairbanks	29	38	-30	-40	-46	-58	-57	-72	-96	-105	-111	-107	-101	-94	-92	-93	-106	-117
SE Fairbanks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valdez-Chitina-Whittier	1	2	2	3	3	4	4	3	1	1	0	1	1	2	2	2	1	0
Mat-Su Communities																		
Palmer	2	2	9	12	14	17	17	15	13	13	12	13	13	14	14	13	12	12
Wasilla	2	2	11	15	16	20	20	19	17	16	15	15	16	17	17	16	15	14
Houston	1	2	8	11	12	15	15	14	13	12	12	12	12	13	13	13	12	11
Trapper Creek	11	15	85	119	133	168	159	137	101	87	79	86	97	108	111	107	90	73
Talkeetna	9	11	61	83	93	117	113	103	87	81	77	79	83	88	89	87	80	72
Other	14	18	78	105	118	148	144	135	121	116	113	114	117	121	122	120	114	106

(a) Excludes employment of workers living in Cantwell and employment of workers who maintain residences outside the region or at the village.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.35: TOTAL POPULATION INFLUX AND EFFLUX: DIRECT AND SUPPORT[a]

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	651	874	950	1338	1498	1867	1713	1225	458	158	-30	133	400	629	691	609	224	-113
Anchorage Subarea	565	761	1033	1449	1624	2027	1873	1430	735	463	293	443	692	900	957	876	530	227
Anchorage	435	589	325	482	537	663	556	254	-219	-405	-523	-411	-219	-75	-36	-92	-333	-532
Mat-Su	110	146	721	985	1107	1389	1337	1210	1013	937	891	924	975	1032	1047	1021	930	837
Kenai-Cook Inlet	20	26	-14	-18	-19	-24	-20	-35	-59	-69	-75	-70	-63	-56	-54	-54	-67	-79
Seward	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairbanks	82	107	-89	-120	-136	-173	-171	-213	-280	-306	-323	-312	-295	-276	-271	-273	-309	-341
SE Fairbanks	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Valdez-Chitina-Whittier	4	5	6	8	9	12	11	8	3	2	0	2	3	5	5	6	3	1
Mat-Su Communities																		
Palmer	5	6	26	35	39	49	48	44	39	37	35	36	37	39	39	39	36	33
Wasilla	5	7	31	42	47	59	57	54	48	46	44	45	46	48	48	47	44	42
Houston	4	5	23	31	35	44	42	40	37	36	35	35	36	37	37	36	35	33
Trapper Creek	32	43	241	337	378	475	451	387	288	250	227	247	278	306	314	302	256	212
Talkeetna	25	33	174	237	267	335	323	294	250	233	222	229	240	253	257	251	230	209
Other	40	52	226	303	341	427	415	390	351	336	327	331	338	349	352	346	328	308

(a) Excludes population influx and efflux for Cantwell and the population influx and efflux associated with workers who maintain permanent residences at the village or outside the region.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.36: TOTAL POPULATION INFLUX AND EFFLUX ASSOCIATED WITH THE DIRECT CONSTRUCTION WORK FORCE (a)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
TOTAL REGION	185	247	104	134	149	183	141	75	-29	-71	-97	-97	-97	-65	-57	-75	-125	-192
Anchorage Subarea	142	188	246	324	363	452	420	367	284	251	231	231	231	256	262	248	209	156
Anchorage	56	76	-266	-357	-403	-509	-518	-533	-555	-565	-570	-570	-570	-564	-562	-565	-577	-591
Mat-Su	79	103	548	727	817	1026	1004	969	914	892	878	878	878	895	899	889	864	828
Kenai-Cook Inlet	6	9	-36	-46	-52	-64	-66	-69	-74	-76	-77	-77	-77	-75	-75	-76	-78	-81
Seward	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fairbanks	43	59	-142	-190	-214	-270	-278	-292	-313	-322	-328	-328	-328	-321	-320	-323	-334	-348
SE Fairbanks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Valdez-Chitina-Whittier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mat-Su Communities																		
Palmer	3	4	22	29	33	41	40	39	37	36	35	35	35	36	36	36	35	33
Wasilla	4	5	27	36	41	51	50	48	46	45	44	44	44	45	45	44	43	41
Houston	3	4	22	29	33	41	40	39	37	36	35	35	35	36	36	36	35	33
Trapper Creek	20	26	137	182	204	256	251	242	228	223	220	220	220	224	225	222	216	207
Talkeetna	20	26	137	182	204	256	251	242	228	223	220	220	220	224	225	222	216	207
Other	29	38	203	269	302	379	372	359	338	330	325	325	325	331	333	329	320	307

(a) Excludes population influx and efflux for Cantwell and the population influx and efflux associated with workers who maintain permanent residences at the village or outside the region.

Source: Frank Orth & Associates, Inc.

TABLE E.5.37: EMPLOYMENT AND POPULATION EFFECTS IN CANTWELL: CASES A & B

	Resident Employment on Project		Cumulative In-migrant Construction Workers		Cumulative Population Influx Associated with In-Migrant Construction Workers		Cumulative Total Population Influx[a]	
	CASE							
	B	A	B	A	B	A	B	A
Year	High	Low	High	Low	High	Low	High	Low
1985	19	19	129	113	276	230	430	230
1986	19	19	138	113	302	230	455	230
1987	20	20	168	75	550	165	638	255
1988	20	20	209	79	686	178	774	255
1989	20	20	233	80	756	184	843	255
1990	20	20	287	85	916	198	999	255
1991	20	20	282	84	898	197	984	255
1992	20	20	274	83	875	194	961	255
1993	20	20	260	82	834	190	920	255
1994	20	20	255	53	761	130	794	163
1995	20	20	216	53	753	129	785	162
1996	20	20	216	53	753	129	785	162
1997	20	20	216	53	753	129	785	162
1998	20	20	219	53	761	130	793	162
1999	20	20	220	53	764	130	796	162
2000	20	20	217	53	755	130	788	162
2001	20	20	210	52	735	128	767	160
2002	20	20	202	51	712	125	744	157

(a) Includes the population influx associated with both in-migrant construction workers and in-migrant support workers.

TABLE E.5.38: IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSING DEMAND IN THE LOCAL IMPACT AREA DURING THE WATANA CONSTRUCTION PHASE

	Projected Housing Stock	Baseline Projection of Households	Cumulative Project-Induced Influx of Households	Total Housing Demand
Total Mat-Su Borough				
1985	11,730	9,927	38	9,965
1986	12,868	10,916	51	10,967
1987	14,095	11,986	251	12,237
1988	15,121	12,910	344	13,254
1989	16,092	13,788	387	14,175
1990	16,754	14,417	486	14,903
1991	17,728	15,354	468	15,822
1992	18,574	16,156	423	16,579
1993	19,761	17,245	352	17,597
Trapper Creek				
1985	84	83	11	94
1986	88	87	15	102
1987	93	92	85	177
1988	98	97	119	216
1989	103	102	133	235
1990	108	107	168	275
1991	114	112	159	271
1992	119	118	137	255
1993	126	124	101	225
Talkeetna				
1985	251	246	9	255
1986	267	262	11	273
1987	284	278	61	339
1988	302	296	83	379
1989	320	314	93	407
1990	340	334	117	451
1991	362	355	113	468
1992	385	377	103	480
1993	409	401	87	488
Cantwell				
1985	97	71	126	197
1986	99	72	135	207
1987	100	73	208	281
1988	102	75	255	330
1989	103	76	279	355
1990	105	78	333	411
1991	107	80	328	408
1992	108	81	320	401
1993	110	83	306	389

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.39: IMPACT OF THE SUSITNA HYDROELECTRIC PROJECT ON HOUSING DEMAND IN THE LOCAL IMPACT AREA DURING THE WATANA OPERATION AND DEVIL CANYON CONSTRUCTION PHASE

	Projected Housing Stock	Baseline Projection of Households	Cumulative Project-Induced Influx of Households	Total Housing Demand
Total Mat-Su Borough				
1994	20,821	18,235	324	18,559
1995	22,043	19,371	308	19,679
1996	23,278	20,528	320	20,848
1997	24,719	21,885	339	22,224
1998	26,048	23,145	360	23,505
1999	27,672	24,670	366	24,036
2000	29,207	26,095	356	26,451
2001	30,626	27,373	323	27,696
2002	32,115	28,715	289	28,004
Trapper Creek				
1994	132	131	89	218
1995	139	138	79	217
1996	147	145	86	231
1997	155	153	97	250
1998	163	161	108	269
1990	171	169	111	280
2000	180	178	107	285
2001	187	186	90	276
2002	195	193	73	266
Talkeetna				
1994	435	426	81	507
1995	462	453	77	530
1996	492	482	79	561
1997	523	513	83	596
1998	557	546	88	634
1999	[illegible]	581	87	670
2000	630	618	80	705
2001	662	650	72	730
2002	696	683	65	755
Cantwell				
1994	112	84	267	351
1995	114	86	264	350
1996	116	88	264	352
1997	118	89	264	353
1998	120	91	264	358
1999	122	93	264	361
2000	124	95	264	360
2001	126	97	258	355
2002	128	99	250	349

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.40: SUPPORT JOBS CREATED IN THE REGION, MAT-SU BOROUGH AND CANTWELL BY THE PROJECT, 1985 - 2002

Year	Railbelt Region		Mat-Su Borough and Cantwell
1985	731		136
1986	984		163
1987	1258		312
1988	1788	Watana Construction	445
1989	2010		499
1990	2518		622
1991	2383		581
1992	1751		460
1993	746		270
1994	353		198
1995	103		135
1996	355		178
1997	770	Devil Canyon Construction	246
1998	1078		301
1999	1166		317
2000	1079		295
2001	550		204
2002	125		123

TABLE E.5.41: EMPLOYMENT IMPACTS IN THE REGION AND MAT-SU BOROUGH, 1985-2005

Year	Total Jobs Created in the Region (a)	Forecast of Jobs for the Region: Base Case	Regional Jobs Created as a Percent of Total Base Case Regional Jobs	Total Jobs Created in the Mat-Su Borough (a)	Forecast of Jobs in the Mat-Su Borough: Base Case	Borough Jobs Created as a Percent of Total Base Case Borough Jobs
1985	1831	179,636	1%	1162	5442	21%
1986	2334	194,212	1%	1434	5975	24%
1987	3160	200,610	2%	2123	6373	33%
1988	4288	200,912	2%	2830	6641	43%
1989	4811	202,596	3%	3173	6858	46%
1990	6016	200,111	3%	3966	6914	57%
1991	5635	202,128	3%	3682	7135	52%
1992	4251	202,846	2%	2813	7296	39%
1993	2115	205,872	1%	1499	7550	20%
1994	1298	208,791	1%	1005	7806	13%
1995	749	212,050	1%	663	8076	8%
1996	1302	216,576	1%	1007	8403	12%
1997	2165	221,561	1%	1523	8755	17%
1998	2823	226,547	1%	1926	9107	21%
1999	3010	232,311	1%	2041	9505	21%
2000	2721	237,812	1%	1818	9897	18%
2001	1595	243,344	1%	1134	10308	11%
2002	446	249,007	Negligible	133	10733	3%
2003	170	254,808	Negligible	170	11176	2%
2004	170	260,749	Negligible	170	11636	1%
2005	170	266,835	Negligible	170	12116	1%

(a) Created as a direct or indirect result of the Susitna Project.

Source: Forecasts by Frank Orth & Associates, Inc.

TABLE E.5.42: MAT-SU BOROUGH SERVICE AREAS REVENUE FORECASTS
($ million)

Year	Without the Project	With the Project	% Impact
1981	1.5	1.5	--
1985	1.7	1.8	6.0
1990	2.7	3.4	25.9
1994	3.1	3.9	25.8
1999	3.7	4.7	27.0
2002	4.2	5.2	23.8

Source: Frank Orth & Associates, Inc. 1982

TABLE E.5.43: MAT-SU BOROUGH BUDGET FORECASTS

(In millions of 1982 dollars)

	GENERAL FUNDS			SERVICE AREAS FUNDS			LAND MANAGEMENT FUNDS			SCHOOL DISTRICT FUNDS		
	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact	Without the Project	With the Project	% Impact
Revenues:												
1981	15.7	15.7	—	1.5	1.5	—	0.9	0.9	--	24.6	24.6	—
1985	19.5	19.7	1.0	1.7	1.8	6.0	1.3	1.3	--	35.5	35.6	0.3
1990	28.0	29.0	3.6	2.7	3.4	25.9	1.9	2.0	5.3	50.3	53.4	6.2
1994	33.1	33.8	2.1	3.1	3.9	25.8	2.3	2.3	--	62.1	64.6	4.0
1999	41.0	41.9	2.2	3.7	4.7	27.0	2.9	3.0	3.4	80.9	83.5	3.2
2002	46.5	47.[illegible]	1.9	4.2	5.2	23.8	3.3	3.4	3.0	93.4	95.1	1.8
Expenditures:												
1981	17.2	17.2	—	4.4	4.5	—	1.1	1.1	--	27.1	27.1	—
1985	24.1	24.2	0.4	6.4	6.5	1.6	1.6	1.6	--	41.3	41.5	0.5
1990	33.1	34.2	3.3	9.4	9.6	2.1	2.2	2.2	--	61.1	65.1	6.5
1994	40.1	40.8	1.7	11.7	11.9	1.7	2.7	2.7	--	76.1	79.5	4.5
1999	51.2	51.9	1.4	15.9	16.1	1.3	3.4	3.5	2.9	100.3	103.8	3.8
2002	58.8	59.4	1.0	19.2	19.3	0.5	3.9	4.0	2.6	116.4	118.6	1.9

Source: Frank Orth & Associates, Inc. 1982

TABLE E.5.44: MAT-SU BOROUGH SCHOOL-AGE CHILDREN FORECASTS

Year	Baseline Projection	Project Associated School Population		Total School Age Population
		At Onsite Village	In the General Population	
1990	10,011	300	359	10,670
1994	12,477	300	249	13,026
1999	16,452	300	277	17,029
2002	19,074	150	223	19,477

Source: Projections by Frank Orth & Associates, Inc.

TABLE E.5.45: UPPER COOK INLET ANNUAL COMMERCIAL CATCH AND VALUE[a]

Ten Year Annual Average 1973 - 1982	Chinook	Sockeye	Species Coho	Pink	Chum
Average Annual Catch (no. of fish)	11,794	1,537,853	296,784	750,650	760,468
Average Annual Catch (no of pounds)	348,136	9,173,314	1,509,155	2,836,288	4,940,850
Average Annual Ex-vessel Value	$449,844	$10,717,244	$1,316,878	$968,993	$3,145,970

(a) Upper Cook Inlet includes catch from the Northern and Central Districts. Value is in 1982 dollars.

Source: Calculated by Frank Orth & Associates, Inc., February 1983. The Alaska Department of Fish and Game provided catch statistics from its current October 1982 IBM files and from the December reports to the Board of Fisheries. Average size per fish was provided by tho Soldotna office of ADF&G (October 1982). Cook Inlet ex-vessel price data was obtained from the Alaska Commercial Fisheries Entry Commission.

TABLE E.5.46: COOK INLET COMMERCIAL SALMON PERMIT USE

	DRIFT GILLNET		SET GILLNET	
	Permits Used	Permanent Permits in Effect	Permits Used	Permanent[(a)] Permits in Effect
1975	438	453	530	657
1976	472	514	521	712
1977	501	539	524	737
1978	537	549	581	742
1979	556	554	581	744
1980	513	554	571	744
1981	576	554	585	744

(a) Permanent permits in effect include both revenued and non-revenued permits. Discrepancies reflect interim use permits utilized in the fishery. Data for 1980 and 1981 are preliminary. There are cases pending which may alter permit numbers in the future.

Source: Commercial Fisheries Entry Commission.

TABLE E.5.47: ESTIMATED POTENTIAL LOSSES TO THE UPPER COOK INLET COMMERCIAL FISHERY - CASE 1

	Estimated Escapement Above Talkeetna (Numbers of Fish)(a)		Estimated Potential Loss (In 1982 $) (b)	
	1981	1982	1981	1982
Sockeye	4,809	3,126	117,724	70,147
Pink	2,335	73,057	12,813	200,439
Chum	20,835	49,197	214,517	467,568
Coho	3,306	5,143	37,428	45,598

(a) Potential losses are estimated using the 1981 and 1982 escapement levels above Talkeetna.

(b) Potential losses are estimated under a number of assumptions, described in the text, which may or may not be valid. One important assumption is a worst case-post project loss of 100 percent above Talkeetna. Harvest to escapement ratios developed by Freise (1975) were used. These are: chums 2.2 to 1; sockeye 3.0 to 1; pinks 3.8 to 1; and coho 2.2 to 1. 1981 and 1982 Cook Inlet ex-vessel salmon prices were used to calculate dollar loss.

Source: Calculated by FO&A, Inc. February 1983.

TABLE E.5.48: ESTIMATED POTENTIAL LOSSES TO THE UPPER COOK INLET

COMMERCIAL FISHERY - CASE 2

	Estimated Salmon Utilizing Slough Habitat for Spawning[a]		Estimated Potential Loss[b] (In dollars)	
	1981	1982	1981	1982
Sockeye	2,315	1,402	56,671	31,461
Pink	28	735	153	2,017
Chum	3,526	3,674	36,303	34,918

(a) Estimated from approximately 20 sloughs from Talkeetna to Devil Canyon (see Section 2.2.1(a)).

(b) Based on the assumption of 100 percent loss of salmon utilizing the sloughs for spawning. Harvest to escapement ratios developed by Freise (1975) were used in calculations, along with 1981 and 1982 ex-vessel salmon prices for Cook Inlet.

Source: Calculated by Frank Orth & Associates, Inc. February 1983.

TABLE E.5.49: SPORT FISH CATCH FOR MAJOR SPECIES IN THE EAST SUSITNA DRAINAGE - WEST COOK INLET - WEST SUSITNA DRAINAGE

Species	1981 Catch	1980 Catch	1979 Catch
Chinook	7,136	7,552	7,164
Coho	13,386	23,137	10,671
Sockeye	2,289	1,984	2,577
Pinks	8,793	57,284	13,107
Chums	4,466	5,043	4,945
Rainbow	21,843	20,060	23,081
Dolly Varden/Arctic Char	5,835	5,771	9,136
Arctic Grayling	17,110	20,206	19,578
Total Angler Days	97,189	139,429	128,596

Source: Michael J. Mills *Statewide Harvest Survey* ADF&G various years.

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TABLE E.5.50: UPPER COOK INLET SUBSISTENCE SALMON CATCH[a]
(Catch in Number of Fish)

	Chinook	Sockeye	Coho	Pink	Chum	Total	No. of Permits
1969	0	1,509	1,259	30	94	5,892	330
1970	3	1,206	2,192	295	139	3,832	335
1971[b]	0	7	148	0	0	155	37
1972	0	4	55	27	15	101	30
1973	0	35	332	12	37	416	123
1974	1	14	291	17	2	325	109
1975	1	4	659	8	92	764	114
1976	0	21	567	113	13	714	111
1977	2	13	327	3	14	359	83
1978	5	42	3,529	128	31	3,735	323
1979	158	5,564	3,570	359	272	9,923	1,161
1980[c]	2,268	5,459	3,912	4,842	492	16,973	1,396
1981[e]	2,072	587	11,752	93	237	14,741	1,178

(a) Includes the Central District and Northern District.

(b) Knik Arm closed to subsistence fishing.

(c) Household permits were issued starting in 1980, whereas individual permits were issued prior to 1980.

(d) Includes 85 permits issued for special openings of the Central District and 65 permits issued for the special king salmon fishery at Tyonek.

(e) Preliminary data.

(f) There were 1,108 non-commercial set net permits issued in the Central District. The Tyonek fishery, with 70 permits, was the only subsistence fishery allowed in the Northern District in 1981.

Source: Alaska Department of Fish and Game, Soldotna Regional Office, May 1982.

TABLE E.5.51: MOOSE HARVEST AND HUNTING PRESSURE IN GMU 13

YEAR	HUNTERS	HARVEST
1970	3,534	1,391
1971	4,881	1,814
1972	3,199	712
1973	2,513	618
1974	2,770	794
1975	2,978	715
1976	3,122	732
1977	2,299	698
1978	3,034	863
1979	2,377	848
1980	2,859	557
1981	3,105	794

Source: Alaska Department of Fish and Game, Division of Game, March 1980. Annual Report of Survey Inventory Activities, Part II and other ADF&G files.

TABLE E.5.52: TRAPPER EXPORTS AND DEALER PURCHASES OF FURBEARER PELTS IN GAME MANAGEMENT UNIT 13, 1977 - 1980

TRAPPER EXPORTS

Species	1977	1978	1979	1980
Beaver	47	24	51	48
Mink	56	105	140	163
Muskrat	525	762	632	473
Marten	61	119	194	102
Otter	3	2	10	10
White fox	2	0	11	1
Other fox	146	302	192	207
Weasel	3	38	29	2
Lynx	78	60	42	53
Number of Trappers	40	57	62	39

DEALER PURCHASES

Species	1977	1978	1979	1980
Beaver	22	11	32	9
Mink	39	42	54	102
Muskrat	552	1,023	351	805
Marten	79	273	280	236
Otter	3	7	2	2
White fox	0	0	2	2
Other fox	124	166	59	142
Weasel	32	10	50	9
Lynx	47	39	14	49

Source: Alaska Department of Fish and Game data for Game Management Unit 13.

TABLE E.5.52: TRAPPER EXPORTS AND DEALER PURCHASES OF FURBEARER PELTS IN GAME MANAGEMENT UNIT 13, 1977 - 1980

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DEALER PURCHASES

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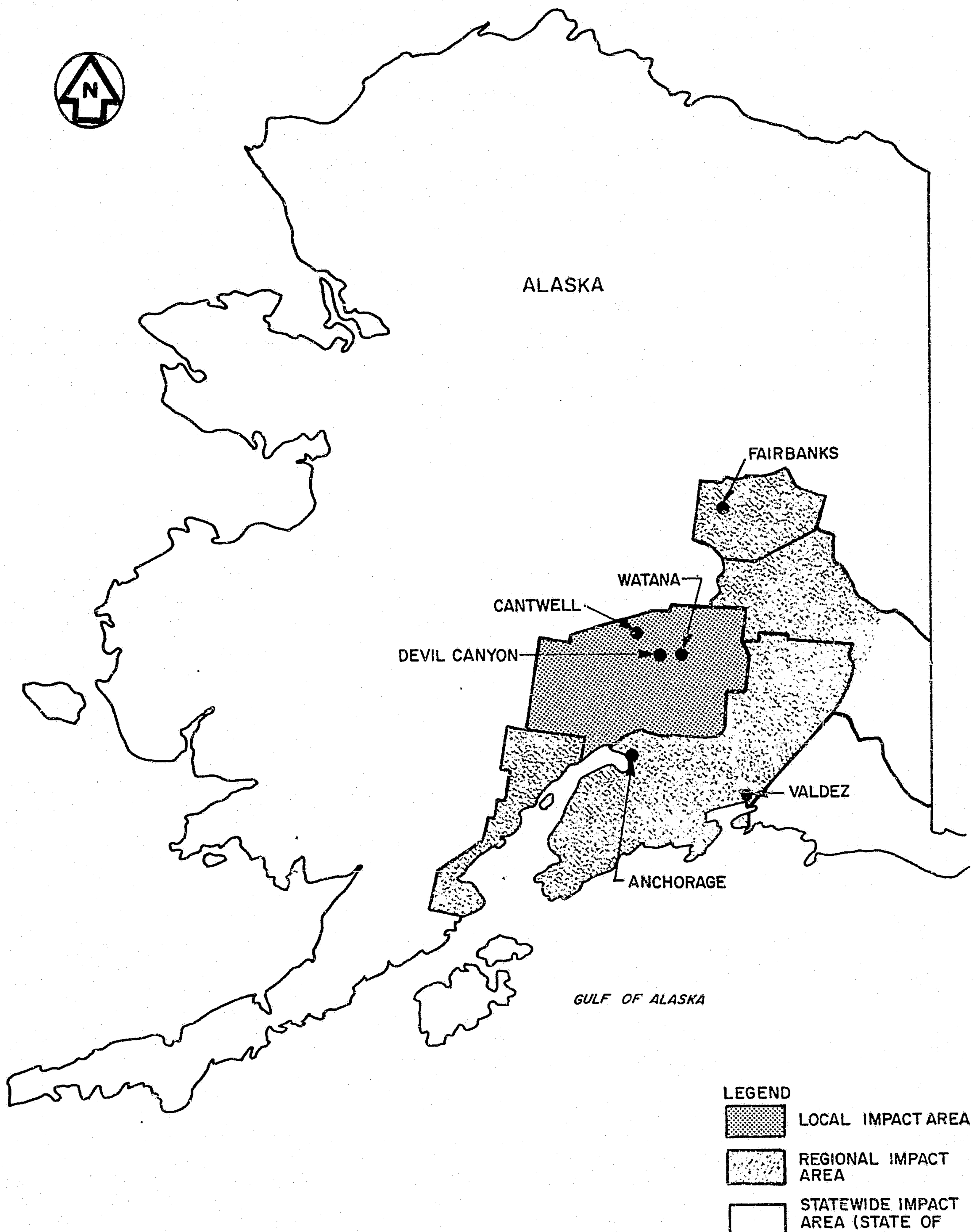
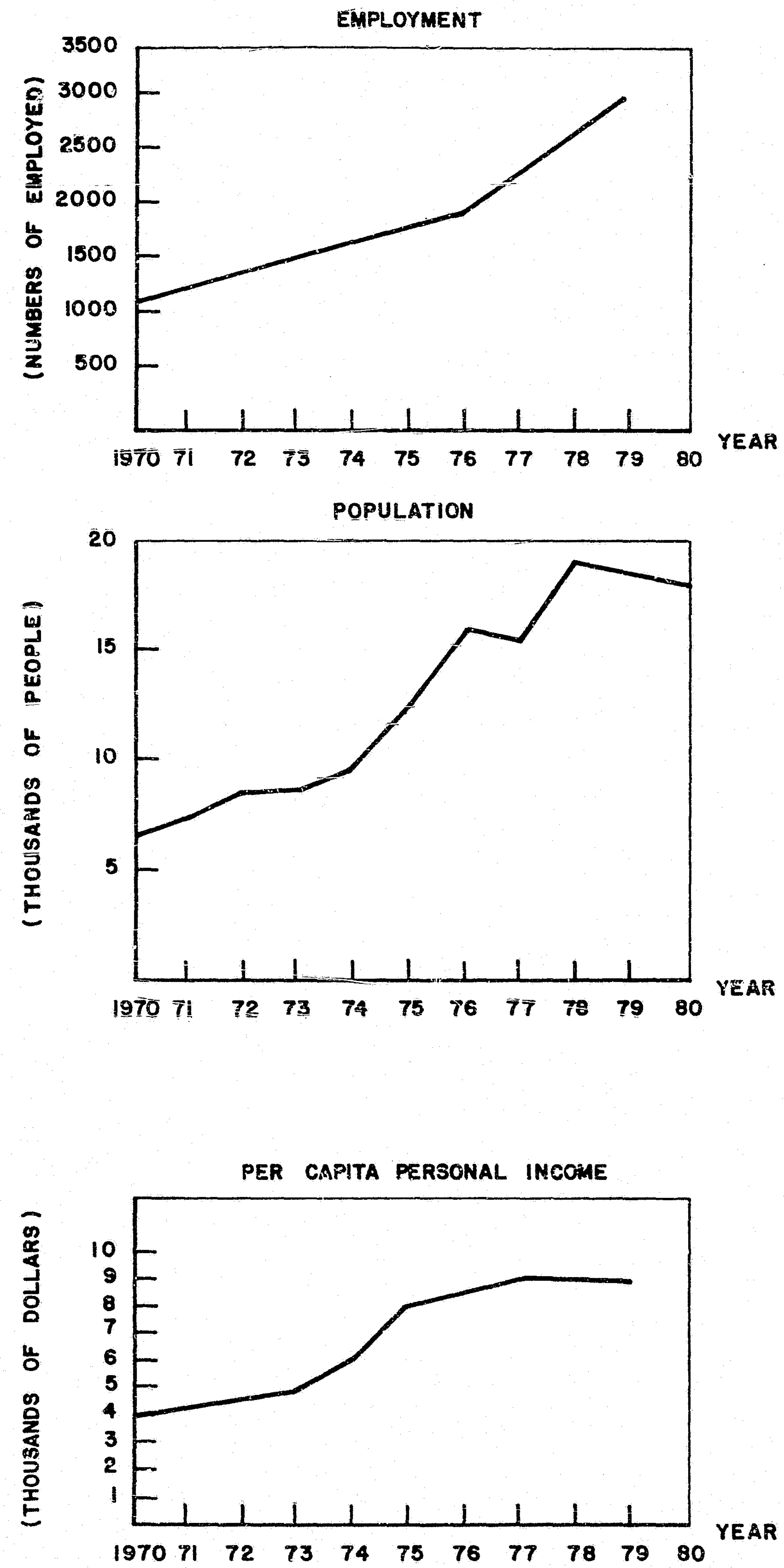
White fox	0	0	2	2
Other fox	124	166	59	142
Weasel	32	10	50	9
Lynx	47	39	14	49

Source: Alaska Department of Fish and Game data for Game Management Unit 13.



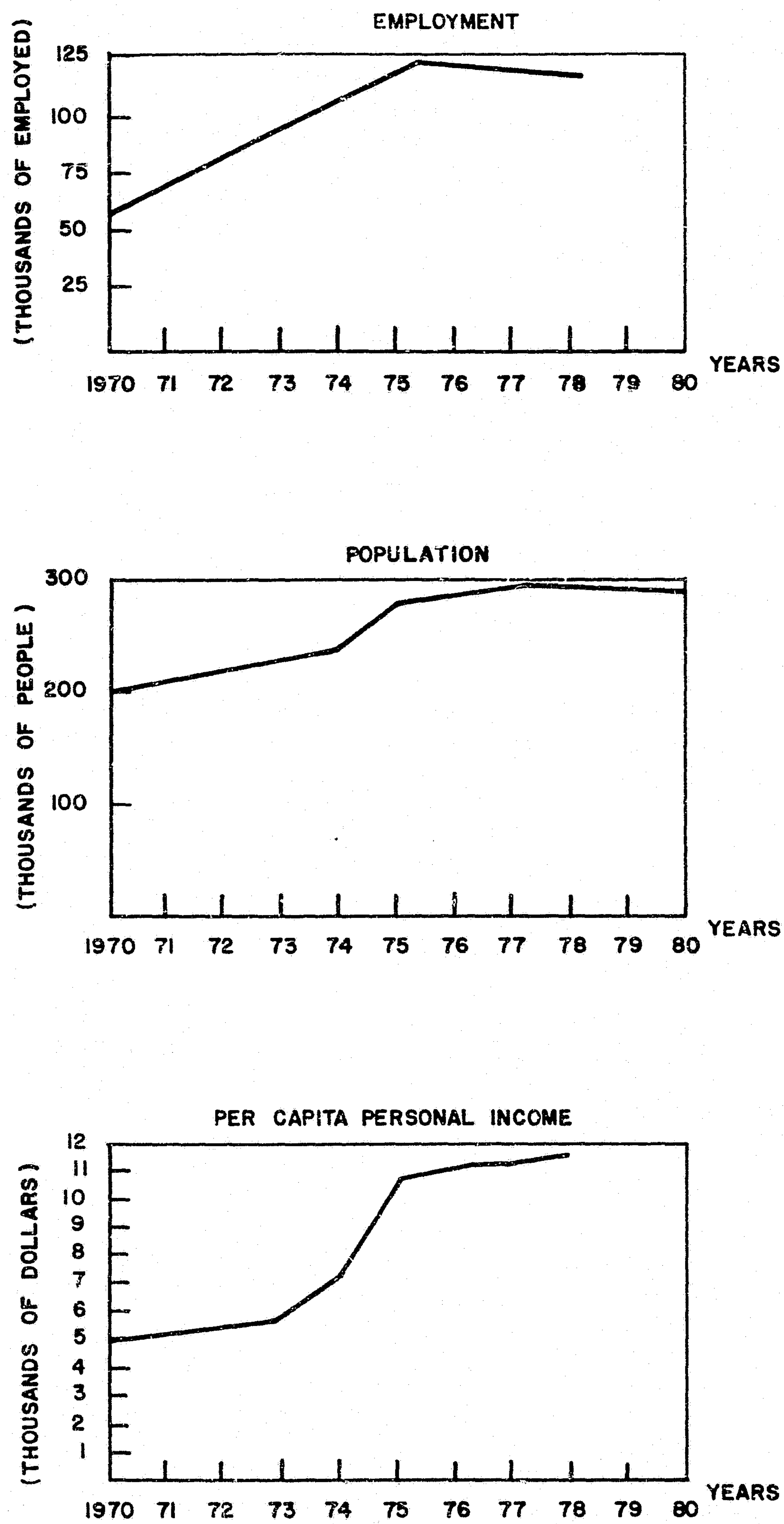
SOCIOECONOMIC IMPACT AREAS

FIGURE E.5.1



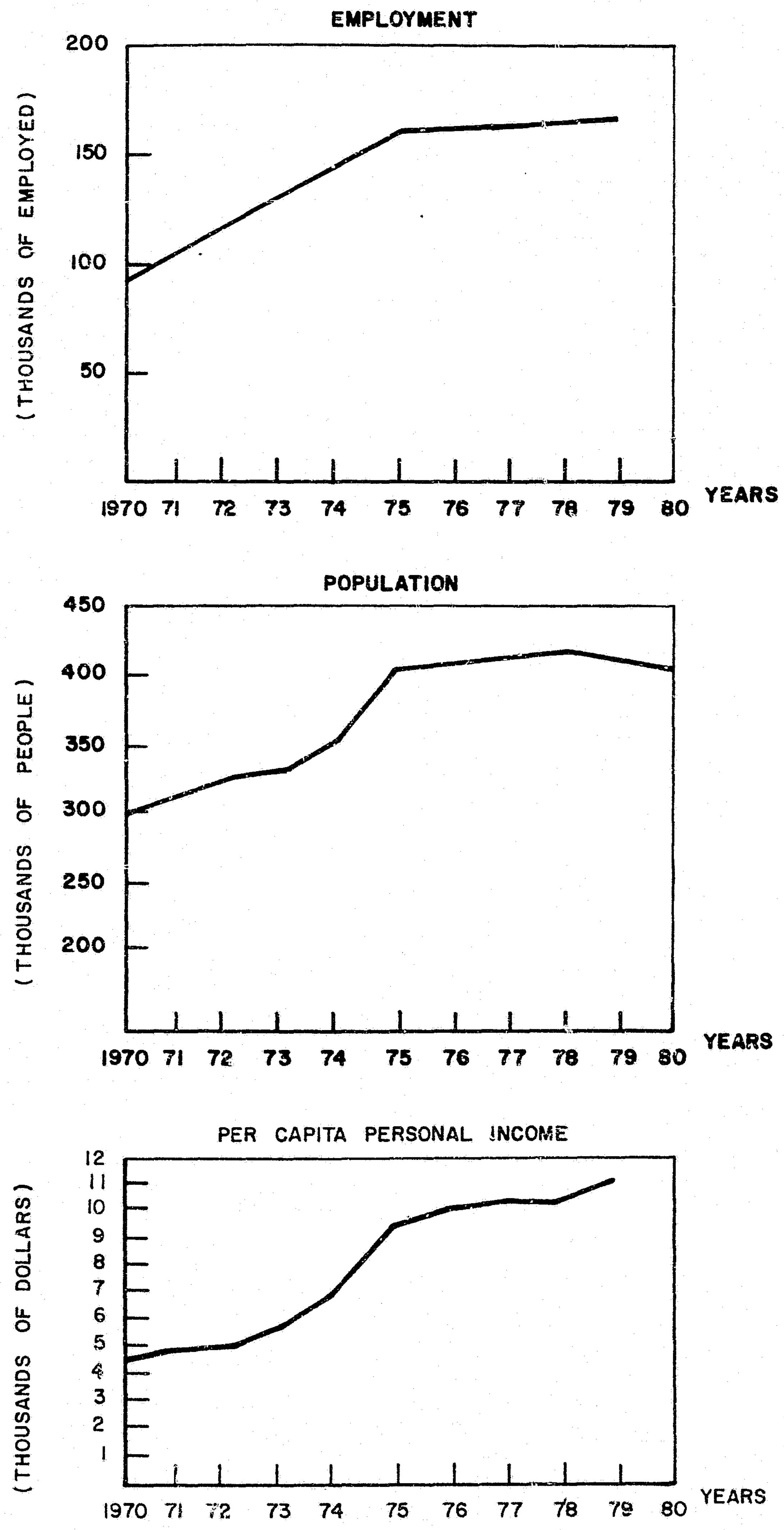
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE MATANUSKA-SUSITNA BOROUGH, 1970-1980

FIGURE E.5.2



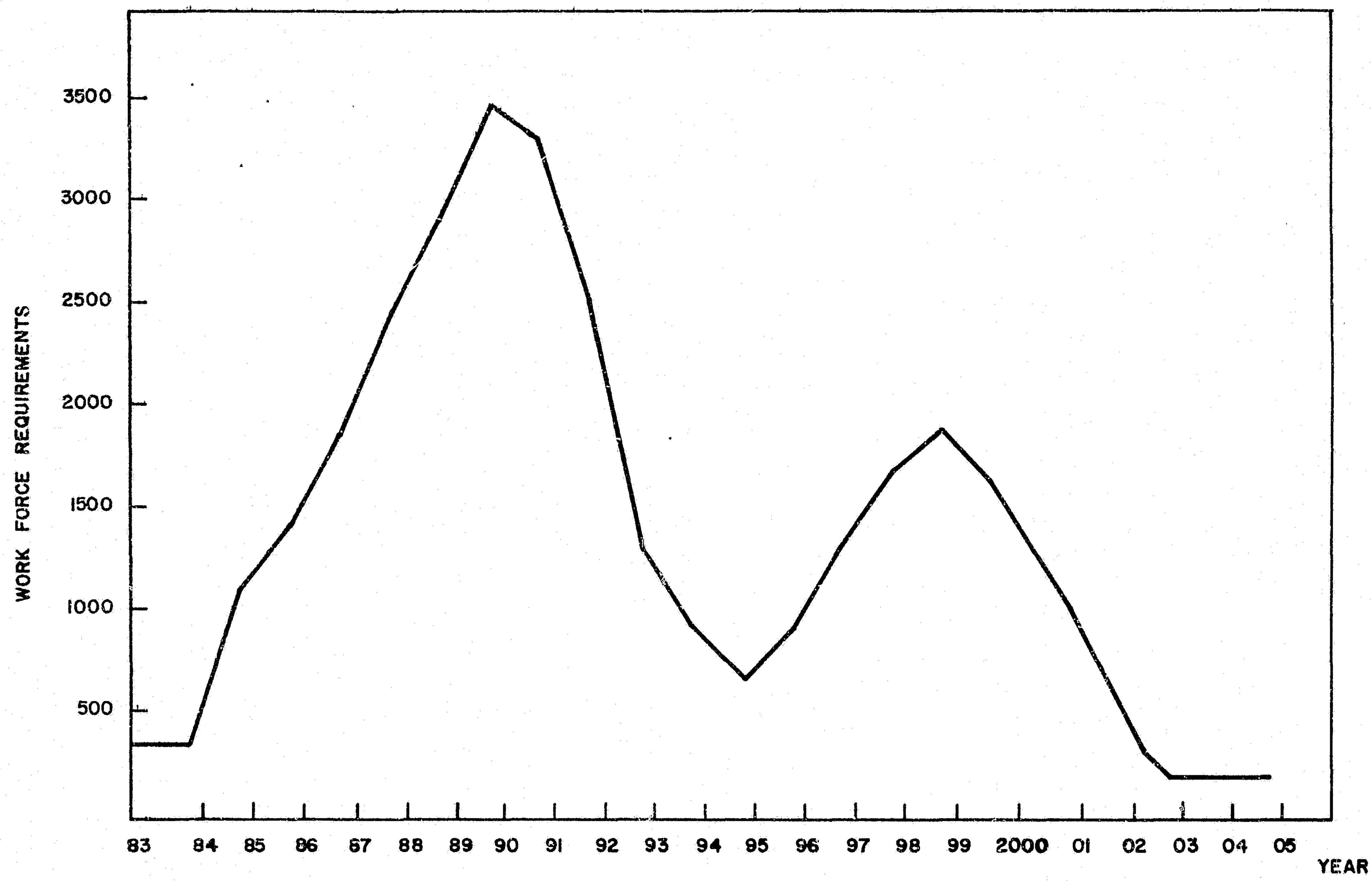
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE RAILBELT REGION

FIGURE E.5.3



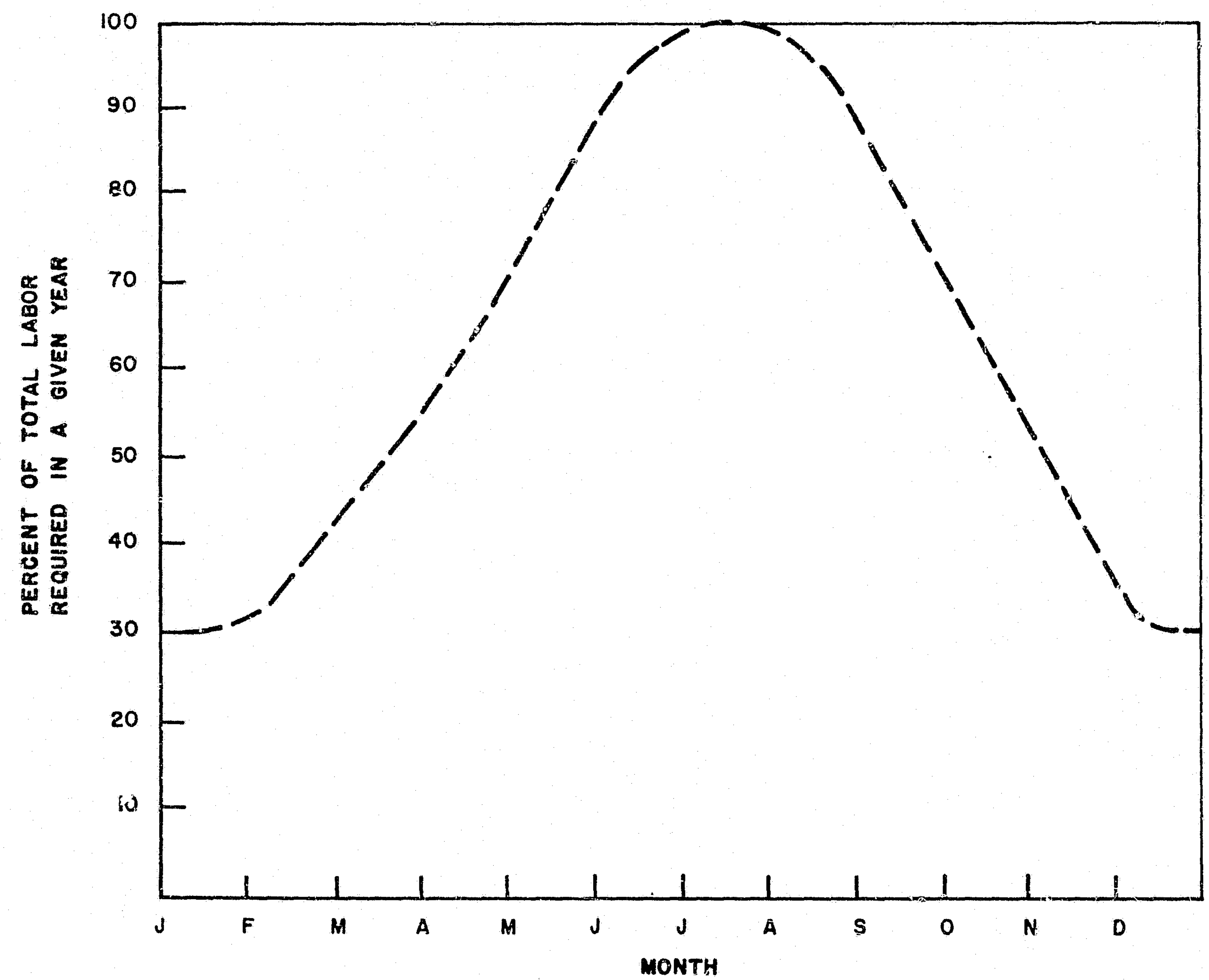
EMPLOYMENT, POPULATION AND PER CAPITA PERSONAL INCOME IN THE STATE OF ALASKA, 1970-1980

FIGURE E.5.4



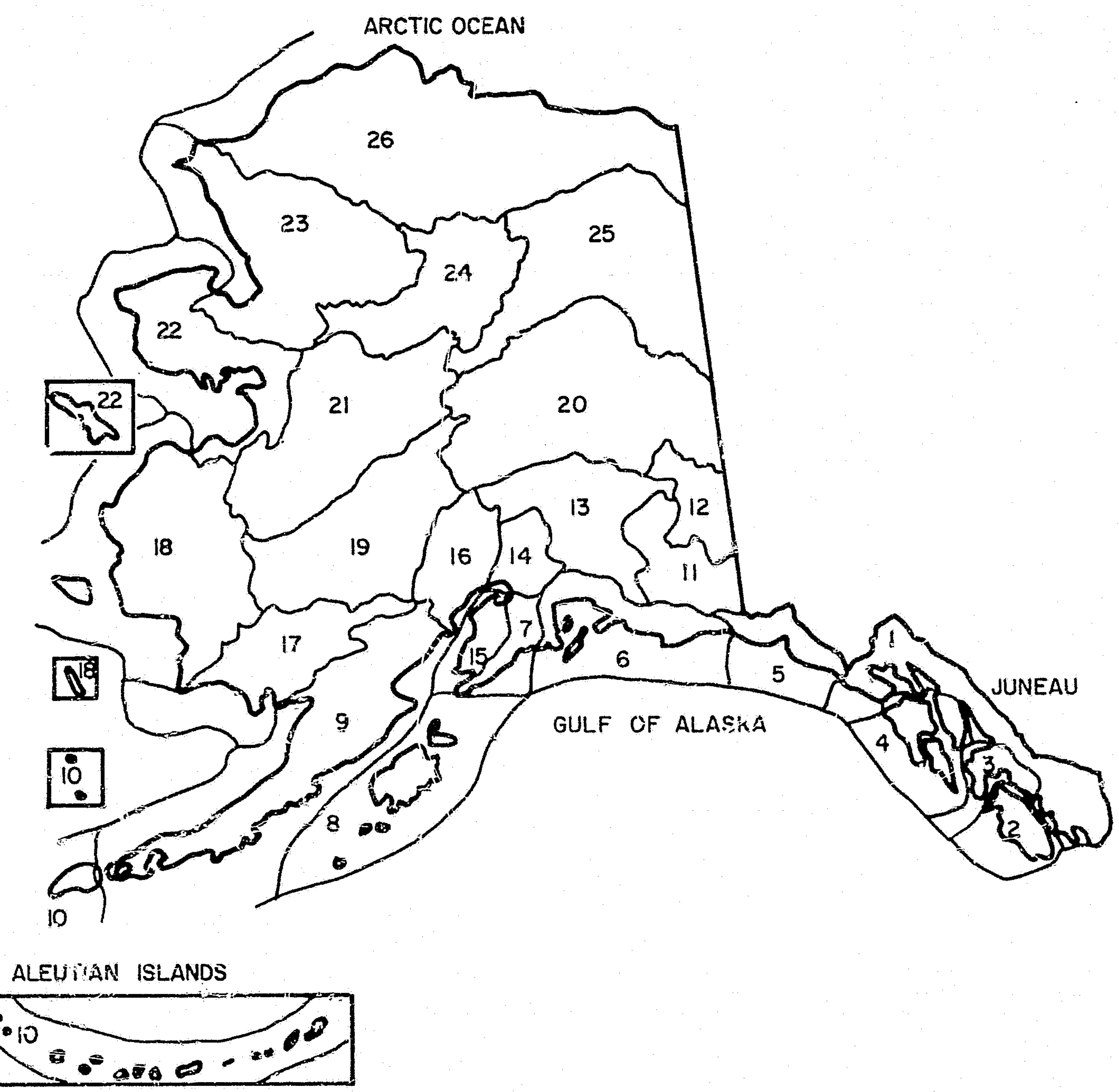
ON-SITE CONSTRUCTION AND OPERATION WORK FORCE REQUIREMENTS

FIGURE E.5.5



SEASONAL LABOR CURVE

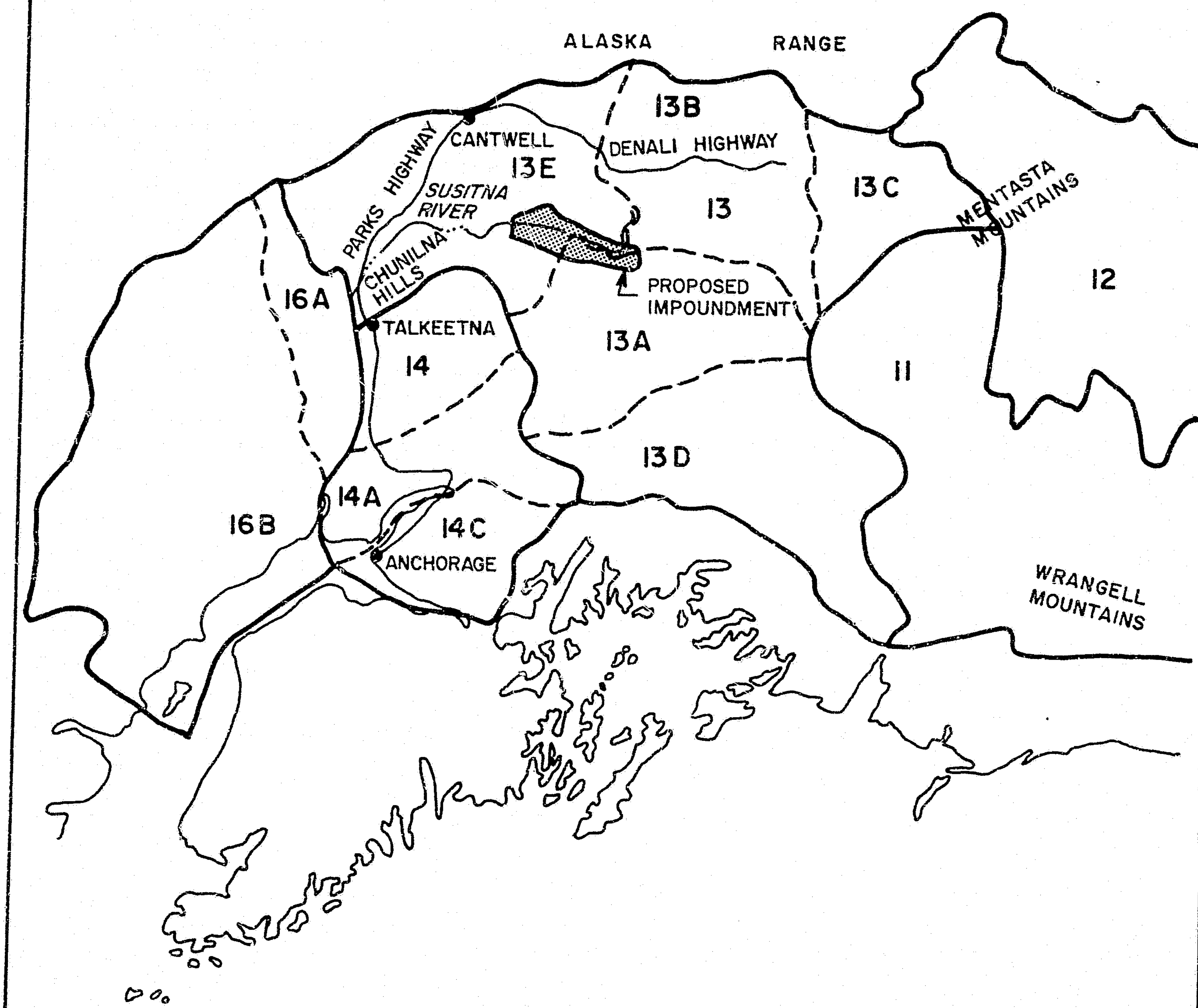
FIGURE E.5.6



ALASKA GAME MANAGEMENT UNITS

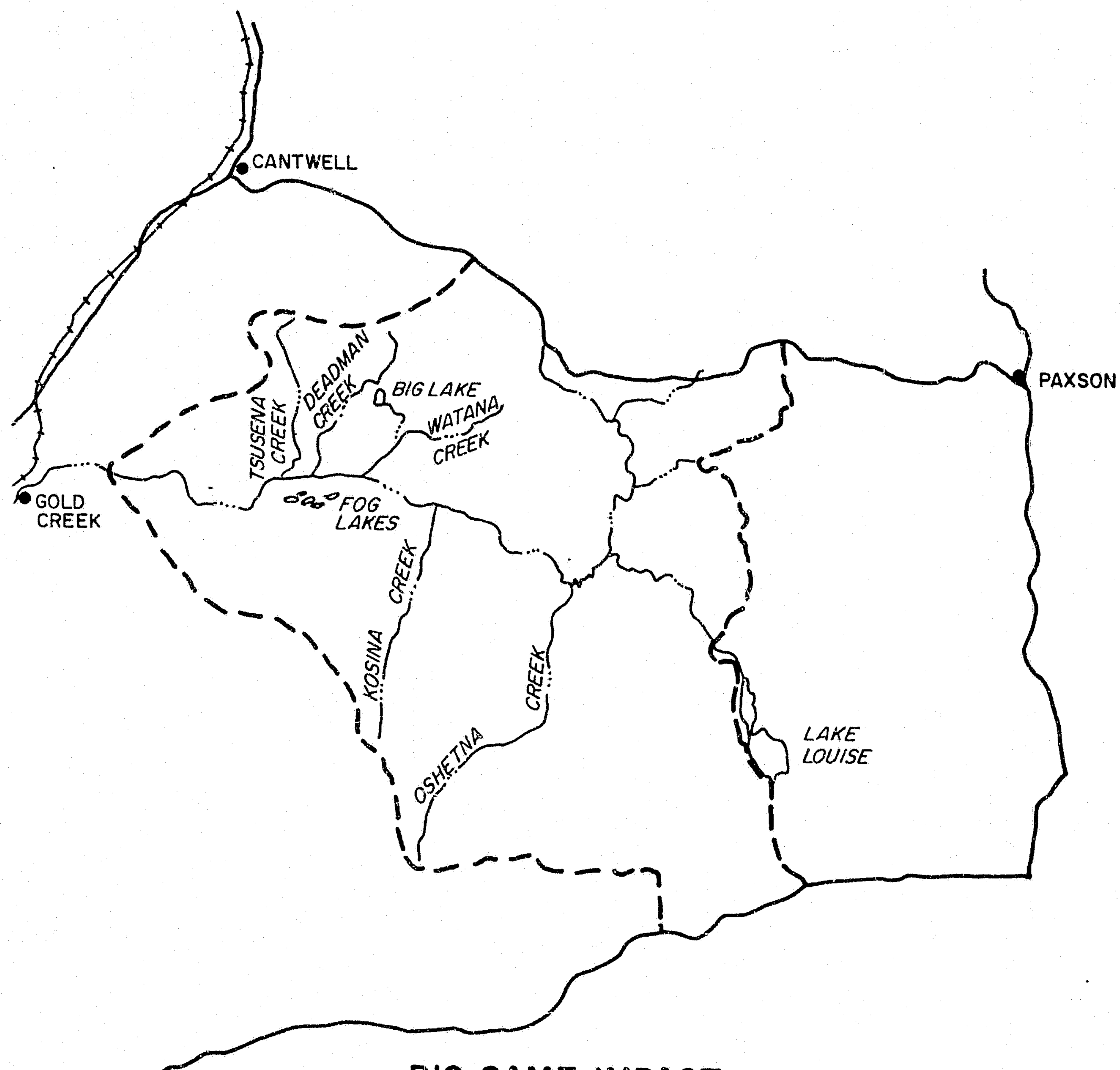
SOURCE: MODIFIED FROM ADF&G, ANNUAL REPORT OF SURVEY-INVENTORY ACTIVITIES 1980

FIGURE E.5.7



GAME MANAGEMENT UNITS
IN THE VICINITY OF THE PROJECT

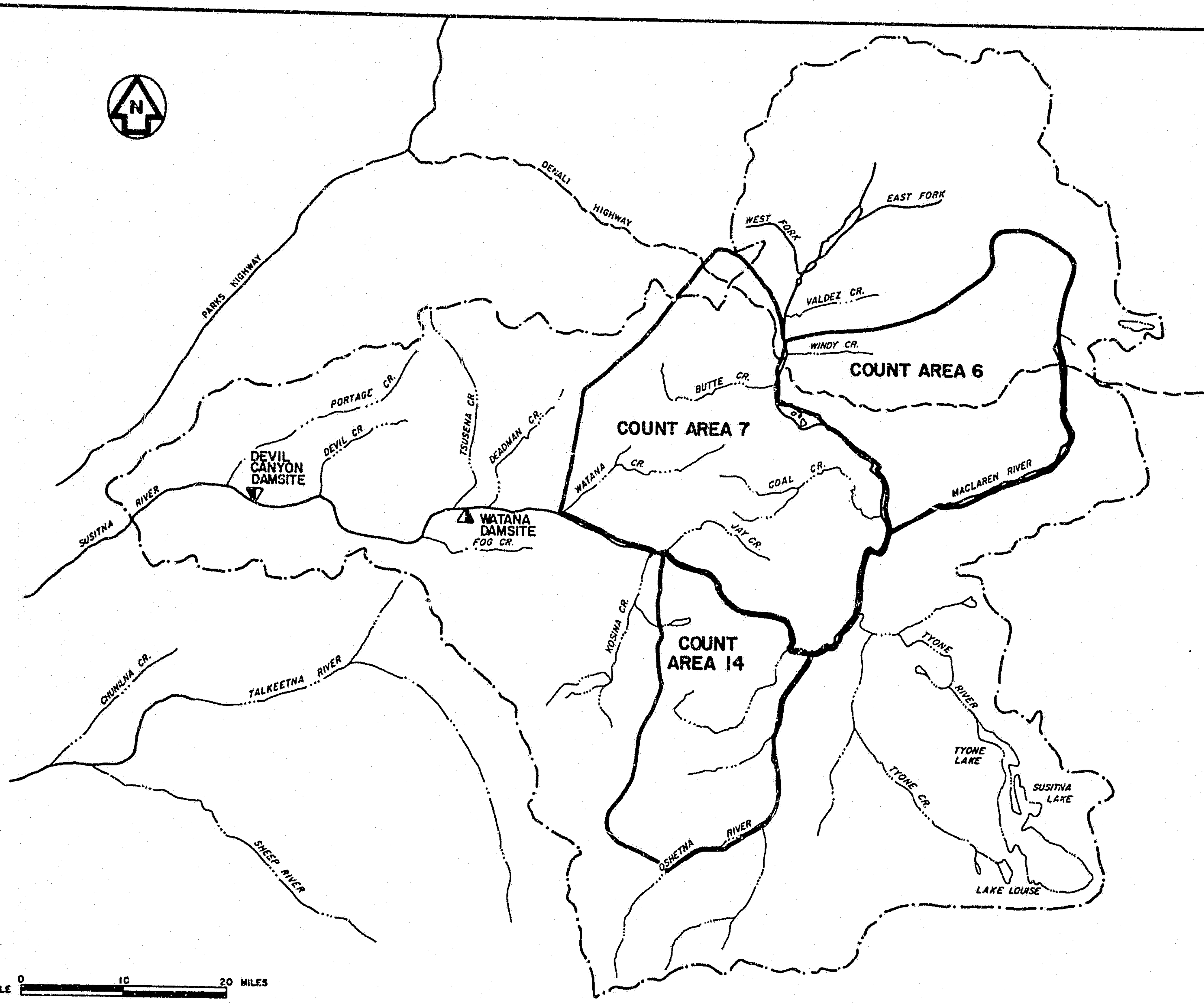
FIGURE E.5.8



BIG GAME IMPACT
STUDY AREA - 1980 STUDIES

SOURCE: MODIFIED FROM ADF & G, 1982;
BIG GAME STUDIES VOLUME III

FIGURE E.5.9



MOOSE STUDY AREA-1955 THROUGH 1980

SOURCE: ADOPTED FROM ADF & G 1982, BIG GAME STUDIES VOLUME III

FIGURE E.5.10

APPENDIX E5A

Elaboration on Approach, Assumptions and Methods

APPENDIX 5.A

ELABORATION ON APPROACH, ASSUMPTIONS, AND METHODS

This appendix is intended to provide (a) an overview of the approach to conducting the impact assessment; (b) an overview of the impact (accounting) model; and (c) an elaboration of several assumptions made in Section 3.3. Further information can be found in Sections 5, 10, and other sections of Frank Orth & Associates (1982).

(a) Approach

After the impact areas were defined, and as a precursor to making base case forecasts, recent and current socioeconomic conditions were analyzed. These included employment, population, income, housing, public facilities and services, local governments' budgets, land use, and other socioeconomic elements. Base case forecasts were then made for selected socioeconomic elements. A brief description of the forecasting techniques used is provided in Table 5.A.1. Forecasts were made for the years 1983-2005.

Next, impact forecasts were made. An "accounting model" was developed to handle the several labor categories and geographic disaggregations. This model was computerized to provide for efficient analysis and to make sensitivity analysis feasible. Techniques used for the impact forecasts are shown in Table 5.A.2. Forecasts were made for 1983-2005.

Base case and impact forecasts were compared and contrasted to identify project-induced changes in the base case. Next, the significance of these changes was analyzed and discussed.

(b) Impact Model

A model was developed that could take into account settlement and traveling/commuting patterns of construction workers. It was specified to allow for in-migration and out-migration of workers and their dependents. These elements were emphasized because they will be the source of most of the project-induced changes.

The model was computerized to make calculations more quickly and to allow for sensitivity analysis. There are likely to be some changes before construction begins in 1985, and it will be helpful to be able to quickly and efficiently determine the socioeconomic implications of these changes.

TABLE 5.A.1: BASELINE FORECASTING TECHNIQUES

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State and Regional	Time-series econometric[(a)]
Census Division	Linear regression
POPULATION	
State and Regional	Time-series econometric[(a)]
Census Division	Linear regression
Community	Population Share (judgmental)
INCOME	
State, Regional, and Census Division	Trend analysis and judgment
HOUSING	
Regional and Census Division	Person per household trend multiplier
FACILITIES AND SERVICES	
Census Division and Community	Per capita planning standards
FISCAL	
Census Division and Community	Per capita multiplier

(a) Includes results from Institute of Social and Economic Research's Man-in-the-Arctic Model, October, 1981.

TABLE 5.A.2: IMPACT FORECASTING TECHNIQUES

ELEMENT	FORECASTING TECHNIQUE
EMPLOYMENT	
State, Regional, and Census Division	Accounting model
State and Regional	Time-series econometric (for comparison purposes only)[a]
POPULATION	
State, Regional, and Census Division	Accounting model
State and Regional	Time-series econometric (for comparison purposes only)[a]
INCOME	
State, Regional, and Census Division	Accounting model
HOUSING	
Regional and Census Division	Person per household trend multiplier
FACILITIES AND SERVICES	
Census Division and Community	Per capita planning standards
FISCAL	
Census Division and Community	Per capita multiplier

(a) Includes results from Institute of Social and Economic Research's Man-in-the-Arctic Model, October, 1981.

APPENDIX E5B

Public Facilities and Services

APPENDIX 5.B

PUBLIC FACILITIES AND SERVICES

This appendix provides additional explanation of the methodology used to project impacts of the project on public facilities and services. The general approach to forecasting public facility and service requirements during 1985-2005 was (1) to develop appropriate standards for each service category and for each relevant community that relate service and facility requirements to the size of population; (2) to assess the adequacy of existing facilities and services and to quantify any over- or under-capacity using these standards; and (3) to estimate future needs based on the application of these standards to the population growth forecasts with and without the Susitna project.

(a) Types of Standards

Standards can be divided into two categories--average and prescriptive. Average standards are based on recent data on existing service levels on a per capita basis for a given area. Average standards may be based on national, regional, state, or local averages or on averages for a given type or size of community; their distinguishing feature is that they are based on an average of what currently exists. For some service types, there exist prescriptive standards that are set by relevant agencies or associations. These standards often vary by size, type, and community and may be of a voluntary or mandatory nature. For instance, a state government may require certain standards for health care and education; standards for fire protection based on insurance tables may be used widely.

A mix of average and prescriptive standards has been used in this analysis. The objective has been to provide detailed measures of adequate service levels for those services which the local governments now provide, while keeping under consideration the resource constraints that communities face. Local preferences, based upon conversations with local, state and borough officials, have been taken into account.

For some facilities and services, the required level of service varies among communities, depending on factors such as the size of the community and the type of community (urban, rural, or suburban).

In some cases, relevant standards may be based on variables other than population per se--for example, the number of dwellings or the number of school-age children. These variables are related to population levels, but the actual ratios may change over time.

Service categories such as education and health care are especially sensitive to demographic changes. Where possible, forecasts of demographic changes have been incorporated into the analysis.

Due to the many factors that influence the needs for public facilities and services, the uniqueness of each community, and the subjectivity in deciding adequate service levels, the standards listed below should not be considered absolutes but rather as general indicators. A summary of the standards used is displayed in Table E.5B.1. In the sections below, specific considerations relating to the choice of standards are discussed.

(b) Water Supply

Water systems comprise three components--the supply source, the treatment facility, and the pipe distribution network. The most widely used standards for water service are the average and peak water consumption per capita, in terms of gallons per day (gpd). Facility standards sometimes include pipe length per thousand dwellings, and treatment capacity.

The standards are relevant only for communities that have or are expected to develop water systems. Only two communities in the local impact area, Palmer and Wasilla, have citywide water supply systems. Other residents, including inhabitants of the communities that will be most affected by the project, rely on individual wells or "community" systems that serve a particular subdivision, trailer park or other small areas.

An average per capita water consumption standard of 120 gpd (456 liters per day) in 1981 rising to 150 gpd (570 liters per day) by the year 2000 was used. The city of Palmer currently has an average per capita water usage rate of 120 gpd (456 liters per day), and this relatively low usage may be attributed to the small amount of industry in the area. It is expected that future growth will include an increase in business activity and, hence, a rise in per capita water consumption.

(c) Sewage Treatment

The amount of sewage generated is a function of the amount of water that is used daily. It has been estimated that an average of 65 percent of total water supplied becomes sewage, or 100 gpd (380 liters per day) per capita, with the remainder used for miscellaneous purposes such as watering lawns and gardens, firefighting and generating steam (Stenehjem and Metzger 1980). This standard may not be as appropriate for application to rural communities. Sewage treatment in Palmer is currently equal to 100 percent of average water usage, or 120 gpd (456 liters per day) per capita. For the purposes of projections of impacts, a constant standard of 120 gpd (456 liters per day) has been used for Palmer, the only community with a sewage treatment system in the Mat-Su Borough.

(d) Solid Waste Disposal

Solid waste can be disposed through incineration or sanitary landfill disposal; sanitary landfill has become the prevalent mode. Facility requirements for solid waste disposal can be measured in terms of the amount of land needed per capita on an annual basis. Published standards range from 0.2 to 0.3 acre (0.08 to 0.12 ha) per thousand people, depending on assumptions of pounds of waste per capita, depth of the site, and the rate of compression of the waste.

A lower standard of 0.11 acre (0.04 ha) per thousand population has been assumed initially for the Mat-Su Borough, based on the premises that waste production per capita is much lower and the fill depth of the central landfills is twice as high as national averages. This standard is calculated to rise to 0.21 acre (0.08 ha) by 2000 and held constant at this level between 2001 and 2005.

(e) Education

The major determinant of the requirement for educational facilities and services is the number of school-age children per capita, modified to take into account private school attendance. Two different methodologies were used to estimate the number of school-age children associated with the (1) base case population and (2) in-migrant population associated with the Susitna project.

Under the base case for the Mat-Su Borough, the standards that the school district uses for planning were used in this study as well. Short-term planning through 1987 uses an estimate of 22.8 percent. For long-range planning purposes, an estimate of 25 percent is used. For the purposes of this study, the ratio is assumed to rise gradually from 22.8 percent in 1987 to 25 percent in 2000 and then hold constant at that level through 2005. In Cantwell, the present 18 percent level was assumed to remain constant over time in the base case.

The number of school-age children accompanying workers on the project has been estimated using a ratio that was calculated through surveys of other large projects of 0.89 school children per in-migrant worker accompanied by dependents. The number of school-age children associated with the in-migrant secondary population was calculated on the same basis as base case school-age children.

A major service standard for education relates the number of school-age children to the number of classes and teachers. Local preferences have been used as standards in this case. In the Mat-Su Borough school district, planning standards include an optimum of 25 students per class for primary schools and 20-22 for secondary schools. In addition, Mat-Su Borough statistics show that teachers comprise about 50 per cent of total school district personnel requirements. In Cantwell, the Railbelt School District's planning standard teacher-student ratio of 15:1 was used.

Requirements for classroom space can be measured in terms of number of classrooms or, alternatively, the number of square feet per pupil [90 square feet(8 square meters) for primary school students and 150 square feet (14 square meters) for secondary school students]. For the purposes of this study, space required has been projected in numbers of classrooms.

It is assumed that the present ratios of primary school students (54 percent of total) and secondary school students (46 percent of total) will remain constant. It is beyond the scope of this analysis to forecast changes in distribution by school and by grade.

(f) Health Care

Standards for acute public health care focus on the capability of hospital facilities and staff to accommodate the expected number of patients without building overcapacity that will then add to hospital costs. While rule-of-thumb bed multipliers of between 2.1 and 5.8 beds per 1000 population are often used, it has become appropriate to base the number of beds on a measure of the long-term average daily census of patients using the hospital divided by the desirable occupancy rate. In Alaska, the recommended occupancy rates are 80 percent for urban hospitals and 55 percent for rural hospitals. The formulas used are:

Acute Care Patient Days at Valley Hospital Plus Days at Alaska and Providence for Borough Residents			÷	Borough Population	=	Hospital Use Rate
Hospital Use Rate For Borough Residents	X	Estimated Borough Population	÷	365 Days in Year	=	Projected Average Daily Census (PADC)
Projected Average Daily Census	X	Proportion of Bed Need Met at Valley Hos.	÷	Minimum Occupancy for Rural Hospital (55%)	=	Valley Hospital Acute Care Bed Need

A significant aspect of the hospital system in Alaska deserves note. The Municipality of Anchorage has developed a comprehensive acute and long-term health care system that provides the main medical care for the residents of south-central Alaska, as well as other areas of the state. A large percentage of people living in areas such as the Mat-Su Borough, as well as Cantwell, presently elect to use hospitals in Anchorage over the hospital in Palmer because of the larger number of doctors (especially specialists) and the more modern facilities. However, the percentage of patients that use the Valley Hospital in Palmer has been rising rapidly in recent years, and this trend is expected to be accelerated by the planned addition to and renovation of this hospital, as well as the possible addition of certain medical specialists to the staff. It is assumed that the usage of Valley Hospital, as a percentage of total Alaskan hospital use by Mat-Su Borough residents, will rise from 38 percent in 1980 to 75 percent in 2000 and remain constant at that level through 2005.

Age and sex distributions of the population are important determinants of hospital use. For the purposes of this study, demographic factors have been assumed to remain constant.

(g) Law Enforcement

Police service standards range from one officer per thousand population in unincorporated rural areas to 1.5 officers per thousand population in small communities and 2 officers per thousand in moderately large cities. For rural parts of the local impact area, a standard of 1.0 officer per thousand was applied to the population projections. For the southern part of the Mat-Su Borough (outside Palmer, which has its own police force), a standard of 1.5 officers per thousand population was used; it is anticipated that the growing suburbanization of the borough will soon justify use of the increased standard.

Alaska State Troopers judge the relative adequacy of their staffs in terms of the average case load (i.e. number of crimes) that each officer is charged with investigating. Six cases per trooper is considered average, and eight is considered the level at which additional staff is needed. Currently, there is about one officer per thousand population in the borough.

(h) Fire Protection

The major variables that are used to judge the fire protection are (1) the available flow of water, (2) the frequency of response, and (3) the manpower needed.

There are several standards that relate these variables to population size in the literature. Water flow, response time or service radii, and the equipment capacity are of particular use. It is common in communities of less than 7,000 to rely on volunteer firefighters, and thus, standards for manpower are not applicable to the communities under study.

Fire protection planning in Alaska, as in many other states, often takes the form of trying to achieve a certain fire rating as measured by the Insurance Service Organization (ISO). The ISO is a national organization that rates fire protection on a scale from 1 (best) to 10 (worst); fire insurance rates closely reflect these ratings.

Communities without a community water system can at best achieve an ISO rating of 8 (which is the objective that the Mat-Su Borough presently hopes to achieve for its most populous fire districts). The requirements, to achieve a rating of 8 are: that dwelling class property be within five road miles of a fire station (on roads that are in good condition) and that the fire department has demonstrated its ability to deliver 200 gallons per minute (gpm) (757 liters per minute) for a period of 20 minutes without interruption. The latter requirement implies a need for a capacity of 4000 gallons (15,140 liters) of water "on wheels."

(i) Recreation

Projected requirements for recreation facilities, in terms of acreage for playgrounds, neighborhood parks, and community parks, were calculated by applying national standards for rural areas. Standards for playgrounds and neighborhood parks are most applicable to the cities of Palmer, Wasilla, and Houston, whereas community parks are planned for larger areas, and the standard pertaining to this category is most relevant to Mat-Su Borough as a whole.

TABLE 5.B.1: SUMMARY OF PUBLIC FACILITY AND SERVICE STANDARDS FOR SELECTED COMMUNITES IN THE LOCAL IMPACT AREA

	Palmer	Wasilla	Houston	Trapper Creek	Talkeetna	Total Mat-Su Borough	Cantwell
Water Supply							
Average Water Supply & Treatment (gpd per capita)	120-150	120-150	---	---	---	---	---
Sewage Treatment							
Sewage Treatment (average gpd per capita)	150	---	---	---	---	---	---
Solid Waste Disposal							
Landfill Requirements (acres per 1,000 population)	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21	.11-.21
Education							
Maximum Primary School-Age Children to Teacher Ratio	31	31	---	31	31	31	15
Maximum Secondary School-Age Children To Teacher Ratio	35	35	---	---	---	35	15
Teacher to Support Staff Ratio	8:1	8:1	8:1	8:1	8:1	8:1	---
Health Care							
Desired Hospital Bed Occupancy Rate	---	---	---	---	---	55%	---
Law Enforcement							
Police Officers (officers per thousand population)	1.5	---	---	---	---	1.0	1.0
Parks and Recreation							
Playgrounds (acres per 1000 dwelling units)	3.9	3.9	3.9	---	---	---	---
Neighborhood Parks (acres per thousand dwelling units)	3.3	3.3	3.3	---	---	---	---
Community Park (acres per thousand dwelling units)	---	---	---	---	---	4.8	---

APPENDIX E5C

Assumptions, Methodology, and Rationale for Fiscal Projections

APPENDIX 5.C

ASSUMPTIONS, METHODOLOGY, AND RATIONALE FOR FISCAL PROJECTIONS

Introduction

The fiscal impact analysis was performed to project impacts of population change on local government revenues and expenditures. The per capita multiplier fiscal impact method was used to supply average cost data per person, per pupil, and per household where applicable. The analysis assumes that current average costs are a good approximation of the real costs to provide services to future residents, and current per capita revenues or their relative proportions will remain constant in the future unless stated otherwise. The results of this analysis, however, should be treated as trend indicators and not predictions of actual experience. Projections are provided for the period 1981-2002.

The methodology described was used for both the Base Case and also for making the impacts analysis. This Appendix concludes with a listing of some assumptions which were used for the impacts assessment but not for the baseline.

(a) Data Base

The analysis relies heavily on secondary data sources including actual 1981 expenditures and revenues from FY 1981-82 budgets, budgets for previous years, and estimates of revenues and expenditures anticipated in FY 1982/83 budgets. Capital Improvement Programs and plans were consulted and time series data were collected and analyzed where available. Some primary data were obtained during personal interviews with local government officials.

Because the "current" fiscal conditions used were mostly for 1981, all the monitary per capita multipliers and other dollar quotations given below are in 1981 real dollars. The analysis results, however, have been translated into January 1982 dollars using the Anchorage consumer price index series. This was done by applying a factor of 1.028 to the 1981 figures (i.e., the inflationary factor from June 1981 to January 1982).

(b) Major Factors Affecting Fiscal Impact Analysis

(i) Population Projections

Baseline population projections were developed by Frank Orth & Associates, Inc. (1982). These projections were then used in the per capita multiplier fiscal impact method.

The anticipated population influx is assumed to be similar in composition to the current population in utilizing social services and facilities.

(ii) Inflation

The revenue and expenditure projections contained in the chapter are presented in current January 1982 dollars and represent real increases or decreases in spending, unless noted otherwise.

(iii) Assessed Valuation

Both real and personal property are used to calculate total assessable property for generating local property taxes.

Projections are based on time series data between 1970 and 1981.

Projections consider both new additions to property tax rolls and increases in the value of existing property.

(iv) Tax Rates

Tax rates remain constant over time unless stated otherwise.

(v) Levels of Service

The supply of services is assumed to remain at current levels (i.e., quantity and quality) with the exception of new or expanded service facilities described in current Capital Improvement Programs.

Service area boundaries are assumed to remain constant throughout the projection period.

The demand schedule for certain services may be different for the incoming population because of a life-style that is different from that of current residents. However, the limitations of a per capita multiplier fiscal impact method require the assumption that the current demand schedules for services remain constant.

(vi) Costs of Service

There are some shortcomings of the per capita method.

The per capita multiplier method does not take into account economies or diseconomies of scale or threshold effects of development.

It can be assumed that communities currently experiencing minimal excess service capacity will cause the analysis to overstate the incremental costs of development; conversely, cases of minimal deficient service capacity will result in an underestimate of the incremental costs of development.

(vii) Revenue Sources

Only the major sources of revenue are identified, and projections are computed from 1981 to 2002. The analysis does not attempt to identify all current sources of revenue, as many of these contribute relatively small amounts of the total revenues collected. The projections should, therefore, be viewed as trend indicators of future revenue schedules and not as predictions of actual future receipts.

The composition and relative proportions of revenue sources will remain constant, unless stated otherwise in the list of assumptions below.

Public policies, regarding the allocation and distribution of revenues, will remain unchanged.

Current surpluses or fund balances will be projected over time.

(viii) Regional Economic Changes

There are many local, state, and national events that could affect economic trends in Alaska, in general, and in the Mat-Su Borough, in particular. These events would cause the rates of population and economic growth to increase, thereby altering many of the assumptions of this analysis. These include, but are not limited to:

- The proposed capital move to Willow. The analysis assumes this will not take place;
- Industrial development of Point MacKenzie;
- Construction of the Knik Arm crossing providing increased access to Anchorage from the Matanuska-Susitna Borough. It is assumed this will be open by 1989;
- Development of mineral resources;
- Development of additional agricultural resources within the Mat-Su Valley and expansion of existing agricultural developments; and
- Construction of the Trans-Alaska Gas Pipeline.

(c) Matanuska-Susitna Borough Fiscal Impact Assessment

(i) General Assumptions

Growth of the borough will be continuous and gradual as new developments are phased in over time.

Relatively more growth will occur outside the incorporated communities, i.e., in the outlying areas between Butte and Wasilla. The outlying areas offer the preferred lifestyle; people seeking urban environments are not necessarily attracted to the incorporated communities.

There are currently no building codes in the Mat-Su Borough, and none are anticipated in the foreseeable future.

Individual wells and septic tanks are an acceptable method of obtaining fresh water and disposing of waste, respectively. There will be no demand for a central water supply system and sewage collection and disposal system beyond those which currently exist within the borough.

(ii) Revenue Sources

Analysis assumes composition of revenues will remain within the following range based upon current proportions:

	Current Proportion	Projected Range
General Fund	36%	1-41%
Service Areas Fund	3%	2-4%
Land Management Fund	3%	2-4%
Education Operating Fund	58%	57-67%

- General Fund-Revenues

Traditionally, six sources of revenue for the general fund may be identified. They include: (1) local property taxes; (2) school debt service reimbursement from the state; (3) state-shared revenues; (4) municipal assistance funds from the state; (5) federal revenue sharing; and (6) miscellaneous sources. The assumptions used regarding each of these sources are outlined below.

Municipal assistance funds average $85.26 per cepita and represent approximately 15 percent of general fund revenues for FY81/82. This is assumed to remain unchanged.

Federal Revenue Sharing is $24.00 per capita and is assumed to remain constant in current dollars.

Miscellaneous sources of revenue, including interest on earnings and recovery of wages and fringe benefits, account for approximately 8 percent of total general fund revenues.

Currently, no local taxes are raised for capital projects because of the availability of state funding from petroleum revenues. This situation is assumed to continue, as petroleum revenues are anticipated to rise steadily, peaking in 1986 and falling off gradually thereafter (University of Alaska, ISER July 1978).

Forecasts of actual bonded indebtedness cannot be made, since the borough applies for state grants to cover the costs of capital improvements. Local shares can only be computed after the level of state funding is determined. Therefore, the estimates of bonded indebtedness used in the analysis were based on an assumed ratio of indebtedness to total assessed valuation.

The ratio of total bonded indebtedness to total assessed valuation is not anticipated to exceed 0.075. This ceiling was used to project total bonded indebtedness for purposes of computing school debt reimbursement from the state.

Average annual total debt service requirement will not exceed $7,000,000, assuming the current level of general obligation bonds is a good approximation of future bond schedules and assuming a 10 percent annual average interest rate.

The use of user charges for borough services is not anticipated beyond the current user charge for ambulance service. This charge will remain in effect.

Revenues from the federal Payment in Lieu of Taxes (PILOT) program are not included in the analysis. The Matanuska-Susitna Borough budget estimated that federal PILOT for FY82 would be -0- because of reduced federal funding.

- Service Areas Fund Revenues

  Baseline projections are provided for Service Areas Fund Revenues based on the following assumptions.

  - The composition of revenue is assumed to remain constant, as follows:

    . Property taxes .... 30 percent
    . State-shared revenues .... 70 percent

  - The current local property tax mill rate of 0.5 for non-areawide services, including fire and road services, is anticipated to remain constant until 1989 and change to 0.75 for the remainder of the projection period.

- Land Management Fund Revenues

  Baseline projections are provided for Land Management Fund Revenues based on the following.

  - Revenues from the sale of private lands are not expected to increase in real terms unless the capital is moved to Willow. The analysis presumes that move will not be made; and

  - Current per capita revenues for this fund are $42.38.

(iii) Expenditures

Baseline projections are provided for the Mat-Su Borough expenditures based upon the following assumptions:

- Real costs (January 1982 $) of services provided by borough will not change significantly until approximately 1990 or 1995 when gradual increases in real terms will begin to occur.

- In general, it is assumed that current average per capita costs are a good approximation of future real costs (inflation not included).

- The costs of services that are relatively capital-intensive and utilize expensive machinery are assumed to increase in real terms. The increases will be a result of high interest rates in the early 1980s which could cause the cost of borrowing money to rise dramatically. These additional costs are built into the cost of capital equipment and thereby drive up the costs of service delivery.

Total general fund per capita cost	$750

- Service areas expenditures may be classified as ambulance service, sanitation landfill, the library, fire service, parks and recreation, and road maintenance and repair. Per capita costs used in the analysis are given below.

Ambulance average per capita cost + 5% 1986 - 1990 + 1% 1991 - 2005	$ 30
Sanitation-landfill per capita cost + 5% 1986 - 2005	$ 16
Library per capita cost	$ 32
Fire service per capita cost + 5% 1986 - 1995 + 1% 1996 - 2005	$ 35
Parks and recreation per capita cost	$ 50
Road maintenance and repair	$2,500 per mile

- A real rate of increase in road maintenance costs of 10 percent per year was assumed. A 10 percent annual increase appears reasonable based on the trend of previous expenditures on road maintenance, consideration of increased demand by new residents for adequate road maintenance, and discussions with local officials. For recent years, the annual increases in expenditure are as follows:

  - 1980 - 1981 increase in expenditures per mile 33.3 percent
  - 1981 - 1982 increase in expenditures per mile 25.0 percent

- Discussion with local officials revealed tremendous increase in demand for improved road maintenance of existing roads and maintenance expanded to rural roads currently not served by the borough.

- The per capita Land Management Program Administration cost was assumed to be $50.

- Education - average per pupil expenditure, including both capital projects and administrative costs, is $5650 per pupil.

- Formula for computing projected costs: average per capita cost x projected population or projected number of pupils.

(iv) Matanuska-Susitna Borough School District Budget

- Revenues

Baseline projections are provided for federal, state, and local sources of revenue based upon the following assumptions:

- Composition of revenue assumed to remain within 3 percent of current proportions:

	Current	Future Range
State Sources	68%	65-71%
Local Property Taxes	26%	23-29%
Federal Sources	6%	3-9%

. State Sources

The foundation program is the primary source of state funds for education. The formula used to determine the funding level is:

Cost per instructional unit = unit cost x cost differential for the specific borough.

Unit cost is assumed to remain $38,600 in real terms between 1981-1989; but will register a 5 percent increase in 1990 and remain constant at that level for the rest of the projection period.

Time series data for 1978 to 1982 indicate the ratio of instructional units to average daily attendance to be 0.08. The school population projections are used as average daily attendance data together with this ratio in order to compute the number of instructional units.

The cost differential for the borough is 1.04.

Total State Foundation Program Revenue = instruction unit cost x number of units.

An additional component of state revenues comes from pupil transportation revenues. It is assumed that $450 per pupil in real terms will be provided. Should costs of fuel increase, these will be offset by economies of scale as the borough continues to grow.

Total state revenues for education are a combination of state foundation program revenues and transportation revenues.

- Local Property Taxes

  Local property tax share is the amount of areawide taxation that is transferred from the general fund as noted above.

  School taxes vary according to assessed valuation and total population and not according to the number of pupils.

  A mill rate of 6.0 mills per $1,000 assessed valuation is assumed to remain constant.

- Federal Sources

  Federal sources currently provide $300.00 per pupil. This is assumed to remain constant over time as the district will continue to apply for federal grant monies.

- Expenditures

Baseline projections of expenditures on education are based on the following assumptions:

- Average per pupil expenditure is $5650 in current dollars until 1989 but will change to $5933 for the balance of the projection period.

- The following relative proportions are assumed for the relative shares of individual cost categories:

	1985-2005	1981-1984
Regular Instruction	30%	33%
Vocational Education	2%	4%
Special Education	10%	6%
Support Services	18%	18%
Operation and Maintenance	18%	19%
Pupil Transportation	10%	8%
Other	12%	12%

- The proportion of regular instruction and vocational education will be reduced from 1981 levels to reflect the increase in special education. PL 94142 requires that a school district provide whatever special educational services may be required by a pupil in that school district.

Total state revenues for education are a combination of state foundation program revenues and transportation revenues.

. Local Property Taxes

Local property tax share is the amount of areawide taxation that is transferred from the general fund as noted above.

School taxes vary according to assessed valuation and total population and not according to the number of pupils.

A mill rate of 6.0 mills per $1,000 assessed valuation is assumed to remain constant.

. Federal Sources

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- The following relative proportions are assumed for the relative shares of individual cost categories:

	1985-2005	1981-1984
Regular Instruction	30%	33%
Vocational Education	2%	4%
Special Education	10%	6%
Support Services	18%	18%
Operation and Maintenance	18%	19%
Pupil Transportation	10%	8%
Other	12%	12%

- The proportion of regular instruction and vocational education will be reduced from 1981 levels to reflect the increase in special education. PL 94142 requires that a school district provide whatever special educational services may be required by a pupil in that school district.

Passage of this law has resulted in tremendous increases in expenditures for special education.

- Capital Improvements Program

The 1980 Six-Year Capital Construction Plan is assumed to remain unchanged; however, annual requests to the legislature for additional projects may be forthcoming.

(d) Conditions Special to Impacts Analysis

The baseline forecast provides all the necessary data to implement the impact forecasts for 1981-2002. The analysis assumes that current average costs are a good approximation of the real future costs of service, and current per capita revenues or their relative proportions will remain constant in the future, with or without the project. The hydroelectric project will, therefore, not change real per capita costs or receipts, but will alter gross revenues and expenditures.

Major factors affecting the fiscal baseline analysis are assumed to also affect the impact analysis. Impact forecasts were made for all budgets analyzed in the baseline forecast and followed the baseline methodology at all stages except where noted below.

(i) Matanuska-Susitna Borough Budget General Fund Revenues

- Property Taxes

Total assessed valuation was assumed to be proportional to population size as follows:

- Per capita assessed valuation from the baseline forecast x the project scenario population data = total assessed valuation under the project conditions. Then, property taxes were computed to equal the product of total assessed valuation and the mill rate.

- The rest of the impact forecasts were made with the same per capita assumptions as used in the baseline projections.

APPENDIX E5D

Traffic Volume Assumptions

APPENDIX 5.D

TRAFFIC VOLUME ASSUMPTIONS

The following assumptions were made in generating Tables E.5.20 and E.5.21 which address projected traffic volumes on the Denali Highway and the project access road during peak years of construction:

1. Unrestricted access for authorized, project-related personnel on the access road (unauthorized traffic will be denied access).

2. An onsite village will house up to 350 workers and their families, and these resident dependents (2 per family) will take excursions offsite once per week on the average. Additionally, they will travel two persons to a vehicle for a total of 100 one-way vehicle excursion trips per week on the project access road.

3. At peak workforce, each of the 3,500 workers will travel on the access road an average of once every two weeks on excursion. Further, they will travel two persons to a vehicle, for a total of 250 one-way vehicle excursion trips per week on the project access road.

4. Ten percent of the 350 excursion vehicles (see 2. and 3. above) will reach and travel some distance down and back the Denali Highway, creating an average daily traffic volume (ADT) of 35 vehicles on the Denali Highway.

5. About 300 workers will have dependent families and/or homes in the Cantwell area and commute once a week to and from the site, each worker using one private vehicle. This commuting will generate an average 86 one-way trips per day on the access road and Denali Highway west end. In a second case (see Case B below) it was assumed that workers would share rides, with 1.72 workers per vehicle, thus reducing the ADT to 50.

6. About 2500 workers will have permanent residences in areas of the region other than Cantwell and commute on an average of once every two weeks to and from the site. In one case (see Case A below), it was assumed that each worker will use his own vehicle. In a second case (see Case B below), it was assumed that workers would share rides, with 1.72 workers per vehicle. Case A generates an access road and Denali Highway ADT of 358, and Case B an ADT of 208.

7. All workers who do not have homes in the region (both out-of-state and Alaskan, but out of region) will be provided transportation in and out of the site by air or bus. The number of these workers is sufficiently small (286) as not to constitute a significant traffic impact.

8. No alternative (to private vehicles) ground transportation program will be provided to commuters.

9. Commuters will not be able to fly private airplanes into the site.

10. Five vehicles carrying government and agency-related personnel will travel the Denali west end and access road round trip per day.

11. Thirty-five heavy trucks will travel the Denali west end and access road round trip per day.

12. Ten vehicles carrying project-support materials will travel the Denali west end and access road round trip per day.

13. Workers are given one day off per week, and workers are assigned to shifts so that one-seventh of the work force is off on any given day.

SUSITNA HYDROELECTRIC PROJECT

VOLUME 7

EXHIBIT E CHAPTER 6

GEOLOGICAL AND SOIL RESOURCES

SUSITNA HYDROELECTRIC PROJECT

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GEOLOGICAL AND SOIL RESOURCES

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6 - GEOLOGICAL AND SOIL RESOURCES

1 - INTRODUCTION

The Devil Canyon and Watana damsites are located on the Susitna River within the Talkeetna Mountains in south-central Alaska. The geologic setting of the Talkeetna Mountains and the Sustina River basin is in a tectonic mosaic of separate continental structural blocks and fragments. The geology and soil resources, stratigraphy, structure, and glacial history are described in this section as well as regional tectonics and seismic geology. Details of the geotechnical and seismic investigations conducted for the Susitna Hydroelectric Project are included in the 1980-81 Geotechnical Report (Acres 1982a), 1982 Supplement to the 1980-81 Geotechnical Report (Acres 1982b), Susitna Hydroelectric Project Feasibility Report (Acres 1982c), Interim Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1980), and Final Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1982). These documents stand as references to this chapter and should be consulted as required to provide detailed discussions and supplemental information.

2 - BASELINE DESCRIPTION

2.1 - Regional Geology

2.1.1 - Stratigraphy

The oldest rocks which outcrop in the region are a metamorphosed upper Paleozoic (Table E.6.1) rock sequence which trends northeastward along the eastern portion of the Susitna River basin (Figure E.6.1). These rocks consist chiefly of coarse to fine grained clastic flows and tuffs of basaltic to andesitic composition, locally containing marble interbeds. This system of rocks is uncomformably overlain by Triassic and Jurassic metavolcanic and sedimentary rocks. These rocks consist of a shallow marine sequence of metabasalt flows, interbedded with chert, argillite, marble, and volcaniclastic rocks. These are best expressed in the project area 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 instrusive rocks form a batholithic complex of the Talkeetna Mountains.

Thick turbidite sequences of argillite and graywackes were deposited during the Cretaceous. These deposits form the bedrock at the Devil Canyon site. These rocks were subsequently deformed and intruded by a series of Tertiary age plutonic rocks ranging in composition from granite to diorite and include related felsic and mafic volcanic extrusive rocks. The Watana site is underlain by one of these large plutonic bodies. These plutons were subsequently intruded and overlain by felsic and mafic volcanics. Mafic volcanics, composed of andesite porphyry, occur downstream from the Watana site.

2.1.2 - Tectonic History

At least three major episodes of deformation are recognized for the project areas:

- A period of intense metamorphism, plutonism, and uplift in the Jurassic;

- A similar orogeny during the middle to late Cretaceous; and

- A period of extensive uplift and denudation from the middle Tertiary to Quaternary.

The first period (early to middle Jurassic) was the first major orogenic event in the Susitna River basin as it now exists. It was characterized by the intrusion of plutons and accompanied by crustal uplift and regional metamorphism.

2.2 - Quaternary Geology

Most of the structural features in the region are the result of the Cretaceous orogeny associated with the accretion of northwest drifting continental blocks into the North American plate. This plate convergence resulted in complex thrust faulting and folding which produced the pronounced northeast/southwest structural grain across the region. The argillite and graywacke beds in the Devil Canyon area were isoclinally folded along northwest-trending folds during this orogeny. The majority of the structural features, of which the Talkeetna Thrust fault is the most prominent in the Talkeetna Mountains, are a consequence of this orogeny. The Talkeetna Thrust is postulated as representing an old suture zone, involving the thrusting of Paleozoic, Triassic and Jurassic rocks over the Cretaceous sedimentary rocks (WCC 1980). Other compressional structures related to this orogeny are evident in the intense shear zones roughly parallel to and southeast of the Talkeetna Thrust.

Tertiary deformations are evidenced by a complex system of normal, oblique slip, and high-angle reverse faults. The prominent tectonic features of this period bracket the basin area. The Denali fault, a right-lateral, strike-slip fault 40 to 43 miles north of the damsites on the Sustina River, exhibits evidence of fault displacement during Cenozoic time. The Castle Mountain-Caribou fault system, which borders the Talkeetna Mountains approximately 70 miles southeast of the sites, is a normal fault which has had fault displacement during the Holocene.

2.2 - Quaternary Geology

A period of cyclic climatic cooling during the Quaternary resulted in repeated glaciation of southern Alaska. Little information is available regarding the glacial history in the upper Susitna River basin. Unlike the north side of the Alaska Range, which is characterized by alpine type glaciation, the Susitna Basin experienced coalescing piedmont glaciers that originated from both the Alaska Range and the Talkeetna Mountains which merged and filled the upper basin area.

At least three periods of glaciation have been delineated for the region based on the glacial stratigraphy. During the most recent period (Late Wisconsinan), glaciers filled the adjoining lowland basins and spread onto the continental shelf (Figure E.6.2). Waning of the ice masses from the Alaska Range and Talkeetna Mountains formed ice barriers which blocked the drainage of glacial meltwater and produced proglacial lakes. As a consequence of the repeated glaciation, the Susitna and Copper River basins are covered by varying

Within the site region, the late Quaternary surfaces include those of Holocene and Pleistocene age (including the Wisconsinan and Illinoian stages). These surfaces range from a few years to approximately 120,000 years before present.

These repeated glaciations have contributed to the land forms found within the project area. Terrain unit maps developed for the project area from aerial photo interpretation are presented in Appendix J of the 1980-81 Geotechnical Report (Acres 1982a), while detailed Quaternary maps of the regions are presented in Section 3 of Final Report on Seismic Studies for Susitna Hydroelectric Project (WCC 1982).

2.3 - Mineral Resources

Mineral exploration and mining have been limited in the immediate project area. Typical of the mining done on the upper Susitna River basin since 1930 is a low density of claims characterized by intermittent activity. Although mining has played an active roll in portions of the Susitna River basin, no mining activity has been undertaken in the immediate project area. Examination of mining records for the project area show only several inactive claims within the proposed Watana and Devil Canyon reservoir impoundments that would be affected by the project. No evidence of any mineral potential has been found within the project area nor has any interest been expressed by outside parties to further explore mineral potentials within the project area during the duration of this project.

Placer mines working alluvial deposits for minerals are found in sites throughout other parts of Mat-Su Borough. Active mining has been more concentrated in Gold, Chunilna (Clear), and Portage creeks than in other areas of the upper Susitna basin with some other active claims around Stephan and Fog Lakes, Jay Creek, and the Watana Hills east of Jay Creek. Mining at Gold Creek was active from the early 1950s through the late 1970s; most claims were gold, copper, and silver placer mines. A concentration of at least six mining claims has existed on Chunilna Creek where gold placer claims have been worked since the late 19th century. Mining has occurred in the Portage Creek area since the late 19th century, but only one claim remains active.

Coal is the major mineral resource in Mat-Su Borough. Although extensive deposits of varying quality are located in the river valley areas, no coal mining activity occurs in the project area. Most coal is mined to the south and west of the project area; much of it is used for household fuel.

2.4 - Seismic Geology

2.4.1 - Introduction

A detailed seismologic study for the Susitna project was undertaken by Woodward-Clyde Consultants (WCC). The study, performed over a two-year period, included:

- Detailed literature research;
- Interpretation of remote sensing data;
- Geologic mapping of faults and linears;
- Microseismic monitoring.
- Ground motion studies; and
- Analysis of dam stability.

Details of WCC's study are presented in Interim Report on Seismic Studies for Susitna Hydroelectric Project (1980) and Final Report on Seismic Studies for Susitna Hydroelectric Project (1982).

2.4.2 - Conceptual Approach

According to present understanding of plate tectonics, the earth's lithosphere, which contains the brittle 12 to 19 miles (20 to 30 km) thickness or so of more rigid crust, overlies the denser and more viscous mantle. Observed major horizontal movements of the crustal plates are considered to be related to, or caused by, thermal convective processes within the mantle.

Within this plate-tectonic framework, faults that have the potential for generating earthquakes have had recent displacement and may be subject to repeated displacements as long as they are in the same tectonic stress regime. In regions of plate collision such as Alaska, the tectonic stress regime is the result of one plate being subducted, or underthrust, beneath the adjacent plate. Within this environment, primary rupture along fault planes can occur: within the downgoing plate where it is decoupled from the upper plate; along the interface between the upper and lower plates where they move past each other; and within the overriding plate. In the site region, faults with recent displacement are present in the overriding (upper) plate and at depth in the downgoing plate where it is decoupled from the upper plate.

Faults with recent displacement in the downgoing plate and in the upper plate can generate earthquakes which result in ground motions at the surface. These earthquakes are considered for seismic design purposes. The faults in the downgoing plate are considered not to have the potential for surface rupture. In the upper plate, if the rupture that occurs on these faults is relatively small and relatively deep, then rupture at the ground surface is likely not to occur. If the rupture along the fault plane is at sufficiently shallow depth and is sufficiently large, then surface rupture can occur.

The criteria for this study were that faults that have been subject to surface displacement within approximately the past 100,000 years were classified as having recent displacement.

Inherent with this concept of "fault with recent displacement" was the basic premise that faults without recent displacement would not have surface rupture nor be a source of earthquakes. Faults without recent displacement (as determined during this investigation) were considered to be of no additional importance to Project feasibility and dam design.

2.4.3 - Tectonic Model

An understanding of the regional geologic and tectonic framework is essential for: the assessment of fault activity, estimation of preliminary maximum credible earthquakes; evaluation of the potential for surface fault rupture; and evaluations of the potential for reservoir-induced seismicity.

The site region is located within a tectonic unit defined here as the Talkeetna Terrain. The Terrain boundaries are the Denali-Totschunda fault to the north and east, the Castle Mountain fault to the south, a broad zone of deformation with volcanoes to the west, and the Benioff zone at depth (Figure E.6.3). All of the boundaries are (or contain) faults with recent displacement except for the western boundary which is primarily a zone of uplift marked by Cenozoic age volcanoes. The Terrain is part of the North American plate.

Results of this study show that the Talkeetna Terrain is a relatively stable tectonic unit with major strain release occurring along its boundaries. This conclusion is based on: the evidence for recent displacement along the Denali-Totschunda and Castle Mountain faults and the Benioff zone; the absence of major historical earthquakes within the Terrain; and the absence of faults within the Terrain that clearly have evidence of recent displacement. Record of historical seismicity in and around the project area is presented in Section 4 of WCC 1980. None of the faults and lineaments found within the Talkeetna Terrain were observed to have strong evidence of recent displacement.

Strain accumulation and resultant release appears to be occurring primarily along the margins of the Terrain. Some compression-related crustal adjustment within the Terrain is probably occurring as a result of the proposed plate movement and the stresses related to the subduction zone.

This tectonic model serves as a guide to understanding tectonic and seismologic conditions in the site region.

2.4.4 - 1980 Approach

(a) Candidate Features

The application of the "fault with recent displacement" concept for this investigation involved:

- Identification of all faults and lineaments in the site region that had been reported in the literature and/or were observable on remotely sensed data.

- Selection of faults and lineaments of potential significance in developing design considerations for the Project, from the standpoint of seismic source potential and/or potential surface rupture through a site. These faults and lineaments were selected using a length-distance criteria set forth in Section 3 of WCC 1980. These faults and lineaments were designated as candidate features.

- Evaluation of the candidate features during the geologic field reconnaissance studies. On the basis of this field work, the micro-earthquake data, and application of the preliminary significance criteria, those faults and lineaments were designated as candidate-significant features. These features were subjected to additional evaluation using refined analyses, as described below, to select those features or potential significance to Project design considerations.

- Refinement of the evaluation process, using the significance criteria. On the basis of this evaluation, significant features were selected for continued studies in 1981.

(b) Significant Features

Of 216 candidate features identified at the outset of the study, a total of 48 candidate-significant features were identified in the site region on the basis of the initial length-distance screening criteria, their proximity to the site, their classification in the field, and application of preliminary significance screening criteria (WCC 1980).

Candidate-significant features are those faults and lineaments which, on the basis of available data at the end of the field reconnaissance, were considered to have a potential effect on Project design. Subsequent evaluation, using a refined, systematic ranking methodology, resulted in the identification of 48 significant features.

The 48 candidate-significant features were subsequently evaluated by making detailed analyses regarding their seismic source potential and surface rupture potential at either site. For the evaluation of seismic source potential, the analyses included: an assessment of the likelihood that a feature is a fault with recent displacement; an estimation of the preliminary maximum credible earthquake that could be associated with the feature; and an evaluation of the peak bedrock accelerations that would be generated by the preliminary maximum credible earthquake at either site.

To evaluate the potential for surface rupture at either damsite, the analyses included: an assessment of the likelihood that a feature is a fault with recent displacement; an assessment of the likelihood that a feature passes through either site; and an evaluation of the maximum amount of displacement that could occur along the feature during a single event (e.g., the preliminary maximum credible earthquake).

The evaluation of the 48 candidate significant faults, applying the judgments described above, resulted in the selection of 13 features, designated significant features, that should have additional studies to understand and more fully evaluate their significance to the Project (Figure E.6.4).

Of these 13 features, four are in the vicinity of the Watana site including the Talkeetna Thrust Fault (KC4-1), Susitna feature (KD3-3), "The Fins" feature (K-27), and lineament KD3-7. Nine of the features are in the vicinity of the Devil Canyon site including an unnamed fault (designated KD5-2) and lineaments KC5-5, KD5-3, KD5-9, KD5-12, KD-5-42, KD5-43, KD5-44, and KD-45 (the alpha-numeric symbol [e.g., KC4-1] has been assigned to each fault and lineament). Detailed discussion of these 13 features are presented in Section 8 in WCC 1980.

These significant features were delineated for study during the 1981 program.

2.4.5 - 1981 Approach

The 1981 study of the 13 significant features identified during 1980 involved the following objectives.

- Assessing the likelihood that each of the 13 features is a fault;

- Assessing the age of the sediments overlying each of the 13 features;

- Selecting and excavating trenches across topographic features that resembled topographic expression of faults in the young geologic deposits;

- Evaluating the likelihood that each of the 13 features is a fault with recent displacement using the guideline established for the project, i.e., rupture of the ground surface during the past 100,000 years;

- Assessing the detectability of faults that may have ruptured the ground surface during moderate to large earthquakes in the past 100,000 years and estimating a detection-level earthquake that could theoretically occur on a fault that might be below the detection level of geologic investigation;

- Evaluating seismological records of moderate-to-large historical earthquakes in the project region to estimate focal mechanism parameters and assess the relation of the earthquakes to recognized faults with recent displacement;

- Applying judgment and experience gained from the study of other faults with recent displacement in Alaska and in similar tectonic environments (e.g., Japan and South America);

- Estimating the maximum credible earthquake and recurrence interval (1) for each fault that is considered to be a seismic source; (2) for the Benioff zone; and (3) for a detection-level earthquake;

- Estimating the potential for surface rupture on any faults with recent displacement within 6 miles (10 km) of the damsites; and

- Estimating the values of ground-motion parameters for the maximum credible earthquake.

2.4.6 - Results of Study

Faults for which evidence of recent displacement was found were considered to be potential seismic sources. Each potential seismic source was evaluated to estimate its potential seismic ground motions at the Watana and Devil Canyon sites and its potential for surface rupture within 6 miles (10 km) of the sites.

On the basis of the 1980 study, the Talkeetna Terrain boundary faults were identified as seismic sources that need to be considered as potential sources of seismic ground motion at the sites. These include: the Castle Mountain Fault, the Denali Fault, the Benioff zone interplate region, and the Benioff zone intraplate region (Figure E.6.3). These sources are considered to be or to contain faults with recent displacement that could cause seismic ground motions at the Watana and Devil Canyon sites; however, because of their distance from the sites, these faults do not have the potential for rupture through the sites. The 1980 study also identified 13 features near the sites that required detailed evaluation during the 1981 study to assess their importance for seismic design (WCC 1980).

On the basis of the 1981 study, no evidence for faults with recent displacement other than the Talkeetna Terrain boundary faults has been observed within 62 miles (100 km) of either site, and none of the 13 features near the sites are judged to be faults with recent displacement. Therefore, when applying the guideline defining faults with recent displacement to the results of the investigation, the 13 features are considered not to be potential seismic sources that could cause seismic ground motions at the sites or surface rupture through the sites.

Interpretation that none of the 13 features are faults with recent displacement is based on data collection during the investigation. The data are limited in the sense that a continuous 100,000-year-old stratum or surface was not found along the entire length of each of the features. For this reason, the available data were analyzed and professional judgment was applied to reach conclusions concerning the recency of displacement of each of the 13 features. Detailed discussions of these 13 features are presented in Section 4 of WCC 1982.

As discussed previously, earthquakes up to a given magnitude could occur on faults with recent displacement that might not be detectable by this geologic investigation. The size of such an earthquake, designated the detection-level earthquake, varies according to the degree of natural preservation of fault-related geomorphic features and from one tectonic environment to another. The detection-level earthquake has been estimated by: (1) evaluating the dimensions of surface faulting associated with worldwide historical earthquakes in tectonic environments similar to the Talkeetna Terrain; (2) identifying the threshold of surface faulting using a group of thoroughly studied earthquakes in California; and (3) evaluating the degree of preservation of fault-related geomorphic features in the Talkeetna Terrain. For this project, it has been judged that the detection-level earthquake is magnitude (M_S) 6 (WCC 1982).

2.4.7 - Design Level Earthquake

(a) Maximum Credible Earthquakes (MCEs)

Maximum Credible Earthquakes (MCEs) were estimated for the boundary faults (in the crust and in the Benioff zone) and for the detection-level earthquake. The MCEs for the crustal faults (the Castle Mountain and Denali Faults) were estimated using the magnitude-rupture-length relationships (WCC 1982).

Sources of moderate earthquake appear to exist within the Talkeetna Terrain, although no faults with recent displacement were detected by the investigation. Therefore, an MCE was estimated for the detection-level earthquake that would be associated with a fault along which no surface rupture was observed. In summary, the MCEs for the crustal and Benioff zone seismic sources are estimated as follows:

Source	MCE (M_S)	Closest Approach to Proposed Damsites: Devil Canyon miles/(km)		Watana miles/(km)	
Castle Mountain fault	7-1/2	71	(115)	65	(105)
Denali fault	8	40	(64)	43	(70)
Benioff zone (interplate)	8-1/2	57	(91)	40	(64)
Benioff zone (intraplate)	7-1/2	38	(61)	31	(50)
Detection-level earthquake	6	<6	(<10)	<6	(<10)

Estimated mean peak horizontal ground accelerations and duration of strong shaking (significant duration) at the sites as the result of the governing maximum credible earthquake are the following:

Earthquake Source	Maximum Magnitude	Mean Peak Acceleration: Watana Site	Mean Peak Acceleration: Devil Canyon Site	Significant Duration (sec)
Benioff Zone	8-1/2	0.35g	0.3g	45
Denali Fault	8	0.2g	0.2g	35
Terrain Earthquake	6	0.5g	0.5g	6

The probabilities of exceedance of peak ground accelerations at the sites were estimated. The Benioff Zone was found to dominate the contributions to the probabilities of exceedance. Other sources of earthquakes, including the Denali Fault and the detection-level earthquake, contributed only slightly to the probabilities of exceedance.

These ground motions were used as a guideline in developing the engineering design criteria.

(b) Reservoir-Induced Seismicity (RIS)

The studies concluded that there would be a high likelihood for reservoir-induced earthquake as a result of impoundment. However, such an event is not expected to cause an earthquake larger than that which could occur in a given region "naturally." A detailed discussion of RIS for the Susitna Project is presented in Section 10 of WCC 1980.

2.5 - Watana Damsite

2.5.1 - Introduction

A detailed discussion of the Watana site geology is presented in reference documents Acres 1982a and 1982b. A summary of the site geotechnical conditions are summarized in the following sections.

2.5.2 - Geologic Conditions

A summary of site overburden and bedrock conditions is presented in the following paragraphs. A geologic map of the damsite area is shown in Figure E.6.5 with a top of rock map shown in Figure E.6.6.

(a) Overburden

Overburden thickness in the damsite area ranges from 0 up to 80 feet (0 to 24 m) in localized areas. On the lower slopes, the overburden consists primarily of talus. The upper areas of the abutments near the top of the slope are deposits of glacial tills, alluvium, and talus. Subsurface investiga- tions show the contact between the overburden and bedrock to be relatively unweathered.

The depth of the river alluvium beneath the proposed dam averages about 80 feet (24 m) and consists of sand, silt, coarse gravels and boulders.

(b) Bedrock Lithology

The damsite is primarily underlain by an intrusive dioritic body which varies in composition from granodiorite to quartz diorite to diorite. The texture is massive and the rock is hard, competent, and fresh except within sheared and altered zones. These rocks have been intruded by mafic and felsic dikes which are generally only a few feet thick. The contacts are healed and competent. The rock immediately downstream from the damsite is an andesite porphyry. This rock is medium to dark gray to green and contains quartz diorite inclusions. The nature of the contact zone of the andesite with the diorite is poorly understood. However, where mapped or drilled, the contact zone is generally weathered and fractured up to 10 to 15 feet. Detailed discussions of the andesite porphyry/diorite contact are presented in Section 6 of Acres 1982a report.

(c) Bedrock Structures

i) Joints

There are two major and two minor joint sets at the site. Set I, which is the most prominent set, strikes 320° and dips to 80° NE to vertical. This set is found throughout the damsite and parallels the general structural trend in the regions. Set I has a subset, which strikes 290° to 300° with a dip of 75° NE. This subset is localized in the downstream area near where the diversion tunnel portals are proposed. This subset also parallels the shear zones in the downstream area of the site. Set II trends northeast to east and dips vertically. This set is best developed in the upstream portion of the damsite area, but is locally prominent in the downstream areas. Sets III and IV are minor sets but can be locally well developed. Set III trends N-S with variable dips ranging from 40° east to 65° west, while Set IV trends 090° with subhorizontal dips. Set III forms numerous open joints on the cliff faces near the "Fingerbuster," and several shear zones parallel this orientation. Set IV appears to have developed from stress relief from glacial unloading and/or valley erosion.

Figure E.6.7 is a composite joint plot for the Watana damsite.

Table E.6.2 details the joint characteristics.

(ii) Shears and Fracture Zones

Several shears, fracture zones, and alteration zones are present at the site (Figure E.6.5). For the most part, they are small and discontinuous. All zones greater than 10 feet in width have been delineated as GF on the geologic map (Figure E.6.5).

Shears are defined as having breccia, gouge, and/or slickenslides indicating relative movement. Two forms of shearing are found at the site. The first type is found only in the diorite and is characterized by breccia of sheared rock that has been rehealed into a matrix of very fine grained andesite/diorite. These shear zones have high rock quality designations (RQDs) and the rock is fresh and hard. The second type is common to all rock types and consists of unhealed breccia and/or gouge. These shear zones are soft, friable, and often have secondary mineralization of carbonate and chlorite showing slickenslides. These zones are generally less than one foot wide.

Fracture zones are also common to all rock types and range from 6 inches to 30 feet (0.15 - 9 m) wide (generally less than 10 feet). These zones are closely spaced joints that are often iron oxide stained or carbonate coated. Where exposed, the zones trend to form topographic lows.

Alteration zones are areas where hydrothermal solutions have caused the chemical breakdown of the feldspars and mafic minerals. The degree of alteration encountered is highly variable across the site. These zones are rarely seen in outcrop as they are easily eroded into gullies, but were encountered in all the boreholes. The transition between fresh and altered rock is gradational. The zones may range to 20 feet (6 m) thick although are usually less than 5 feet (1.5 m).

2.5.3 - Structural Features

The Watana site has several significant geologic features consisting of shears, fractures, and alteration zones described previously (Figure E.6.5).

The two most prominent areas have been named "The Fins" and the "Fingerbuster." "The Fins" is located on the north bank of the river upstream from the diversion tunnel intake. It is an area approximately 400 feet (120 m) wide, characterized by three major northwest trending zones of shearing and alteration that have eroded into steep gullies. These alteration zones are separated by intact rock bands (ribs) 5 to 50 feet (1.5 - 15 m) wide. The 20-foot-wide (6 m) upstream zone of the series coincides with the diorite/andesite porphyry contact. The other two zones, approximately 55 and 30 feet (16.5 - 9 m) wide, are filled with severely altered rock. This zone trends 310° with a near vertical dip. The extension of the zone has been extrapolated to extend northwestward outcropping in Tsusena Creek.

The "Fingerbuster" is located downstream from the damsite and is exposed in a 40-foot-wide, deep, talus-filled gully along the andesite porphyry/diorite contact (Figure E.6.5). The rock is severely weathered with closely spaced joints trending parallel to Set I (330°) and Set III (0°). Slickenslides indicate vertical displacement. The extension of this zone to the south is based on a strong north-south topographic lineament. Because of the lack of exposure, its location and extent have been approximated.

A prominent alteration zone was encountered on the south bank where a drill hole encountered approximately 200 feet (60 m) of hydrothermally altered rock. Although core recovery in this boring was good, the quality of rock was relatively poor.

2.5.4 - Ground Water Conditions

The ground water regime in the bedrock is confined to movement along fractures and joints. The water table is a subdued replica of the surface topography. Water levels on the right abutment are deep, ranging from about 110 to 280 feet (33 - 84 m). Ground water conditions on the south abutment are complicated because of the apparent continuous thick permafrost resulting in a perched water table near surface and a deep table below the frost.

2.5.5 - Permafrost Conditions

Permafrost conditions exist on the north-facing slopes (left bank) of the damsite area. Measurements indicate that permafrost exists to a depth of 200 to 300 feet (60 - 90 m). Temperature measurements show the permafrost to be "warm" (within 1°F [1°C] of freezing). No permafrost was found on the north abutment but sporadic areas of frost can be expected.

2.5.6 - Permeability

The rock permeability does not vary significantly within the site area, generally ranging between 3.28×10^{-6} ft/sec (1×10^{-4} cm/sec) to 3.3×10^{-8} ft/sec (1×10^{-6} cm/sec). The permeability is controlled by a degree of fractures within the rock, with the higher permeability occurring in the more sheared and fractured zone. Permeabilities tend to decrease with depth (Figure E.6.7).

2.5.7 - Relict Channels

(a) Watana Relict Channel

A relict channel exists north of the Watana damsite. The location of this preglacial feature is shown in Figure E.6.9. The maximum depth of overburden in the thalweg channel, as shown in Figure E.6.9, is approximately 450 feet (135 m).

The stratigraphy in the channel has been described by a number of stratigraphy units shown in Figures E.6.10 and E.6.11 as A through K. A detailed discussion of the Watana Relict Channel is presented in Section 6 of Acres 1982b report.

(b) Fog Lakes Buried Channel

In the area between the Watana damsite and the higher ground some 5 miles (8 km) to the southeast, the bedrock surface dips to 350 feet (105 m) below ground surface, or 174 feet (52 m) below maximum pool elevation. The channel is overlain by glacial deposits (Figure E.6.12). A discussion of the Fog Lakes Buried Channel is presented in Section 7 of Acres 1982b report.

2.5.8 - Borrow Sites

Extensive investigations have been conducted both prior to and during the current studies to identify quantities of suitable materials for the construction of an embankment dam and for concrete aggregate. Detailed discussion of these borrow and quarry sites is presented in both Acres 1982a and 1982b reports.

A total of seven borrow sites and three quarry sites have been identified for dam construction material delineated as sites A, B, C, D, E, F, H, I, J, and L (Figure E.6.13). Of these, Borrow Sites D and H are considered as potential sources for semi-pervious to pervious material; Sites C, E, and F for granular material; Sites I and J for pervious gravel; and Quarry Sites A, B, and L for rockfill. Several of these sites (B, C, F, and H) were not considered as primary sites for this project because of lengthy haul distance to the damsite, adverse environmental impacts, insufficient quantities, and poor quality material. Detailed discussion of material properties, geology, and quantities are addressed in Acres 1982a and 1982b reports.

In summary, estimated reserves of borrow and quarry materials from the primary sources are:

- Quarry Site A = 70 - 100 mcy
- Quarry Site D = 180 mcy
- Quarry Site E = 80-90 mcy
- Borrow Sites I & J = 200 mcy

2.6 - Devil Canyon Damsite

2.6.1 - Introduction

A detailed description of the site investigations and the geologic and geotechnical conclusions at the Devil Canyon site is provided in the Acres 1982a and 1982b reports. The following is a brief summary and interpretation of the findings presented in those reports.

2.6 - Devil Canyon Damsite

2.6.2 - Geologic Conditions

The overburden and bedrock conditions at the Devil Canyon site are summarized in the following paragraph. A geologic map of the damsite area is shown in Figure E.6.14 in this section.

(a) Overburden

The valley walls at the Devil Canyon site are very steep and are generally covered by a thin veneer of overburden consisting primarily of talus at the base. A top of bedrock map is shown in Figure E.6.15. The flatter upland areas are covered by 5 to 35 feet (1.5 - 10.5 m) of overburden of glacial origin. A topographic depression along the elongated lakes on the south bank has an overburden cover in excess of 85 feet (25.5 m) of glacial materials. The overburden on the alluvial fan or point bar deposit at the Cheechako Creek confluence thickens from 100 feet (30 m) to more than 300 feet (90 m) over a distance of less than 400 feet (120 m).

The river channel alluvium appears to be composed of cobbles, boulders, and detached blocks of rock and is inferred to be up to 30 feet (9 m) thick.

(b) Bedrock Lithology

The bedrock at the Devil Canyon site is a low-grade, metamorphosed sedimentary rock consisting predominantly of argillite with interbeds of graywacke (Figure E.6.14). The argillite is a fresh, medium to dark gray, thinly bedded, fine grained argillaceous rock with moderately well-developed foliation parallel to the bedding. The graywacke is a fresh, light gray, mainly fine grained sandstone within an argillaceous matrix. The graywacke is well indurated and exhibits poorly developed to nonexistent foliation. The graywacke is interbedded with the argillite in beds generally less than six inches thick. Contacts between beds are tight, and both rock types are fresh and hard. Minor quartz veins and stringers are commonly found in the argillite. These are generally less than one foot wide and unfractured with tight contacts. Sulphide mineralization is common, with pyrite occurring in as much as five percent of the rock.

The area has also been intruded by numerous felsic and mafic dikes ranging from 1 inch (2.5 cm) to 60 feet wide (18 m) (averaging 20 feet [6 m]). The dikes have northwest to north orientation (Figure E.6.14) with steep dips. When closely fractured they are easily eroded and tend to form steep, talus-filled gullies, some of which exhibit shearing with the host rock. The felsic dikes are light gray and include aplite and rhyolite. The mafic dikes are fine grained and appear to be of diorite to diabase composition.

(c) Bedrock Structures

(i) Bedding

The argillite/graywacke has been severely deformed as evidenced by refolded folds and the development of multiple foliations. The primary foliation parallels the bedding at 035° to 090°, subparallel to the river, and dips 45° to 80° SE (Figure E.6.14). Where exposed, the foliation planes appear slaty and phyllitic. The north canyon wall at the damsite appears to be controlled by the bedding planes and dips 45° to 80° SE. Where exposed, the foliation planes appear slaty and phyllitic. The north canyon wall at the damsite appears to be controlled by the bedding planes.

(ii) Joints

Four joint sets have been delineated at Devil Canyon. Set I (strikes 320° to 355° and dips 60° to 70° NE) and Set II (strikes 040° to 065° and dips 40° to 60°S) are the most significant. A composite joint plot is shown in Figure E.6.16. Set I joints are the most prominent with spacing of 15 feet to 2 feet (4.5 - 0.6m), and on the upper canyon walls of the south bank these joints are open as much as 6 inches (15 cm). Set III is subparallel to the bedding/foliation and, when it intersects with Set I, can cause the formation of loose blocks. Set III joints (strikes 005° to 030° and dip 85° NW to 85° SE) are also often open on the south bank and where they dip towards the river they may create potential slip planes. This set has variable spacing and sporadic distribution. The fourth set is a minor set with low dip angles and variable strike orientation.

Joint spacings measured from the borehole cores range from less than 1 foot (0.3 m) to more than 10 feet (3 m) for the most part. Based on RQD measurements and water pressure test data, the spacing and tightness of the joints increase with depth (Section 7, Acres 1982a).

Tables E.6.3 and E.6.4 characterize the joints at Devil Canyon.

(iii) Shears and Fracture Zones

Shears and fracture zones were encountered in localized areas of the site in both outcrops and boreholes (Figure E.6.14). Shears are defined as areas containing breccia, gouge, and/or slikenslides indicating relative movement. These zones are soft and friable and are characterized by high permeability and core loss during drilling. Fracture zones, often encountered in conjunction with the shears, are zones of very closely spaced joints. With depth, these zones become tighter and more widely spaced. Where exposed, they are eroded into deep gullies.

The most common trend of these features is northwest, parallel to Joint Set I. These zones have vertical to steep northeast dips and are generally less than one foot wide. Northwest trending shears are also associated with the contacts between the argillite and mafic dikes and are up to 1 foot (0.3m) wide.

A second series of shears trend northeasterly, subparalleling the bedding/foliation and Joint Set II, with high angle southeasterly dips. These average less than 6 inches (15 cm) in width.

2.6.3 - Structural Features

Several structural features at the Devil Canyon site were investigated during the 1980-1981 program (Acres 1982a).

In summary, these included the east-west trending sheared and fractured zone beneath the proposed saddle dam area; a bedrock drop-off beneath Borrow Site G; and bedrock conditions beneath the Susitna River.

Seismic refraction and drilling data confirm the existence of a highly sheared and fractured zone on the left bank beneath the proposed saddle dam that generally trends parallel to the river. The dip on this feature is inferred to be parallel or subparallel to the bedding/foliation at approximately 65° to the south. The linear extent of the feature has not been determined but may be up to 2500 feet (755m). No evidence was found during the 1980-81 program to suggest movement along this feature. This conclusion was confirmed during the seismic investigations (Acres 1982a). Further investigation of this feature will be required to define its extent and to determine the type of foundation treatment that will be required beneath the saddle dam.

2.6 - Devil Canyon Damsite

Upstream from the damsite, a dropoff of several hundred feet was detected in the bedrock surface under the alluvial fan by seismic refraction surveys. Land access restrictions imposed during the study prohibited any further investigation of this area. Possible explanation for this apparent anomalous dropoff could be attributed to misinterpretation of the seismic data or else the lower velocity material could be either a highly fractured rock in lieu of soil or an offset of the rock surface caused by faulting. The latter interpretation is unlikely, in that work performed in this area gave rise to the conclusion that there was no compelling evidence for a fault. Future work remains to be done in this area to define this feature more clearly.

Detailed examination of rock core and mapping in the river valley bottom showed no evidence for through-going faulting in the riverbed.

2.6.4 - Ground Water Conditions

Ground water migration within the rock is restricted to joints and fractures. It is inferred that the ground water level is a subdued replica of the surface topography with the flow towards the river and lakes. Measured water levels in the boreholes varied from ground surface to 120 feet (36 m) deep.

2.6.5 - Permafrost

Although no permafrost was found in either the bedrock or surficial material at or around the damsite, additional instrumentation will be required to accurately define the subsurface thermal regime. Aerial photo interpretation suggests the potential of permafrost in some areas of the south abutment (see Section 2.7).

2.6.6 - Permeability

Rock permeability ranges from approximately 3.28×10^{-6} ft/sec (1×10^{-4} cm/sec) to 3.3×10^{-8} ft/sec (1×10^{-6} cm/sec) with lower permeabilities generally at depth. Higher permeability occurs in the more weathered fractured rock zones (Figure E.6.17).

2.6.7 - Geology Along Proposed Long Tailrace Tunnel

(a) Introduction

This section discusses the lithology and structure along the proposed long tailrace tunnel for the Devil Canyon damsite. Reconnaissance mapping was done along the Susitna River from about 2500 feet (750 m) to 10,000 feet (3000 m) downstream from the site. Rock exposures are nearly continuous from the damsite to the bend in the river where the proposed portal area is located. From that point downstream, outcrops are scattered and poorly exposed.

(b) Lithology

As in the area of the main dam, the lithology along the proposed tailrace consists of interbedded argillite and graywacke which have been intruded by mafic and felsic dikes. The argillite is medium to dark gray, very fine to fine grained argillaceous rock with occasional grains of fine to medium sand. The graywacke is medium grained, light to medium gray within a matrix of very fine grained argillite. The interbeds of argillite and graywacke are generally 6 inches (15 cm) thick. Contacts between beds are sharp and tight.

Bedding is parallel to weakly developed foliation. Bedding foliation strikes generally northeast with moderate dips to the southeast. A secondary foliation (which is poorly developed at the damsite) is locally well developed near the proposed tunnel portal. The secondary foliation strikes nearly north-south with high angle dips to the northwest. The argillite and graywacke have been intruded by numerous quartz veins and stringers at the damsite.

Felsic and mafic dikes were mapped in outcrops along the river and to the north of the tunnel route. The lithology and structure of these dikes are similar to those found at the damsite. The felsic dikes consist of two varieties: rhyolite and granodiorite. The rhyolite dikes are light yellowish gray to gray. The texture is aphanitic to fine grained with fine to medium grained quartz phenocrysts. The granodiorite dikes are primarily medium grained plagioclase phenocrysts in a fine grained groundmass of plagioclase, orthoclase, biotite, and quartz. The felsic dikes are generally slightly to moderately weathered, medium hard, with very close to closely spaced joints. Iron oxide staining is common. Widths are generally 10 to 20 feet (3 - 6 m). Contacts with argillite and graywacke are generally fractured and/or sheared. Up to 3-foot-wide (1 m) contact metamorphic zones are common in the adjacent argillite and graywacke. The felsic dikes strike northwest and northeast.

Mafic dikes are generally dark green to dark gray. These dikes are fresh to slightly weathered and hard. Mafic dikes are composed of feldspar in a fibrous groundmass with accessory pyroxene, biotite, hornblende, and calcite. These dikes are generally 2 to 10 feet (0.6 - 3 m) wide and trend northwest with high angle vertical dips. Like the felsic dikes, the mafic dike contacts are generally sheared and/or fractured. Joint spacing is very close to closely spaced.

(c) Structures

Joints sets and shear/fracture zones similar to those mapped at the damsite are likely to occur along the tailrace tunnel (Figure E.6.18).

The four joint sets identified at the damsite continue downstream; however, variations in orientation and dip occur. Table E.6.4 contains a list of joint characteristics for joints along the tailrace tunnel.

Joint Set I is northwest trending with moderate to high angle dips to the northeast and southwest. The average strike and dip of this set in the tailrace area are 325° and 70° northeast, respectively, which differ slightly from its average orientation in the damsite of 340° and 80° northeast. Spacings are highly variable but average about 1.5 feet (0.5 m). The river flows parallel to this set in the vicinity of the outlet portal.

Joint Set II includes joints parallel and subparallel to the bedding/foliation planes. This set strikes 065° with moderate (60°) dips to the southeast. The strike is essentially the same as at the damsite, although the dip is slightly steeper.

Joint Set III strikes nearly north-south at an average of 022°. Dips are variable from 63° east to 84° west. The strike of Set III is similar to that found on the south bank of the damsite; but about 30° more northerly than the average strike found on the north bank. Dips are generally similar to those at the damsite. Set III joints are well developed in the vicinity of the outlet portal.

Joint Set IV consists of low-angle (dipping less than 40°) joints of various orientations.

Although no shears or fracture zones were found during the reconnaissance mapping downstream from the damsite, it is anticipated that several such features will be encountered along the tunnel. These shears and fracture zones will likely be less than 10 feet (3 m) wide and spaced from 300 to 500 feet (90 - 150 m) apart. Preliminary investigations suggest that the tailrace tunnels will intersect any shear/fracture zones at near right angles thereby minimizing support requirements.

2.6.8 - Borrow Sites

Borrow Site G, the alluvial fan immediately upstream from the dam (Figure E.6.14), has been identified as a source of granular material for concrete aggregate.

2.7 - Reservoir Geology

A reserve of about 3 mcy, with an additional 3 mcy potential reserve, has been estimated for this borrow source. Details of material properties have been included in Acres 1982a and 1982b reports. Tests performed during 1980-82 indicate a variation of material properties within the borrow site. Therefore, additional testing will be required to confirm adequate source of suitable materials.

A rock quarry area designated as Borrow Site K has been identified approximately 5300 feet (1590 m) south of the saddle dam. This area contains a granodiorite similar to rock found at the Watana damsite.

2.7 - Reservoir Geology

2.7.1 - Watana

(a) General

The topography of the Watana Reservoir and adjacent slopes is characterized by a narrow, V-shaped, stream-cut valley superimposed on a broad, U-shaped, glacial valley. Surficial deposits mask much of the bedrock in the area, especially in the lower and uppermost reaches of the reservoir. A surficial geology map of the reservoir, prepared by the COE, and airphoto interpretation performed during this study identified tills, lacustrine and alluvial deposits, as well as predominant rock types. Details of this photoanalysis are contained in Appendix J of Acres 1982a report. Additional geologic and surficial mapping in the Watana damsite areas are contained in Acres 1982b report.

(b) Surficial Deposits

Generally, the lower section of the Watana Reservoir and adjacent slopes are covered by a veneer of glacial till and lacustrine deposits. Two main types of till have been identified in this area: ablation and basal tills. The basal till is predominately over-consolidated, with a fine grain matrix (more silt and clay) and low permeability. The ablation till has fewer fines and a somewhat higher permeability. Lacustrine deposits consist primarily of poorly graded fine sands and silts with lesser amounts of gravel and clay, and exhibit a crude stratification.

On the south side of the Susitna River, the Fog Lakes area is characteristic of a fluted ground moraine surface. Upstream in the Watana Creek area, glaciolacustrine material forms a broad, flat plain which mantles the underlying glacial till and the partially lithified Tertiary sediments. Significant disintegration features such as kames and eskers have been observed adjacent to the river valley.

Permafrost exists in the area, as evidenced by ground ice, patterned ground stone nets, and slumping of the glacial till overlying permafrost. Numerous slumps have been identified in the Watana reservoir area, especially in sediments comprising basal till. In addition, numerous areas of frozen alluvium and interstitial ice crystals have been observed in outcrops and identified from drill hole drive samples. Areas of potential permafrost and current slope instability for the Watana and Devil Canyon reservoirs are shown in Figures E.6.19 to E.6.45.

(c) Bedrock Geology

The Watana damsite is underlain by a diorite pluton. Approximately three miles upstream from the Watana damsite, a nonconformable contact between argillite and the dioritic pluton crosses the Susitna River. An approximate location of this contact has also been delineated on Fog Creek, four miles to the south of the damsite. Just downstream from the confluence of Watana Creek and the Susitna River, the bedrock consists of semiconsolidated, Tertiary sediments and volcanics of Triassic age. These Triassic rocks consist of metavolcaniclastics and marble. Just upstream from Watana Creek to Jay Creek, the rock consists of a metavolcanogenic sequence predominantly composed of metamorphosed flows and tuffs of basaltic to andesitic composition. From Jay Creek to just downstream from the Oshetna River, the reservoir is underlain by a metamorphic terrain of amphibolite and minor amounts of greenschist and foliated diorite. To the east of the Oshetna River, glacial deposits are predominant (Figure E.6.1).

The main structural feature within the Watana Reservoir is the Talkeetna Thrust fault, which trends northeast-southwest and crosses the Susitna River approximately eight miles upstream from the Watana damsite. The southwest end of the fault is overlain by unfaulted Tertiary volcanics (Figure E.6.1).

2.7.2 - Devil Canyon

(a) Surficial and Bedrock Geology

The topography in and around the Devil Canyon reservoir is bedrock-controlled. Overburden is thin to absent, except in the upper reaches of the proposed reservoir where alluvial deposits cover the valley floor.

A large intrusive plutonic body, composed predominantly of biotite granodiorite with local areas of quartz diorite and diorite, underlies most of the reservoir and adjacent slopes. The rock is light gray to pink, medium grained and composed of quartz, feldspar, biotite, and hornblende. The most common mafic mineral is biotite. Where weathered, the rock has a light yellow-gray or pinkish yellow-gray color, except where it is highly oxidized and iron stained. The granodiorite is generally massive, competent, and hard with the exception of the rock exposed on the upland north of the Susitna River where the biotite granodiorite has been badly decomposed as a result of mechanical weathering.

The other principal rock types in the reservoir area are the argillite and graywacke, which are exposed at the Devil Canyon damsite. The argillite has been intruded by the massive granodiorite, and as a result, large isolated roof pendants of argillite and graywacke are found locally throughout the reservoir and surrounding areas. The argillite/graywacke varies locally to a phyllite of low metamorphic grade, with possible isolated schist outcrops.

The rock has been isoclirally folded into steeply dipping structures which generally strike northeast-southwest. The contact between the argillite and the biotite granodiorite crosses the Susitna River just upstream from the Devil Canyon damsite. It is nonconformable and is characterized by an aphanitic texture with a wide chilled zone. The trend of the contact is roughly northeast-southwest where it crosses the river. Several large outcrops of the argillite completely surrounded by the biotite granodiorite are found within the Devil Creek area.

3 - IMPACTS

3.1 - Reservoir-Induced Seismicity (RIS)

3.1.1 - Introduction

The potential for the possible future occurrence of reservoir-induced seismicity (RIS) in the vicinity of the proposed reservoirs was evaluated. Reservoir-induced seismicity is defined here as the phenomenon of earth movement and resultant seismicity that has a spatial and temporal relationship to a reservoir and is triggered by nontectonic stress.

Several reservoir-induced seismic events (at Kremasta, Greece; Koyna, India; Kariba, Zambia-Rhodesia; and Xinfengjiang, China) have exceeded magnitude (Ms) 6. Damage occurred to the dams at Koyna and Xinfengjiang, and additional property damage occurred at Koyna and Kremasta.

Studies of the occurrence of RIS (WCC 1980), have shown that RIS is influenced by the depth and volume of the reservoir, the filling history of the reservoir, the state of tectonic stress in the shallow crust beneath the reservoir, and the existing pore pressures and permeability of the rock under the reservoir. Although direct measurements are difficult to obtain for some of these factors, indirect geologic and seismologic data, together with observations about the occurrence of RIS at other reservoirs, can be used to assess the potential for the possible effects of the occurrence of RIS at the proposed Project reservoirs.

The scope of this study included: (a) a comparison of the depth, volume, regional stress, geologic setting, and faulting at the Devil Canyon and Watana sites with the same parameters at comparable reservoirs worldwide; (b) an assessment of the likelihood of RIS at the sites based on the above comparison; (c) a review of the relationship between reservoir filling and the length of time to the onset of induced events and the length of time to the maximum earthquake; (d) an evaluation of significance of these time periods for the sites; (e) the development of a model to assess the impact of RIS on groundmotion parameters; (f) a review of the relationship between RIS and method of reservoir filling; and (g) an assessment of the potential for landslides resulting from RIS.

For this study, the two proposed reservoirs were considered to be one hydrologic entity (designated the proposed Devil Canyon-Watana reservoir) because the hydrologic influence of the two proposed reservoirs is expected to overlap in the area between the Watana site and the upstream end of the Devil Canyon reservoir. The proposed Devil Canyon-Watana reservoir will be approximately 87 miles (140 km) long. The following parameters were used:

3.1 - RIS

	Devil Canyon	Watana	Combined
Max. Water Depth	551 ft	725 ft	725 ft
Max. Water Volume	1.09×10^6 ac-ft	9.52×10^6 ac-ft	10.61×10^6 ac-ft
Stress Regime	Compressional	Compressional	Compressional
Bedrock	Metamorphic	Ingneous	Ingneous

The combined body of water, as proposed, would constitute a very deep, very large reservoir within a primarily igneous bedrock terrain that is undergoing compressional tectonic stress.

Details of this study are presented in WCC 1980 and 1982 reports. A summary of this study is presented in the following sections.

3.1.2 - Evaluation of Potential Occurrence

(a) Likelihood of Occurrence

For comparative purposes, a deep reservoir has a maximum water depth of 300 feet (90m) or deeper; a very deep reservoir is 492 feet (150m) deep or deeper; a large reservoir has a maximum water volume greater than 1×10^6 acre feet; and a very large reservoir has a volume greater than 8.1×10^6 acre feet. Twenty-one percent of all deep, very deep, or very large reservoirs have been subject to RIS. Thus, the likelihood that any deep, very deep, or very large reservoir will experience RIS is 0.21. However, the tectonic and geologic conditions at any specific reservoir may be more or less conducive to RIS occurrence.

Models have been developed by Baecher and Keeney in Packer et al. (WCC 1980) to estimate the likelihood of RIS at a reservoir, characterized by its depth, volume faulting, geology, and stress regime. The models from which the likelihoods are calculated are sensitive to changes in data classification for the geologic and stress regime. The calculations from models, however, do not significantly influence the basic relatively high likelihood of RIS at the Devil Canyon-Watana reservoir considering its depth and volume.

(b) Location and Maximum Magnitude

Woodward-Clyde Consultants (1980), among others, has discussed the concept, based on theoretical considerations and existing cases of RIS, that an RIS event is a naturally occurring event triggered by the impoundment of a reservoir. That is, reservoirs are believed to provide an incremental increase in stress that is large enough to trigger strain release in the form of an earthquake. In this manner, reservoirs are considered capable of triggering an earlier occurrence of an earthquake (i.e., of decreasing the recurrence interval of the event) than would have occurred if the reservoir had not been filled. In this regard, reservoirs are not considered capable of triggering an earthquake larger than that which would have occurred "naturally."

The portion of crust that a reservoir may influence is limited to the area affected by its mass and pore pressure influences. This area of influence is often referred to as a reservoir's hydrologic regime. Documented cases of RIS (WCC 1980) indicate that the RIS epicenters occur within an area that is related to the surface area that the reservoir covers. For the purposes of this study, the hydrologic regime of the proposed reservoir has been described as an envelope with a 19-mile (30 km) radius that encompasses the reservoir area, as discussed in WCC 1980.

Previous studies (WCC 1980) present evidence that strongly suggests that moderate to large RIS events are expected to occur only along faults with recent displacement. Among the reported cases of RIS, at least 10 have had magnitudes of (Ms) 5. Field reconnaisance and information available in the literature indicate that Quaternary or late Cenozoic surface fault rupture (i.e., rupture on faults with recent displacement) occurred within the hydrologic regime of eight of these ten reservoirs (WCC 1980).

On the basis of this investigation, it has been concluded that there are no faults with recent displacement within the hydrologic regime of the proposed reservoir. Therefore, the maximum earthquake which could be triggered by the reservoir is an earthquake with a magnitude below the detection level of currently available techniques (i.e., the detection-level earthquake). Thus, the magnitude of the largest earthquake that could be triggered by the proposed reservoir is judged to be (M_S) 6, which is the maximum magnitude of the detection level earthquake.

Based on model studies (WCC 1982), this event is most likely to occur within a 20-mile (32 km) belt on either side of the reservoir.

3.2 - Seepage

As the result of construction of the Watana and Devil Canyon dams and the impoundment of the reservoirs, one of the main potential impacts will be the possible seepage through and around the dams.

Specifically, as in any dam, there will be the tendency for seepage through the foundation rock. Permeabilities in the foundation of both dams are not high and are amenable to grouting.

Buried channels which bypass the dam present the only other seepage path of concern at either of the two damsites. At the Devil Canyon site, the channel on the south bank does not present a problem, since the saddle dam will be constructed across it with adequate foundation preparation and grouting.

At the Watana site there are two channels which will be impacted by increased seepage gradients. The channel to the south of the river in the Fog Lakes area is not expected to pose seepage problems because of the low gradient and long travel distance (approximately 4-5 miles) (6.4 - 8 km) from the reservoir to Fog Creek. However, additional work will be required in this area to accurately determine subsurface conditions.

The relict channel north of the Watana site poses the greatest potential for seepage, particularly through the deepest deposits on a path from the reservoir to Tsusena Creek. In addition to loss of water from the reservoir, the main impact of seepage through the buried channel area could result in piping and erosion of materials at the exit point on Tsusena Creek.

A further potential impact is saturation of the various zones in the buried channel combined with the thawing of permafrost in this area. This could lead to a condition that could culminate in liquefaction of one of the horizons resulting in breaching of the reservoir rim. It could, most likely, occur during a strong earthquake, but could be triggered as the result of surface loading. The stratigraphy of the relict channel was defined during 1980-82 exploration work (Acres 1982a, 1982b). The preliminary results of that work show that there are no apparent widespread or continuous units within the relict channel that are susceptible to liquefaction. In addition, it appears that multiple periods of glaciation may have resulted in overconsolidating the majority of the unconsolidated sediments within the relict channel, thereby minimizing their potential for liquefaction.

3.3 - Reservoir Slope Failures

3.3.1 - General

Shoreline erosion will occur as a result of two geologic processes: (1) beaching, and (2) mass movement. The types of mass movement expected to occur within the reservoirs will be:

3.3 - Reservoir Slope Failures

- Bimodal flow;
- Block slide;
- Flows;
- Multiple regressive flow;
- Multiple retrogressive flow/slide;
- Rotational slides,
- Skin flows;
- Slides; and
- Solifluction flow.

Aside from the formation of beaches resulting from erosion, instability along the reservoir slopes can result from two principal causes: a change in the ground water regime and the thawing of permafrost. Beach erosion can give rise to general instability through the sloughing or failure of an oversteepened backslope, thereby enlarging the beach area.

(a) Changes in Ground Water Regime

As a reservoir fills, the ground water table in the adjacent slope also rises. This may result in a previously stable slope above the ground water table becoming unstable because of increased pore pressures and seepage acting on the slope.

Rapid drawdown of a reservoir may also result in increased instability of susceptible slopes.

(b) Thawing of Permafrost

Solifluction slopes, skin flows, and the lobes of bimodal flows are caused by instability on low-angle slopes resulting from thawing of permafrost. Mobility is often substantial and rapid, as the movements are generally distributed throughout the mass.

(c) Stability During Earthquakes

Submerged slopes in granular materials, particularly uniform fine sands, may be susceptible to liquefaction during earthquakes. This is one example where a small slide could occur below the reservoir level. In addition, areas having a reservoir rim where the ground water table has reestablished itself could have a greater potential for sliding during an earthquake because of the increased pore water pressures.

Thawing permafrost could generate excess pore pressures in some soils. In cases where this situation exists in liquefiable soils, small slides on flat-lying slopes could occur.

3.3 - Reservoir Slope Failures

The existence of fine-grained sands, coarse silts, and other liquefaction susceptible material does not appear extensive in the reservoir areas. Therefore, it is considered that the extent of failures caused by liquefaction during earthquakes will be small and primarily limited to areas of permafrost thaw. No evidence of liquefaction was noted within the project area. Some slides could occur above the reservoir level in previously unfrozen soils as the result of earthquake shaking.

3.3.2 - Slope Stability Models for Watana and Devil Canyon Reservoirs

Following a detailed evaluation of the Watana and Devil Canyon reservoir geology, four general slope-stability models were defined for this study. These models are shown in Figures E.6.19 and E.6.20 and consist of several types of beaching, flows, and slides that could occur in the reservoir during and after impoundment. Based on aerial photo interpretation and limited field reconnaissance, potentially unstable slopes in the reservoir were classified by one or more of these models as to the type of failure that may occur in specific areas. In addition to identifying potential slope-instability models around the reservoir, attempts were made to delineate areas of existing slope failures and permafrost regions. These maps are shown in Figures E.6.21 through E.6.45. As stated above, these maps have been constructed using photo interpretation and limited field reconnaissance and are intended to be preliminary and subject to verification in subsequent studies.

Further details of the slope stability of the reservoirs is presented in Appendix K of the 1980-81 Geotechnical Report (Acres 1982a).

3.3.3 - Devil Canyon Slope Stability and Erosion

The Devil Canyon reservoir will be entirely confined within the walls of the present river valley. This reservoir will be narrow and deep with minimal seasonal drawdown. From Devil Canyon Creek downstream to the damsite, the slopes of the reservoir and its shoreline consist primarily of bedrock with localized areas of thin veneer of colluvium or till. Upstream from Devil Canyon Creek, the slopes of the reservoir are covered with increasing amounts of unconsolidated materials, especially on the south abutment. These materials are principally basal tills, coarse-grained floodplain deposits, and alluvial fan deposits.

3.3 - Reservoir Slope Failure

Existing slope failures in this area of the Susitna River, as defined by photogrammetry and limited field reconnaissance, are skin and bimodal flows in soil and block slides and rotational slides in rock. The basal tills are the primary materials susceptible to mass movements. On the south abutment, there is a possibility of sporadic permafrost existing within the delineated areas. Upstream from this area, the basal till is nearly continuously frozen as evidenced by field information in Borrow Area H.

Downstream from the Devil Creek area, instability is largely reserved to small rock falls. Beaching will be the primary process acting on the shoreline in this area. Although this area is mapped as a basal till, the material is coarser grained than that which is found in the Watana Reservoir and is, therefore, more susceptible to beaching.

In areas where the shoreline will be in contact with steep bedrock cliffs, the fluctuation of the reservoir may contribute to rockfalls. Fluctuation of the reservoir and, therefore, the ground water table, accompanied by seasonal freezing and thawing, will encourage frost heaving as an erosive agent to accelerate degradation of the slope and beaching. These rock falls will be limited in extent and will not have the capacity to produce a large wave which could affect dam safety. In Devil Creek, a potential small block slide may occur after the reservoir is filled.

Above Devil Creek up to about River Mile (RM) 180, beaching will be the most common erosive process. Present slope instability above reservoir normal pool level will continue to occur, with primary beachin~ occurring at the shoreline. At approximately RM 175, there is an old landslide on the south abutment. This large rotational slide is composed of basal till which, for the most part, is frozen. A large bimodal flow exists within this block headed by a large block of ground ice. Yearly ablation of the ice results in flowage of saturated material downslope. The landslide has an accurate back scarp which has become completely vegetated since its last movement. However, this landslide, which has an estimated volume of 3.4 mcy, could possibly be reactivated as the result of continued thawing or change in the ground water regime brought about with reservoir filling.

Since the maximum pool elevation extends only to the toe of this slide, it is unlikely that a large catastrophic slide could result from normal reservoir impoundment. However, potential for an earthquake-induced landslide is possible. A mass slide in this area could result in temporary blockage of river flow.

In summary, the following conclusions can be made regarding the Devil Canyon reservoir slope stability:

- The lack of significant depths of unconsolidated materials along the lower slopes of the reservoir and the existence of stable bedrock conditions are indicative of stable slope conditions after reservoir impounding.

- A large old landslide in the upper reservoir has the potential for instability, which, if failed, could conceivably create a temporary blockage of the river in this area.

- The probability of a landslide-induced wave in the reservoir overtopping the dam is remote.

3.3.4 - Watana Slope Stability and Erosion

Most of the slopes within the Watana reservoir are composed of unconsolidated materials. As a generalization, permafrost is nearly continuous in the basal tills and sporatic to continuous in the lacustrine deposits. The distribution of permafrost has been delineated primarily on the flatter slopes below an elevation of 2300 feet (700m) (Figures E.6.13 through E.6.45). Inclined slopes may be underlain by permafrost, but based on aerial photo reconnaissance, the active layer is much thicker indicating that permafrost soils are thawing, and/or that permafrost does not exist. Existing slope instability within the reservoir (as defined by aerial photographic interpretation and limited field reconnaissance) indicates that the types of mass movement are primarily solifluction, skin flows, bimodal flows, and small rotational slides. These types of failure occur predominantly in the basal till or areas where the basal till is overlain by lacustrine deposits. In some cases, solifluction, which originated in the basal till, has proceeded downslope over some of the floodplain terraces.

Three major factors which will contribute significantly to slope instability in the Watana Reservoir are changes in the ground water regime, large seasonal fluctuation of the reservoir level (estimated at 100 feet [30 m]), and thawing of permafrost.

It is estimated that filling of the reservoir to normal pool level will take approximately three years. Because of the relatively slow rate of impounding, the potential for slope instability occurring during flooding of the reservoir will be minimal and confined to shallow surface flows and possibly some sliding. Slopes will be more susceptible to slope instability after impoundment when thawing of the permafrost soils occurs and the ground water regime has reestablished itself in the frozen soils.

Near the damsite, assuming that the present contours will remain unchanged, the north abutment will primarily be subject to beaching except for some small flows and slides that may occur adjacent to Deadman Creek. On the south abutment, thawing of the frozen basal tills will result in numerous skin and bimodal flows. There is also a potential for small rotational sliding to occur primarily opposite Deadman Creek.

On the south bank between the Watana damsite and Vee Canyon, the shoreline of the reservoir has a high potential for flows and shallow rotational slides. In contrast to the north bank, the shoreline is almost exclusively in contact with frozen basal tills, overburden is relatively thick, and steeper slopes are present. Thermal erosion, resulting from the erosion and thawing of the ice-rich, fine grained soils, will be the key factor influencing their stability. On the north bank below Vee Canyon and on both banks upstream from Vee Canyon, the geological and topographic conditions are more variable and, therefore, have a potential for varying slope conditions.

In the Watana Creek drainage area, there is a thick sequence of lacustrine material overlying the basal till. Unlike the till, it appears that the lacustrine material is largely unfrozen. All four types of slope instability could develop here, depending on where the seasonal drawdown zone is in contact with the aforementioned stratigraphy. In addition, slope instability resulting from potential liquefaction of the lacustrine material during earthquakes may occur. Overall, slopes on the north bank, in contrast with the south bank, are less steep and slightly better drained, which may be indicative of less continuous permafrost and/or slightly coarse material at the surface with a deeper active layer.

In general, the potential for beaching is high because of: (a) the wide seasonal drawdown zone that will be in contact with a thin veneer of colluvium over bedrock; and (b) the large areas around the reservoir with low slopes.

In the Oshetna-Goose Creeks area, there is a thick sequence of lacustrine material. Permafrost appears to be nearly continuous in this area based on the presence of unsorted polygonal ground and potential thermakarst activity around some of the many small ponds (thaw lakes/ kettles). The reservoir in this area will be primarily confined within the floodplain, and therefore, little modification of the slopes is expected. Where the slopes are steep, there could occur thermal niche erosion resulting in small rotational slides.

Studies performed show that the potential for a large block slide occurring and generating a wave which could overtop the dam is very remote (Appendix A of Acres 1982c). For this to occur, a very high, steep slope with a potentially unstable block of large volume would need to exist adjacent to the reservoir. This condition was not observed within the limits of the reservoir. In approximately the first 16 miles (26 km) upstream from the dam, the shoreline will be in contact with the low slopes of the broad, U-shaped valley. Between 16 and 30 miles (26 - 48 km) upstream from the dam, no potentially large landslides were observed. Beyond 30 miles (48 km) upstream, the reservoir begins to meander and narrows; therefore, any wave induced in this area by a large landslide would, in all likelihood, dissipate prior to reaching the dam.

In general, the following conclusions can be drawn about the slope conditions of the Watana reservoir after impounding:

- The principal factors influencing slope instability are the large seasonal drawdown of the reservoir and the thawing of permafrost soils. Other factors are the change in the ground water regime, the steepness of the slopes, coarseness of the material, thermal toe erosion, and the fetch available to generate wave action;

- The potential for beaching is much greater on the north abutment of the reservoir;

- A large portion of the reservoir slopes are susceptible to shallow slides, mainly skin and bimodal flows, and shallow rotational slides;

- The potential for a large block slide that might generate a wave that could overtop the dam is remote; and

- The period in which restabilization of the slopes adjacent to the reservoir will occur is largely unknown.

In general, most of the reservoir slopes will be totally submerged. Areas where the filling is above the break in slope will exhibit less stability problems than those in which the reservoir is at an intermediate or low level. Flow slides induced by thawing permafrost can be expected to occur over very flat-lying surfaces.

3.4 - Permafrost Thaw

The effect of thawing permafrost has already been discussed in relation to reservoir slope failures and liquefaction potential above the relict channel at the Watana site.

In addition to these two impacts, thawing can also induce settlement to surface facilities constructed in areas of deep overburden north of the Watana damsite as well as cause increased seepage through the south abutment of the Watana dam.

3.6 - Reservoir Freeboard for Wind Waves

With regard to settlement, it is anticipated that the freeboard dike, the airstrip, and the camps, as well as site roads, will all encounter areas of permafrost. Although the soils in this area are not ice rich, some settlements will occur because of thawing of the permafrost.

Since fractures in the rock below the south abutment of the Watana dam are ice-filled to approximately 200 feet (60 m), thawing of this permafrost may cause additional seepage, even though thawing will be induced prior to grouting of the cutoff below the core. This thawing will be generated because of the thermal effect of the large reservoir which will remain several degrees above freezing throughout the year. It is anticipated that thawing in the cutoff zone can be effectively accomplished prior to grouting and that grouting the foundation below the core in this zone is feasible.

3.5 - Seismically-Induced Failure

Details of seismically-induced failures in the reservoir are addressed in Section 3.3.

Seismically-induced failure in the relict channel area has been addressed in Acres 1982b report. Work performed in the relict channel during 1980-82 shows that there are no continuous liquefiable soils in the upper 200-250 feet (60-75 m) of the channel.

The access route and transmission lines in the immediate site area, that is between the Watana site and Gold Creek and between the Watana site and the Denali Highway, cross areas which have the potential for liquefaction, or landslides could occur during earthquakes. The same is true of the north and south transmission corridors, particularly in the area near Anchorage. Areas of high potential in the Stephan and Fog Lakes areas south of the Susitna River have been avoided.

3.6 - Reservoir Freeboard for Wind Waves

Studies were undertaken to determine freeboard requirements for wind-induced waves for the Watana and Devil Canyon damsites (Appendix A of Acres 1982c). Two effects of wind conditions were considered: wave run-up and wind set-up. Results of the study showed that the wave heights in both Watana and Devil Canyon reservoirs are governed by the respective fetch lengths. The narrowness and bends in the reservoirs reduce the effective fetch, and thus reduce wind-induced waves. The wind setup for both reservoirs was found to be 0.1 foot (3 cm). Setup was found not to be significant, considering the degree of accuracy inherent in the wave height and run-up calculations.

Wind-induced freeboard requirements of 5.2 feet (1.6 m) for a Watana rockfill dam and 3.4 feet (1.0 m) for Devil Canyon has been included in the total freeboard requirements.

3.7 - Development of Borrow Sites and Quarries

The principal borrow sites to be developed for construction material will be Borrow Sites D, E, I, and J. Localized construction material for auxiliary facilities such as airstrips and camps may be provided from Borrow Sites F and C. Quarry rock, if required, will be provided from Quarry Sites A and L. Development of these sites will result in disturbance of the natural terrain and impact on aesthetics, noise levels, and air quality. Impacts will be minimal for Borrow Sites E, I, and J, and Quarry L which will ultimately be inundated by either the Watana or Devil Canyon reservoirs. In addition, these sites are sufficiently removed from the camp facilities to minimize noise and air quality impacts. Current design scheme does not anticipate major development of Quarry A. Therefore, the principal impact will be in the development of Borrow Site D. Although the method of excavation of this site will be developed in the subsequent design phases, it is anticipated that the upper 2-3 feet (0.6 - 0.9 m) of soil and organic material will be stripped and stockpiled. Trenching and ditching will likely be excavated throughout the borrow site to provide for free drainage and rapid runoff of surface water. The borrow site will be developed in stages using high soil cuts to allow for selective mining and mixing of material.

4 - MITIGATION

4.1 - Impacts and Hazards

Six impacts which will or could be generated because of construction of the Susitna project are:

- Reservoir-induced seismicity;
- Seepage;
- Reservoir slope failures;
- Permafrost thaw;
- Seismically-induced failure; and
- Borrow site and quarry development.

The effect of these impacts on the project and mitigating measures are discussed in this section. In addition to the above mentioned impacts, the avoidance of geologic hazards is also addressed.

4.2 - Reservoir-Induced Seismicity

The magnitude of an earthquake generated by the effect of the reservoir will not exceed the magnitude of any earthquake which would normally occur in the Talkeetna Terrain. Therefore, the detection-level earthquake developed for the project will provide the design criteria for any reservoir-induced earthquakes.

In order to monitor the effect of reservoir-induced earthquakes, a complete long-term monitoring program will be instituted in the region which will be installed prior to completion of the project. This system will provide earthquake data on all earthquakes in the region including all those induced by the effect of the reservoir. Considerations of the correlations between filling curves and seismicity for other cases of RIS has been reviewed, and it appears that sudden changes in water levels and sudden deviations in rate of water level change can be triggers of induced seismicity. A controlled, smooth-filling curve, with no sudden changes in filling rate, should be less likely to be accompanied by induced seismicity than rapid, highly fluctuating filling rates.

The filling rate for the Watana reservoir covers three years, which is relatively slow. Seasonal variations are steady and do not fluctuate rapidly. The Devil Canyon reservoir fills more rapidly, but is held steady with very little seasonal variation.

4.3 - Seepage

Seepage normally occurring through the foundation rock below each of the dams will be controlled by two means: the installation of a grout curtain and by a pattern of drain holes drilled from the gallery below the dams. The effects of these is to reduce the amount of seepage as well as control the downstream internal pressures in the rock by the pressure relief affected by the drain holes.

Should excessive seepage develop during impoundment, provisions have been made in the design for the construction of underground grouting galleries which will provide access for remedial grouting. In addition, extensive instrumentation of the dam and abutments will be implaced during postconstruction for long-term monitoring of seepage.

Preliminary assessment of seepage rates through the Watana Relict Channel, assuming certain permeabilities, suggests that there is no negligible impact on project operation (Acres 1982b). However, a two-step approach is proposed in handling this potential problem. First, a more detailed drilling program will be initiated at the beginning of 1983 to investigate the materials at depth in the channel. This will provide data on grain size, permeability, continuity of horizons and, hence, the potential for seepage.

Second, the design provides for a downstream filter to control piping should it occur. Materials would be stockpiled and used for construction of filters to control exit gradients at locations where seepage is observed.

4.4 - Reservoir Slope Failures

Some amount of slope failure will be generated in the Watana and Devil Canyon reservoirs as a result of reservoir filling and seasonal fluctuation. The principal slope failures will occur in the Watana reservoir where there are greater amounts of surficial deposits and permafrost. It is anticipated that skin flows, minor slides, and breaching will be a long-term progressive activity as a result of seasonal fluctuation of the reservoir and thawing of permafrost. Tree root systems, left from reservoir clearing, will tend to hold shallow surface slides and, in some cases where permafrost exists, may have a stabilizing influence, since the mat will hold the soil in place until excess pore pressure has dissipated. Many of the slides will occur underwater, thereby leaving no impact on the project area. Other slides occurring along the rim of the reservoir are expected to be localized. After failure, wave action will likely result in the creation of new beaches along these new slopes.

The magnitude of waves generated in the reservoir because of slides has been evaluated and found to pose no threat to the safety of the dams.

Additional freeboard has also been provided at the Watana dam so that the effect of slides into the reservoir is further minimized. Normal freeboard at normal maximum water surface elevation at Watana is 22 feet (6.6 m).

The relatively small fluctuation in the reservoir levels at the Devil Canyon site will mitigate against ongoing slope failures.

Monitoring of key slopes will be initiated prior to impoundment, particularly the large slide mass identified in the upper reaches of the Devil Canyon reservoir as well as areas having the potential for larger slides in the Watana reservoir.

4.5 - Permafrost Thaw

Two possible impacts will be felt because of permafrost thaw, both at the Watana site: settlement of facilities in areas of deep overburden and increased seepage through the dam foundation.

Adequate structural design is possible to mitigate against the hazards of settlement in permafrost areas. In the case of the main construction camp, a large pad of granular material has been provided which will evenly distribute the load and insulate the subsoil, hence, retarding thaw.

Regrading of the airstrip and monitoring of settlements at the freeboard dike will be necessary as a maintenance program to offset the effects of differential settlement in these areas.

The permanent camp is located in an area relatively free of permafrost and on good soils to prevent long-term problems.

4.6 - Seismically-Induced Failure

If subsequent studies show the potential for liquefaction in the buried channel area, it is feasible to excavate through this horizon and rebuild the freeboard dike foundation to a point below this layer.

Seismically-induced failure of reservoir slopes, although possible, will not be hazardous to the project.

The design of the main structures have been analyzed to accommodate the ground motions induced by the maximum credible earthquake. Therefore, the overall safety of the project is assured with the safety of the major structures.

4.7 - Geologic Hazards

There are only three main geologic structures which can have an affect on the construction and operation of the power facilities at the two sites. These are the short shear zone south of the parallel to the river at Devil Canyon, "The Fins" feature upstream from the Watana site, and the "Fingerbuster" zone downstream from the Watana site.

At the Watana site, all of the main project features have been located between the two features, "The Fins" and the "Fingerbuster," thus avoiding the need to tunnel through these shear zones.

Since the main concrete dam does not cross potentially hazardous geologic features at Devil Canyon, no danger to the structure is posed. Tunneling through such a feature could pose problems with large tunnels. However, only the small drainage gallery is planned to pass beneath the saddle dam.

4.8 - Borrow and Quarry Sites

All temporary access roads will be graded, recontoured, and seeded following abandonment. Areas near streams or rivers, where erosion may occur, will be riprapped during the construction period and reseeded when construction is complete. Borrow sites will be excavated only if necessary and will either be regraded and seeded with appropriate species, or, if excavation is deep enough, converted to ponds.

Rock excavated and not used in construction will be placed as riprap, used as backfill in the borrow site, or disposed of in areas which will be inundated by the reservoir.

GLOSSARY

Andesitic - from andesite rock which is fine grained extrusive rock

Aphanitic - pertaining to a texture of rocks in which the crystalline constituents are too small to be distinguished with the unaided eye

Argillite - a compact rock derived from mudstone on shale

Breccia (shears) - fragmented rock whose components are angular; may be rock which is crushed due to shearing

Chert - small piece of compact rock such as flint or silica

Clastic flow - the method of sediment transport of volcaniclastic sediments

Felsic - a general term applied to igneous rock having light colored minerals; the opposite of mafic

Gouge (shears) - rock material that has been ground to a uniformly fine particle size of clay or fine silt sizes

Grandodiorite - a group of coarse grained plutonic rock

Graywackes - a gray or greenish gray, very hard coarse grained sandstone with dark rock and mineral fragments

Kame - a long low hill, mound or ridge, composed chiefly of poorly sorted and artificial sand and gravel

Lithosphere - the earth's solid crust

Metabasalt - a basalt which has undergone some degree of metamorphism

Metamorphic - rocks which have formed in the solid state in response to pronounced changes of temperature, pressure, and the chemical environment

Orthoclase - a mineral, a member of the feldspar group commonly seen in granitic rocks

Mafic - an igneous rock having dark colored minerals. The opposite of felsic

Orogeny - the process by which mountains are formed involving folding and thrusting

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Orogeny - the process by which mountains are formed involving folding and thrusting

Phenocrysts - the relatively large crystals which are found set in a fine-grained ground mass

Phyllitic - an argillaceous rock formed by regional metamorphism and intermediate in grade between slate and mica schist

Plagioclase - a mineral group, members of the feldspars. One of the commonest rock - forming minerals

RQD's - rock quality designation. This is a form of recording rock core recovery; the RQD is the ratio of the total length of core pieces four inches and longer to the length of the coring run actually drilled

Slickenslides - a polished and smoothly striked surface that results from friction along a fault/shear plane

Stoss and lee bedrock forms - asymmetric arrangement of bosses (small igneous intrusion at the surface) and hills in a strongly glaciated area, each hill having a gently abraded slope on the stoss side (side to the ice), and a steeper and rougher quarried slope on the lee side

Tectonic - of, pertaining to, or designating the rock structure and external forms resulting from deformation of the earth's crust

Thalweg Channel - the line connecting the lowest points along a shear bed or valley

Thermakarst - settling or caving of the ground due to melting of ground ice

Tuff - a rock formed of compacted volcanic fragments, generally smaller than 4 mm in diameter

Turbidite - a deposit formed by a highly turbid and relatively dense current which moves along the bottom of a body of standing water

Volcaniclastic rock - a sedimentary rock composed primarily of volcanic rock fragments

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TABLE E.6.1: GEOLOGIC TIME SCALE

ERA	PERIOD	EPOCH	GLACIATION	MILLION OF YEARS AGO
Cenozoic	Quaternary	Holocene Pleistocene	Wisconsinan Illinoian Kansan Nebraskan	1.8
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene		70
Mesozoic	Cretaceous Jurassic Triassic			230
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian			600
Precambrian				

TABLE E.6.2: WATANA JOINT CHARACTERISTICS*

Joint Set	Site Quadrant	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	All	290°-330°	320°	75°NE-80°SW	90°	1"-15'	2')		Carbonate locally	Parallel to major shears, fracture zones and alteration zones
	NE, SE				80°NE	2"-10'	2')		Carbonate at WJ-6 and WJ-7	
	NW, SW		320°		90°	1"-15'	2')	Planar, smooth to locally rough, continuous	Major carbonate at WJ-4	
	I6 NW, SW		295°		75°NE	1"-15'	2')		Minor carbonate at WJ-9	
II	All	045°-080°	060°	80°SE-80NW	90°	1"-5'	2'	Planar, smooth to rough	Carbonate locally	No shears or alteration zones, minor fracture zone
	NE, SE		050°		85°NW	1"-5'	1.5'	Planar to irregular, smooth to slightly rough	Carbonate at WJ-5	
	NW, SW		065°		90°	2"-5'	2'	Planar, smooth to rough	Carbonate at one outcrop	
III	All	340°-030°	0°	40°E-65°W	60°E	0.5"-5'	1.5'	Planar to irregular, rough	Carbonate locally	Parallel to minor shears and fracture zones
	NE		005°		60°E	2"-2'	1'	Curved, rough	--	Weakly developed
	SE		350°		65°W	6"-4'	1.5'	Planar to irregular, smooth to rough	--	Weakly developed
	NW, SW		345°		60°E	0.5"-5'	2'	Planar to irregular, rough	Carbonate locally	Strongly developed
IV		Variable orientations		Shallow to moderate						
	Strongest Concentrations:									
	NE		080°		10°N	2"-3'	1')	Planar to irregular, smooth to rough, discontinuous	--	Probably stress relief, near surface
	SE		090°		25°S)		)			
			310°		40°NE)		)			
	NW		090°		10°S	1"-3'	2')			
	SW		0°		05°E)	6"-10'	2')			
			090°		25°N)		)			

*Surface data only
**When set is present

TABLE E.6.3: DEVIL CANYON JOINT CHARACTERISTICS*

Joint Set	Location	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	North Bank	320°-0°	345°	60°NE-70°SW	80°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to shears, fracture zones and most dikes. Major stress relief, open joints on south bank. Ib found locally
	Ib DCJ-4		320°		55°NE					
	South Bank	310°-350°	340°	60°NE-75°SW	90°	0.5"-5'	2'			
II	North Bank	040°-090°	065°	40°-75°SE	55°SE	6"-3'	2'	Planar to curved, smooth to rough	None	Parallel and sub-parallel to bedding/foliation. Some open to 6" near river level. Parallel to major and minor shears. IIb is found locally
	IIb DCJ-4		015°		85°SE					
	South Bank	020°-100°	075°	30°-75°SE	55°SE	2"-6'	1'			
	IIb DCJ-1		015°		75°SE	2"-5'	1.5'			
III	North Bank	045°-080°	060°	50°NW-70°SE	80°NW	4"-10'	3'	Planar to irregular, smooth to rough, tight to open joints	Occasional iron oxide and carbonate	Occurs locally, cliff former above Elevation 1400 on the north bank
	South Bank	015°-045°	025°	68°-80°NW	65°NW	6"-10'	3'			Locally open joints
IV	North Bank	Variable orientations		Shallow to moderate		3"-8'	2'	Planar, rough, discontinuous	Occasional iron oxide and carbonate	Probably stress relief, near surface
	Strongest Concentrations:									
	Composite		060°		15°SE					
	DCJ-2		060°		30°NW					
	DCJ-3		090°		10°S					
	DCJ-4		045°		25°NW					
	South Bank	Variable orientations		Shallow to moderate						
	Strongest Concentrations:									
	Composite		050°		25°NW					
			330°		20°NE					
			330°		15°SW	1"-8'	2'			
			060°		40°NW					
	DCJ-1		345°		15°NE					

*Surface joints only
**Where present

TABLE E.6.4: DEVIL CANYON TAILRACE TUNNEL - JOINT CHARACTERISTICS*

Joint Set	Strike		Dip		Spacing**		Surface Conditions		Remarks
	(Range)	(Avg.)	(Range)	(Avg.)	(Range)	(Avg.)	Texture	Coating	
I	284°-355°	325°	50°NE-55°SW	70°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to shears, fracture zones and most dikes
II	052°-085°	065°	37°SE-80°SE	60°SE	2"-5'	2'	Planar to curved, smooth to rough	None	Parallel and subparallel to bedding/foliation. Minor shears
III	006°-038°	022°	63°E-84°W	--	4"-10'	3'	Planar to irregular, smooth to rough	Occasional iron oxide and carbonate	Locally well developed
IV	Variable		less than 40°				Planar, rough, discontinuous	Occasional iron oxide and carbonate	Probably stress relief, near surface

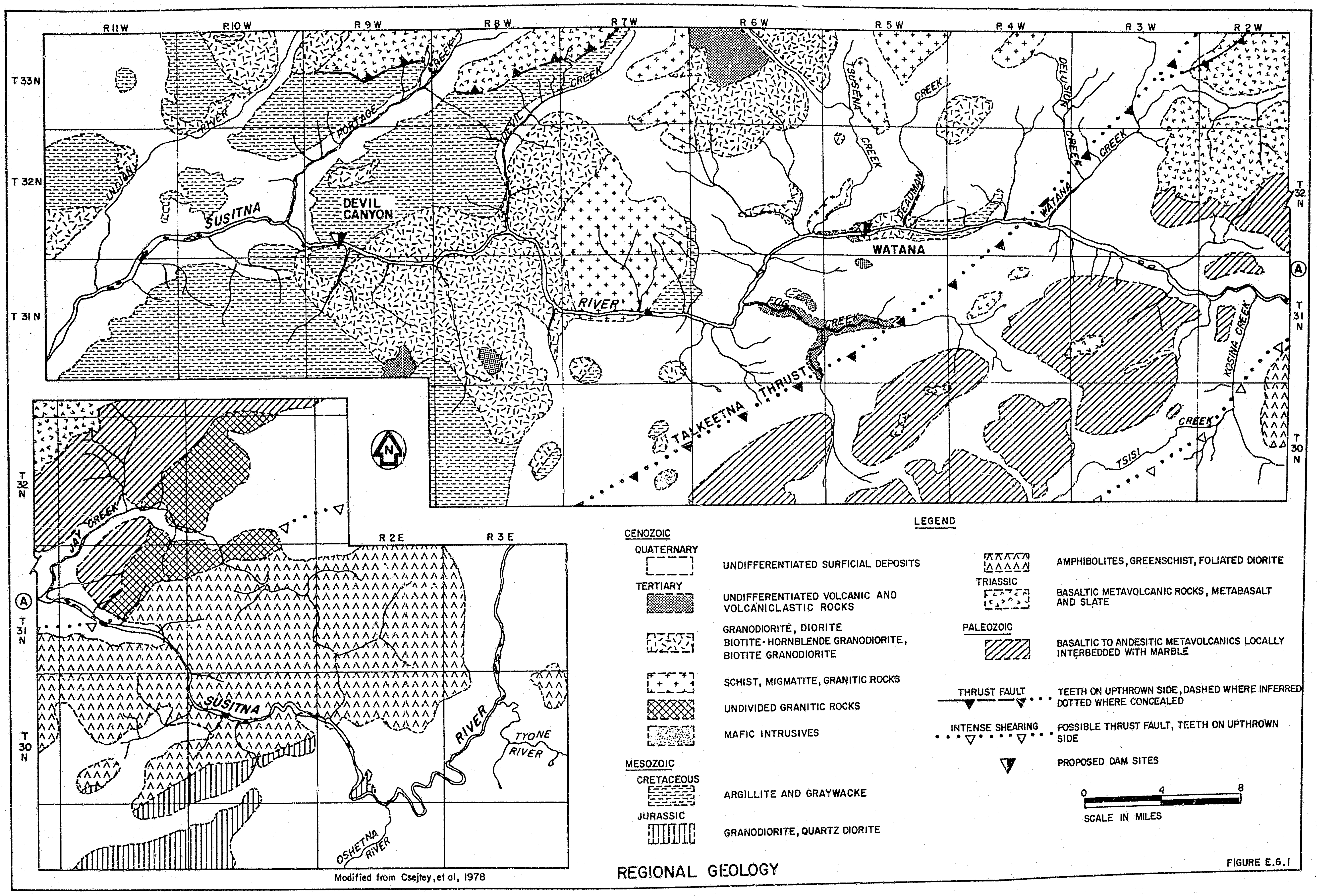
*Surface joints only
**When present

TABLE E.6.4: DEVIL CANYON TAILRACE TUNNEL - JOINT CHARACTERISTICS*

Joint Set	Strike (Range)	Strike (Avg.)	Dip (Range)	Dip (Avg.)	Spacing** (Range)	Spacing** (Avg.)	Surface Conditions: Texture	Surface Conditions: Coating	Remarks
I	284°-355°	325°	50°NE-55°SW	70°NE	0.5"-10'	1.5'	Planar, smooth, occasional rough, continuous	Occasional iron oxide and carbonate	Parallel to shears, fracture zones and most dikes
II	052°-085°	065°	37°SE-80°SE	60°SE	2"-5'	2'	Planar to curved, smooth to rough	None	Parallel and subparallel to bedding/foliation. Minor shears
III	006°-038°	022°	63°E-84°W	--	4"-10'	3'	Planar to irregular, smooth to rough	Occasional iron oxide and carbonate	Locally well developed
IV	Variable		less than 40°				Planar, rough, discontinuous	Occasional iron oxide and carbonate	Probably stress relief, near surface

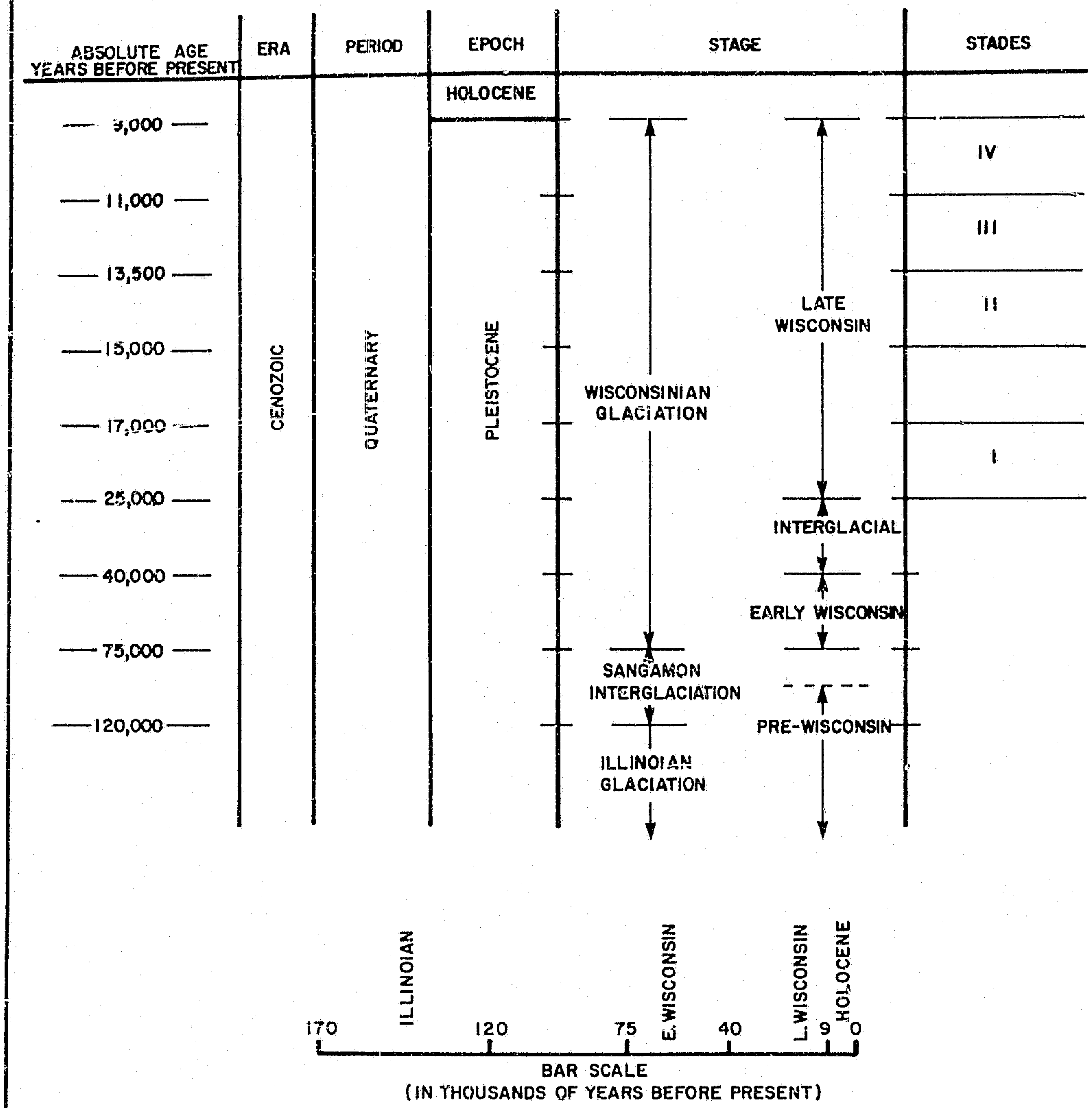
*Surface joints only
**When present

0 0 1 8 0 5



REGIONAL GEOLOGY

FIGURE E.6.1

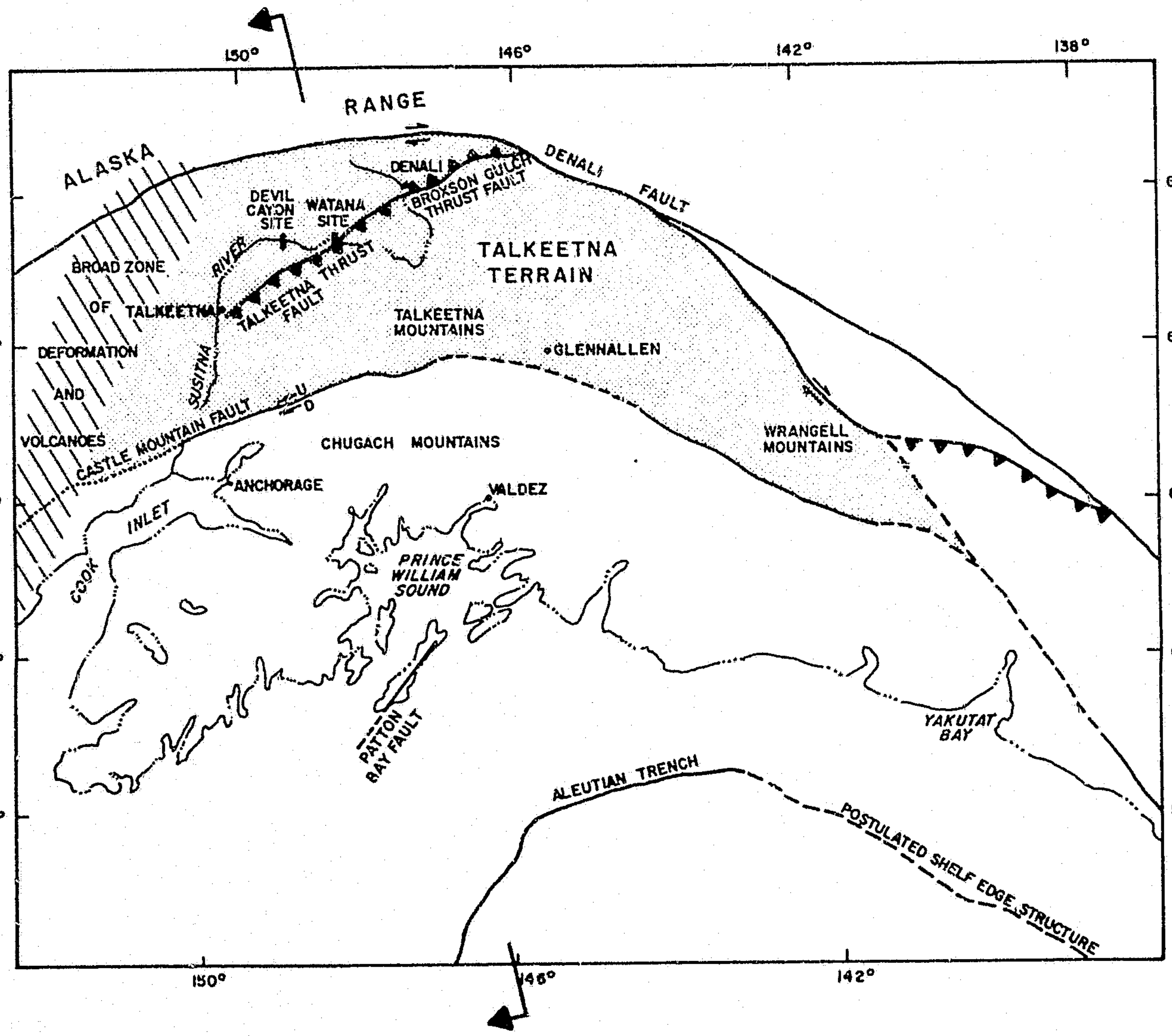


NOTES:

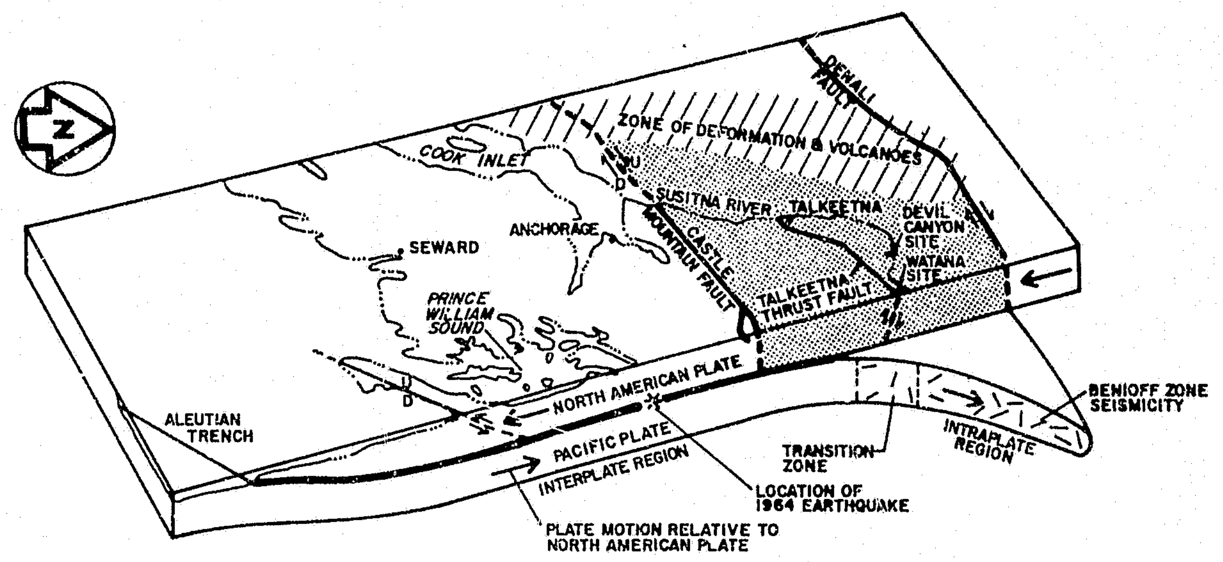
1. ERA THROUGH EPOCH TERMINOLOGY AND ABSOLUTE AGES ARE AFTER VAN EYSINGA (1978).
2. STAGE TERMINOLOGY AND AGE ARE AFTER PEWE' (1975).
3. STADE AGE ARE MODIFIED AFTER TEN BRINK AND WAYTHOMAS (IN PRESS)

QUATERNARY STUDY REGION TIME SCALE

FIGURE E.6.2



TALKEETNA TERRAIN MODEL



SCHEMATIC TALKEETNA TERRAIN SECTION

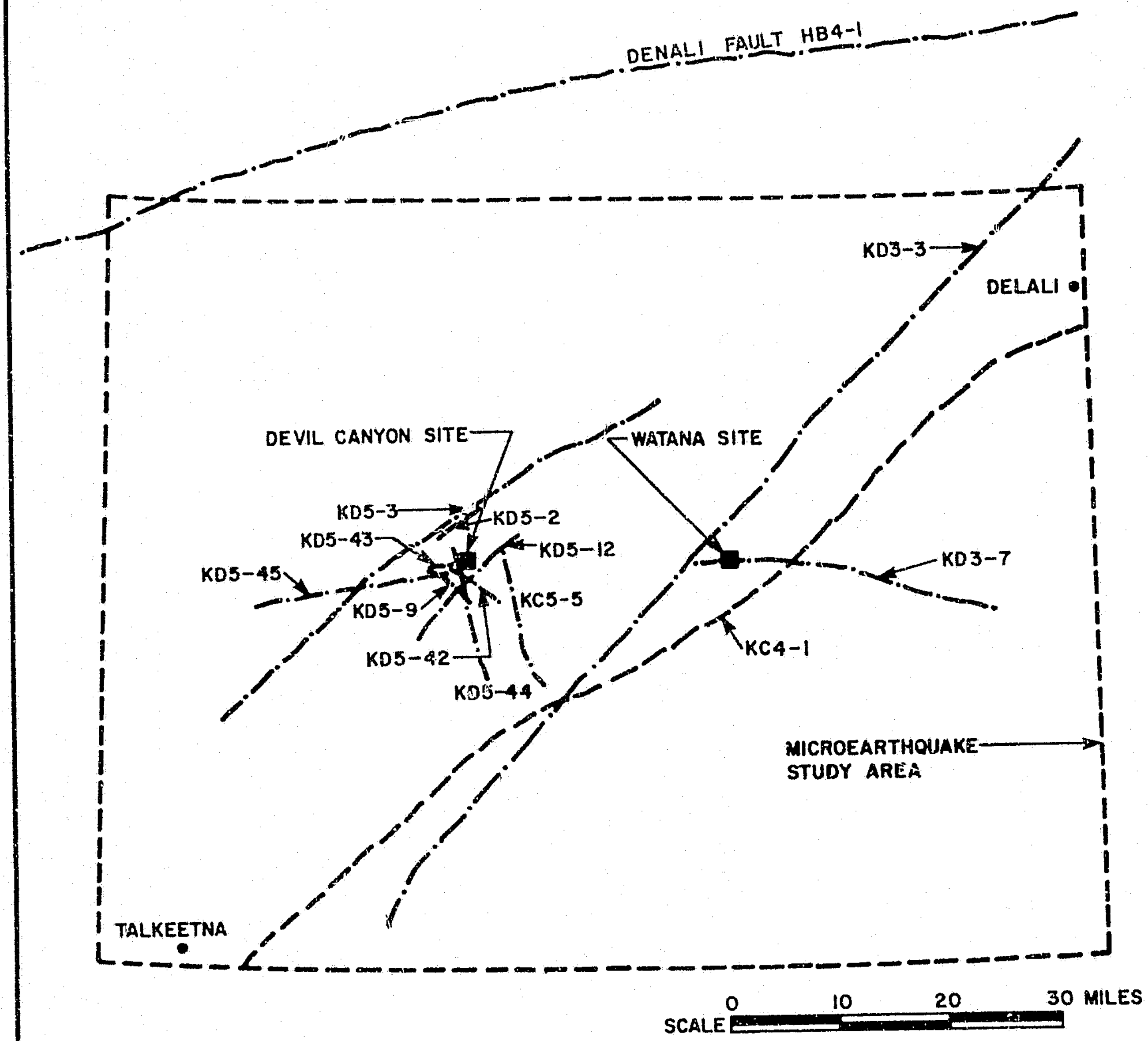
LEGEND:

- MAPPED STRIKE-SLIP FAULT, ARROWS SHOW SENSE OF HORIZONTAL DISPLACEMENT.
- MAPPED STRIKE-SLIP FAULT WITH DIP SLIP COMPONENT, LETTERS SHOW SENSE OF VERTICAL DISPLACEMENT: U IS UP, D IS DOWN.
- MAPPED FAULT, SENSE OF HORIZONTAL DISPLACEMENT NOT DEFINED.
- INFERRED STRIKE-SLIP FAULT.
- MAPPED THRUST FAULT, SAWTEETH ON UPPER PLATE.

SCALE 0 50 100 MILES

TALKEETNA TERRAIN MODEL AND SECTION

FIGURE E.6.3



FEATURES SELECTED FOR 1981 STUDIES

FIGURE E.6.4

001805

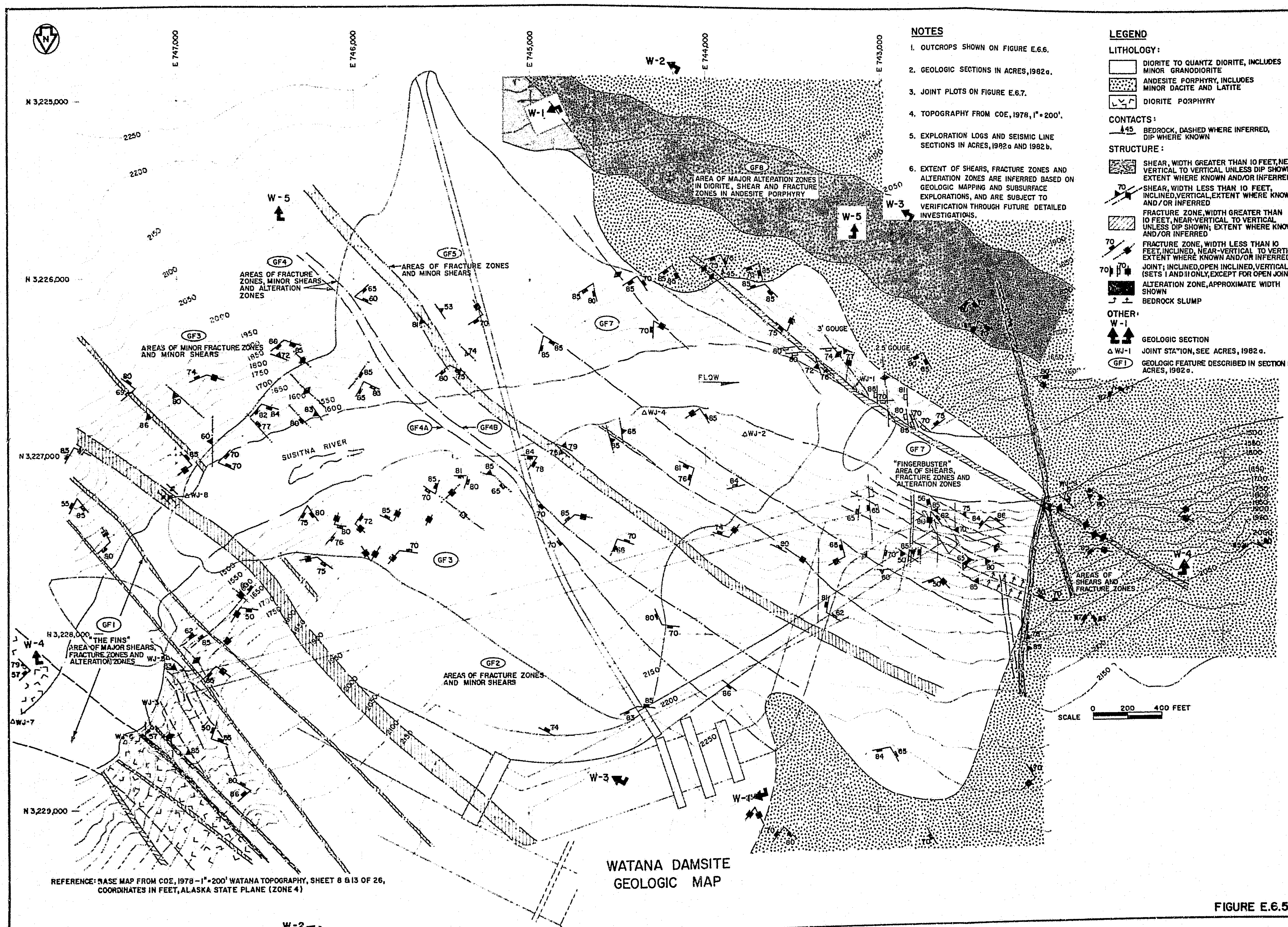
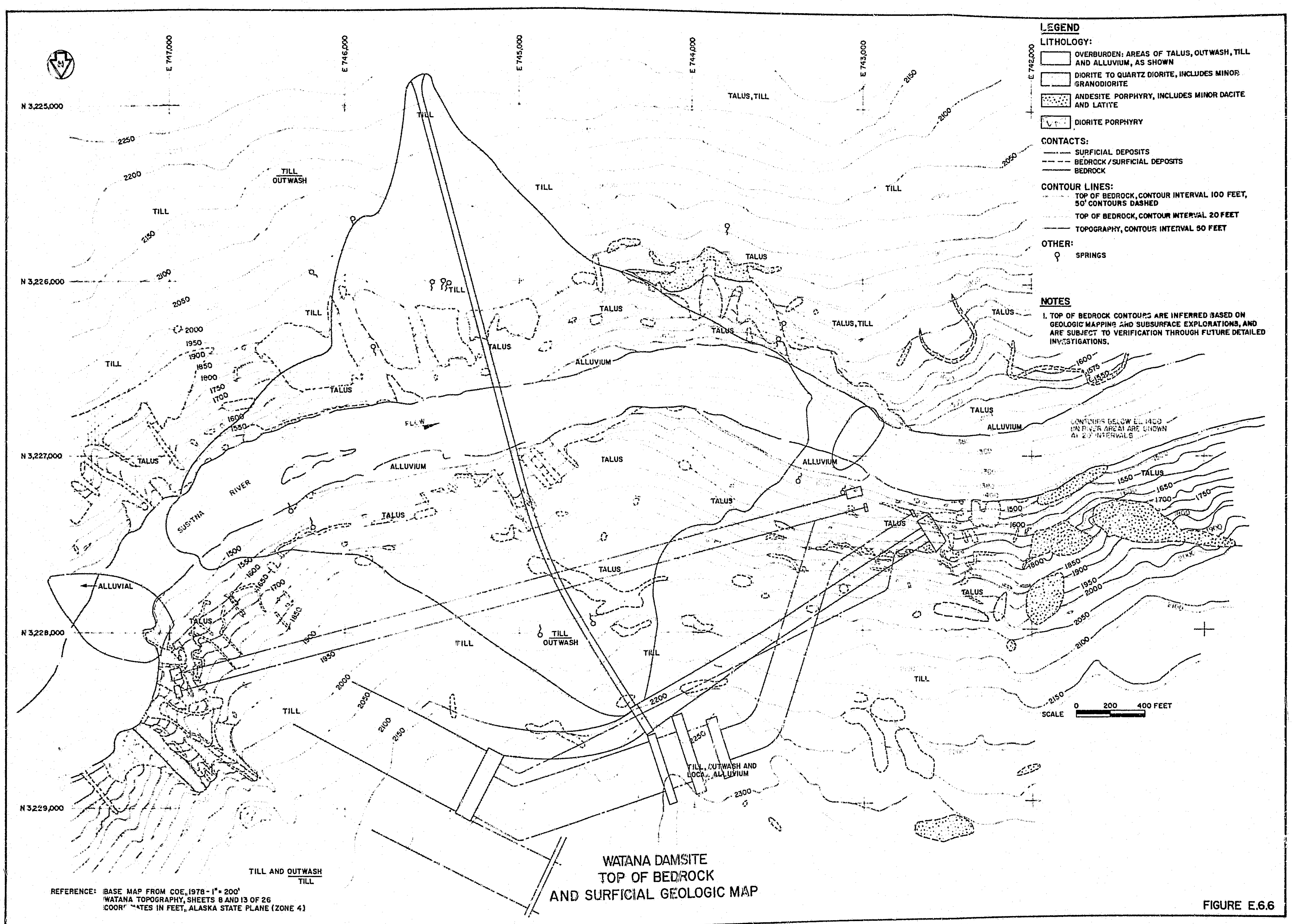
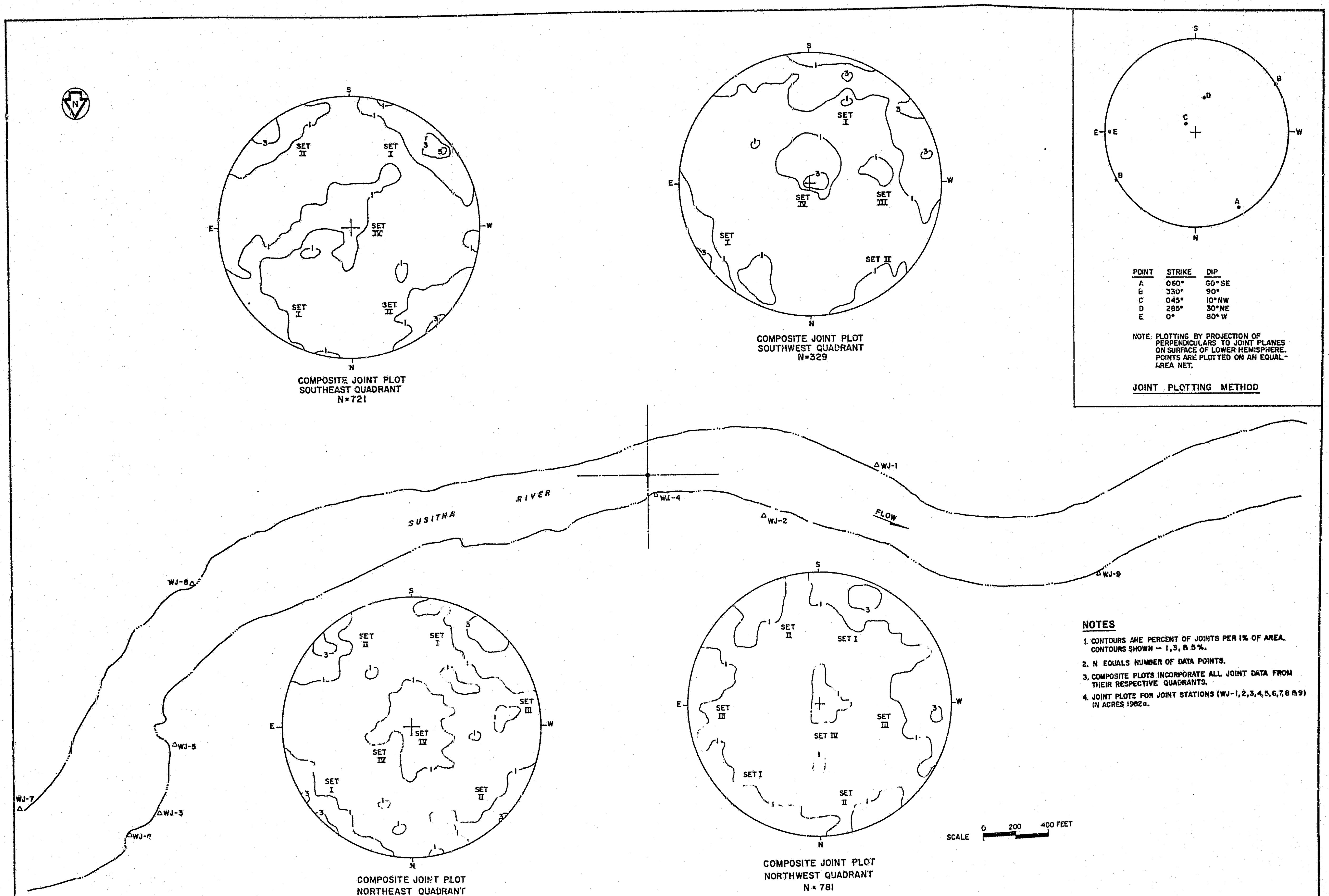


FIGURE E.6.5



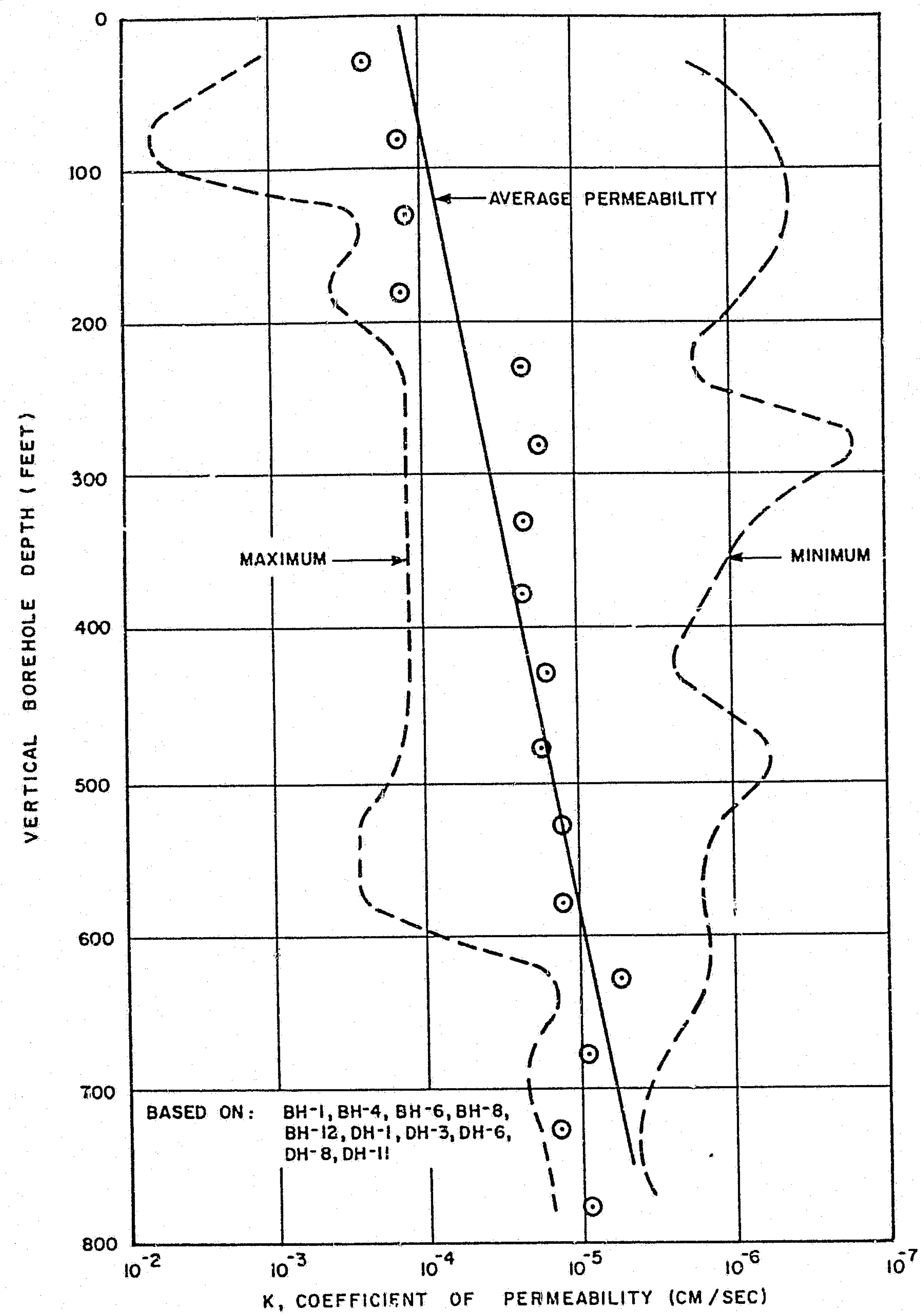
WATANA DAMSITE
TOP OF BEDROCK
AND SURFICIAL GEOLOGIC MAP

FIGURE E.6.6



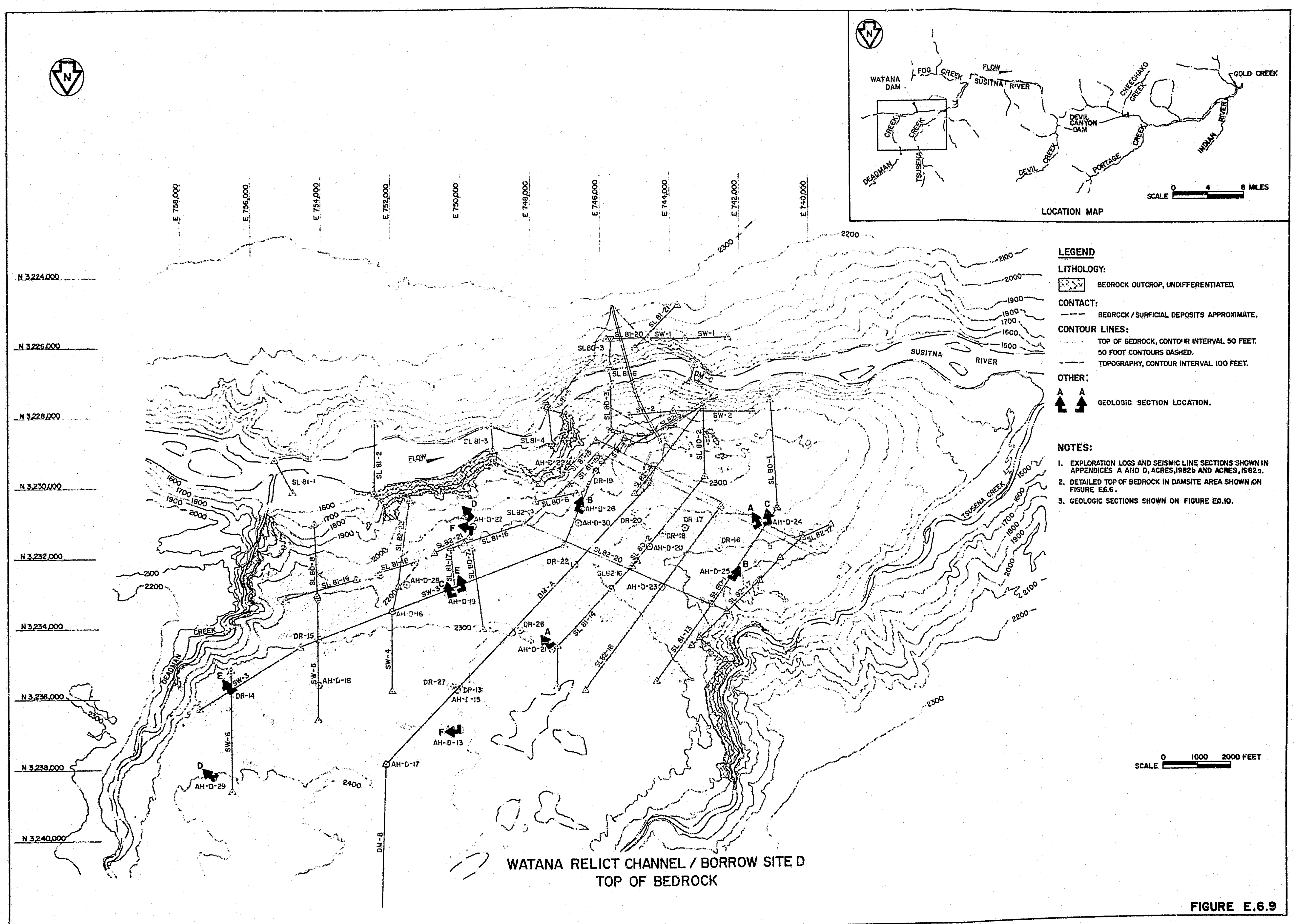
WATANA DAMSITE
COMPOSITE JOINT PLOTS

FIGURE E.6.7



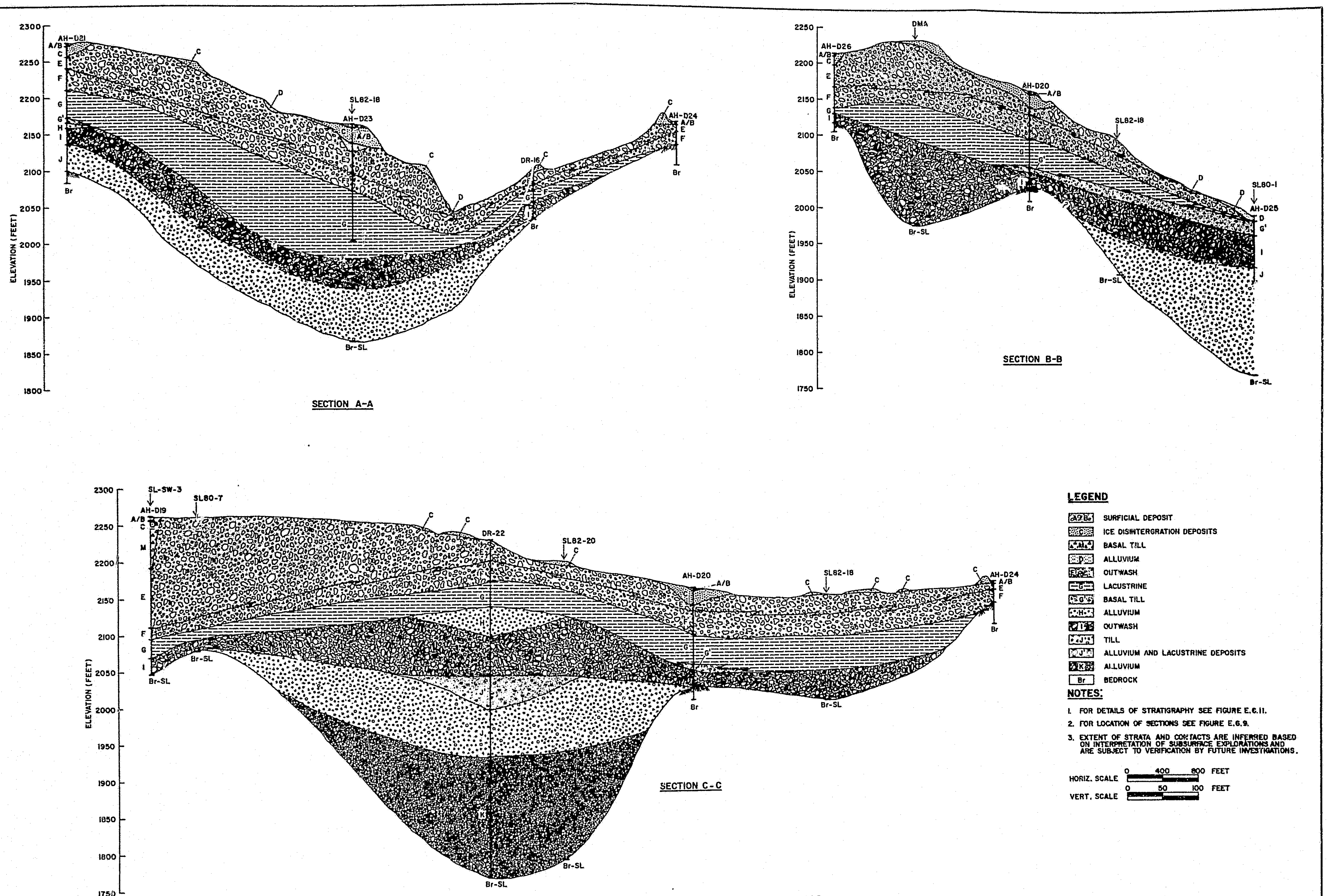
WATANA ROCK PERMEABILITY

FIGURE E.6.8



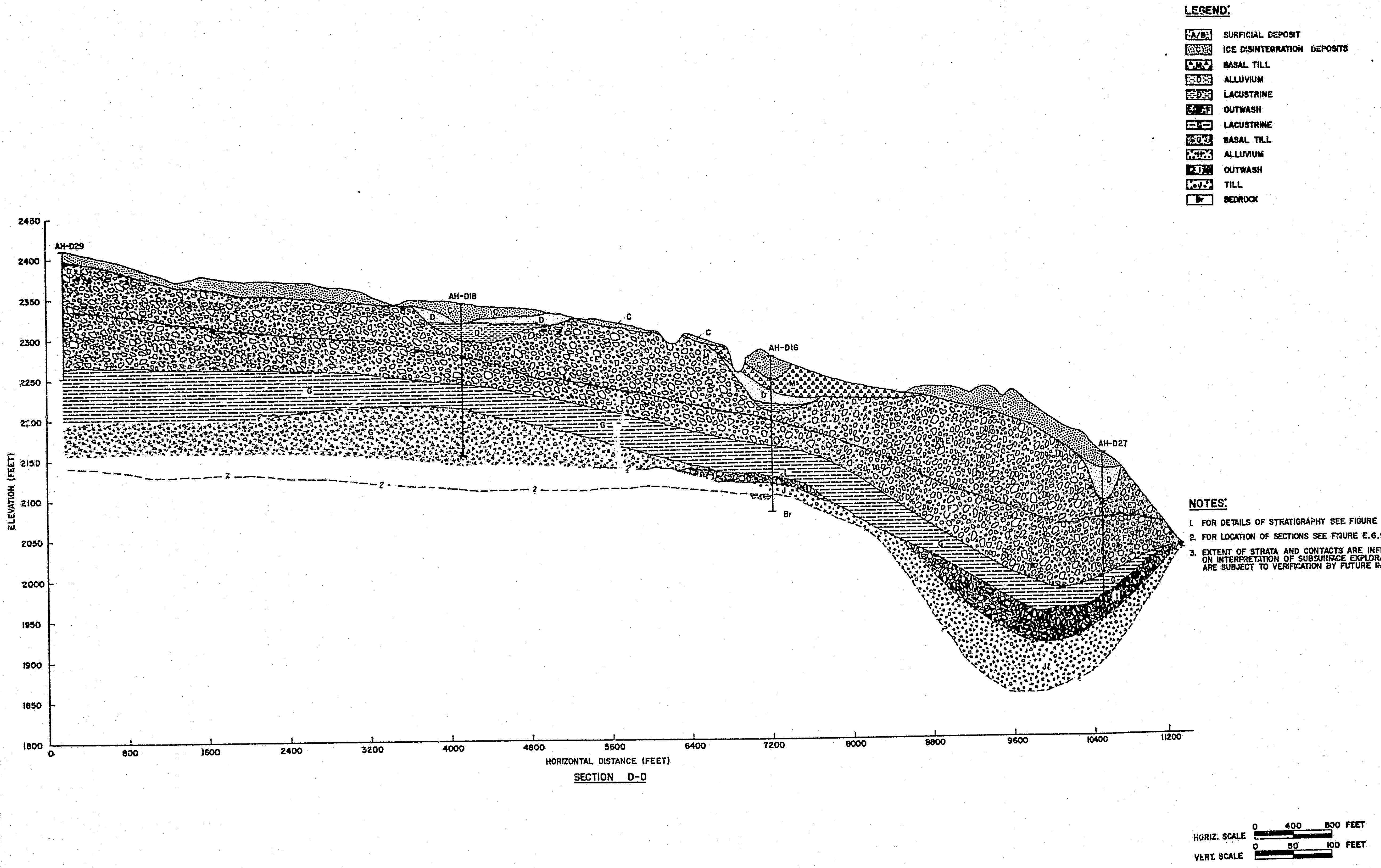
WATANA RELICT CHANNEL / BORROW SITE D
TOP OF BEDROCK

FIGURE E.6.9



WATANA RELICT CHANNEL CROSS SECTIONS
SHEET 1 OF 3

FIGURE E.6.10

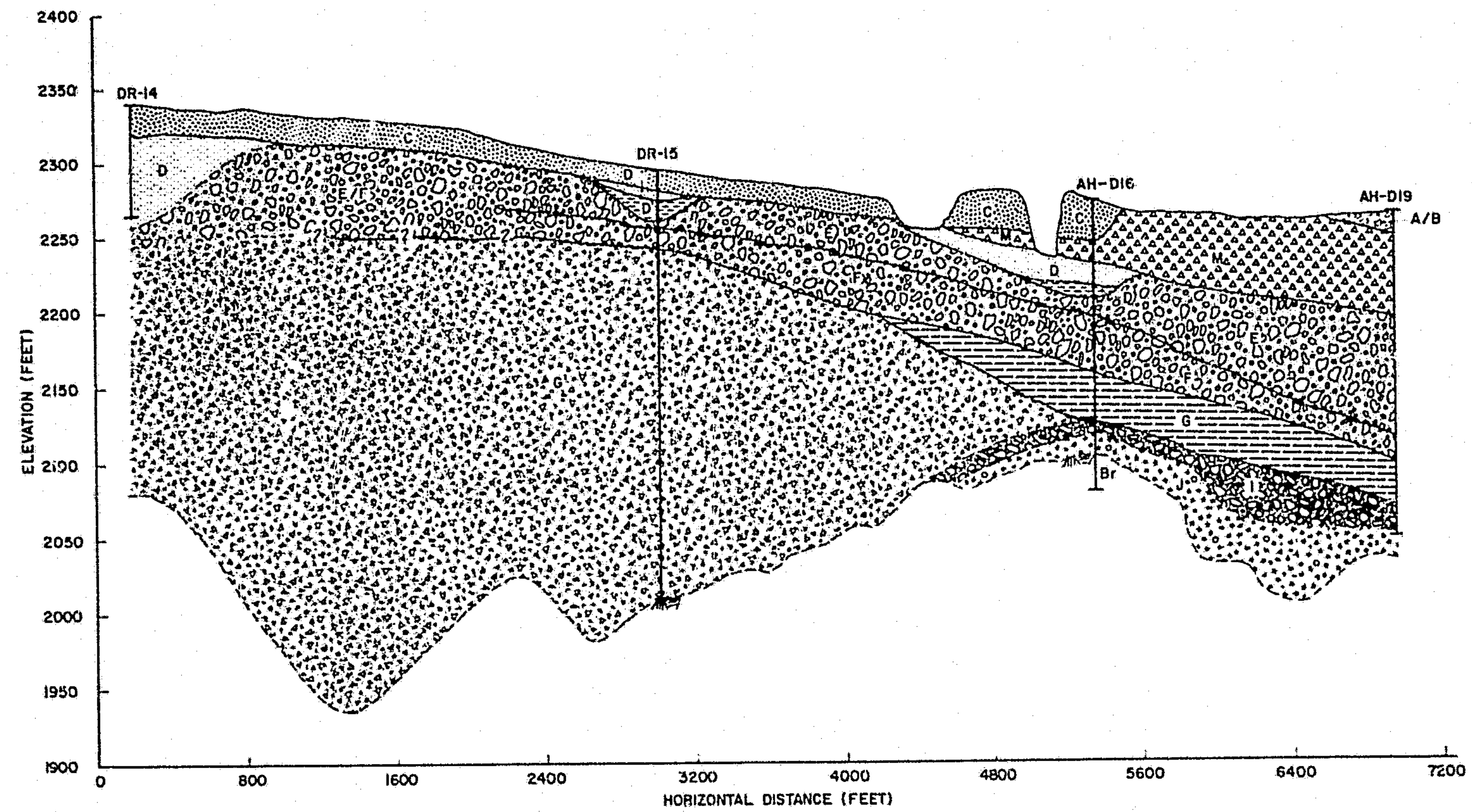


NOTES:

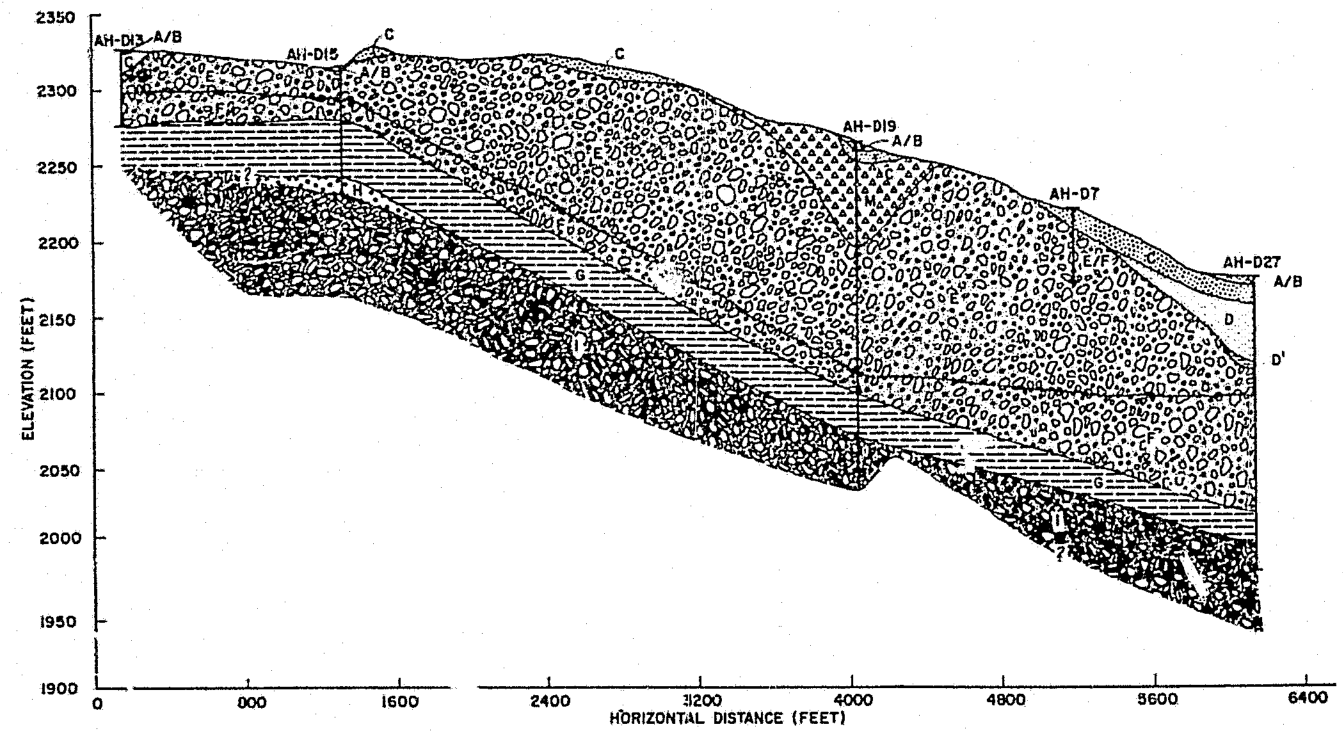
1. FOR DETAILS OF STRATIGRAPHY SEE FIGURE E.6.11.
2. FOR LOCATION OF SECTIONS SEE FIGURE E.6.9.
3. EXTENT OF STRATA AND CONTACTS ARE INFERRED BASED ON INTERPRETATION OF SUBSURFACE EXPLORATIONS AND ARE SUBJECT TO VERIFICATION BY FUTURE INVESTIGATIONS.

WATANA
BORROW SITE D
CROSS SECTION
SHEET 2 OF 3

FIGURE E.6.10



SECTION E-E



SECTION F-F

LEGEND:

- A/B SURFICIAL DEPOSIT
- ICE DISINTEGRATION DEPOSITS
- BASAL TILL
- ALLUVIUM
- LACUSTRINE
- OUTWASH
- LACUSTRINE
- BASAL TILL
- ALLUVIUM
- OUTWASH
- TILL
- Br BEDROCK

NOTES:

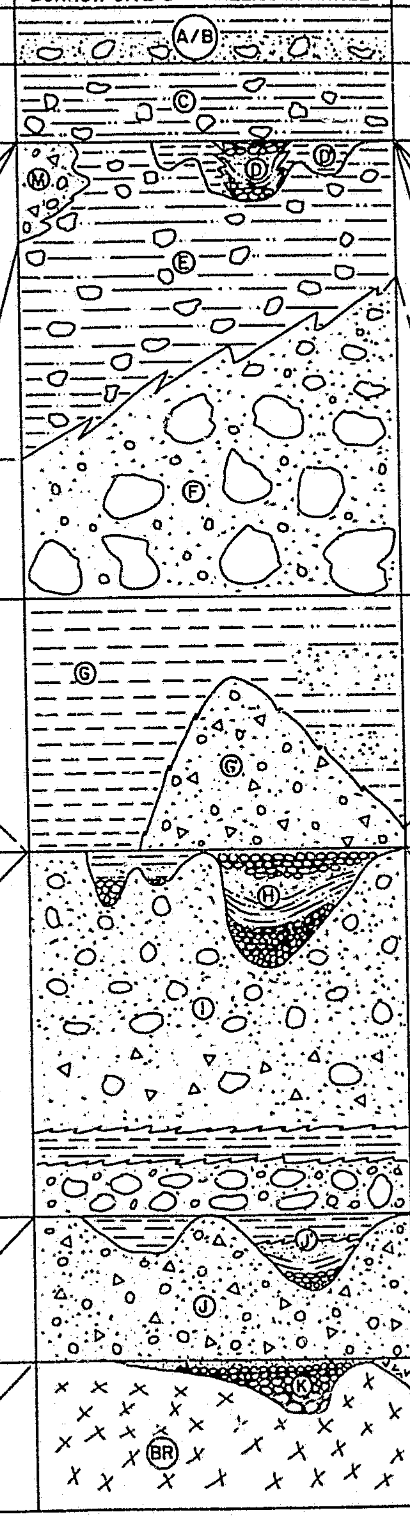
1. FOR DETAILS OF STRATIGRAPHY SEE FIGURE E.6.11.
2. FOR LOCATION OF SECTIONS SEE FIGURE E.6.9.
3. EXTENT OF STRATA AND CONTACTS ARE INFERRED BASED ON INTERPRETATION OF SUBSURFACE EXPLORATIONS AND ARE SUBJECT TO VERIFICATION BY FUTURE INVESTIGATIONS.

HORIZ. SCALE 0 400 800 FEET

VERT. SCALE 0 50 100 FEET

WATANA
BORROW SITE D
CROSS SECTIONS
SHEET 3 OF 3

FIGURE E.6.10

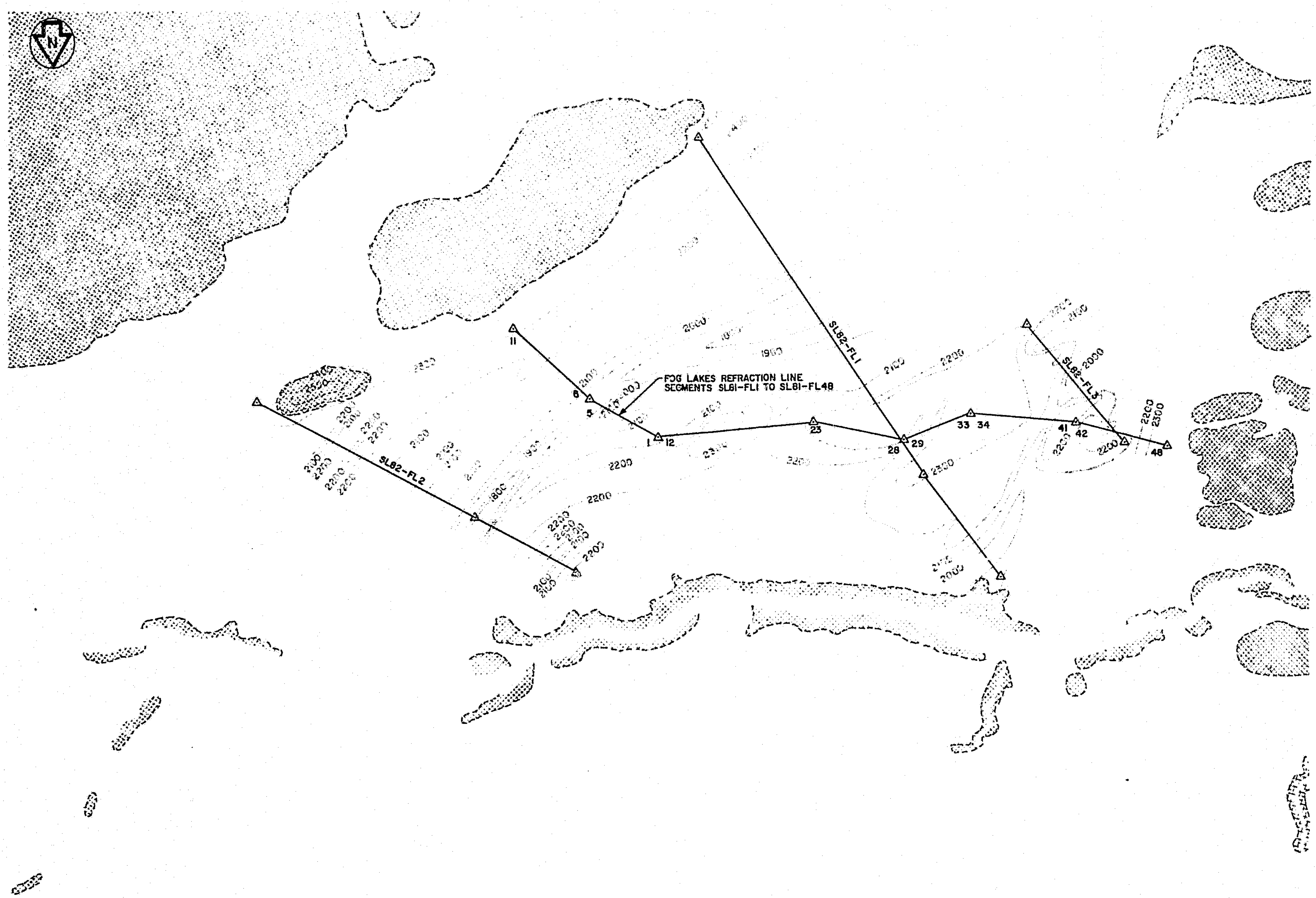


UNIT	TYPE OF DEPOSIT	GEOLOGIC EVENT	STRATIGRAPHIC COLUMN BORROW SITE D RELICT CHANNEL	THICKNESS	DESCRIPTION	REMARKS
A/B	SURFICIAL DEPOSITS	POST GLACIAL EROSION & FROST HEAVING.		RANGE 0.7 FT. AVG. 3 FT.	ORGANICS, PEAT, SILT & BOULDERS RAISED BY FROST ACTION.	SURFICIAL BOULDER FIELDS, SWAMPS & BOGS.
C	ICE DISINTEGRATION	ABLATION OF LAST GLACIAL ADVANCE & MELTING OF ICE LENSES. MAJOR GLACIAL ADVANCE		RANGE 0-38 FT. AVG. 9 FT.	TAN-BROWN SAND WITH SOME COBBLES & GRAVEL. LOOSE TO DENSE, CONTAINS LESS SILT THAN OUTWASH UNITS E & F.	HUMMOCKY TOPOGRAPHY, KNOB & KETTLE FEATURES, NO OVERCONSOLIDATION. UPPER LIMIT OF OVERCONSOLIDATION
D	ALLUVIUM	INTERGLACIAL, ICE FRONT A LONG DISTANCE FROM DEPOSITIONAL AREA.		RANGE 0-40 FT.	GRAY STRATIFIED SAND, GRAVEL & COBBLES, VERY DENSE.	CONFINED TO TOPOGRAPHIC LOW AREAS ON TOP OF UNIT "E" & RELATED FLOW CHANNELS.
D'	LACUSTRINE	LOCALIZED PONDING OF LAKES DURING INTERGLACIAL. RETREAT OF GLACIATION "M"		RANGE 0-21 FT.	GRAY/ BROWN LAMINATED CLAY & SILT, VERY DENSE.	LIMITED EXTENT, NOT FOUND IN ALL BORINGS. LAMINATIONS PRESENT. GENERALLY THIN.
M	BASAL TILL	VALLEY TYPE GLACIAL ADVANCE CONFINED TO FORMER SUSITNA VALLEY.		RANGE 0-79 FT.	GRAY CLAY WITH ANGULAR TO SUBANGULAR GRAVEL & COBBLE, VERY DENSE. COARSE FRACTION MAINLY PHYLLITE & ARGILLITE.	FOUND NEAR SUSITNA VALLEY. PEBBLES & COBBLES SUBANGULAR & STRIATED. APPEARANCE SIMILAR TO "G" BUT MUCH HIGHER PERCENTAGE OF PHYLLITE & ARGILLITE FRAGMENTS.
E	OUTWASH	GLACIAL MELTING & RETREAT; ICE FRONT AT A DISTANCE FROM SITE.			BROWN TO GRAY-BROWN SILTY SAND WITH GRAVEL & COBBLES. PARTICLES SUBANGULAR TO SUBROUNDED.	SUBANGULAR TO SUBROUNDED PARTICLES. FEWER COBBLES & BOULDERS THAN UNIT "F" BELOW. PARTIALLY SORTED.
F	OUTWASH	GLACIAL RETREAT; ICE FRONT NEAR SITE. {DRAINING OF LAKE "G" / GLACIAL RETREAT BEGINS}		RANGE E/F 0-131 FT. AVG. 37 FT.	BROWN SILTY SAND WITH GRAVEL & MANY COBBLES & BOULDERS, POORLY SORTED. SIZE OF COARSE FRACTION INCREASES WITH DEPTH. OFTEN CONTAINS A ZONE OF COBBLES & BOULDERS AT BASE OF UNIT.	LARGE COBBLES & BOULDERS INDICATES HIGH ENERGY ENVIRONMENT WITH ICE FRONT NEARBY. LARGE BOULDER ZONE AT BASE GRADING TO SMALLER FRAGMENTS TOWARD THE TOP OF UNIT INDICATES RECEDING ICE.
G	GLACIOLACUSTRINE & WATERLAIN TILL	LAKES & FLOATING ICE. ICE MASS PARTIALLY DETACHED (FLOATING). BASAL MELTING, ICE THICKENING		RANGE 0-74 FT.	GRAY CLAY, LAMINATED, VERY DENSE. CONTAINS SILTY OR SANDY INTERLAMINATIONS WHICH ARE MORE PREVALENT IN RELICT CHANNEL AREA. OCCASIONALLY VARVED.	ORGANICS FOUND IN LAMINATIONS OF UNIT "G". WOOD FOUND IN UPPER HORIZONS OF UNIT "G". LACUSTRINE LAMINATIONS & VARVES PRESENT TOGETHER WITH STRIATED PEBBLES & SAND AS WELL.
G'	BASAL TILL	MAJOR GLACIAL ADVANCE.		RANGE 0-231 FT.	GRAY CLAY WITH ANGULAR & SUBANGULAR GRAVEL & COBBLES. UNSORTED, VERY DENSE.	STRIATIONS ON COARSE FRACTION, LITTLE OXIDATION, BASAL TILL STRUCTURE INCLUDING POOR SORTING, HIGH DENSITY & IMBRICATION OF ELONGATED FRAGMENTS.
H	ALLUVIUM	INTERGLACIAL, ICE FRONT REMOVED FROM SITE.		RANGE 0-41 FT.	BROWN GRAVEL, SAND & SILT, STRATIFIED, SORTED, VERY DENSE. CONFINED TO VALLEY AREAS IN THE AT-THE-TIME TOPOGRAPHY OF THE UPPER SURFACE OF UNIT "I".	ROUNDED PARTICLES, SORTED. ORGANICS FOUND IN UNIT "H".
I	OUTWASH (TILL ?)	GLACIAL MELTING & RETREAT, ICE FRONT NEARBY PARAGLACIAL ENVIRONMENT. MINOR GLACIAL RE-ADVANCE. GLACIAL MELTING & RETREAT CONTINUES. RETREAT OF GLACIATION "J"		RANGE 0-77 FT.	BROWN TO RED-BROWN SAND & SILT WITH GRAVEL & COBBLES. OXIDATION ON SURFACES OF PARTICLES. VERY ROCKY, OVERCONSOLIDATED. MAY BE AN OUTWASH RE-WORKED BY A MINOR READVANCE. OF ICE.	ORGANICS FOUND IN UPPER HORIZON OF UNIT "I", INCLUDING WOOD. OXIDATION (LIMONITE & HEMATITE) INDICATES WEATHERING & OLDER AGE. OCCASIONALLY DISPLAYS SOME CHARACTERISTICS OF A TILL INCLUDING REMNANT STRIATIONS ON PEBBLES & ANGULAR FRAGMENTS. LACUSTRINE SAND, SILT OR CLAY OFTEN FOUND IN MIDDLE OF UNIT.
J'	LACUSTRINE &/OR STRATIFIED DEPOSITS	BASAL MELTING & PONDING; FLOWING WATER.		RANGE 0-48 FT.	BROWN SAND, SILT, GRAVEL & CLAY, LAMINATED & / OR STRATIFIED. SAND OCCASIONALLY OXIDIZED.	LIMITED EXTENT, OFTEN APPEARS SORTED, FRAGMENTS ROUNDED.
J	TILL	MAJOR GLACIAL ADVANCE.		RANGE 0-62 FT.	BROWN SILT WITH MANY COBBLES & MUCH GRAVEL. VERY DENSE, OXIDIZED. PARTICLES ANGULAR & SUBANGULAR.	STRIATED PEBBLES, SUBANGULAR PARTICLES, HIGH DEGREE OF OVERCONSOLIDATION.
K	ALLUVIUM	OLDEST UNCONSOLIDATED DEPOSITS FOUND IN WATANA RELICT CHANNEL AREA.		RANGE 0-161 FT.	BOULDERS, COBBLES, SAND & GRAVEL, ROUNDED.	FOUND ONLY LOCALLY ALONG CHANNEL COURSES (THALWEGS) CUT INTO BEDROCK.
BR	BEDROCK				PRIMARILY DIORITE & GRANODIORITE WITH OCCASIONAL INCLUSIONS OF ARGILLITE. ANDESITE FOUND IN WESTERN PORTION OF AREA.	DRILLED) 10' INTO BEDROCK TO VERIFY.

NOTE: STRATIGRAPHIC COLUMN DIAGRAMMATIC & NOT TO SCALE.

GENERALIZED STRATIGRAPHIC COLUMN
WATANA RELICT CHANNEL AND BORROW
SITE D AREA

FIGURE E.6.11



LEGEND:

LITHOLOGY:

BEDROCK OUTCROP OR SHALLOW BEDROCK, UNDIFFERENTIATED.

CONTACT:

BEDROCK/SURFICIAL DEPOSITS, APPROXIMATE.

CONTOUR LINES:

TOP OF BEDROCK, CONTOUR INTERVAL 100 FEET.
TOPOGRAPHY, CONTOUR INTERVAL 500 FEET.
TOPOGRAPHY, EL. 2250 CONTOUR DASHED.

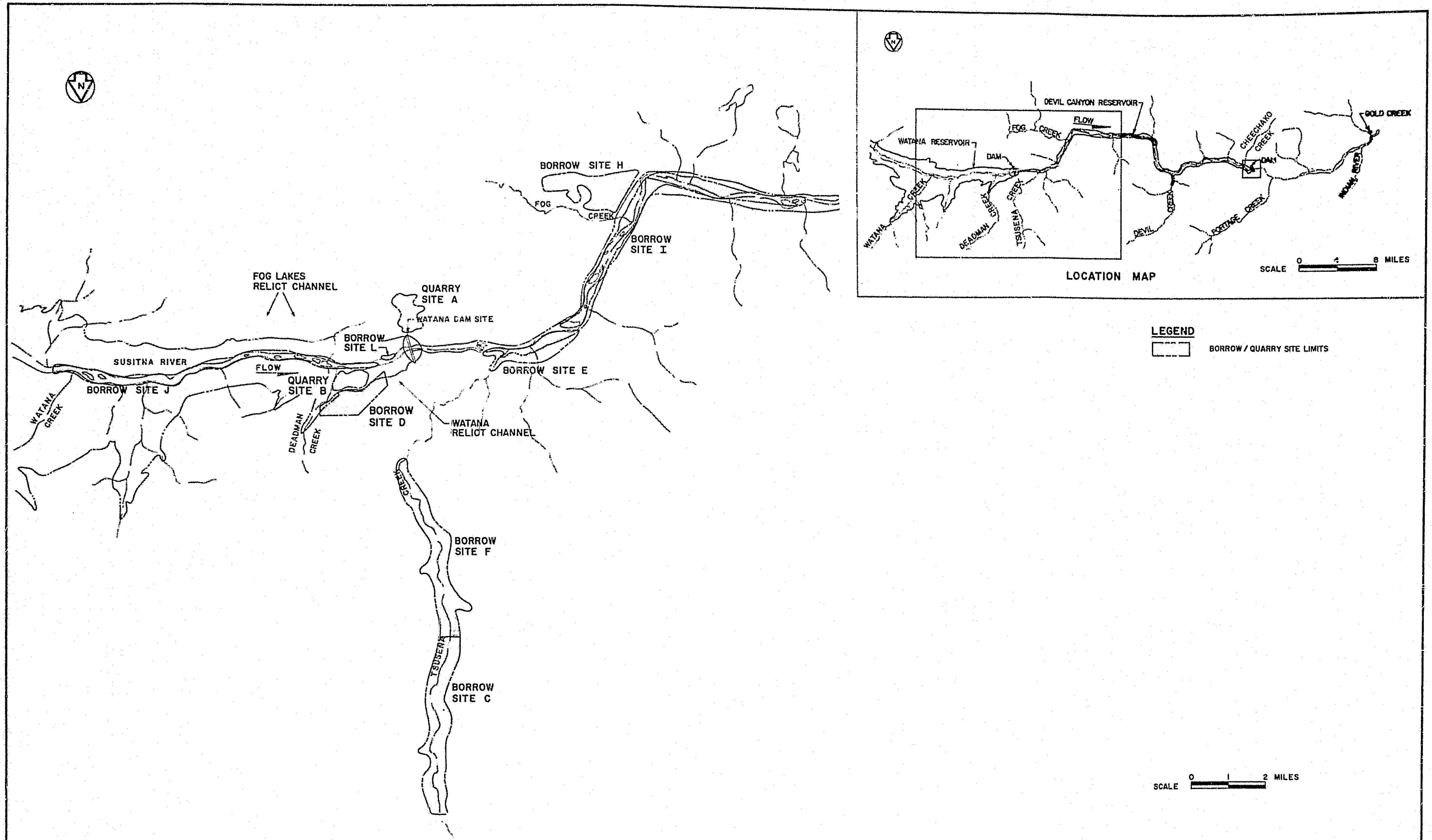
NOTES:

1. BASE MAP MODIFIED FROM U.S.G.S. TALKEETNA MOUTAINS D-3 AND D-4 QUADRANGLE MAPS, SCALE 1IN.=1MI.
2. SEISMIC LINE SECTIONS SHOWN IN APPENDIX D, ACRES, 1982b AND ACRES, 1982a.

SCALE 0 2000 4000 FEET

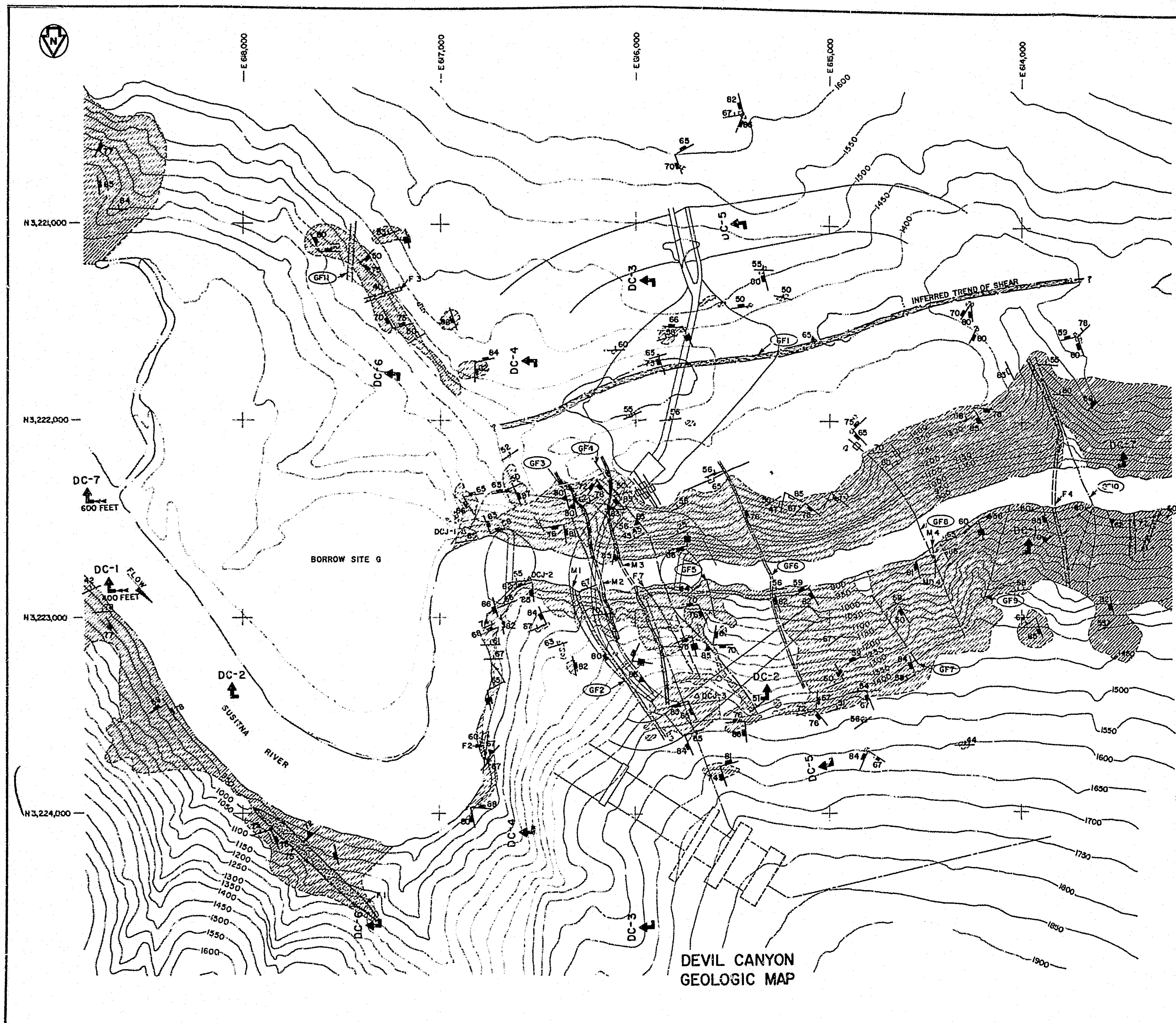
WATANA
FOG LAKES RELICT CHANNEL
TOP OF BEDROCK

FIGURE E.6.12



WATANA
BORROW SITE MAP

FIGURE E.6.13



LEGEND

LITHOLOGY:

- OVERBURDEN, UNDIFFERENTIATED
- ARGILLITE AND GRAYWACKE
- FELSIC DIKE, WIDTH SHOWN WHERE GREATER THAN 10 FEET
- MAFIC DIKE, WIDTH SHOWN WHERE GREATER THAN 10 FEET

CONTACTS:

- BEDROCK/SURFICIAL DEPOSITS

STRUCTURE:

- SHEAR, WIDTH AS SHOWN, INCLINED, EXTENT WHERE KNOWN AND/OR INFERRED.
- SHEAR, WIDTH LESS THAN 10 FEET, INCLINED, VERTICAL, EXTENT WHERE KNOWN AND/OR INFERRED.
- FRACTURE ZONE, WIDTH AS SHOWN, VERTICAL UNLESS DIP SHOWN, EXTENT WHERE KNOWN AND/OR INFERRED.
- JOINTS, INCLINED, OPEN INCLINED, VERTICAL (SETS I AND II ONLY)
- BEDDING/FOLIATION, INCLINED, VERTICAL

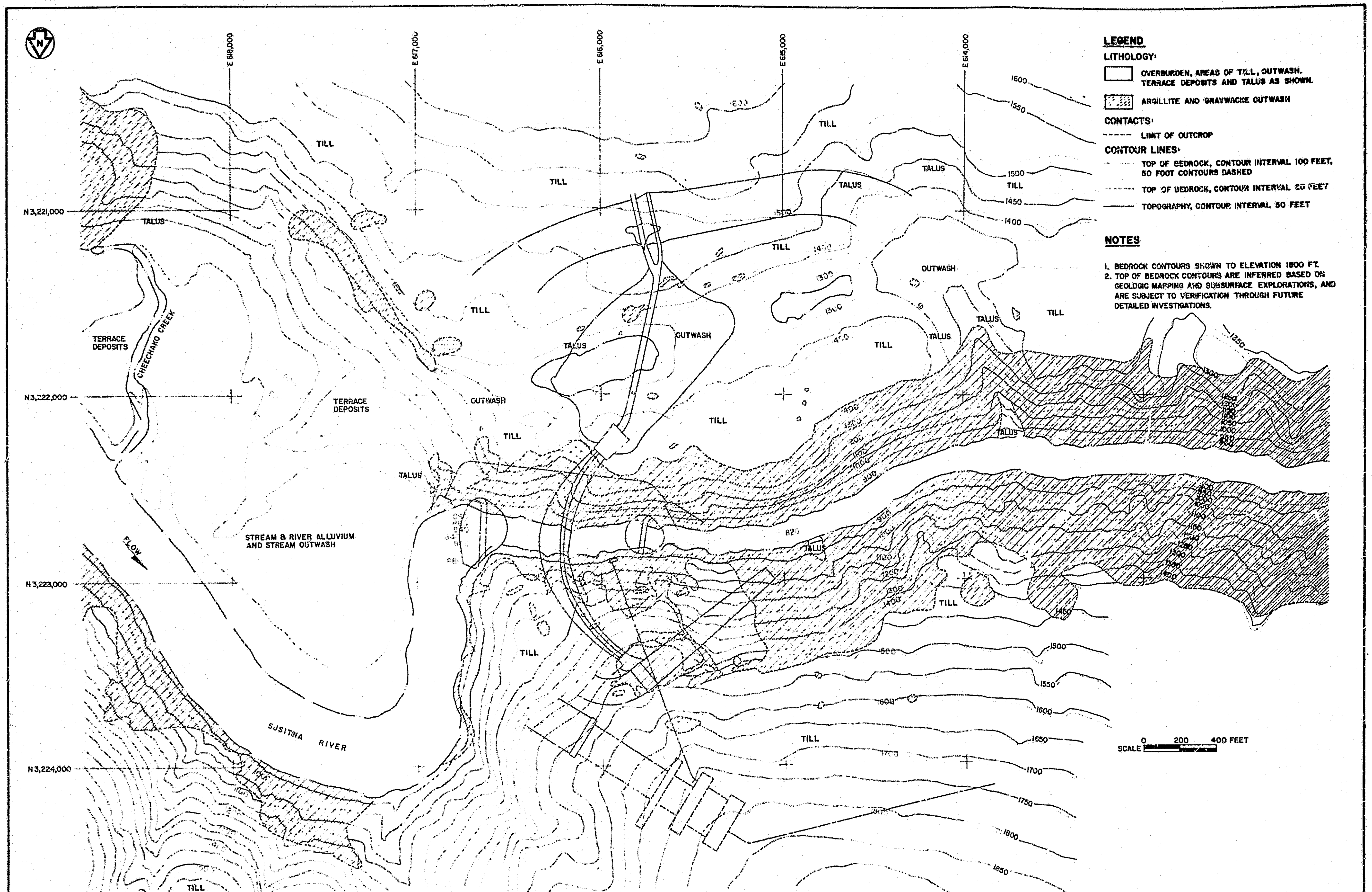
OTHER:

- DC-1 GEOLOGIC SECTION LOCATION, SEE ACRES, 1982a
- ΔDCJ-1 JOINT STATION
- GF1 GEOLOGIC FEATURE DESCRIBED IN ACRES, 1982a
- M1 MAFIC DIKE DESCRIBED IN ACRES, 1982a
- F1 FELSIC DIKE DESCRIBED IN ACRES, 1982a

NOTES

1. GEOLOGIC SECTIONS SHOWN IN ACRES, 1982a.
2. JOINT PLOTS SHOWN ON FIGURE E.6.16.
3. ADDITIONAL GEOLOGIC DATA FROM USBR, 1960.
4. TOPOGRAPHY FROM R & M, 1981, 1" = 200'.
5. EXPLORATION LOGS AND SEISMIC LINE SECTIONS IN ACRES, 1982a.
6. EXTENT OF SHEARS, FRACTURE ZONES AND ALTERATION ZONES ARE INFERRED BASED ON GEOLOGIC MAPPING AND SUBSURFACE EXPLORATIONS, AND ARE SUBJECT TO VERIFICATION THROUGH FUTURE DETAILED INVESTIGATIONS.

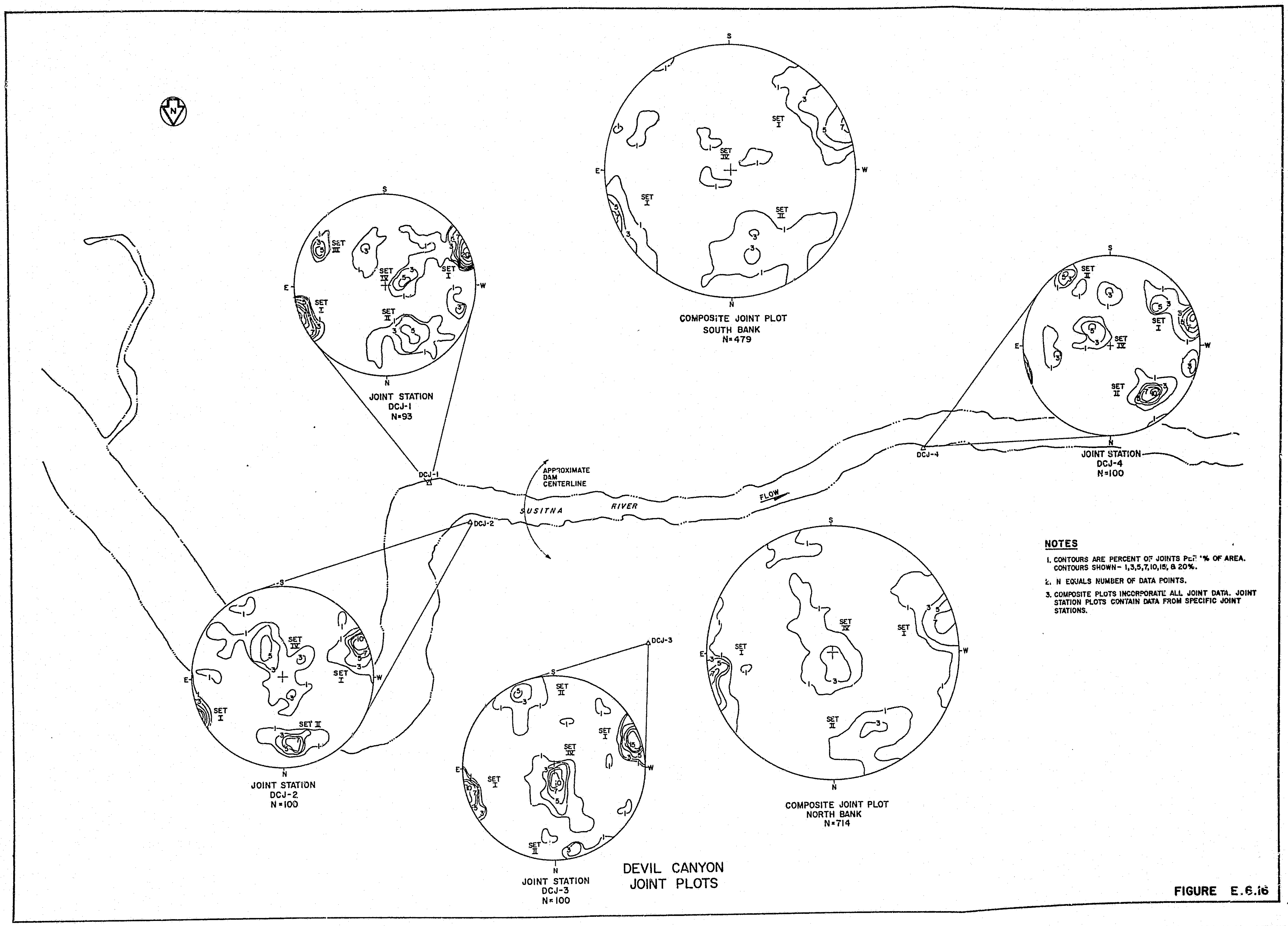
FIGURE E.6.14



DEVIL CANYON
TOP OF BEDROCK
AND SURFICIAL GEOLOGIC MAP

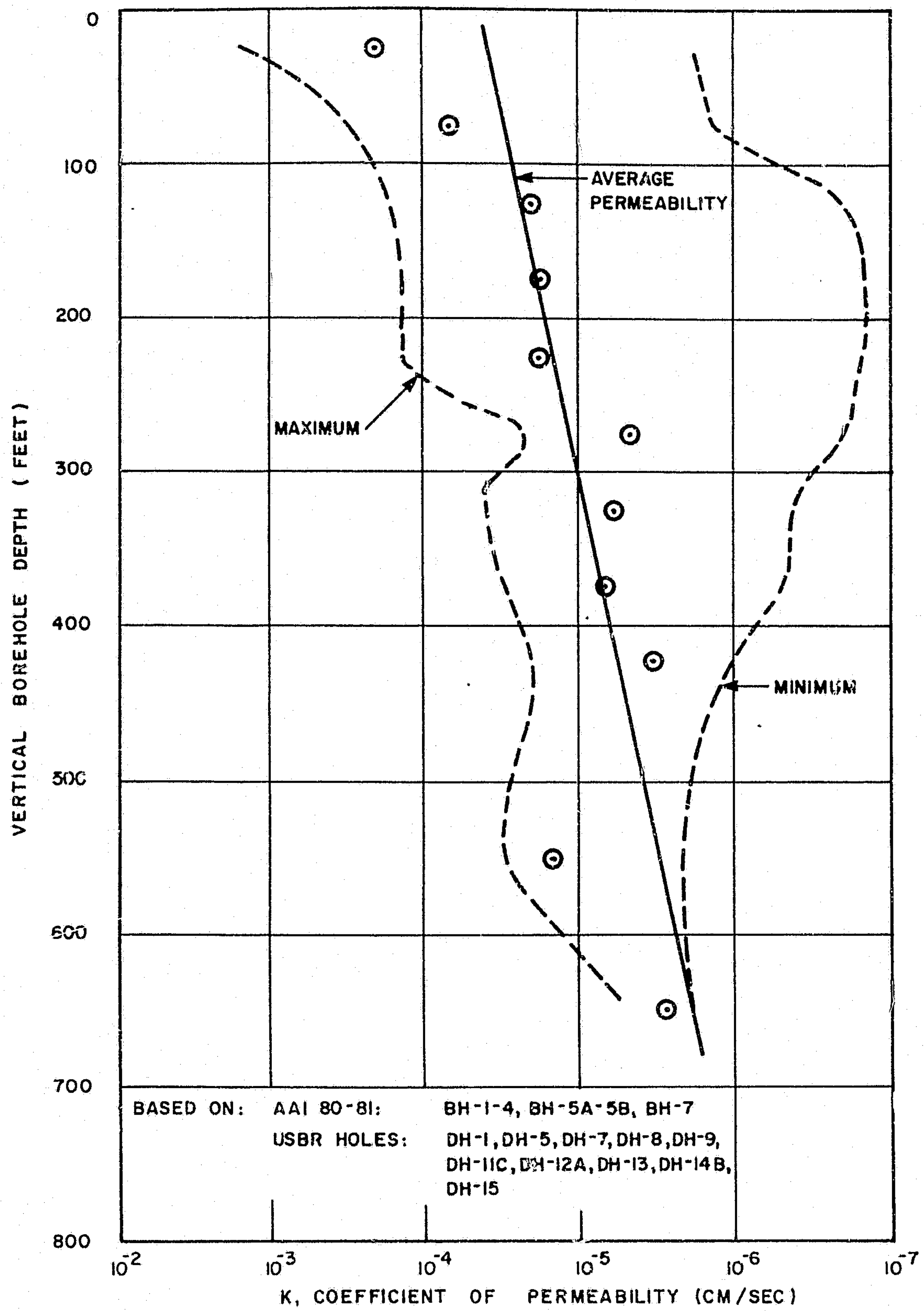
FIGURE E.6.15

REFERENCE: BASE MAP FROM R&M, 1981 - 1"=200'
DEVIL CANYON TOPOGRAPHY.
COORDINATES IN FEET, ALASKA STATE PLANE (ZONE 4)



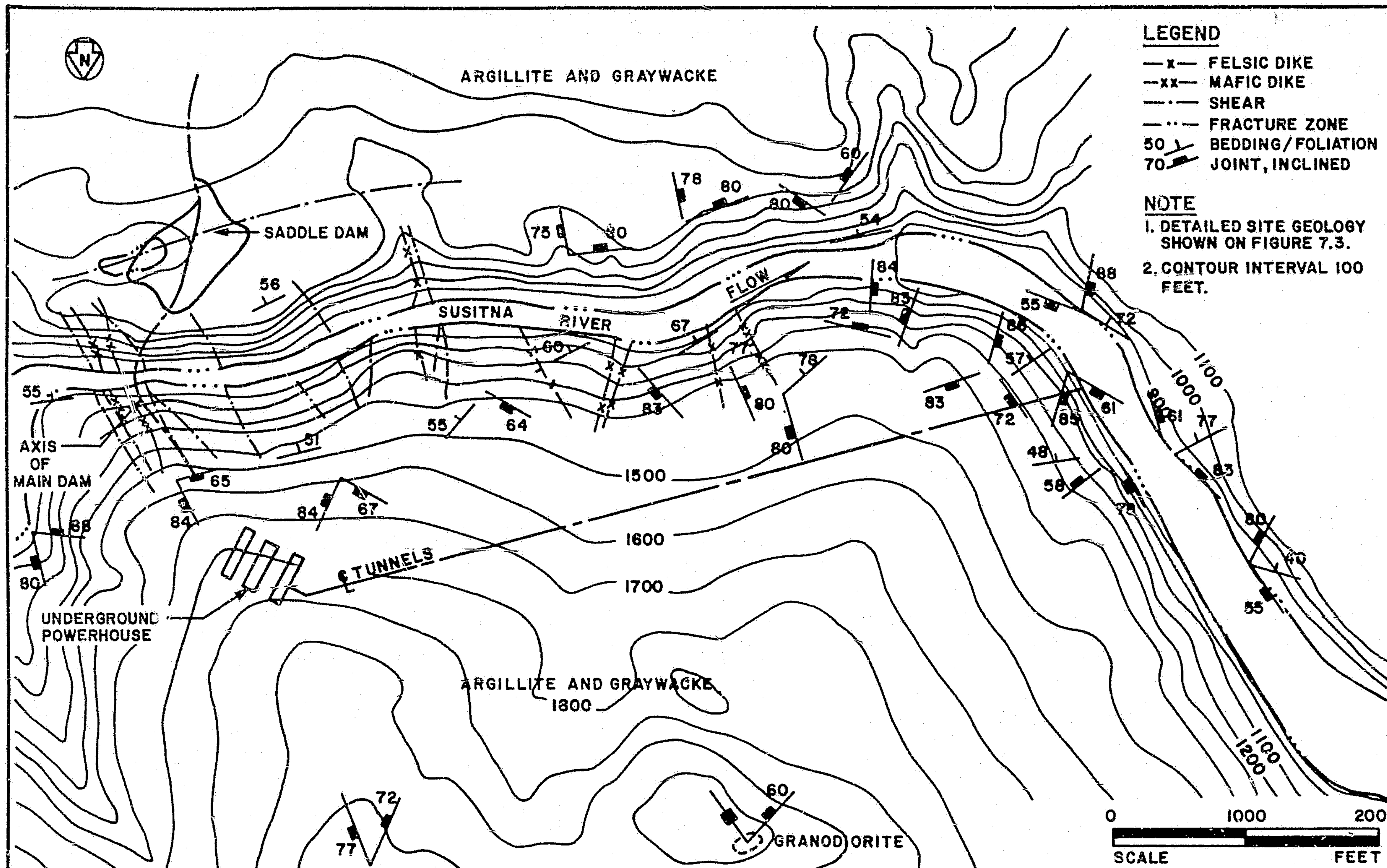
DEVIL CANYON
JOINT PLOTS

FIGURE E.6.16



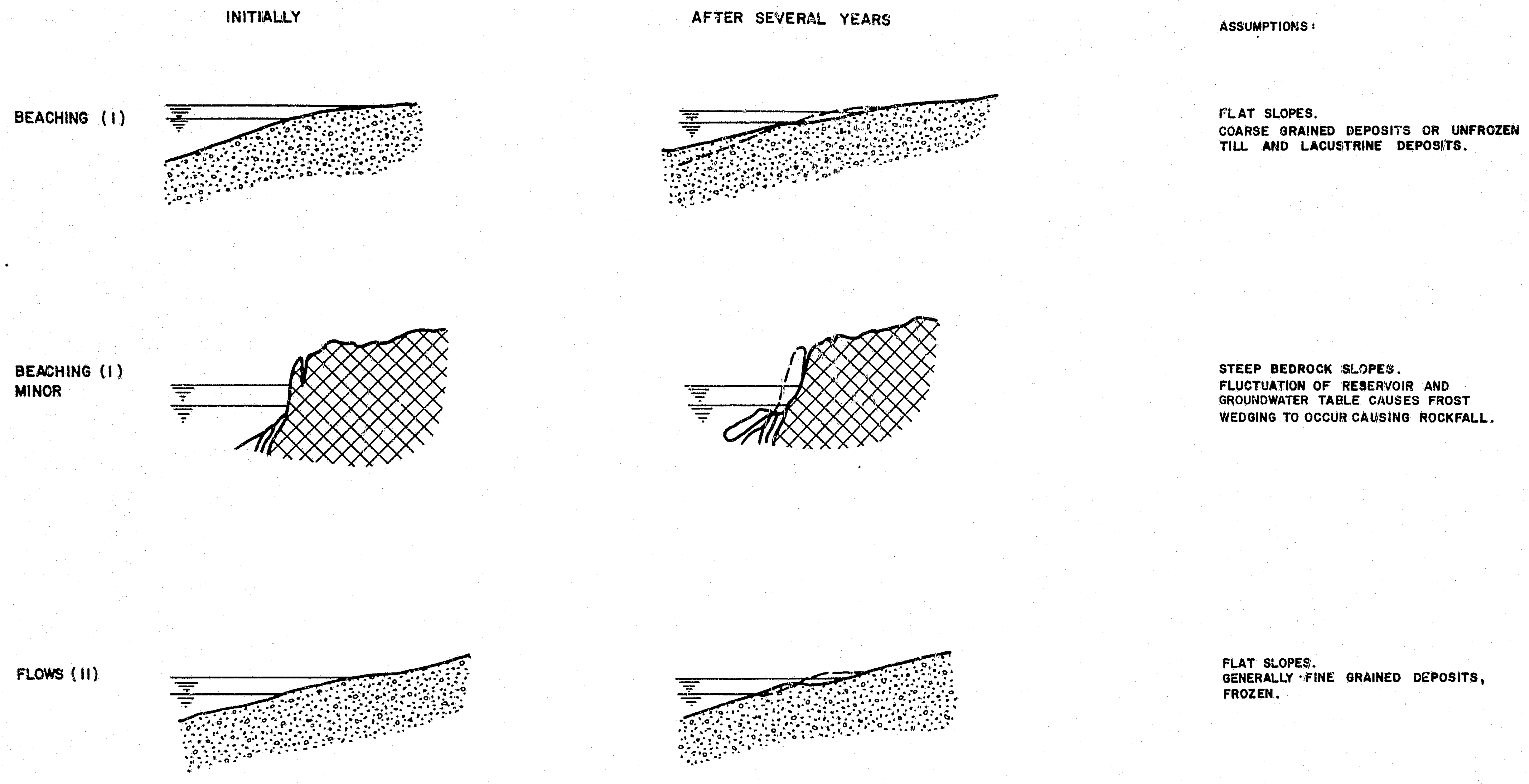
DEVIL CANYON ROCK PERMEABILITY

FIGURE E.6.17



DEVIL CANYON
TAILRACE GEOLOGIC MAP

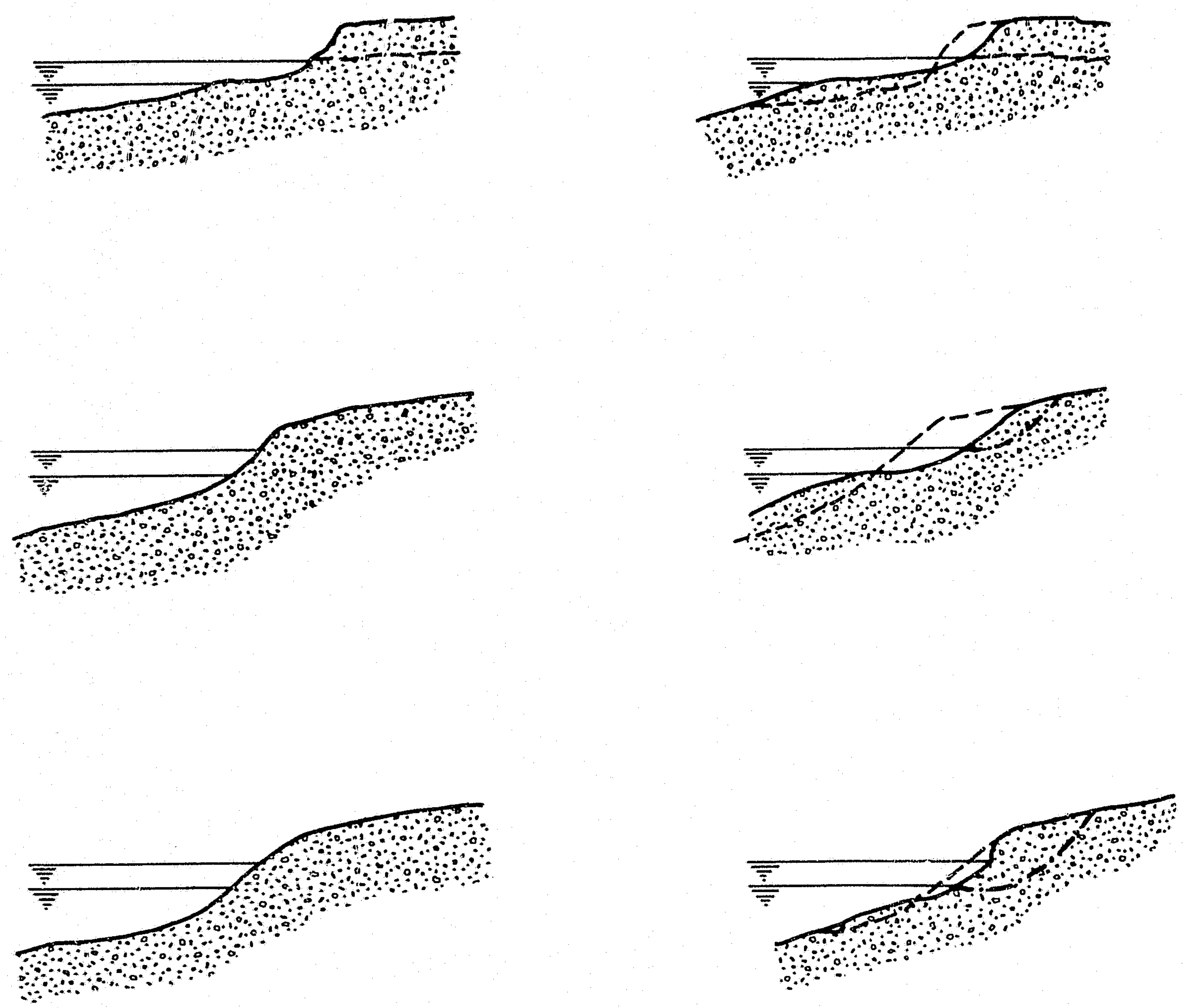
FIGURE E.6.18



SLOPE MODELS FOR THE WATANA AND DEVIL CANYON RESERVOIRS

FIGURE E.6.19

INITIALLY | AFTER SEVERAL YEARS | ASSUMPTIONS :



SLIDING (III)

STEEP SLOPES.
TWO LAYER CASE, LOWER LAYER IS FINE GRAINED AND FROZEN. UPPER LAYER IS COARSER GRAINED, PARTLY TO COMPLETELY FROZEN.
FLOWS IN LOWER LAYER ACCOMPANY SLOPE DEGRADATION .

SLIDING (IV)

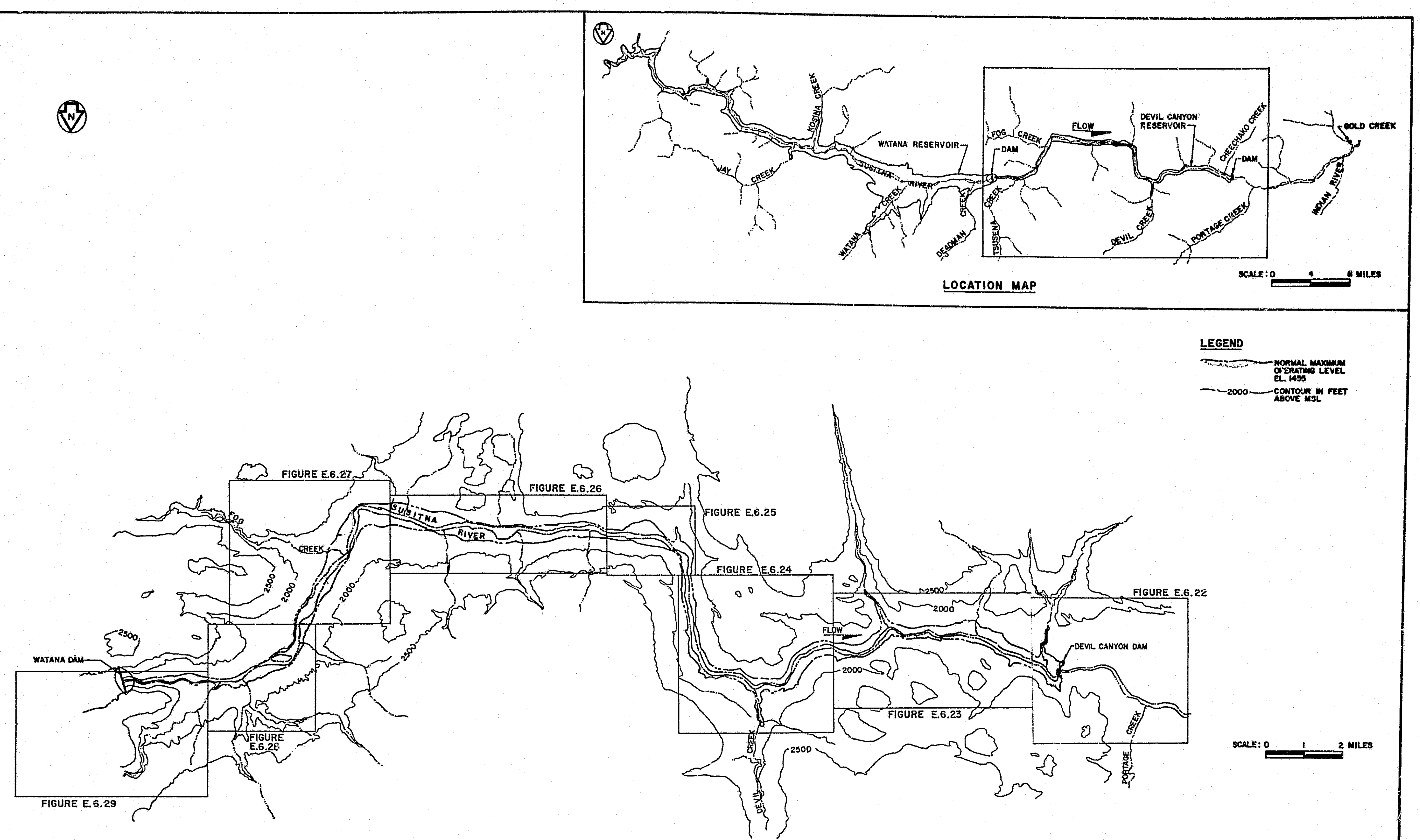
STEEP SLOPES.
FINE GRAINED AND UNFROZEN.

(IV)

STEEP SLOPES.
FINE GRAINED AND UNFROZEN
NOTE: POSSIBLE FURTHER SLIDING IF THAW BULB EXTENDS INTO SLOPE WITH TIME .

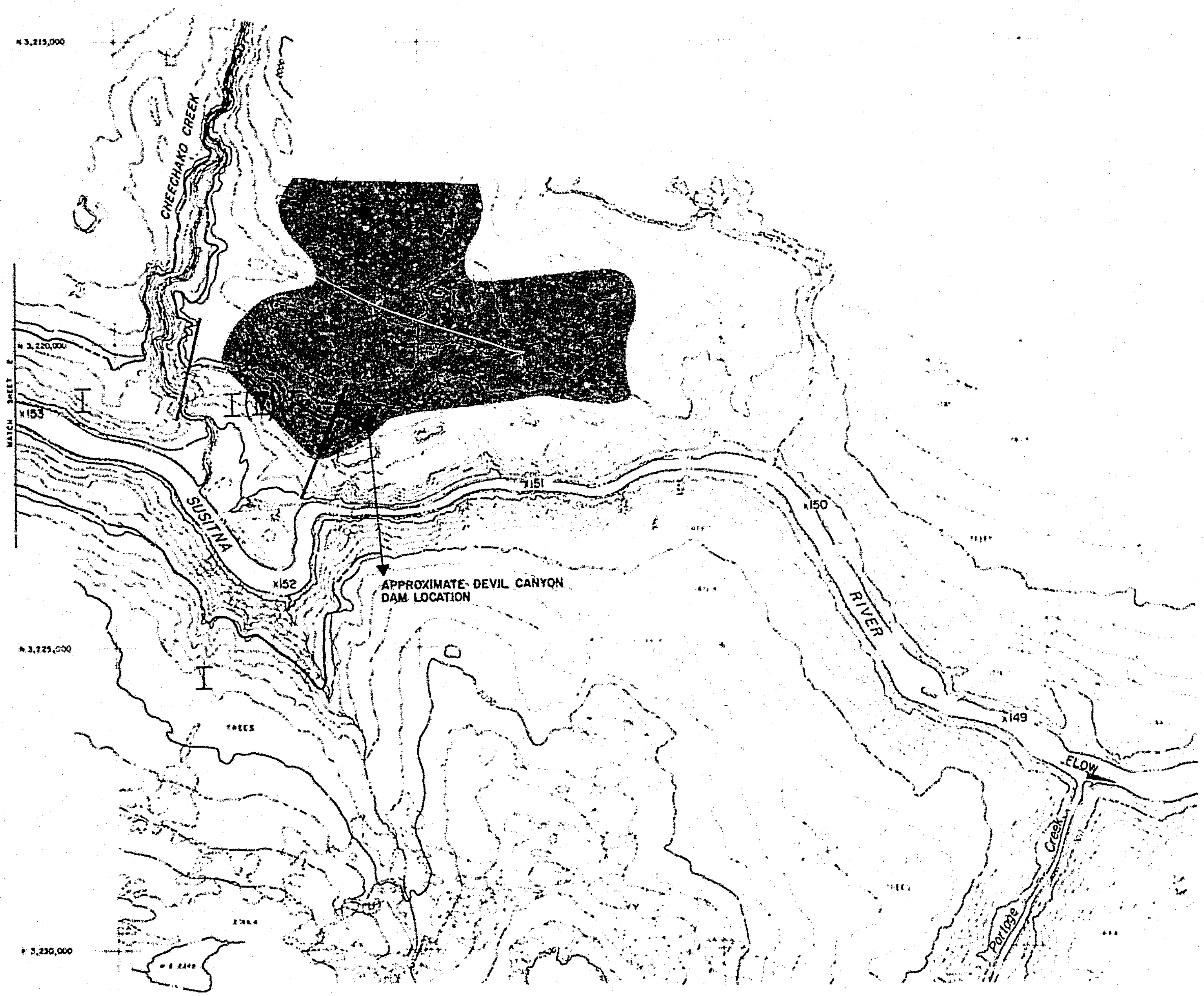
SLOPE MODELS FOR THE WATANA AND DEVIL CANYON RESERVOIRS

FIGURE E.6.20



DEVIL CANYON RESERVOIR
INDEX MAP

FIGURE E.6.21



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- —— NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

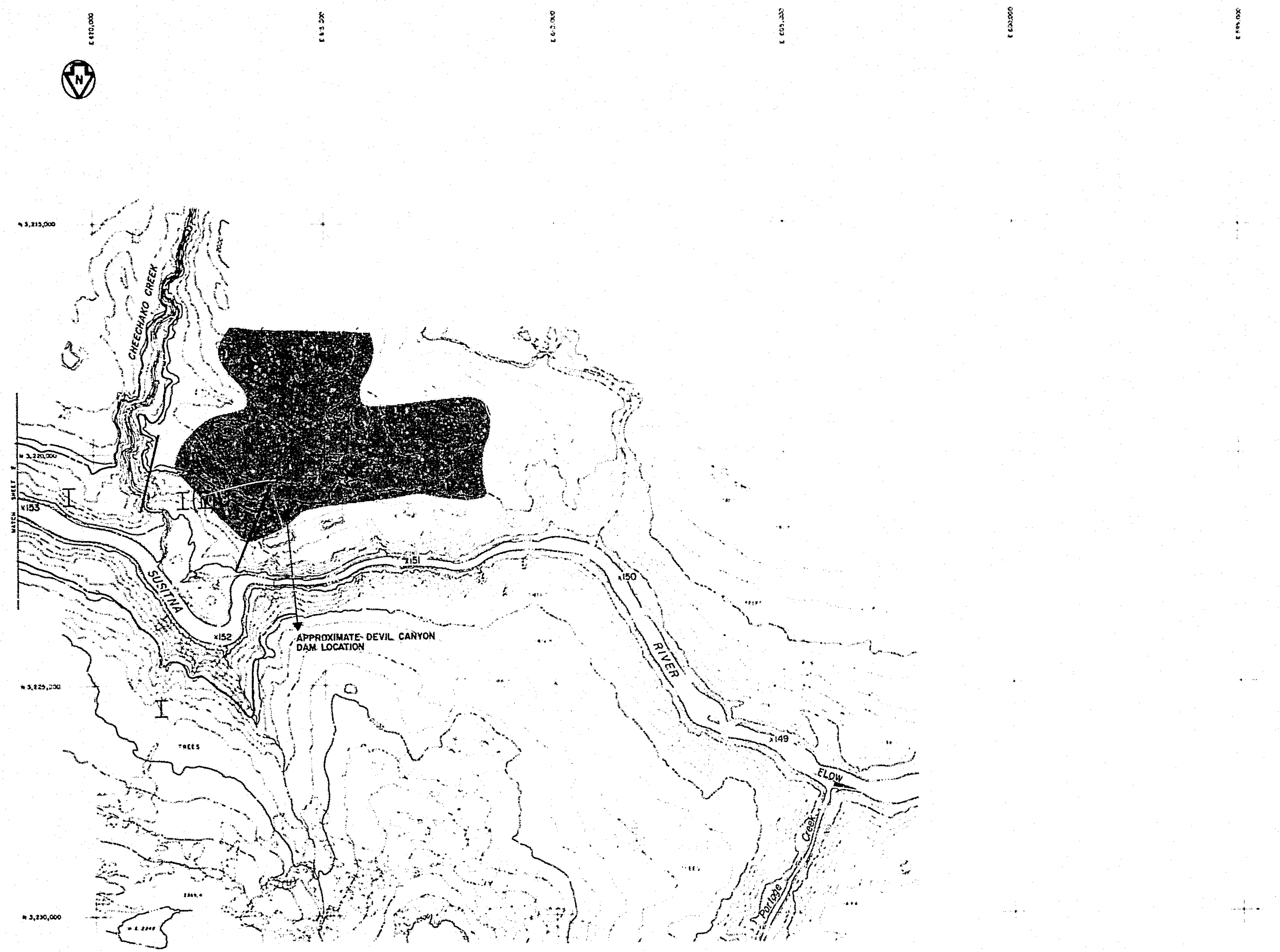
1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

SHEET INDEX

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.22



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
———	NORMAL MAXIMUM OPERATING LEVEL
	RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

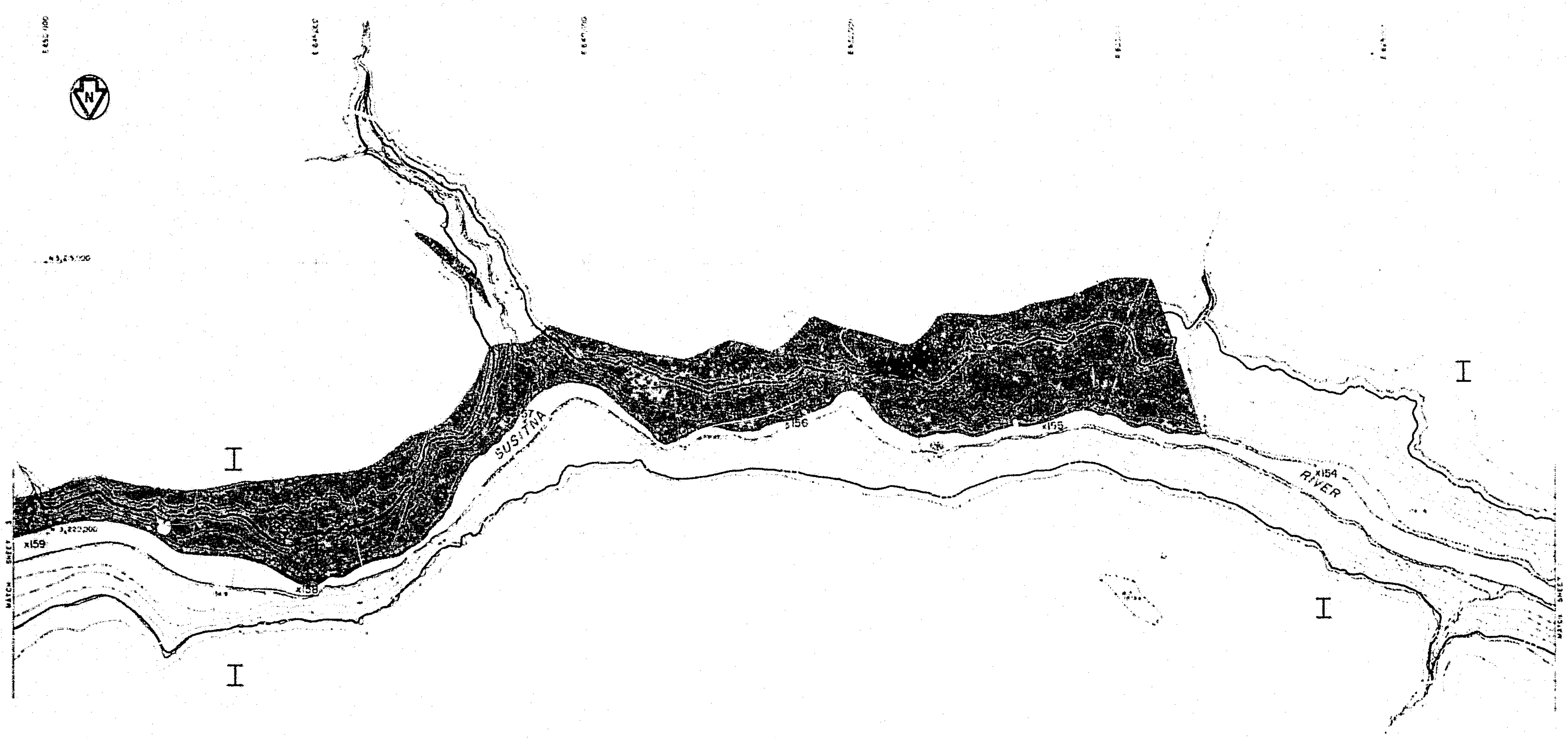
SCALE 0 1000 2000 FEET

Date of Photography 7-3-81
Scale 1"=1000 Contour interval 100'

SHEET INDEX

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.22



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——	NORMAL MAXIMUM OPERATING LEVEL
x	RIVER MILES

AREA OF POTENTIAL PERMAFROST

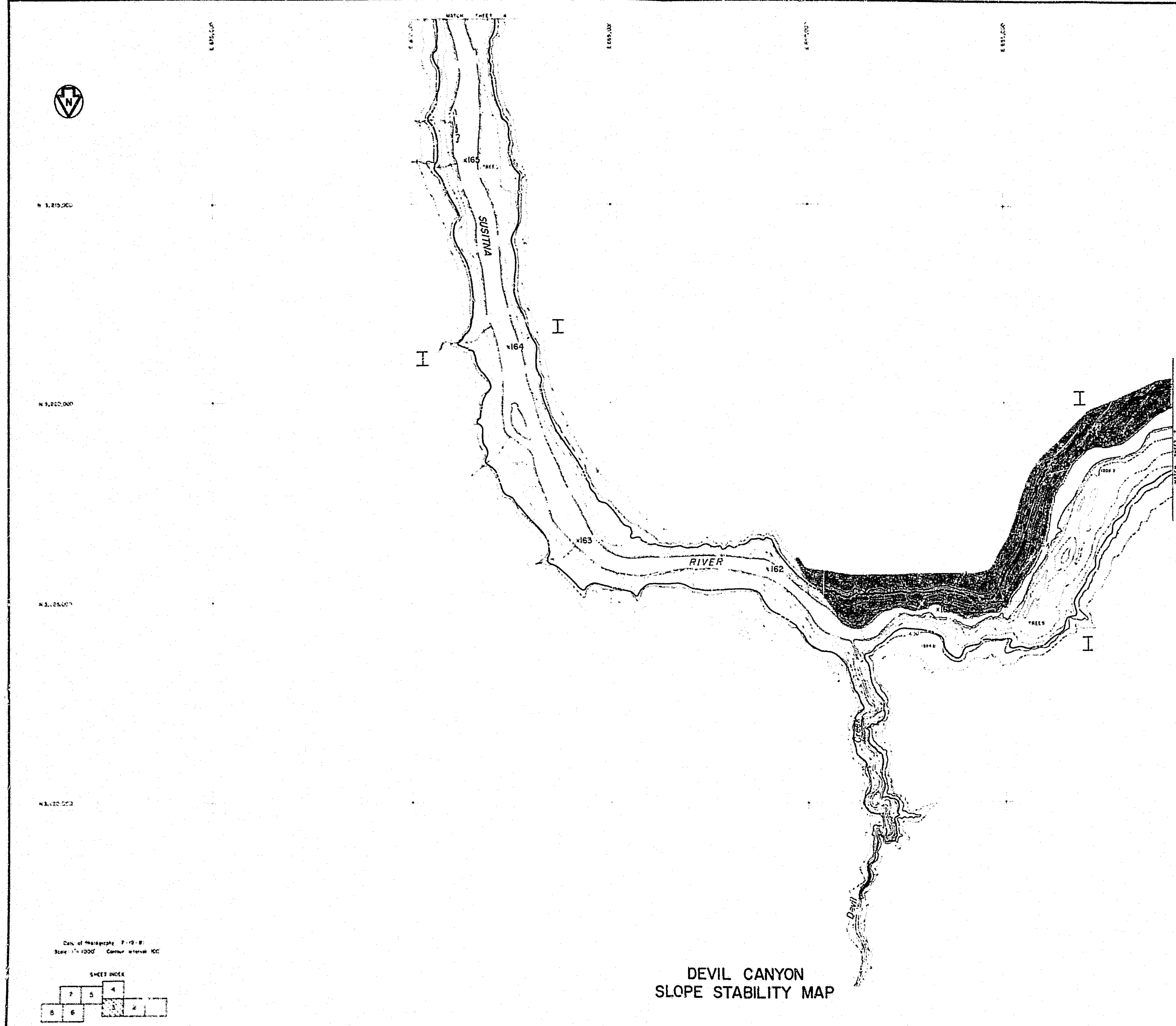
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.23



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- —— NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

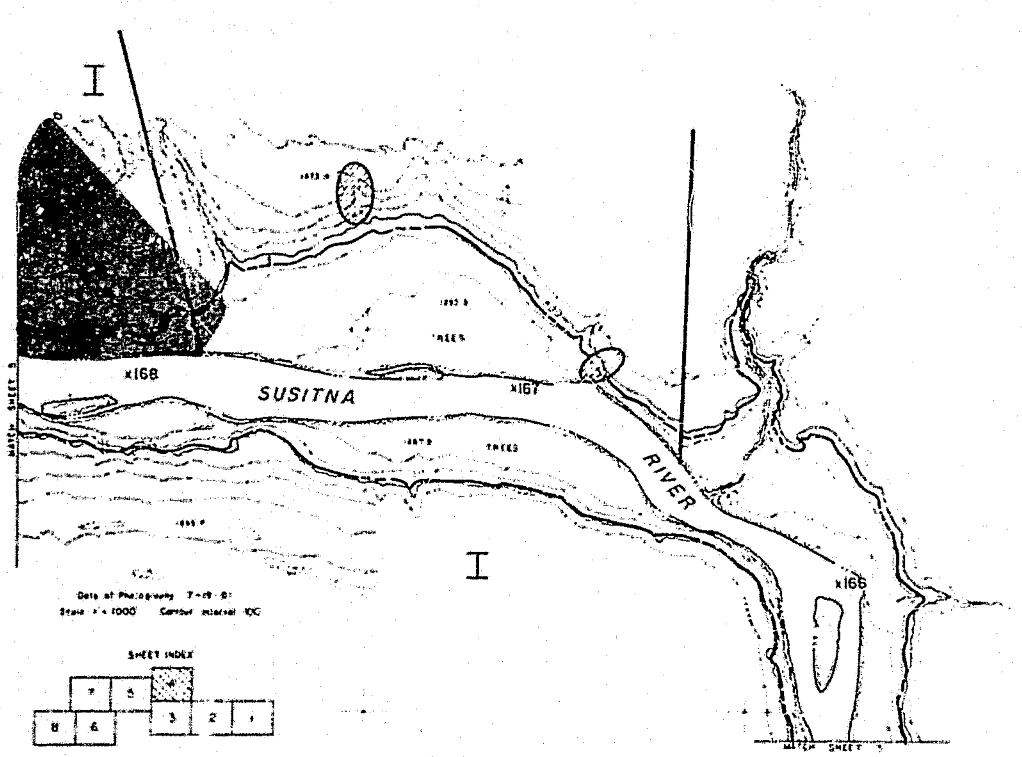
1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.24

001805



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

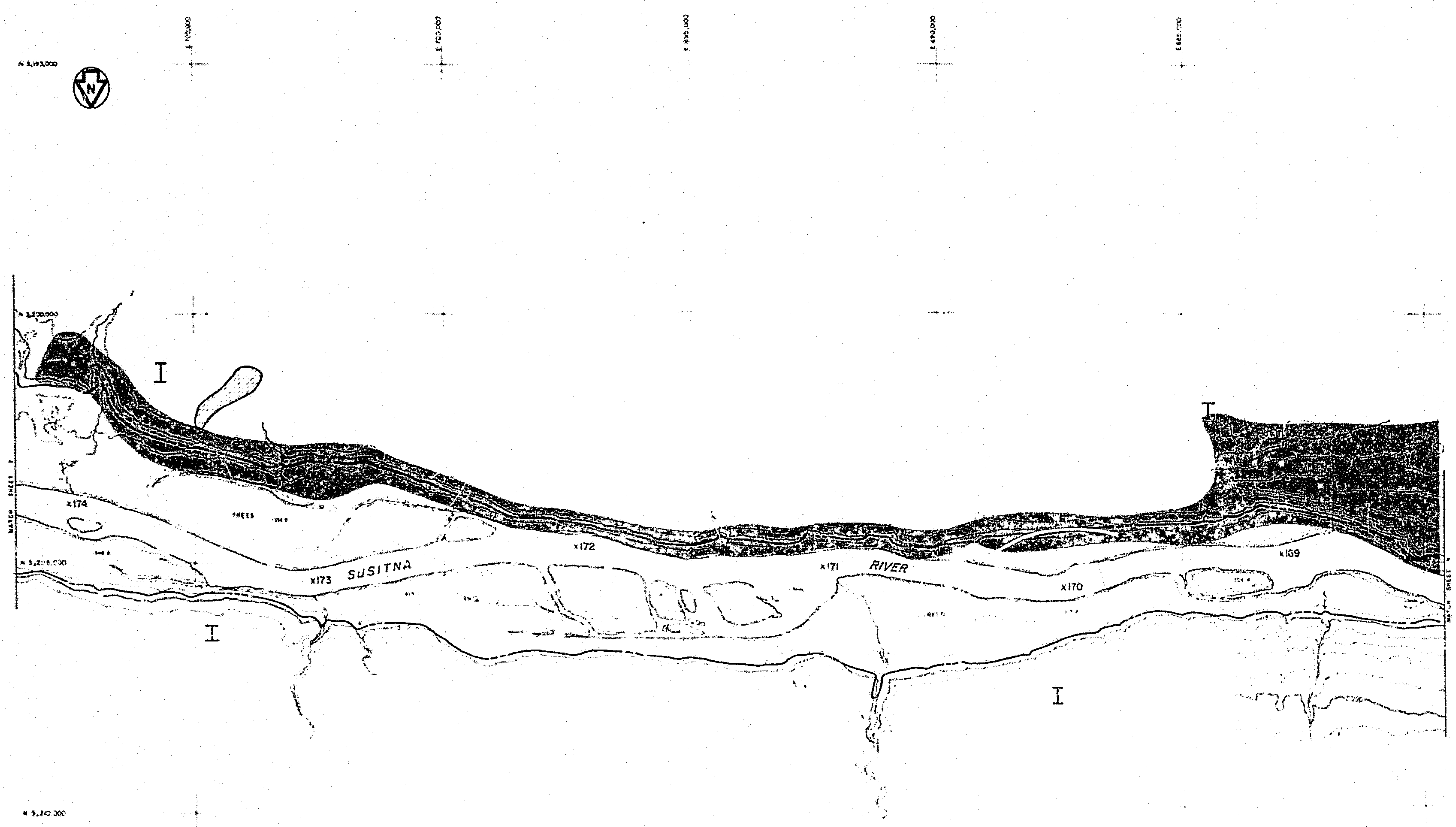
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.25



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

SHEET INDEX

7 4

8 6 3 2 1

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.26

001805

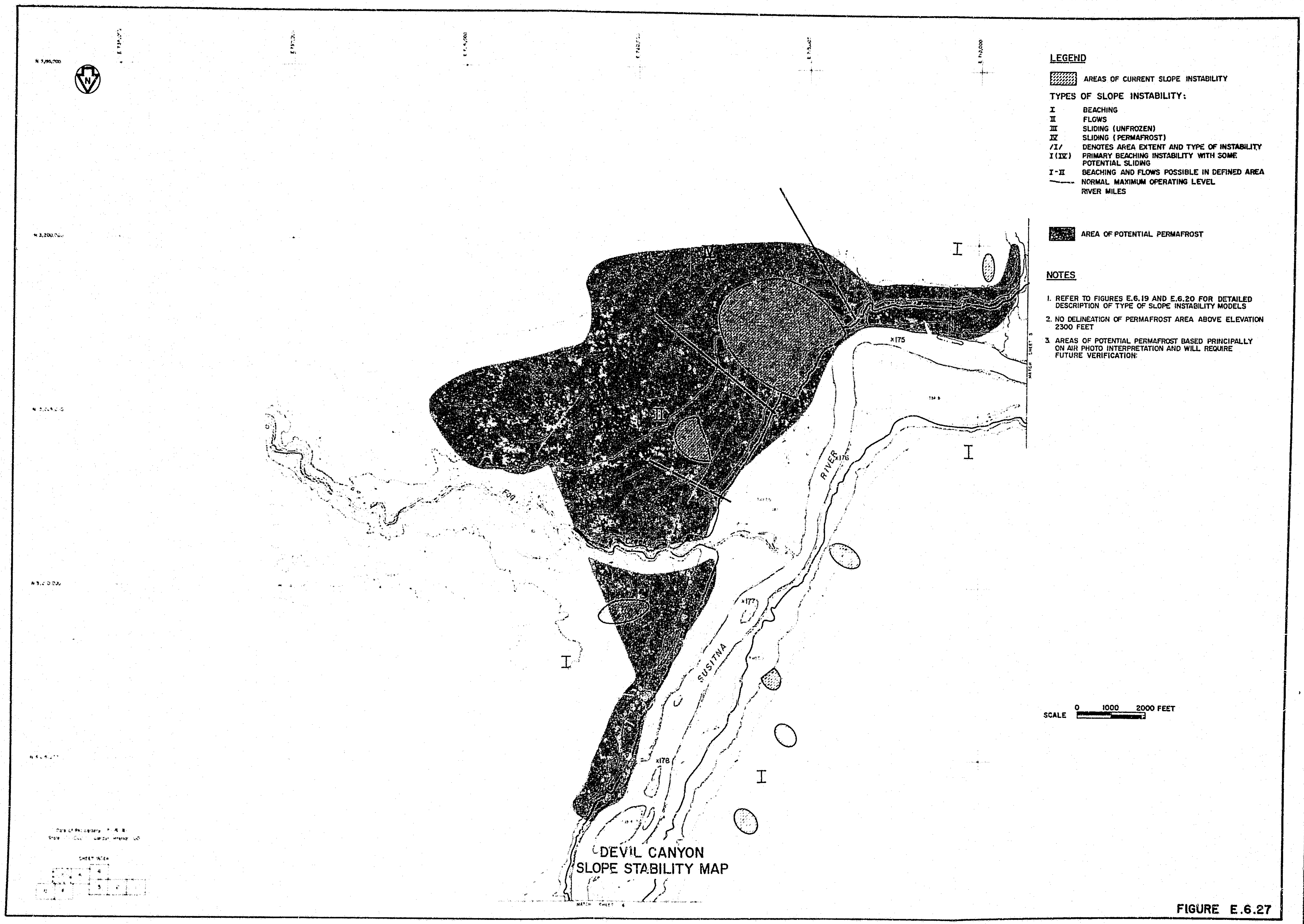
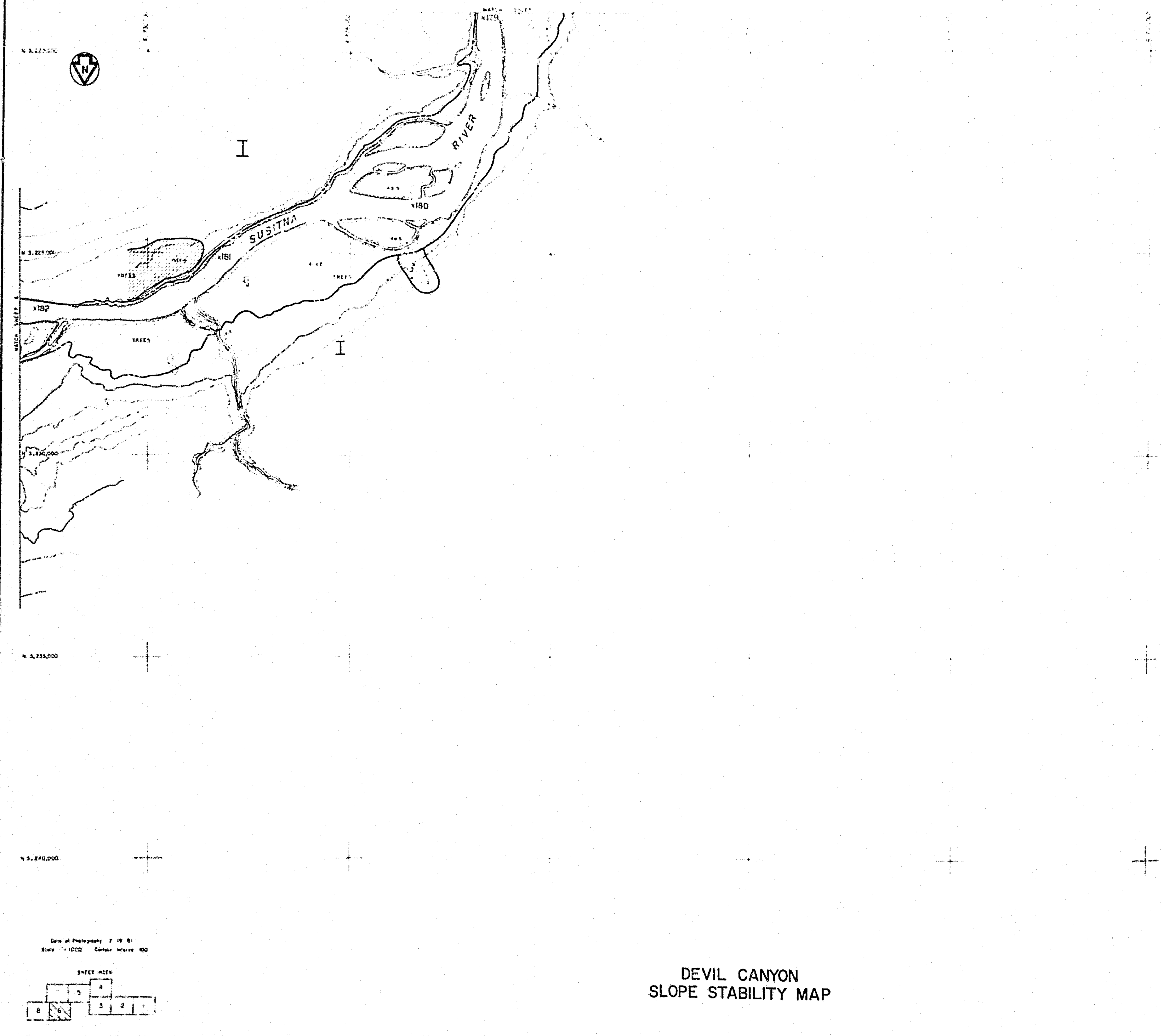


FIGURE E.6.27



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(III) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- RIVER MILES

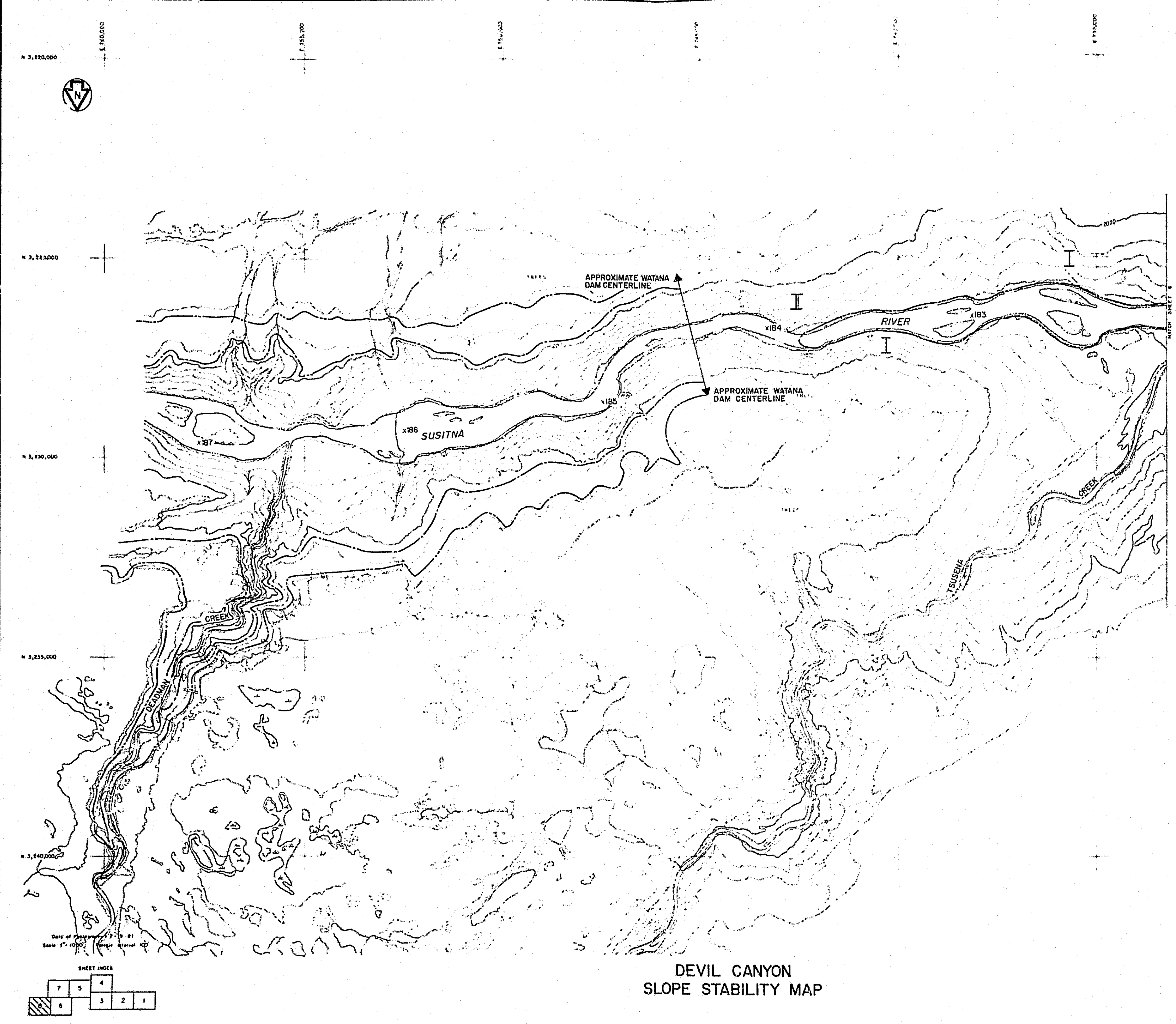
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.28



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- X RIVER MILES

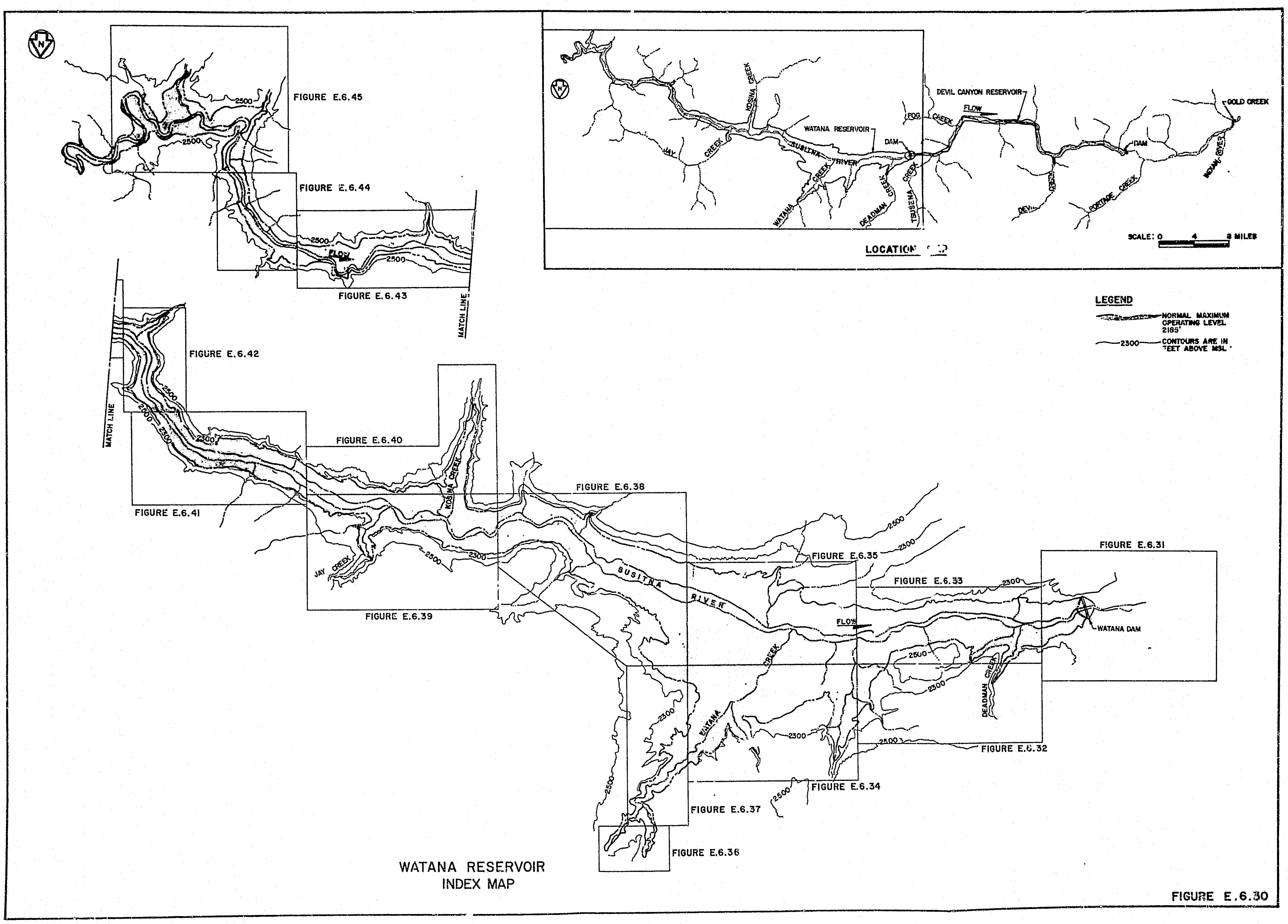
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

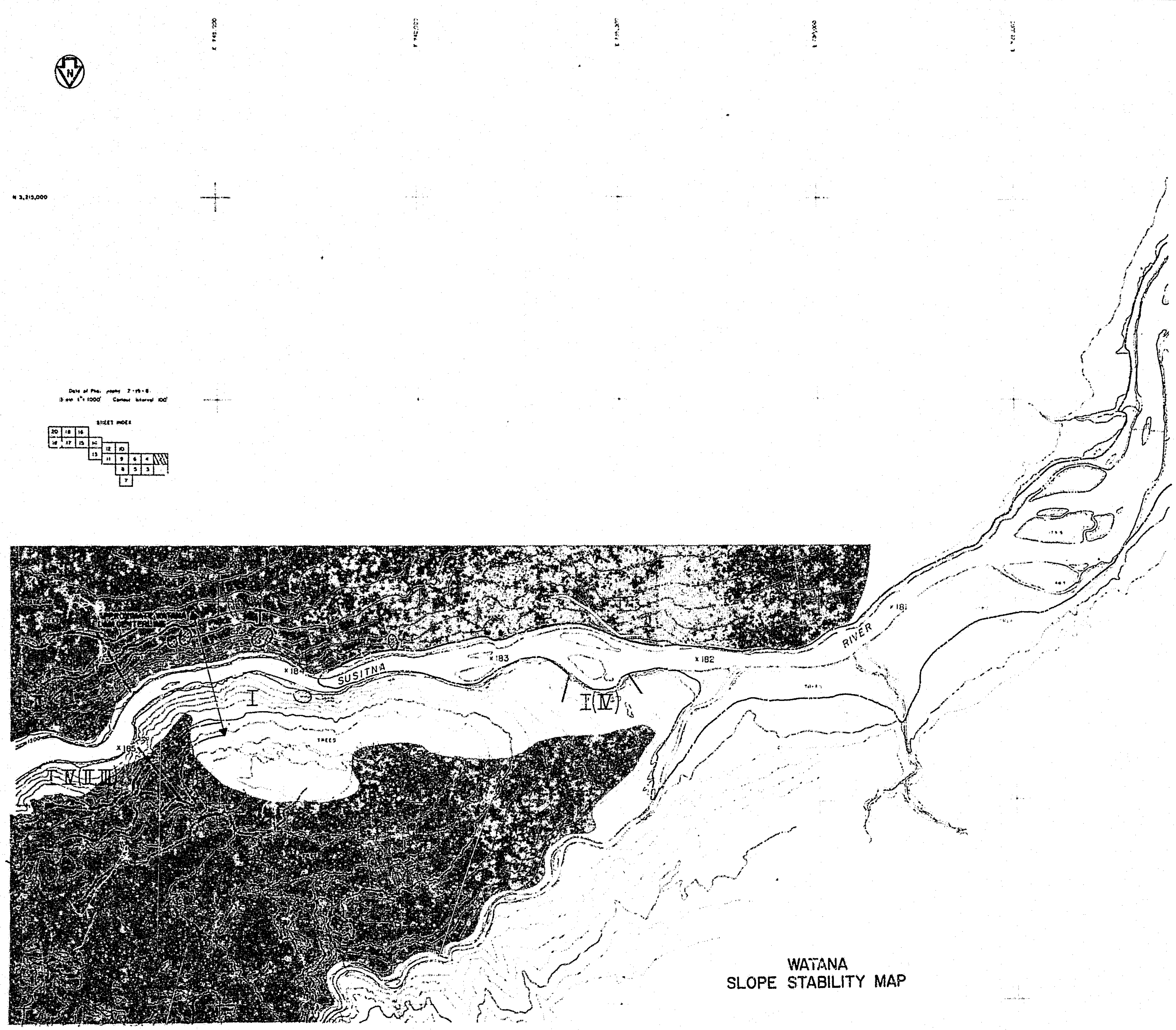
DEVIL CANYON
SLOPE STABILITY MAP

FIGURE E.6.29



WATANA RESERVOIR
INDEX MAP

FIGURE E.6.30



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

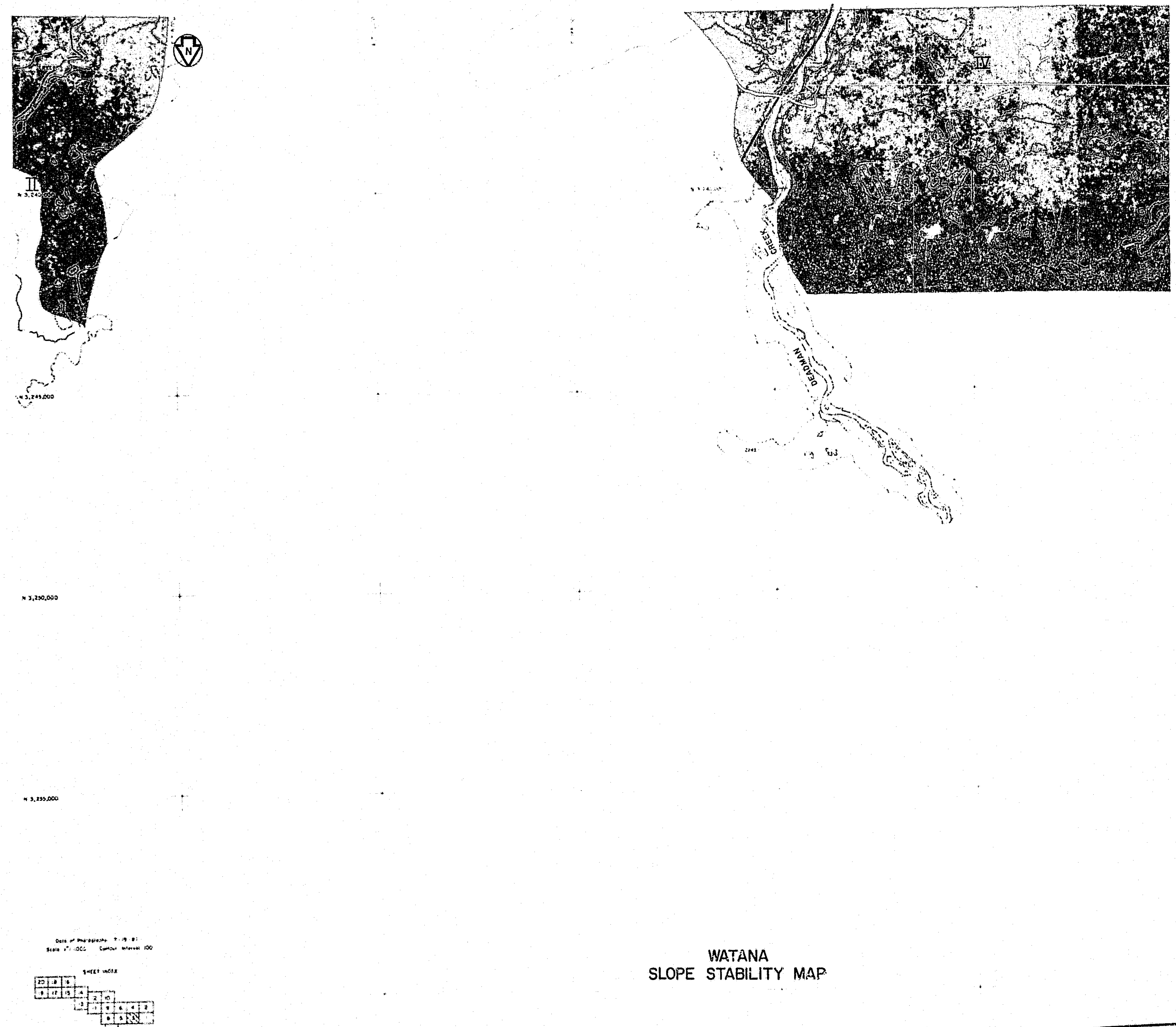
1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.31

00805



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL

AREA OF POTENTIAL PERMAFROST

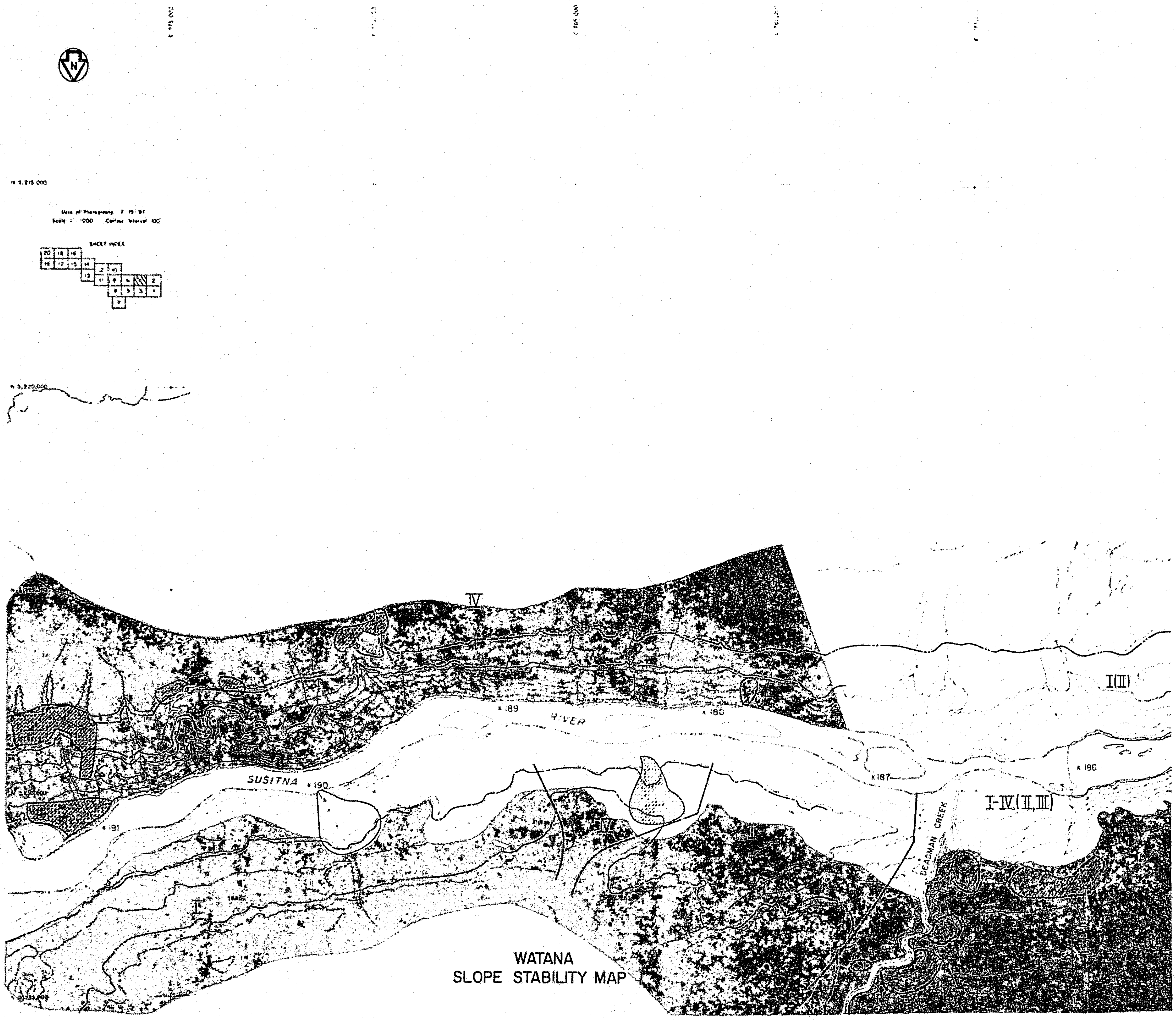
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.32



WATANA
SLOPE STABILITY MAP

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(III)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
———	NORMAL MAXIMUM OPERATING LEVEL
-·-·-	NORMAL MINIMUM OPERATING LEVEL
	RIVER MILES

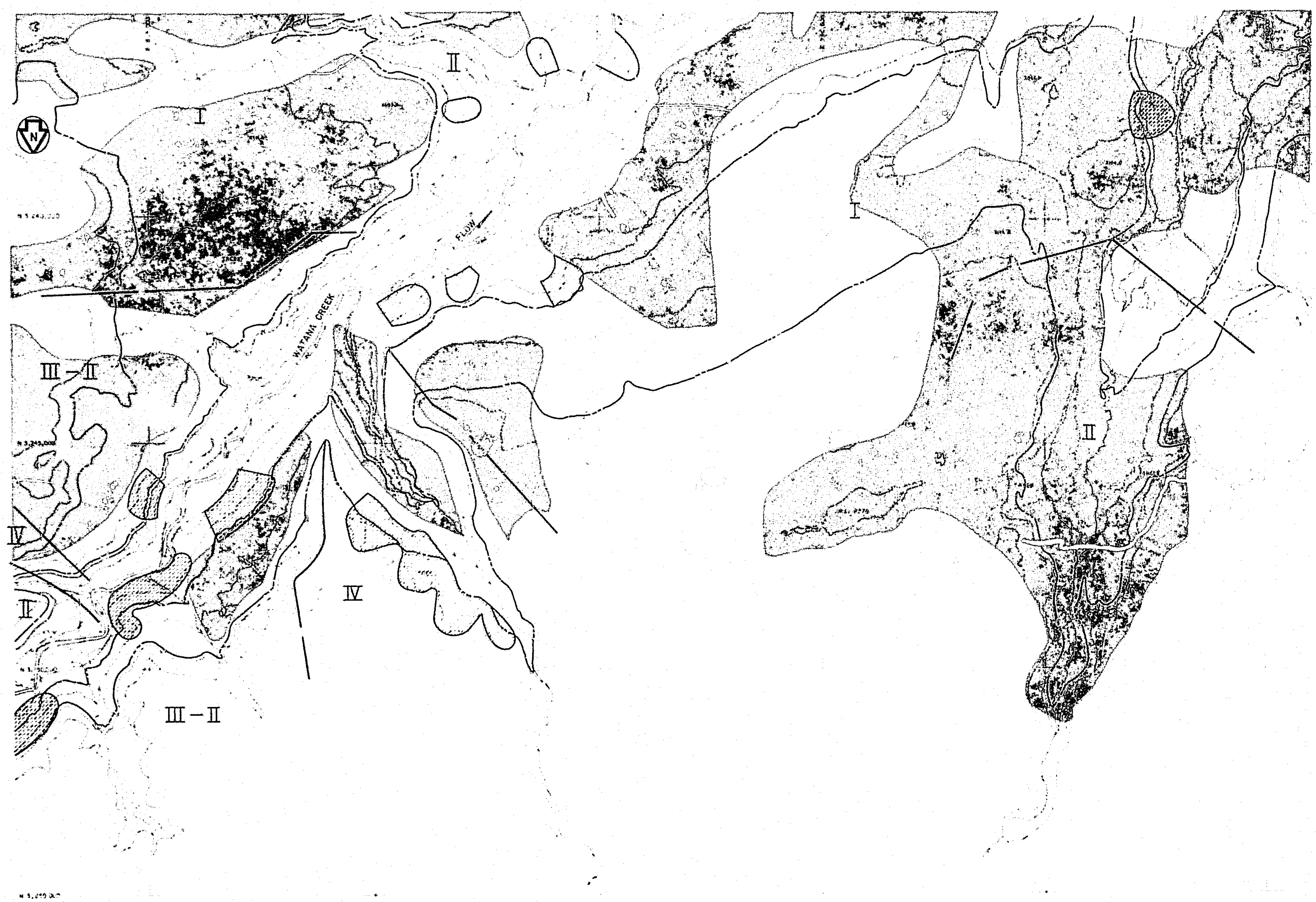
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.33



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I (IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I - II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

AREA OF POTENTIAL PERMAFROST

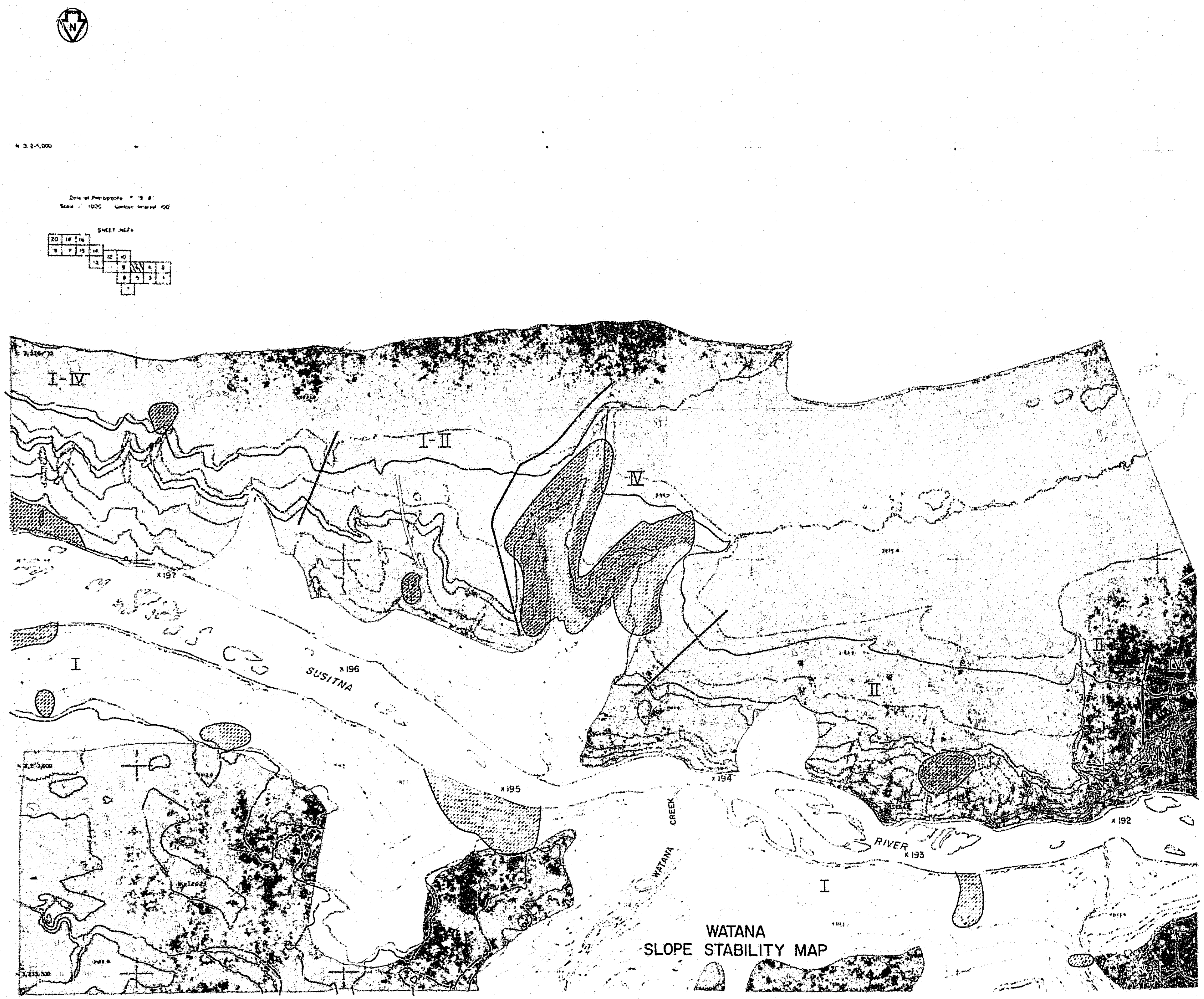
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.34



WATANA
SLOPE STABILITY MAP

LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I	BEACHING
II	FLOWS
III	SLIDING (UNFROZEN)
IV	SLIDING (PERMAFROST)
/I/	DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV)	PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II	BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
——----	NORMAL MAXIMUM OPERATING LEVEL
--——-—	NORMAL MINIMUM OPERATING LEVEL
X	RIVER MILES

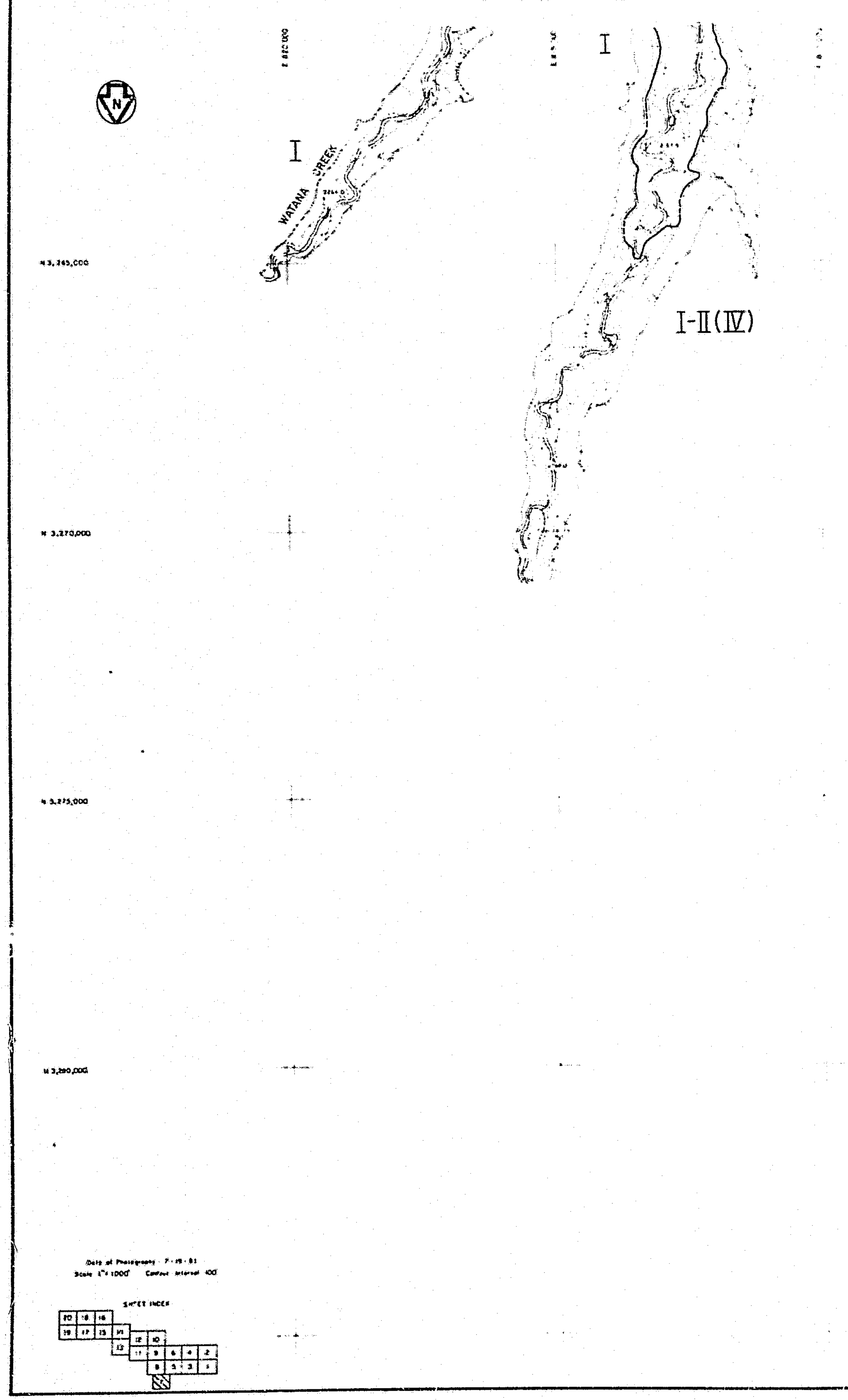
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.35



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

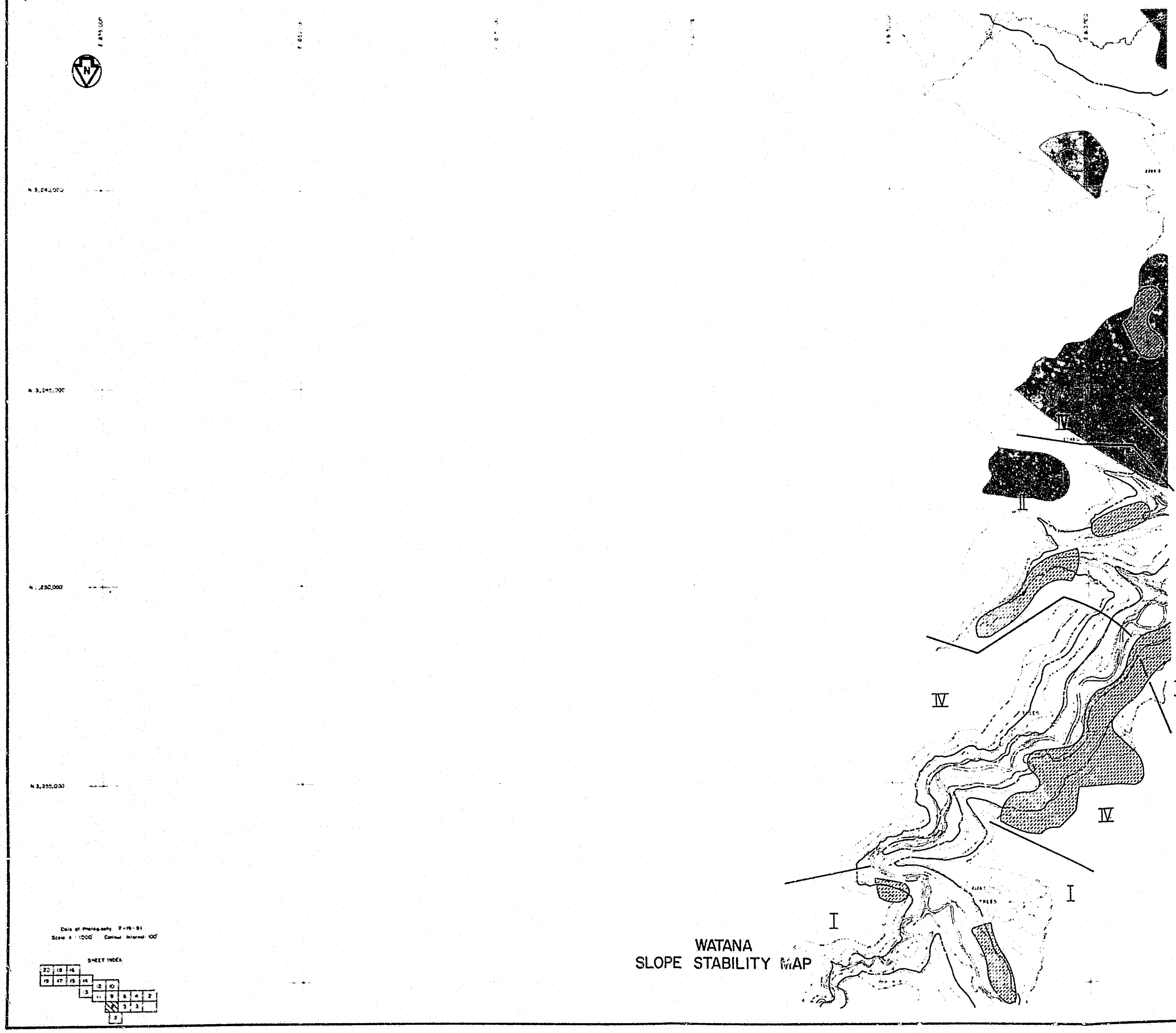
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.36



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY[1]

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- RIVER MILES

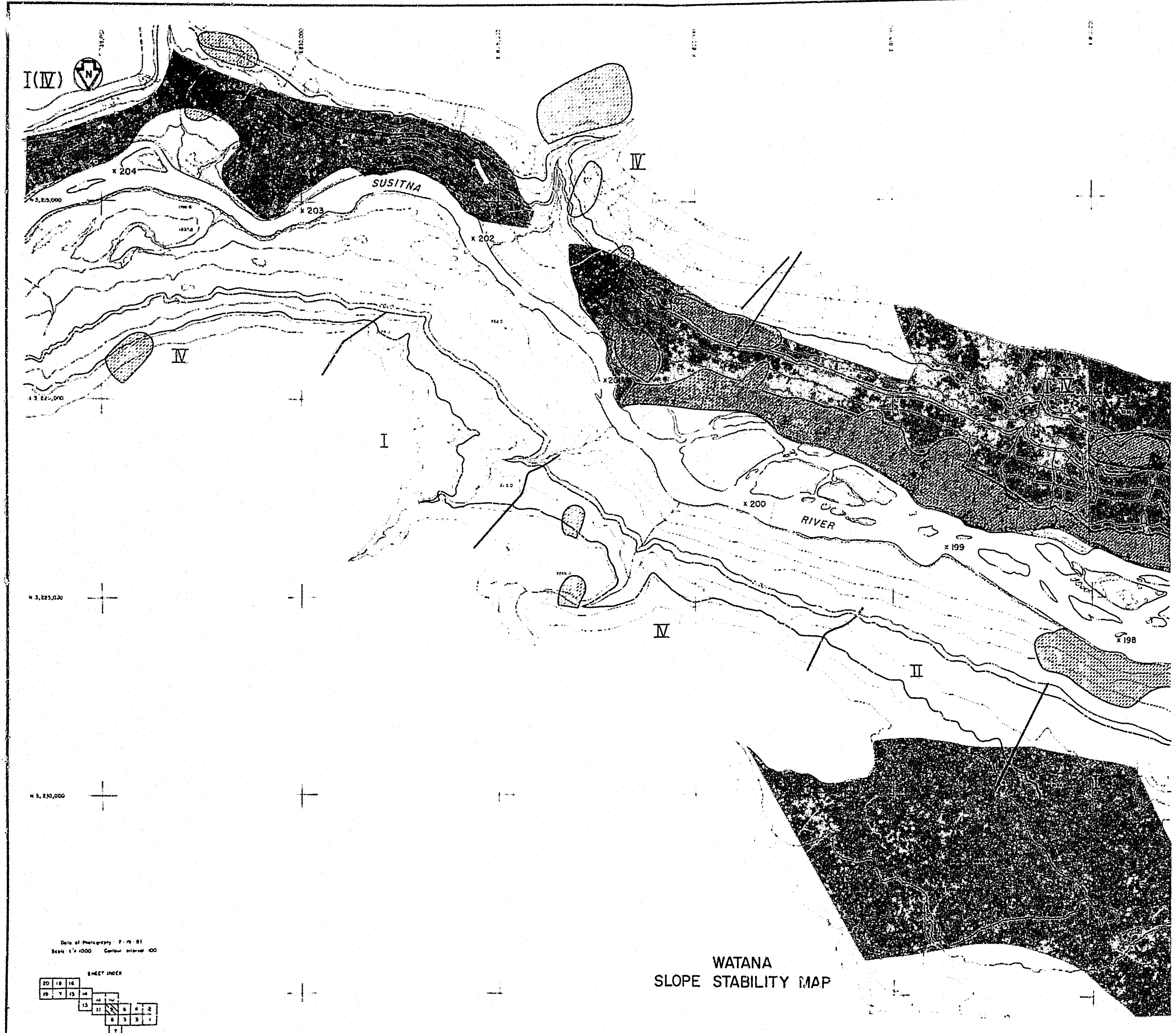
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION.

WATANA
SLOPE STABILITY MAP

FIGURE E.6.37



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I — BEACHING
- II — FLOWS
- III — SLIDING (UNFROZEN)
- IV — SLIDING (PERMAFROST)
- /I/ — DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) — PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II — BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- X — RIVER MILES

AREA OF POTENTIAL PERMAFROST

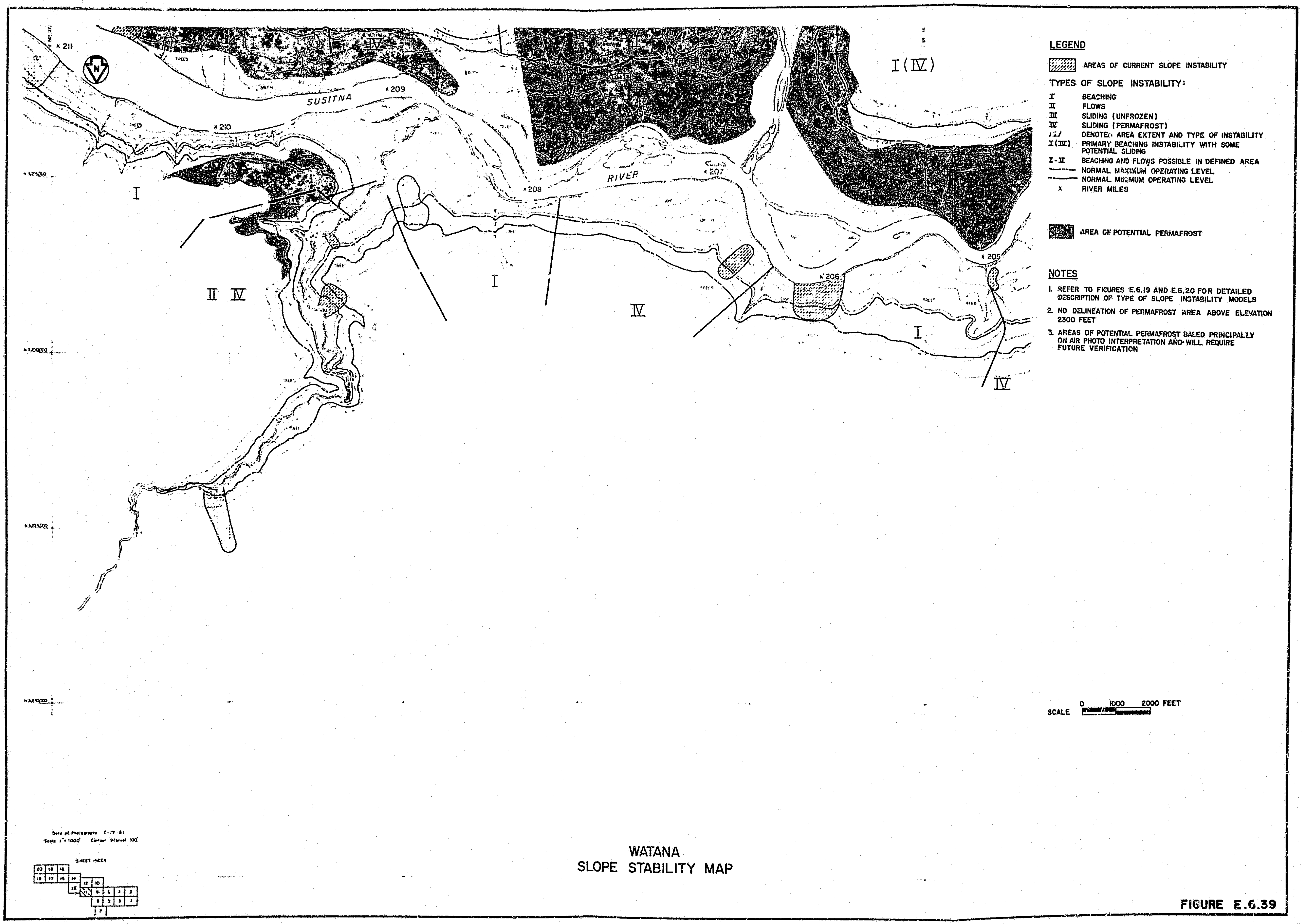
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

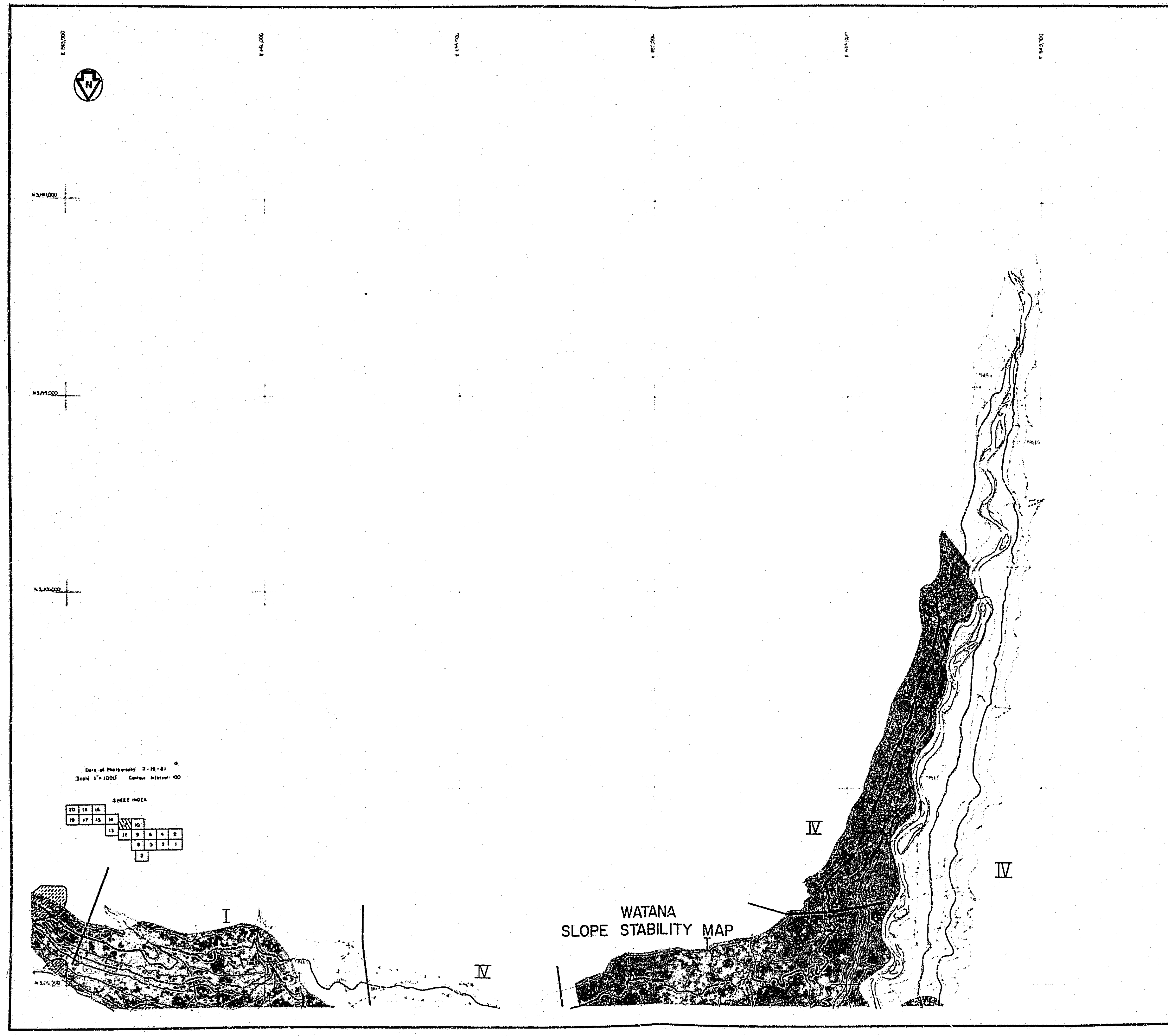
WATANA
SLOPE STABILITY MAP

FIGURE E.6.38



WATANA
SLOPE STABILITY MAP

FIGURE E.6.39



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

I BEACHING
II FLOWS
III SLIDING (UNFROZEN)
IV SLIDING (PERMAFROST)
/I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
NORMAL MAXIMUM OPERATING LEVEL.
NORMAL MINIMUM OPERATING LEVEL
RIVER MILES

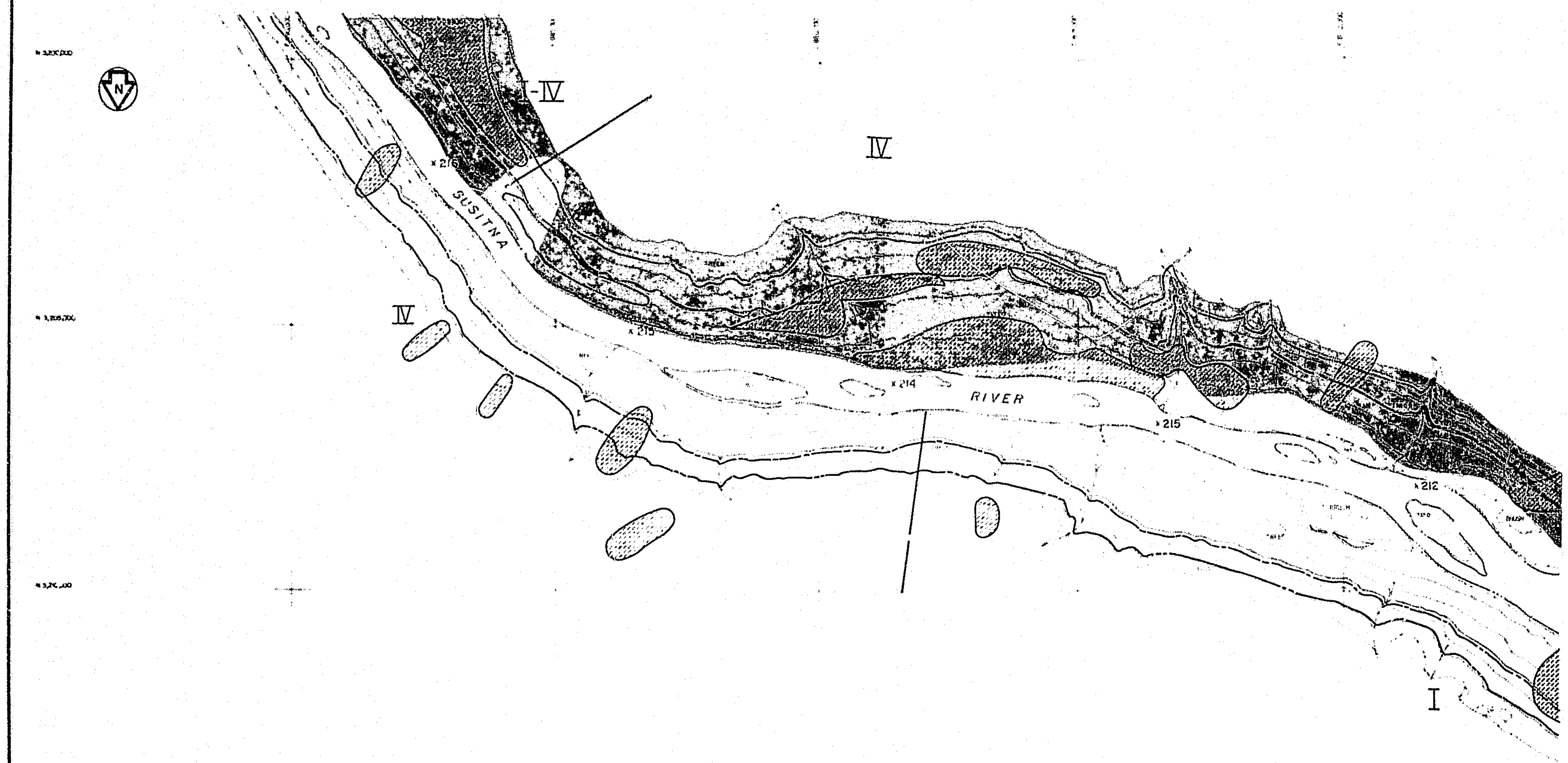
AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

FIGURE E.6.40



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- X RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

Date of Photography 7 19 81
Scale 1" = 1000' Contour Interval 100

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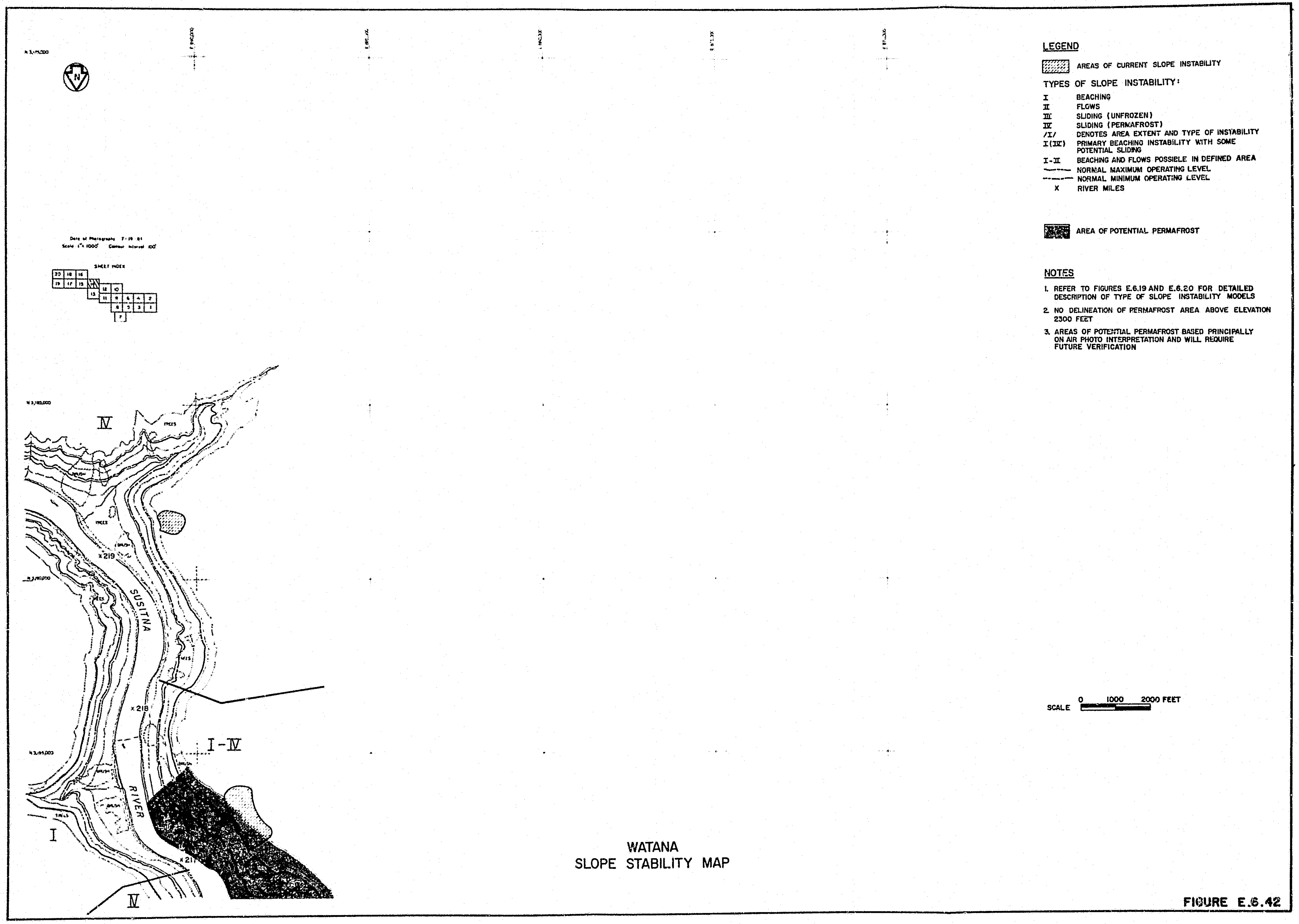
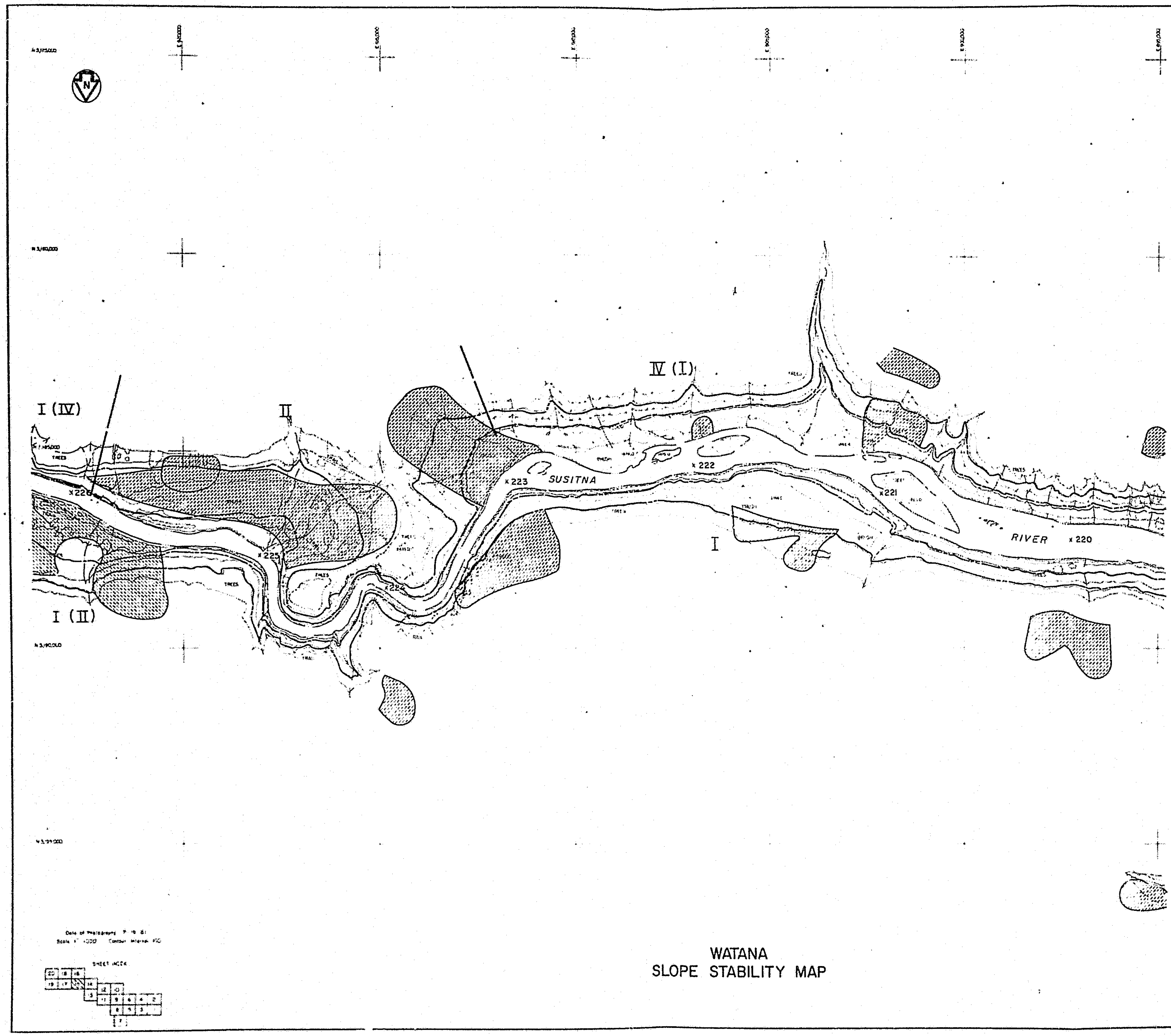
WATANA
SLOPE STABILITY MAP

FIGURE E.6.41



WATANA
SLOPE STABILITY MAP

FIGURE E.6.42



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- ------ NORMAL MAXIMUM OPERATING LEVEL
- -·-·-· NORMAL MINIMUM OPERATING LEVEL
- x RIVER MILES

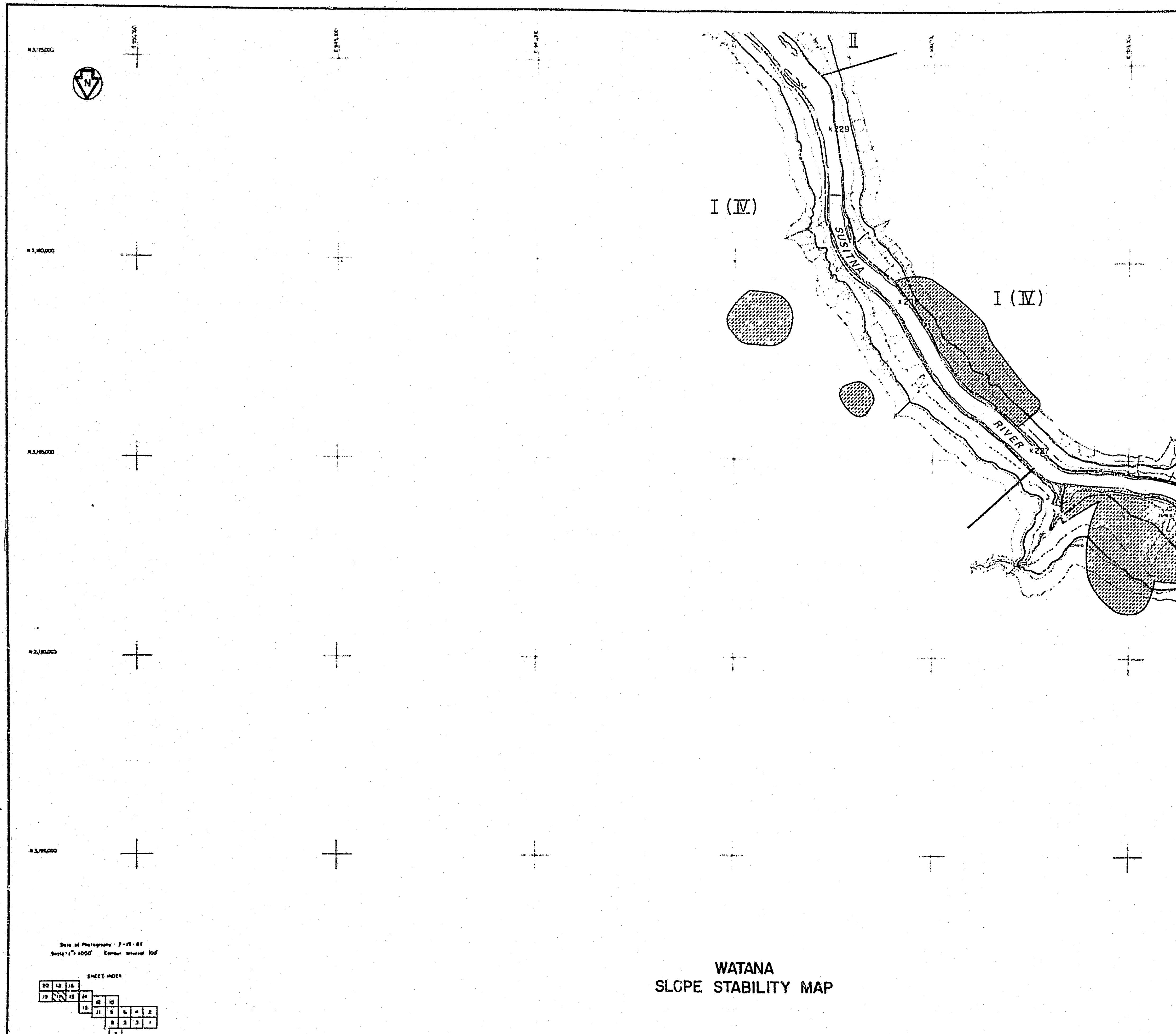
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.43



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- X RIVER MILES

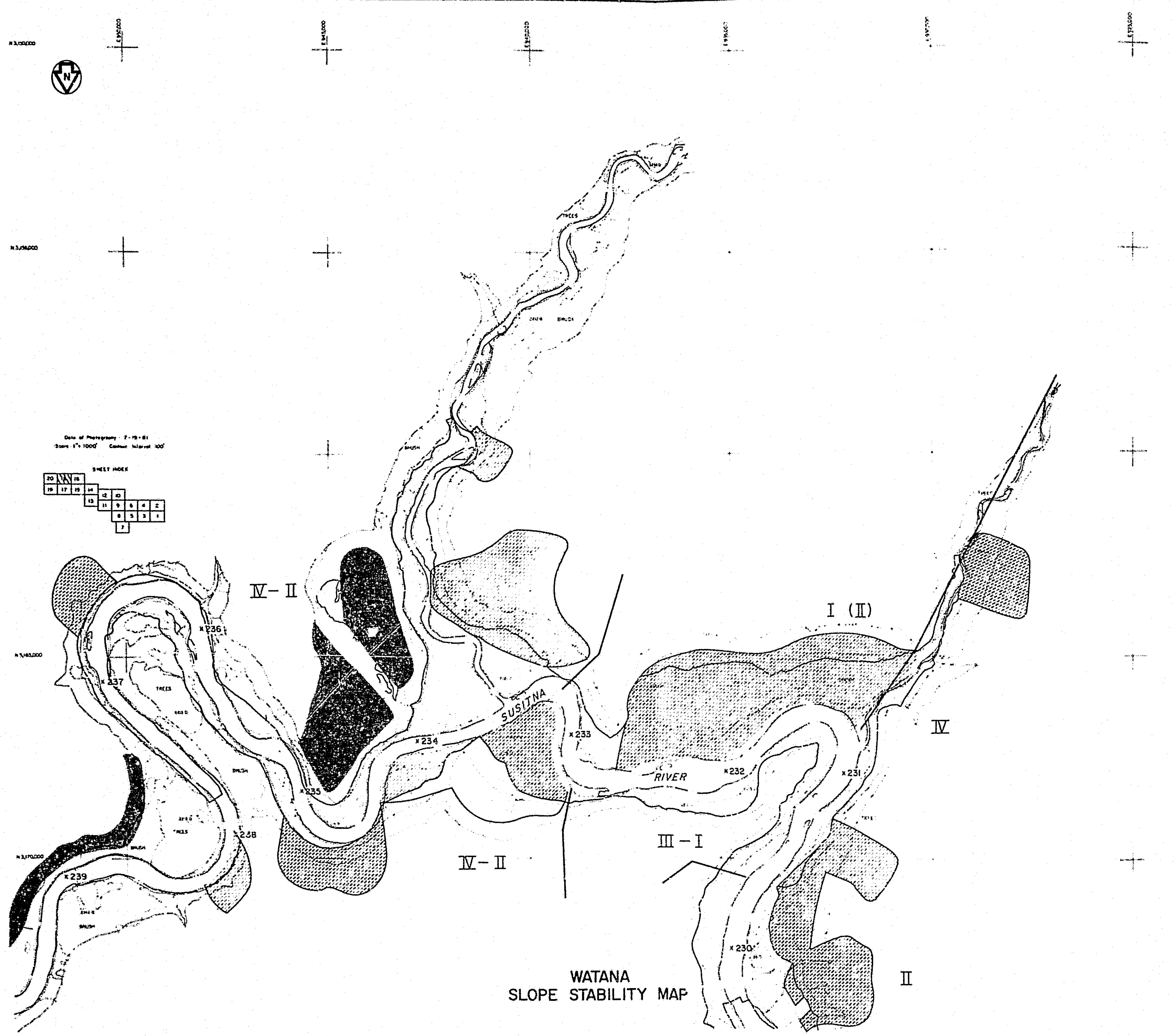
NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.44



LEGEND

AREAS OF CURRENT SLOPE INSTABILITY

TYPES OF SLOPE INSTABILITY:

- I BEACHING
- II FLOWS
- III SLIDING (UNFROZEN)
- IV SLIDING (PERMAFROST)
- /I/ DENOTES AREA EXTENT AND TYPE OF INSTABILITY
- I(IV) PRIMARY BEACHING INSTABILITY WITH SOME POTENTIAL SLIDING
- I-II BEACHING AND FLOWS POSSIBLE IN DEFINED AREA
- NORMAL MAXIMUM OPERATING LEVEL
- NORMAL MINIMUM OPERATING LEVEL
- x RIVER MILES

AREA OF POTENTIAL PERMAFROST

NOTES

1. REFER TO FIGURES E.6.19 AND E.6.20 FOR DETAILED DESCRIPTION OF TYPE OF SLOPE INSTABILITY MODELS
2. NO DELINEATION OF PERMAFROST AREA ABOVE ELEVATION 2300 FEET
3. AREAS OF POTENTIAL PERMAFROST BASED PRINCIPALLY ON AIR PHOTO INTERPRETATION AND WILL REQUIRE FUTURE VERIFICATION

SCALE 0 1000 2000 FEET

WATANA
SLOPE STABILITY MAP

FIGURE E.6.45