ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

TASK 8 - TRANSMISSION

SUBTASK 8.02 - PROGRESS REPORT
ELECTRIC SYSTEM STUDIES

MARCH 1981

ACRES AMERICAN INCORPORATED
1000 Liberty Bank Building
Main at Court
Buffalo, New York 14202

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT
TASK 8 - TRANSMISSION

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1 - INTRODUCTION

1.1 - Background

The Plan of Study (POS) for the Susitna Hydroelectric Project, which is currently being undertaken for the Alaska Power Authority by Acres American Inc. includes studies of the required transmission system under Task 8.

Subtask 8.02 of Task 8 is entitled Electric System Studies. The objective of this subtask, as defined in the February 1980 POS is as follows:

> "To ensure that the electrical aspects of the project design are integrated with the existing Railbelt area power systems and to design an electrical power system which is reliable and economic."

The Transmission System for the Susitna Project, as currently envisaged, will ultimately involve lines from the Watana and Devil Canyon sites to both Fairbanks and Anchorage. The system will also be compatible with the proposed intertie between Healy and Fairbanks which is presently under study for the Alaska Power Authority by Commonwealth Associates.

Work on Subtask 8.02 commenced in June 1980 and is scheduled to be complete by March 5, 1982. The purpose of this progress report is to present the results of work completed under Subtask 8.02 through February 15, 1981.

1.2 Report Contents

A summary of the report is presented in Section 2 and the approach adopted in the studies in Section 3. A description of studies undertaken and a discussion of preliminary results follows in Section 4. General comments on the results to date are presented in Section 5.

Appendices A and B and an attachment are also included as support documents which have been issued to advise APA of early study findings.

2 - SUMMARY

2.1 - Scope of Work

The scope of work includes the following:

- planning criteria
- system data assembly
- power delivery points
- line loading
- preliminary system configurations
- preliminary cost for alternatives
- preliminary screening of systems
- recommend transmission configuration, voltage, and conductor size.

2.2 - Reports Reviewed

The following reports were reviewed as to content relating to the scope of work.

- U.S. Corps of Engineers/Alaska Power Administration - Susitna Hydroelectric Project Interim Feasibility Report. Section H - Transmission System, December 1975.

- International Engineering Co, Inc/Robert W. Retherford Associates Economic Feasibility Study Report, December 1979.

- Institute of Social and Economic Research - Electric Power Consumption for the Railbelt: A Projection of Requirements, May 1980.

- Woodward - Clyde Consultants: Forecasting Peak Electrical Demand For Alaska's Railbelt, draft September, 1980 and final report December, 1980 - Subtask 1.02.

- Subtask 1.01 - Closeout Report, Review of ISER Work December, 1980.

- Commonwealth Associates Inc - Anchorage - Fairbanks Transmission Intertie draft November, 1980.

- Commonwealth Associates Inc - Anchorage - Fairbanks Interconnection Feasibility Study, January, 1981.

- Subtask 6.36, Generation Planning - Preliminary Information.

2.3 - Planning Criteria

System planning criteria (Appendix A) were submitted to APA in August, 1980. The system study assumes a fully developed Susitna potential so that final system parameters can be determined. The criteria are based on the desirability to maintain rated power flow to Anchorage and Fairbanks during the outage of any single line or transformer element. The essential features of the criteria are as follows:

- total power output of Susitna to be delivered to two stations at Anchorage and one at Fairbanks

- "breaker-and-a-half" switching station arrangements

- dynamic overvoltages during line energizing not to exceed specified limits

- system voltages to be within established limits during normal operation

- power delivered to the loads to be maintained and system voltages to be kept within established limits for system operation under emergency conditions

- transient stability during a 3-phase line fault cleared by breaker action with no reclosing

- where performance limits are exceeded, the most cost effective corrective measures are to be taken.

3 - APPROACH

The following steps were adopted and pursued to achieve the preliminary subtask objectives.

- develop system planning criteria (paragraph 2.3)
- assemble existing system data (obtained by RWRA)
- study present load distribution to Anchorage and Fairbanks
- establish bulk power delivery points
- obtain development capabilities (from Task 6)
- determine line loadings at each development stage
- examine various system configurations
- compare various systems on a performance and cost basis
- make preliminary voltage recommendation

4 - DESCRIPTION OF STUDIES AND PRELIMINARY RESULTS

4.1 - System Data Assembly

The services of R. W. Retherford Associates were obtained August, 1980 to gather system data from the utilities. The final data assembly was completed late October, 1980.

4.2 - System Load Distribution

Based on the ISER load forecasts (low, medium and high load growth), the distribution of the total Railbelt load between Anchorage and Fairbanks areas remains essentially constant throughout the range of load growth predictions. Anchorage is predicted to have approximately 80 percent of the total load with Fairbanks having the remaining 20 percent. To allow for some variations in the forecasted load split, the transmission system will be designed to deliver 85 percent of total Susitna power to Anchorage and 25 percent to Fairbanks.

The foregoing was studied after receipt of system data and the delivery points, two at Anchorage and one at Fairbanks were established in November, 1980.

4.3 - Description of Studies

(a) Power Transfer - After studying various reports listed above and obtaining preliminary information on the staging of Susitna from Subtask 6.36, Generation Planning, the electric system studies were able to proceed in December, 1980. Table 4.1 shows the staging schedule for the Susitna Development. The maximum power to be transmitted to Anchorage and Fairbanks for each stage of development, based on the 85 percent and 25 percent limits is given in Table 4.2. The load power factor is assumed to be 0.95 and the power factor capability of the Susitna generators is assumed to be 0.90.

Following determination of the system power transfer requirements for each stage of Susitna development, alternative system configurations were developed taking into account the following:

- initial Susitna development at the Watana site
- a major switching station at Devil Canyon or near Gold Creek
- possible intermediate switching at Willow and Healy.

Preliminary line lengths for the system configurations under study were obtained from Subtask 8.03, Transmission Line Route Selection.

Having established the peak power to be delivered and the distances over which it is to be transmitted, transmission voltages and number of circuits required were determined. To maintain a consistency with standard ANSI voltages used in other parts of the U.S.A., the following voltages were considered for Susitna transmission.

- Watana to Devil Canyon or Gold Creek and on to Anchorage — 500 kV or 345 kV

- Devil Canyon or Gold Creek to Fairbanks — 345 kV or 230 kV

(b) Conductor Sizes - Based on the selected transmission and power transfer requirements at the various stages of Susitna development, economic conductor sizes can be selected. The methodology used to obtain the economic conductor size and the results obtained are outlined in Appendix B, "Transmission Line - Economic Conductor Size". Also included in Appendix B are the capitalized costs of transmission line losses. The cost of these losses are taken into account in comparing the overall costs of alternative transmission schemes.

When determining appropriate conductor size, the selected conductor is checked for radio interference (RI) and corona requirements. If RI and corona performance are within acceptable limits, then the selected conductor based on economic analysis may be used. On the other hand, where necessary to satisfy RI and corona performance requirements, a larger conductor size may be selected.

Total line losses for the proposed conductor size for each of the different line voltages being considered are given in Table 4.3. These losses are for the alternatives where a major switching station is located at Devil Canyon. The losses given are the total losses for transmission from Devil Canyon to Anchorage and from Devil Canyon to Fairbanks. The line from Devil Canyon to Anchorage is 155 miles long. The losses were calculated for the maximum expected power transfer to Anchorage and to Fairbanks for each of the stages of Susitna development as given in Table 4.2.

(c) Line Energizing and Outage Conditions - Following selection of the conductor sizes using economic, RI and corona criteria, computer simulations of line energizing were carried out. These simulations were performed to determine shunt reactor requirements necessary to ensure that dynamic overvoltages during line energizing remained below the values established in the system planning criteria. (See attached Appendix A).

Once the line reactor requirements were established, computer load flow simulations of single contingency outage conditions were commenced. The purpose of these simulations is to determine the following:

- need for intermediate switching stations
- transformer tap settings
- need for, and magnitude of series compensation
- var generation requirements at the load centers

These simulations are being carried out for the various transmission system configurations and stages of development of Susitna being considered and are currently in progress.

(d) Preliminary Capital Cost Estimates - These estimates will be engineering type estimates with an appropriate contingency to cover any unforeseen construction problems.

In working up the transmission line costs, Acres referred to RWRA experience in Alaska. The line costs are based on an X-type tower. The cost figures developed are consistent with CAI January, 1981 transmission line costs.

Appendix B shows the methodology of obtaining the line costs as a function of voltage and conductor size. The capitalized cost of line losses are also treated in this appendix.

Substation equipment costs were developed, based on unit costs in the U.S. Department of Energy, Federal Energy Regulatory Commision publication, "Hydroelectric Power Evaluation", August 1979 edition. The costs obtained from this publication were escalated to reflect 1981 levels and the higher cost of labor in Alaska.

4.4 - Preliminary Results of Studies

The studies performed to date (February 15, 1981) have given preliminary results as follows:

(a) 345 kV is a viable voltage for transmission from Susitna to Anchorage and to Fairbanks and appears to be the economic choice.

(b) Two circuits are expected to be adequate to each load center, however, the circuits to Anchorage will require series compensation to handle the heavier loading to the south. System configuration is shown in Figure 4.1.

(c) Conductor sizes (preliminary) are 2 x 1272 MCM to Anchorage and 2 x 795 MCM to Fairbanks.

(d) Costs and performance calculations to date are inconclusive as to the preferred location of the Susitna terminal station - either Gold Creek or Devil Canyon. Final decision may be based on other factors.

(e) Intermediate switching at Willow is a cost-effective way of improving the contingency performance of transmission to Anchorage. It also has the advantage of facilitating the supply of future load at this point (e.g. future capital).

(f) Studies are based on two delivery points in the Anchorage area to handle the ultimate loading of 1020 to 1190 MW. [This is based on assumed requirements for subtransmission rights of way in the load area and has no impact on the question of primary transmission voltage and configuration].

(g) Transmission to Fairbanks does not need an intermediate switching station at Healy to satisfy contingency requirements. This could be added if required for load or generation at this point.

The cost estimates obtained from these studies were used to calculate transmission system costs for the "1981 Upper Limit Capital Cost Estimate and Associated Economic Analyses" dated March. 1981.

TABLE 4.1 - STAGING OF THE SUSITNA DEVELOPMENT

Year	Susitna Capacity - MW Watana Increments	Total	Devil Canyon Increments	Total	Susitna Total
1993	400	400	-	-	400
1996	400	800	-	-	800
2000	-	-	400	400	1,200
2000 (optional)	-	-	200	600	1,400

TABLE 4.2 - MAXIMUM POWER TO BE TRANSMITTED TO ANCHORAGE

AND FAIRBANKS FOR EACH STAGE OF SUSITNA DEVELOPMENT

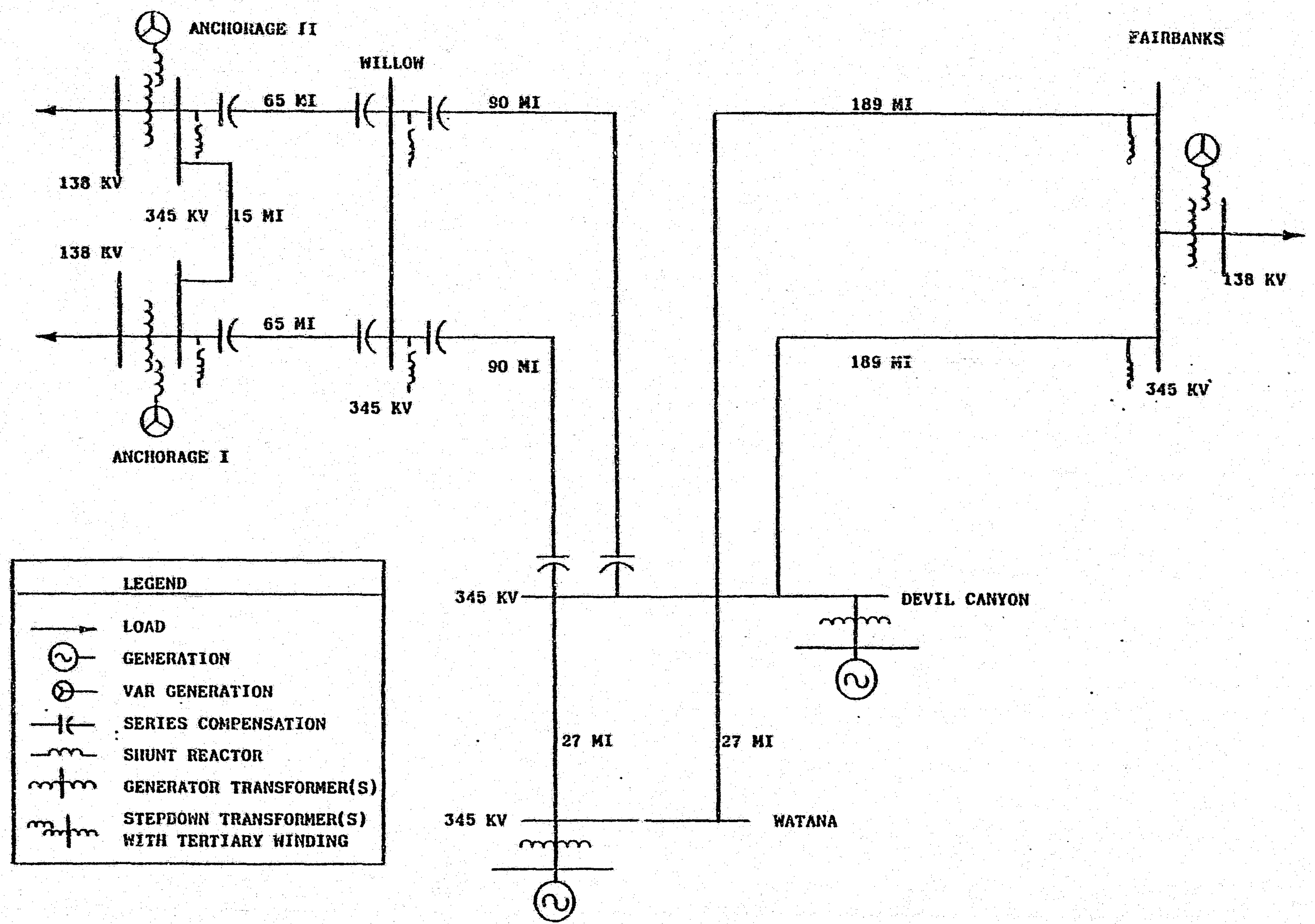
Total Susitna Capacity (MW)	Maximum Power Transmission To Anchorage (MW)	To Fairbanks (MW)
400	340	100
800	680	200
1,200	1,020	300
1,400	1,190	350

Note: For system planning purposes a maximum of 85 percent of Susitna generation is assumed to be transmitted to Anchorage and a maximum of 25 percent to Fairbanks.

TABLE 4.3: LINE LOSSES UNDER MAXIMUM POWER TRANSMISSION

Susitna Capacity (MW)	Devil Canyon to Anchorage (155 miles)			
	Power Transmitted (MW)	500 kV 2 Circuits (MW)	345 kV 2 Circuits (MW)	3 Circuits (MW)
400	340	1.5	3.2	2.9
800	680	6.2	12.8	11.2
1,200	1,020	13.8	28.8	25.5
1,400	1,190	18.8	39.2	35.3

Susitna Capacity (MW)	Devil Canyon to Fairbanks (189 miles)		
	Power Transmitted (MW)	345 kV 2 Circuits (MW)	230 kV 2 Circuits (MW)
400	100	0.5	1.5
800	200	2.0	6.1
1,200	300	4.6	13.7
1,400	350	6.3	18.6



345 KV SYSTEM

FIGURE 4.1

5 - GENERAL COMMENTS

Transmission planning studies are still in progress examining the impact of contingency outages and transient stability on system configuration. Other details which are not yet finalized and which may influence the transmission configuration are the sizes and staging of generation at Watana and Devil Canyon sites.

Current work on transient stability has shown that survival of a three-phase fault on the EHV system will be difficult (and costly) to achieve. The arbitrary choice of a three-phase design fault in the planning criteria may have been unduly severe, since multiphase faults are rare in EHV systems. Further study is needed but we may propose changing to EHV design fault in the planning criteria from "three-phase" to "single-line-to-ground".

Structural and mechanical details of the transmission system have not been studied as yet. These will be addressed after completion of the electrical system studies.

APPENDIX A

PROPOSED PLANNING CRITERIA

SUSITNA TRANSMISSION PLANNING

July 22, 1980
P5700.08

PROPOSED PLANNING CRITERIA

In general, we propose to plan transmission facilities so that single contingency outages will not result in restrictions in power transfer although voltages may be temporarily outside of normal limits. The proposed guidelines concerning stability, system performance limits and thermal overloads are detailed below.

(a) Stability

The system will be checked at each stage of development for transient stability. In the case of multiphase faults, delayed reclosing is assumed, whereas high speed reclosing would be attempted following single-phase faults that were cleared by single pole switching.

The design fault for transient stability check would be a 3-phase fault cleared in 6 cycles by the local breaker and 8 cycles by the remote breaker, with no reclosing.

(Note: At later stages of design it may be useful to check dynamic stability for unsuccessful reclosure of a SLG fault cleared eventually by 3-phase trip and lock-out following initial single-pole trip. For the present, a 3-phase design fault is considered to be equivalent in terms of severity.)

(b) Station Configurations

The determination of system transmission requirements will be based (initially at least) on assumed successful breaker operations. When the affect of a stuck breaker is examined, the clearing of back-up breakers will be based on "breaker-and-a-half" switching arrangements.

(c) System Energizing

Line energizing initially and as part of routine switching operations will generate some dynamic overvoltages. System design should be arranged to keep these overvoltages within the following limits

- line open-end voltages at the remote end should not exceed 1.15 pu on line energizing

- following line energizing, switching of transformers and VAR control devices at the receiving end should bring the voltage down to 1.10 pu or lower

- the step-change in voltage at the energizing end of the line should not exceed 5 percent.

(d) Load Flow

System load flows will be checked at each stage of development to ensure that the system configuration and component ratings are adequate for normal and emergency operating conditions. The load levels to be checked will include peak load, minimum load (assumed 50 percent of peak) and also any intermediate load level that is judged to be critical due to off-peak shut down of load-center generation.

Normal system flows must be within all normal thermal limits for transformers and lines, and should give bus voltages on the EHV system within +5 percent, -10 percent, and at subtransmission buses within +5 percent, -5 percent.

Emergency system flows with the loss of one system element must be within emergency thermal limits for lines and transformers (20 percent O/L). Bus voltages on the EHV system should be within +5 percent, -10 percent, and at subtransmission buses within +5 percent, -10 percent.

(e) Corrective Measures

Where limiting performance criteria are exceeded, system design modifications will be applied that are considered to be most cost-effective. Where conditions of low voltage are encountered, for example, power factor improvement would be tried. Where voltage variations exceed the range of normal corrective transformer tap change, supplementary VAR generation and control would be applied. Where circuit and transformer thermal limits are about to be exceeded, additional elements would be scheduled.

(f) Power Delivery Points

For study purposes, it will be assumed that when Susitna generation is fully developed (i.e., to approximately 1,500 MW), the total output will be delivered to terminal stations as follows

- Fairbanks - one station at Gold Hill

- Anchorage - two stations
  - one at Palmer
  - one "elsewhere"

  - (the two stations at Anchorage would be interconnected at EHV.)

The provision of intermediate switching stations along the route may prove to be economic and essential for stability and operating flexibility. Utilization of these switching stations for the supply of local load will be examined, but security of supply to Anchorage and Fairbanks will be given priority consideration.

M. W. Stoddart

MWS:rf M. W. Stoddart

APPENDIX B

TRANSMISSION LINE ECONOMIC CONDUCTOR SIZE

February 13, 1981

TRANSMISSION LINE -
ECONOMIC CONDUCTOR SIZE

1 - INTRODUCTION

In EHV transmission, line conductors and conductor bundles must be sized to minimize corona, RI and audible noise effects. An additional factor that needs to be quantified is the economic incentive to increase the conductor section still further to achieve savings in the future cost of line loss.

This appendix deals with the economic aspects of conductor sizing, and since both line costs and line losses are proportional to line length, the analysis is carried out on the basis of costs per circuit - mile.

2 - LINE CAPITAL COST

Transmission costs are generally a function of the transmission voltage and conductor size, modified by local considerations such as meteorological factors, access, transport costs and local labor costs. At a particular voltage, the variation in line cost as a function of conductor area is normally of the form

$$\text{line cost per mile} = K1 + K2\,(MCM)^{a}.$$

On the basis of line cost estimates for Alaska, values of "$K1$", "$K2$" and "a" have been determined. These are approximate, but they describe the relationship between line cost and conductor size sufficiently well to be used as a guide in determining the economic size of line conductor. The equations are shown below

$$230\ kV = \$/mile \simeq 125{,}000+2\ (MCM)^{1.45}$$

$$345\ kV = \$/mile \simeq 175{,}000+2\ (MCM)^{1.45}$$

$$500\ kV = \$/mile \simeq 300{,}000+2\ (MCM)^{1.45}.$$

3 - CAPITALIZED COST OF LOSS

Line loss varies directly as the square of the line loading and inversely as the conductor cross sectional area. Since the line loading varies in a daily pattern and also throughout the life of the facility, these variations must be taken into account.

Daily variations in load are described by the Load Factor (LF) which in the railbelt area is expected to be about 62.5 percent. The average annual energy capability at Susitna is also of the same order, and the load factor of line losses (LLF) is estimated to be

$$LLF = \frac{(LF)^2+LF}{2}$$

$$= \frac{(0.625)^2+0.625}{2}$$

$$= 0.508$$

$$LLF \simeq 0.50.$$

Transmission line loading over the life of the facility can only be estimated at this time. According to generation planning studies, each time a block of 400 MW of generation is commissioned (in years 1993, 1997 and 2000), this capability is fully absorbed by the system. Generation additions after year 2000 cannot be forecast with any certainty. The contribution to loss energy from any additional peaking capacity would be negligible, hence, the following load pattern is assumed.

Period	Susitna Capacity (MW)	Line Loadings - (MW) To Anchorage	To Fairbanks
1993 - 1996	400	320	80
1996 - 2000	800	640	160
2000 - 2043	1 200	960	240

Expressing line loading and line resistance in per unit on Surge Impedance Loading (SIL) and surge impedance (Zc) base leads to the following expressions

Line resistance $= \frac{100}{MCM}$ *ohms per mile*

$= \frac{100}{MCM} \times \frac{1}{Zc}$ *per unit per mile*

If line loading = *S per unit on SIL base*

Then line loss per mile $= S^2 \times \frac{100}{MCM} \times \frac{1}{Zc}$ *per unit*

and since SIL $= \frac{kV^2}{Zc}$ (MW)

Line loss per mile $= S^2 \times \frac{100}{MCM} \times \frac{1}{Zc} \times \frac{kV^2}{Zc}$ (MW/mile)

Annual loss energy/mile $= S^2 \times \frac{100}{MCM} \times \frac{kV^2}{Zc^2} \times 8.76 \times LLF$

(GW·h/mile)

And if the cost of loss energy $= c$ \$/kW·h

$= c$ \$ Million/GW·h

Then annual cost of loss $= S^2 \times \frac{100}{MCM} \times \frac{kV^2}{Zc^2} \times 8.76 \times LLF \times c$

(\$ Million/mile)

Typical values of LLF and C for Susitna are

LLF = 0.50 (as developed earlier)

c = \$0.035/kW·h (an average figure derived in the OGP-5 planning studies based on zero inflation and 3 percent net cost of money)

$\therefore$ Annual cost of loss $= \frac{15.33\ S^2\ kV^2}{MCM\ Zc^2}$ (\$ Million/mile).

In tables 1 and 2 the capitalized cost of loss per mile is derived for transmission to Anchorage and Fairbanks, respectively, as a function of conductor size and for the line voltages that are being considered.

In Table 3 the line capital cost and capitalized cost of loss are shown for each voltage and transmission route. Also shown are the optimum conductor sizes based on loss evaluation. The relationship between total cost and conductor size is shown graphically in Figure 1 for transmission to Fairbanks and Anchorage. Line loadings at 500 kV to Anchorage and at 345 kV to Fairbanks are low and lead to conductor sizes below the acceptable limit from an RI and Corona point of view. Proposed conductor sizes for the various line sections, taking into account Corona and RI effects, are shown at the bottom of Table 3.

TABLE 1

TRANSMISSION LINE TO ANCHORAGE
DEVELOPMENT OF CAPITALIZED COST OF LOSS

Period	Total Load (MW)	Loading Per Circuit[1] (MW)		Loading Per Circuit[1] on SIL Base[2] (S-pu)	Annual Cost of Loss[3] ($M/MCM)	Duration of Load Period (n-years)	Offset from P.W. Datum (m-years)	Factor[4] $\frac{1}{i}\left[1 - \frac{1}{(1+i)^n}\right] \times \frac{1}{(1+i)^m}$	Capitalized Cost of Loss ($M/MCM)
1993 - 1996	320	160	345 kV	0.386	3.305	3	0	2.8286	9.349
1996 - 2000	640	320	345 kV	0.771	13.186	4	3	3.4017	44.855
2000 - 2043	960	480	345 kV	1.157	29.695	43	7	19.4995	579.037
								Total at 345 kV =	$M 633.241/MCM
1993 - 1996	320	160	500 kV	0.178	1.5737	3	0	2.8286	4.451
1996 - 2000	640	320	500 kV	0.356	6.2949	4	3	3.4017	21.413
2000 - 2043	960	480	500 kV	0.533	14.1105	43	7	19.4995	275.147
								Total at 500 kV =	$M 301.011/MCM

[1] Two circuits are assumed.
[2] SIL base values are: 415 MW (345 kV) and 900 MW (500 kV).
[3] Annual cost of loss = $15.33\ S^2\ kV^2/Zc^2$, based on losses valued at $0.035/kW·h and a 50 percent loss load factor.
[4] Present worth discounting is at annual rate of 3 percent.

TABLE 2

TRANSMISSION LINE TO FAIRBANKS
DEVELOPMENT OF CAPITALIZED COST OF LOSS

Period	Total Load (MW)	Loading Per Circuit[1] (MW)	Loading Per Circuit[1] on SIL Base[2] (S-pu)		Annual Cost of Loss[3] ($M/MCM)	Duration of Load Period (n-years)	Offset from P.W. Datum (m-years)	Factor[4] $\frac{1}{i}\left[1-\frac{1}{(1+i)^n}\right] x \frac{1}{(1+i)^m}$	Capitalized Cost of Loss ($M/MCM)
1993 - 1996	80	40	0.292	230 kV	0.4665	3	0	2.8286	1.3195
1996 - 2000	160	80	0.584	230 kV	1.8660	4	3	3.4017	6.3476
2000 - 2043	240	120	0.876	230 kV	4.1984	43	7	19.4995	81.8670
								Total at 230 kV =	$M 89.5337/MCM
1993 - 1996	80	40	0.10	345 kV	0.2061	3	0	2.8266	0.5830
1996 - 2000	160	80	0.20	345 kV	0.8243	4	3	3.4017	4.2260
2000 - 2043	240	120	0.30	345 kV	1.8547	43	7	19.4995	36.1660
								Total at 345 kV =	$M 40.9747/MCM

[1] Two circuits are assumed.
[2] SIL base values are: 137 MW (230 kV) and 400 MW (345 kV).
[3] Annual cost of loss = 15.33 S^2 kV^2/Zc^2, based on losses valued at $0.035/kW·h and a 50 percent loss load factor.
[4] Present worth discounting is at annual rate of 3 percent.

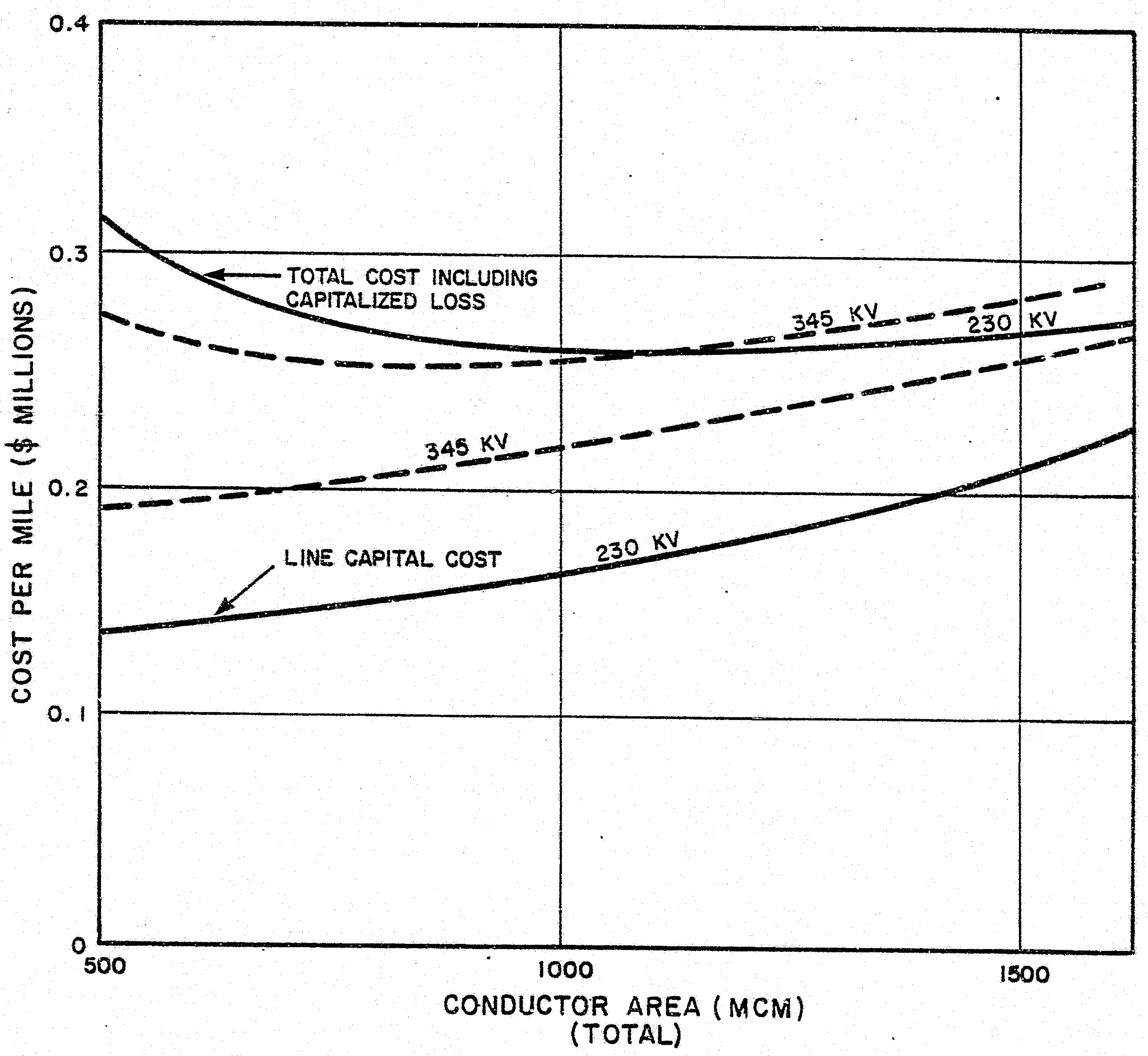
TABLE 3

SUMMARY OF ECONOMIC FACTORS AND PROPOSED CONDUCTOR SIZES

Voltage	Transmission to Anchorage 500 kV	Transmission to Anchorage 345 kV	Transmission to Fairbanks 345 kV	Transmission to Fairbanks 230 kV
Capital cost of line ($M/mile)	$0.30 + \frac{2}{10^6}(\text{MCM})^{1.45}$	$0.175 + \frac{2}{10^6}(\text{MCM})^{1.45}$	$0.175 + \frac{2}{10^6}(\text{MCM})^{1.45}$	$0.125 + \frac{2}{10^6}(\text{MCM})^{1.45}$
Capitalized[1] cost of loss ($M/mile)	$\frac{301.011}{\text{MCM}}$	$\frac{633.241}{\text{MCM}}$	$\frac{40.975}{\text{MCM}}$	$\frac{89.534}{\text{MCM}}$
Optimum conductor size (MCM)	$\left(\frac{301.011\times10^6}{2.9}\right)^{\frac{1}{2.45}}$ = 1,870 MCM[2]	$\left(\frac{633.241\times10^6}{2.9}\right)^{\frac{1}{2.45}}$ = 2,533 MCM	$\left(\frac{40.975\times10^6}{2.9}\right)^{\frac{1}{2.45}}$ = 829 MCM[2]	$\left(\frac{89.534\times10^6}{2.9}\right)^{\frac{1}{2.45}}$ = 1,140 MCM
Proposed conductors	3x795 MCM	2x1,272 MCM	2x795 MCM	1x1,272 MCM

[1] Capitalized cost of loss expressions are derived in tables 1 and 2.

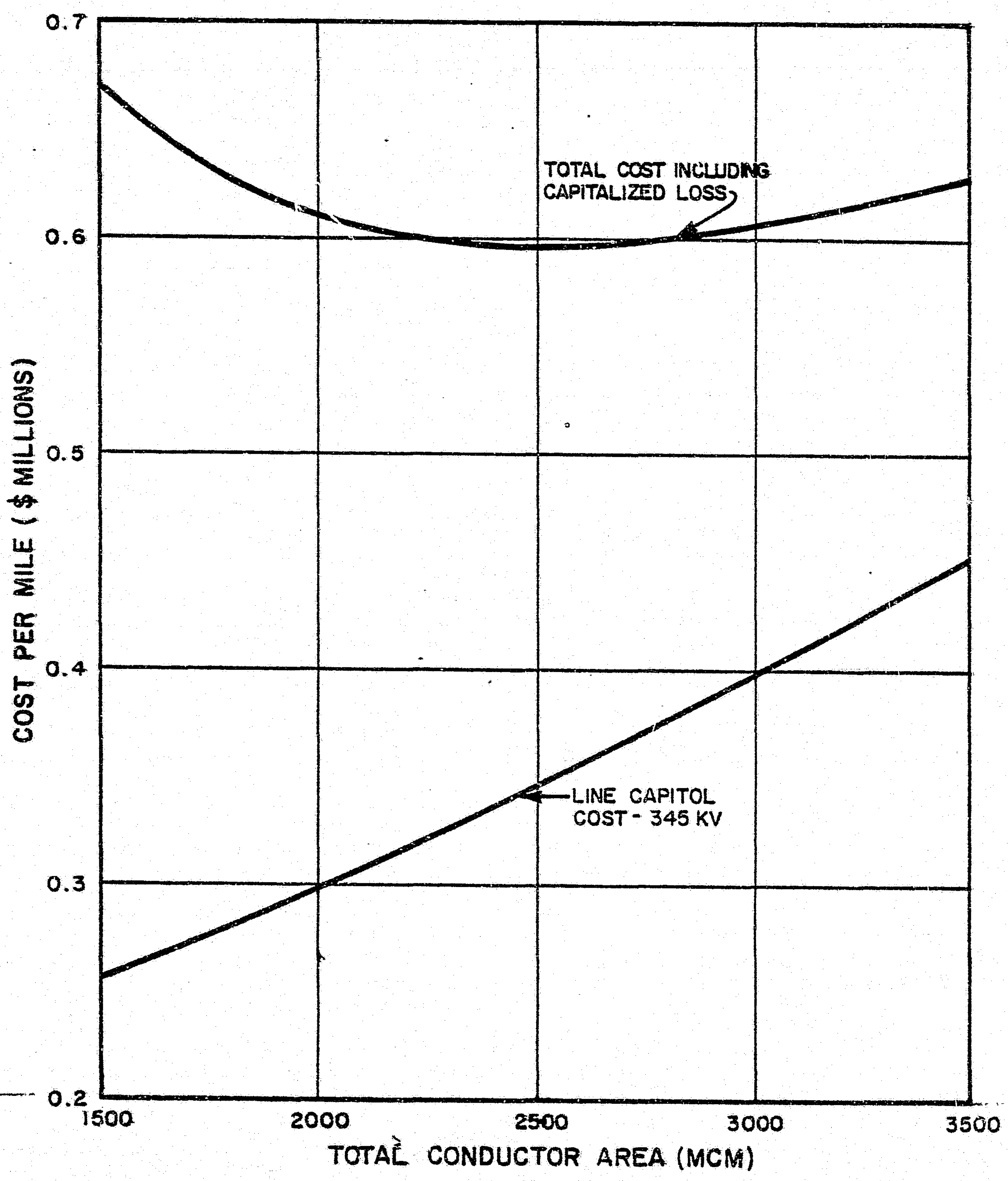
[2] The economic conductor areas for 500 kV to Anchorage and 345 kV to Fairbanks are smaller than the minimum needed for RI and Corona performance. Hence, RI considerations will dictate conductor size.



TRANSMISSION TO FAIRBANKS

ACRES

FIGURE 1A



TRANSMISSION TO ANCHORAGE

FIGURE I B

ATTACHMENT

March 24, 1981
P5700.11
T.783

Mr. Eric P. Yould
Executive Director
Alaska Power Authority
333 West 4th Avenue
Suite 31
Anchorage, Alaska 99501

Attention: Mr. David Wozniak

Dear Dave:

Susitna Hydroelectric Project
Transmission Line Characteristics

We are attaching one copy of interoffice memo from M. W. Stoddart/ I. R. Shepanik to E. N. Shadeed. This memo outlines the transmission line characteristics required which will carry the projected 1400 mw Susitna capacity to Anchorage and Fairbanks.

This information was previously given to A. Poppens of CAI on February 20, 1981.

As noted in the memo, the types of conductor used in the study are typical but the conductor capacity is considered as a minimum. If the intertie proceeds with 345 kv construction, any conductor choice will be closely coordinated with the Susitna requirements.

Sincerely,

for John D. Lawrence
Project Manager

ENS/ljr

Attachment

cc: A. D. Poppens

ACRES AMERICAN INCORPORATED
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Other Offices: Columbia, MD; Pittsburgh, PA; Raleigh, NC; Washington, DC

OFFICE MEMORANDUM

TO: E. N. Shadeed

Date: March 5, 1981

File: P5700.07.08

FROM: M. W. Stoddart
I. R. Shepanik

cc:

SUBJECT: SUSITNA TRANSMISSION LINES

We are currently carrying out electric system studies to determine transmission requirements for the Susitna development. The work performed to date indicates that the recommended characteristics for the lines from Susitna to Anchorage and Susitna to Fairbanks will be as follows

	Susitna to Anchorage	Susitna to Fairbanks
Voltage	345 kV	345 kV
Number of circuits	2	2
Number of conductors per bundle	2	2
Conductor size	1272 MCM	795 MCM
Conductor type	Pheasant	Mallard

The conductor size for the line from Susitna to Anchorage was chosen for economic reasons. For the Susitna to Fairbanks line the conductor size was selected to satisfy radio interference and corona requirements, which in this case override economic considerations.

The tower-line dimensions on which calculations of radio interference and corona performance were based are given below. Similar dimensions were used for both the lines from Susitna to Anchorage and those from Susitna to Fairbanks.

- tower height - 95 ft
- conductor height above ground - 85 ft at tower
  - 30 ft midspan
- horizontal phase spacing - 27 ft
- bundle spacing - 18 in.

Our studies related to conductor selection focussed on conductor cross sectional area and conductor diameter. These indicated approximately 2x1272 MCM for circuits to Anchorage and 2x795 MCM for the circuits to Fairbanks. When the total line design is being optimized there will be some trade-offs between tower cost and conductor cost, and these will lead to the selection of conductor types with stranding and strength characteristics that are part of an optimized design. The conductor types used in our calculations, Pheasant and Mallard, are considered typical but not necessarily the final choice.

Any significant departures from the above that are being considered for a 345-kV intertie should be checked for compatability with future Susitna requirements.