Alaska Power Authority

FEASIBILITY REPORT

TAZIMINA RIVER
HYDROELECTRIC PROJECT

September 1986

DRAFT

Stone & Webster Engineering Corporation

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MEMORANDUM (Brief Communications)

State of Alaska

	Name	Dept./Div./Sect.	
TO:	Dick Russell	Comm Fish - King Salmon	Mail Stop
FROM:	Kim Sundberg	Habitat - Anchorage	Telephone
SUBJ.:	Tazimina Hydro Feasibility Report	Date 10/27/86	

Attached is a draft feasibility report for the Tazimina Falls hydro scheme. I apologize for not sending earlier but I've been so busy it slipped my attention. Our comments are due to APA on 10/31. Essentially the project looks OK to me. One comment ~~I had~~ is that the drawing for the fish screen (Fig 7.2) does not show how fish can get back into the river if they enter the intake structure. I'm inclined to support screening the intake because 1.) the char/grayling resource will become more valuable once the road is constructed and 2) it sets a good presidence for other projects in the future.

02-001C (12/80)

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DRAFT

FEASIBILITY REPORT

TAZIMINA RIVER HYDROELECTRIC PROJECT

September 1986

Prepared for:

ALASKA POWER AUTHORITY

by

STONE & WEBSTER ENGINEERING CORPORATION

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SECTION 1

SUMMARY

The purpose of this feasibility study is to assess the technical, economic, and environmental aspects of the Tazimina River Hydroelectric Project. The proposed hydro development would provide power to the system of Iliamna-Newhalen-Nondalton Electric Cooperative (INNEC) which serves three communities of the same name in the Iliamna Lake/Lake Clark area. The project site is at Tazimina Falls on the Tazimina River north of Iliamna Lake. The project is a run-of-river development. The features of the project are an intake, penstock, and powerhouse at the falls and transmission line and access road.

Evaluation of the proposed project has included consideration of various factors as discussed below.

Energy Demand

Load requirements are much less than the hydraulic potential of the site. A "medium" load growth of 3 percent per year is the design basis. This gives annual energy requirements of 1834 MWh in 1986, increasing to 3216 MWh at the end of the planning period in 2005. There is the potential for significant increases in energy demand when development of a resort community proceeds at Keyes Point on Lake Clark. However, the timing of these increases is somewhat speculative. Therefore, Keyes Point is considered only in the sensitivity case of "high" load growth.

Hydrology

Tazimina River flows peak in July and August with a monthly average discharge of nearly 2100 cfs. Flows are significantly reduced in the low flow season of November through May. Therefore, flow duration curves for each of these months are developed to appropriately define hydro generation capability on a monthly basis in the power study.

Power Study

The power study defines hydro generation capability of a given installation to meet load requirements. This is done by evaluating ability to meet peak demands, ability to operate at low loads, and sufficiency of river flow for generation. Power study methodology allows consideration of appropriate hydro generation in the economic evaluation of any hydro scheme. Economics decide the optimum installed capacity by identifying the hydro scheme which has the lowest total present worth cost. The optimum installed hydro capacity is 700 kW with two units at 350 kW each. Annual hydro generation varies through the planning period as the load grows. Based on load growth projections, hydro generation is 1971 MWh in the first year of operation in 1991 and levels off at 3025 MWh in 2005.

Project Features

The shoreline intake structure is approximately 250 ft upstream of the falls on the left bank. Provisions are included for a stationary fish screen, to be installed if necessary, to exclude adult char and grayling. The 4 ft diameter penstock extends 270 ft from the intake structure to the powerhouse and is buried in the left bank. It is routed along the terrace roughly adjacent to the river. Substantial cut and fill is required because the adjacent terraces are high relative to river water level.

The steep ruggedness of the canyon below the falls limits options for powerhouse siting to obtain reasonable access for construction and for normal operations. Several alternatives are considered. Civil costs for viable powerhouse concepts are the dominate factor in defining total capital cost of the hydro project. The preferred hydro alternative is one which reduces civil capital costs and provides the lowest total present worth.

The preferred scheme (Alternative 1) uses a vertical turbine/generator arrangement. It is shown on Figure 7.3. The unit is designated as TKW by the manufacturer. The turbine runner is at the end of a water column/ lineshaft assembly at the bottom of a drilled hole. Flow returns to the river channel by a tailrace tunnel. This machine arrangement is similar to a pump in a well. However, it is a turbine with adjustable wicket gates which is needed to meet the widely varying load requirements. At full output, the total hydraulic capacity of the two units is about 100 cfs.

The project access road is from the existing Newhalen-Nondalton road to the project site. The road is routed north of Alexcy Lake to avoid stream crossings and associated aquatic impacts. The transmission line is a 24 kV system buried along an alignment immediately adjacent to the access road. The line ties into the existing line running north to Nondalton. The access road and the transmission line are both 6.7 miles long.

Alternatives

Alternative powerhouse arrangements and locations studied in the process of selecting an appropriate scheme of hydro development are as follows.

Alternative 2 - Canyon powerhouse with access and penstock routing down canyon wall.

Alternative 3 - Underground powerhouse

Alternative 4 - Canyon powerhouse with access and penstock routing in vertical shaft

Alternative 5 - Downstream canyon powerhouse with vertical shaft

The second least costly concept (Alternative 3), is an underground powerhouse as shown on Figure 7.5. This arrangement provides personnel access and penstock routing in a vertical shaft. The more conventional powerhouse layout allows the use of one 700 kW crossflow unit to meet load requirements. Other alternatives using powerhouse arrangements within the canyon were considered. Increased civil requirements, particularly for additional buried penstock, result in higher project costs.

Environmental Assessment

The major factor in assessing environmental impact of the proposed hydro project is consideration of fishery resources. Sockeye salmon spawn on the lower Tazimina River below the falls. Sport fishing for rainbow trout is significant below the falls. Arctic grayling and char occur throughout the Tazimina drainage. Field investigations include a general survey of the Tazimina River below Upper Tazimina Lake in 1981. Site-specific work occurred in May 1982, July 1985, August 1985, and May 1986. High velocities and hard substrates at the falls offer poor habitat. Little if any successful spawning occurs in the canyon near the falls. With proper mitigative measures, the powerhouse and tailrace should not have a negative impact upon fish. Low numbers of resident grayling and char occur at the intake site. The construction of the access road to the project site will improve human access to the area. This will result in increased fishing pressure on resources. This is perhaps the greatest impact of the project.

An archeological survey of the project area was done in May 1986. The project site at the falls has no archeological potential. The river terrace above the Tazimina River has a very high archeological potential. Two cultural remains were found during the survey along the edge of the river terrace northeast of Alexcy Lake on the access road alignment. Prior to or during construction, further investigation of the river terrace area may be required. This is not expected to be a significant impact on project feasibility.

Based on the above findings, there are no impacts from the project that would preclude its development.

Project Costs

To estimate direct costs for hydro alternatives, quantities are developed from layouts and site-specific unit costs are applied. The total estimated capital cost of each hydro alternative is given below.

Alternative	Description	Total Estimated Capital Cost ($000)
1	Well Scheme	7,400
3	Underground PH with vertical shaft	7,900
2	Canyon PH with access down canyon wall	8,500
4	Canyon PH with vertical shaft	8,900
5	D/S Canyon PH with vertical shaft	10,200

Each estimate includes allowance for indeterminates at 10 percent of direct costs. Also included are the indirect costs of engineering and design, construction management, and interest during construction. Cost of land is not included in the estimates.

Economic Evaluation

To analyze economic feasibility of hydro development, alternatives are compared to the diesel base case on a total present worth cost basis. The base case is the continuation of diesel power generation. Comparison is by present worth ratio (PWR). Present worth ratio is obtained by dividing the present worth of the hydro scheme into the present worth for the diesel base case. A PWR greater than 1.0 indicates that the hydro case is more economically attractive than the diesel base case. Conversely, a PWR of less than 1.0 indicates that the diesel base case is more attractive than the alternative being compared.

Hydro alternatives and their economic feasibility versus the diesel base case are evaluated on the basis of "medium" parameters. These represent the most likely scenarios for future load growth, diesel fuel escalation, and discount rate. Sensitivity cases for the preferred hydro alternative consider economic feasibility for variations in parameters to "high" and/or "low" values.

Diesel fuel base cost is from current 1986 prices and is escalated accordingly to reflect changing fuel prices through the economic study period. The base price of fuel used in this study is $1.10 per gallon. For the "medium" case, diesel fuel escalation is 2.8 percent per year from 1987 through 2005. This results in a fuel price in 2005 of $1.86 per gallon. It is assumed that fuel costs remain constant with no further price escalation in the remaining years of the economic analysis.

Hydro Alternatives 1 and 3 were evaluated in present worth analyses to determine the preferred scheme. These alternatives have the two lowest capital costs. The present worth comparison using "medium" case criteria is given below.

Alternative	Hydro Present Worth Cost ($000)	Diesel Base Present Worth Cost ($000)	Present Worth Ratio (PWR)
No. 1 - Well Scheme with 2 TKW units @ 350 kW (700 kW)	11,181	12,510	1.12
No. 3 - Underground powerhouse 1 crossflow @ 700 kW	11,768	12,510	1.06

Alternative 1 is the preferred hydro scheme because it has the lower total present worth cost. Furthermore, the PWR of 1.12 shows that Alternative 1 is 12 percent less costly than continuing with diesel generation.

The sensitivity of PWR for variation in parameters is considered for Alternative 1. This includes analysis of a 1000 kW hydro development to meet the high load growth forecast. The results indicate that the 700 kW hydro scheme has an advantage over diesel for high load growth when the benefit of additional hydro generation is realized. The PWR is 1.36. For variation in other parameters, diesel generation is less costly with PWR's from 0.87 to 0.99. The 1,000 kW hydro development shows a slight advantage with a PWR of 1.05. It has a substantial advantage over the diesel base case in meeting high load growth requirements.

Results of the economic evaluation are sensitive to diesel fuel cost. The

1986 cost of fuel is relatively low compared to recent years. Using the current fuel cost of $1.10 per gallon, the hydroelectric development has some economic advantage over the base case. Future change in diesel fuel prices could bring a more favorable advantage to development of the hydroelectric project.

Project Schedule

The initial operation of the hydro project is anticipated at the beginning of 1991. This is based on filing a FERC license application by April 1987. Then, allowing 18 months for the FERC process, a license should be issued by October 1988. Construction could start in May 1989.

Conclusions

The Tazimina River Hydroelectric Project is found to be technically and environmentally feasible. It is also economically feasible based on "medium" criteria. However, its economic feasibility is sensitive to assumptions regarding future load growth in the area and future cost of diesel fuel.

SECTION 2

INTRODUCTION

2.1 BACKGROUND

The state of Alaska in recent years has been taking steps to address energy problems in remote regions of the state. The state has undertaken studies to evaluate potential alternative sources of electrical energy production. Hydroelectric power is recognized as one of the renewable energy sources which could provide an economical option to more expensive diesel generation, the prevalent source of electrical energy in many remote areas.

The Bristol Bay region (see Figure 2.1) relies primarily on diesel fuel for electricity generation. The cost of energy production has increased rapidly in recent years, due not only to world-wide price escalation of fuel oil, but also to regional factors. Even though fuel oil prices have declined in the mid-1980's, the cost of electrical energy production in remote areas served by small diesel generator systems is substantially larger than that of interconnected central systems in larger population centers of Alaska and in other parts of the United States.

In 1980, a reconnaissance study by R. W. Retherford Associates for the Alaska Power Authority (APA), evaluated the feasibility of potential hydroelectric developments in the Bristol Bay region. Projects were identified which were considered attractive for limited areas. The Retherford study also evaluated a regional hydro site on the Tazimina River. Based on the Retherford recommendation, the Power Authority retained Stone & Webster Engineering Corporation (SWEC) in July 1981 to undertake the Bristol Bay Regional Power Plan and Detailed Feasibility Analysis. The purpose of this study was to assess the technical, economic, and environmental aspects of regional alternative electric power generation plans. A specific objective of the study was to evaluate in detail the feasibility of a regional Tazimina Hydroelectric Project. The results of this study are presented in the Interim Feasibility Assessment

(IFA) dated July 1982. The IFA identified the attractiveness of developing a 16 MW Newhalen River Hydroelectric Project.

Fisheries investigations on the Newhalen River were conducted in 1982-1985 to evaluate potential impacts of hydro development. In 1985, SWEC conducted an updated economic evaluation of selected promising alternatives from the IFA. Updated economic parameters including current diesel fuel prices were used to reassess economic feasibility. Based on the results of this evaluation, the Power Authority concluded that the Newhalen Project and other regional projects are not economical at the present time due to declining oil prices and the relatively large capital cost of the projects. Although a regional power grid system for a power supply system could still be the long term answer for reliable power for the Bristol Bay Region, current electrical loads are too low to justify the magnitude of the required capital investment.

The problem of high diesel fuel prices is more acute in the northeast portion of the Bristol Bay region around Iliamna Lake and Lake Clark. Charges for river barge transportation add to the cost of diesel fuel. The communities of Iliamna, Newhalen, and Nondalton are served by Iliamna-Newhalen-Nondalton Electric Cooperative (INNEC). In addition, there is the potential for significant increases in energy demand as development of a resort community proceeds at Keyes Point on Lake Clark.

The Tazimina River Hydroelectric Project evaluated in this feasibility report is an alternative generation source for the area served by INNEC. This subregional project was previously identified and considered in the IFA. The 1985 economic update indicated an apparent benefit for its development. The present, more detailed feasibility study provides the basis for deciding whether to proceed with further licensing activities and engineering and design.

2.2 GENERAL

The site of the proposed project is at Tazimina Falls on the Tazimina River north of Iliamna Lake. It is about 12 miles northeast of the community of

Iliamna and about 175 miles southwest of Anchorage. Figures 2.1 and 2.2 define the project location. The Tazimina River lies in the Alaska-Aleutian Range physiographic province. Broad glaciated valleys lie between rugged, snow-capped glaciated ridges. Many lakes, such as the Tazimina Lakes upstream of the project site, occupy parts of these glaciated valleys.

The Tazimina River has its headwaters in the Aleutian Range and flows to the west. Lower Tazimina Lake is approximately 8 miles upstream of the falls. Immediately below the falls a rugged, steep-walled canyon extends for about one mile. The river runs on a steep gradient through a series of rapids in the canyon. The river enters Sixmile Lake in the Newhalen River drainage approximately 9.5 miles downstream of the falls.

Weather patterns are largely controlled by oceanic influences and therefore the area has a relatively narrow range of seasonal temperature changes compared to interior Alaska. Clouds, fog, and precipitation are frequent but are moderated somewhat inland. Winters are long with moderate snow cover.

The project is a run-of-river development. The components of the project are an intake, penstock, powerhouse, transmission line, and access road. These features are discussed in detail in Section 7.

2.3 PURPOSE

The purpose of the feasibility study is to assess the technical, economic, and environmental aspects of the subregional, run-of-river Tazimina River Hydroelectric Project. A specific objective of the study is to compare the benefits of the project with continuing dependence on diesel generation for the area's electric power needs.

2.4 SCOPE OF WORK

The feasibility study has been completed for the Power Authority by SWEC in accordance with Amendment No. 11 to Contract No. 855003. The work performed during the feasibility study is defined in the following specific tasks.

Energy Demand Analysis: Review and evaluate electrical energy requirements of the three intertied communities (Iliamna, Newhalen, Nondalton) and identify appropriate energy forecasts. Potential load increases from development at Keyes Point are also considered.

Environmental Assessment: Evaluate the proposed development with respect to aquatic, terrestrial, archeological, water use, and aesthetic factors.

Hydrologic Analysis: Evaluate available flow records to estimate Tazimina River flows for power production.

Power Study: Evaluate hydro generation capability and determine range of installed capacity to suit energy demand forecast.

Geotechnical Analysis: Review and evaluate available geologic information for the area. Develop site-specific geotechnical information through limited field work to provide input to preliminary engineering.

Preliminary Engineering: Identify and evaluate various alternative project concepts. Layouts are developed in sufficient detail to support comparative cost estimates.

Cost Estimates: Develop comparative feasibility-level capital cost estimates.

Economic Evaluation: Define optimum installed hydroelectric capacity by evaluating total present worth of the preferred hydro concept and evaluate economic feasibility of the hydro scheme versus diesel generation.

Feasibility Report: Prepare a feasibility report documenting the results of the above tasks including methods and conclusions.

The following sections of this report present the methodology and results of the work performed in accordance with the above scope of work and our conclusions regarding project feasibility.

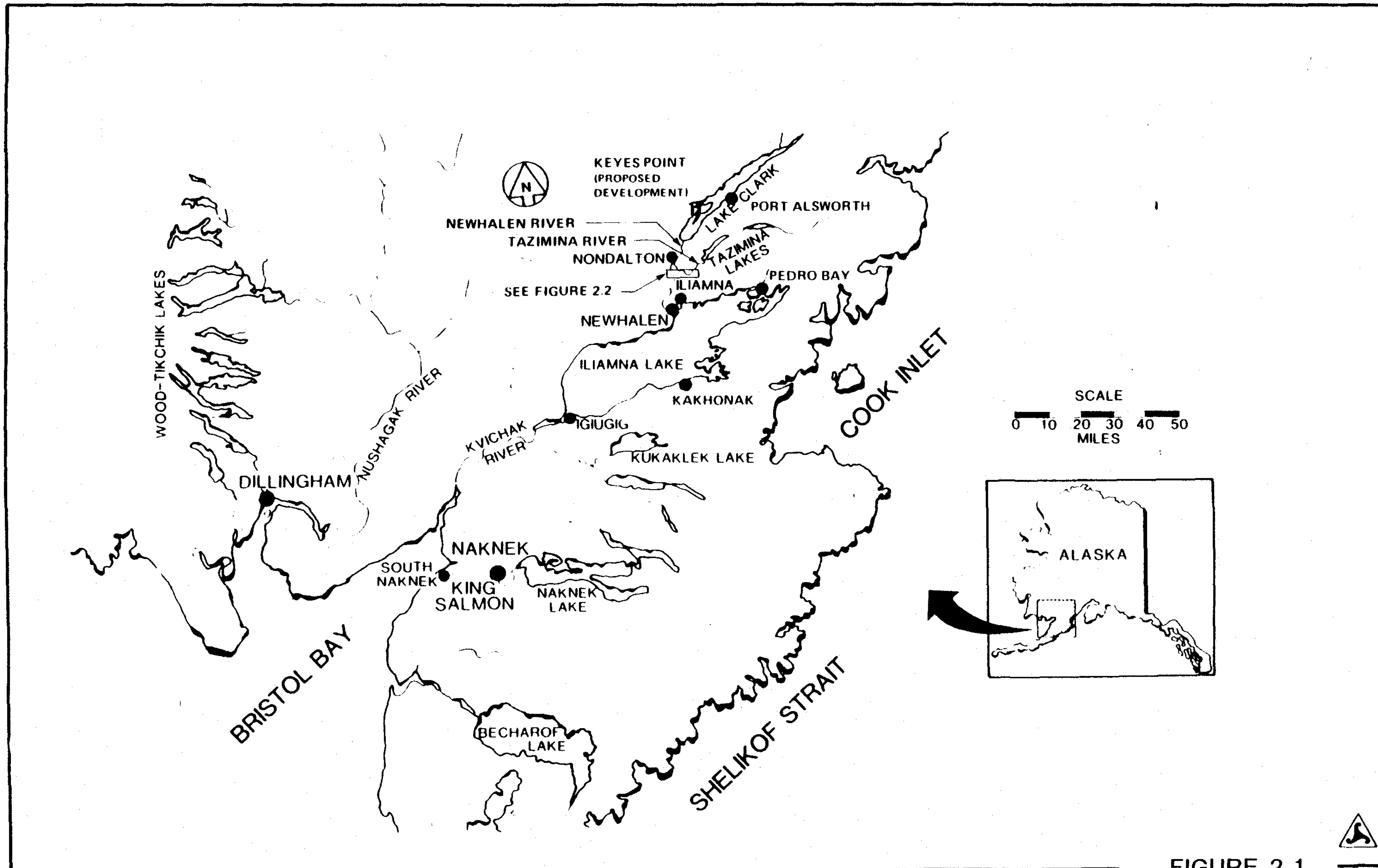
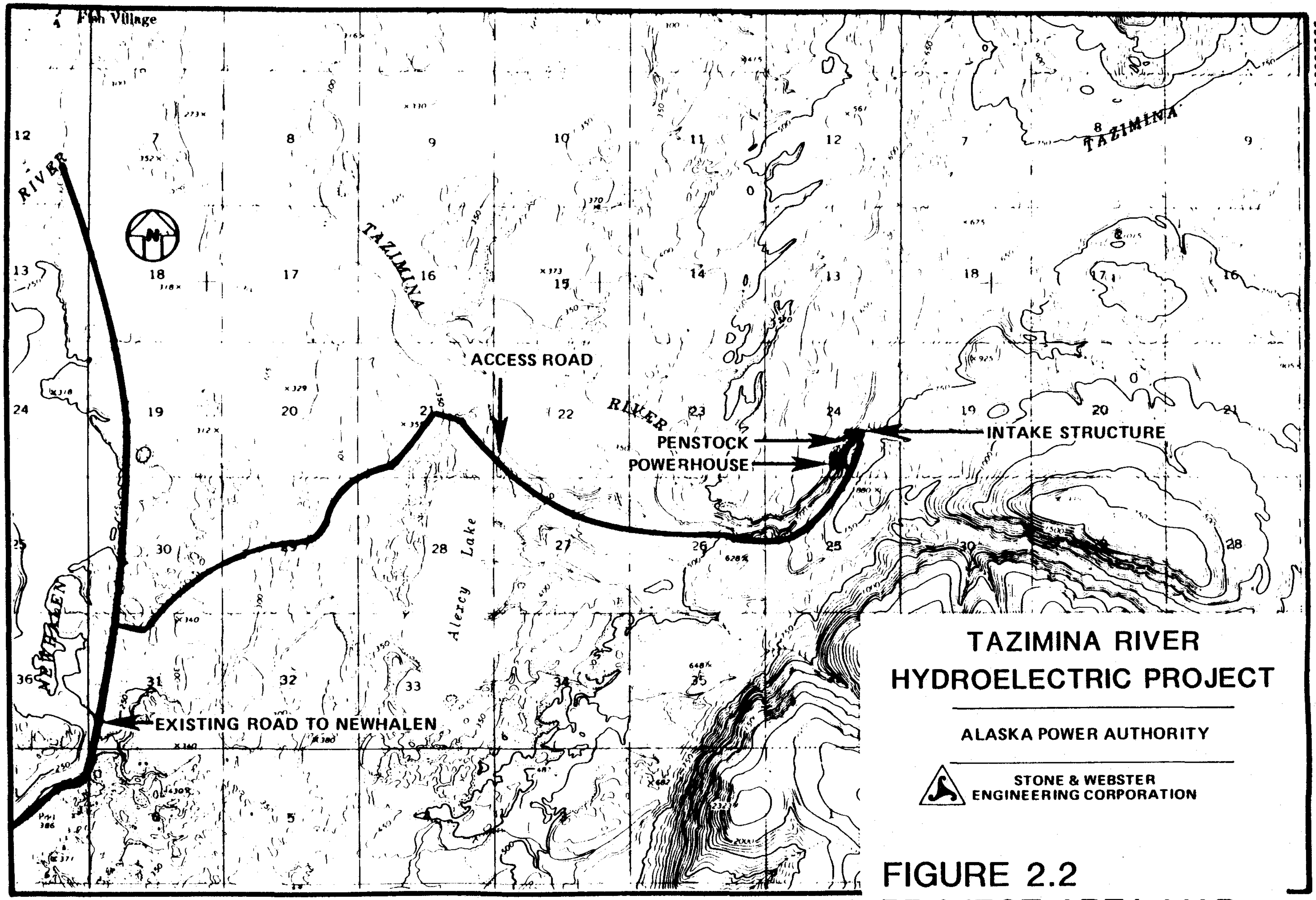


FIGURE 2.1
LOCATION MAP



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TAZIMINA RIVER HYDROELECTRIC PROJECT

ALASKA POWER AUTHORITY

STONE & WEBSTER ENGINEERING CORPORATION

FIGURE 2.2 PROJECT AREA MAP

SECTION 3

ENERGY DEMAND

3.1 INPUT AND ASSUMPTIONS

Iliamna-Newhalen-Nondalton Electric Cooperative (INNEC) operating records provide monthly generation requirements for January 1984 through February 1986 for Iliamna, Newhalen, and Nondalton. Monthly peak demand information is available for November 1983 through June 1985. Monthly demand information is complete for 1984. This defines the relationship of monthly peak to annual peak given in Table 3.1. The annual peak occurs in December. It is assumed for all months that the minimum load is 25 percent of the peak. Evaluation of monthly peak demands allows definition of monthly energy requirements. This leads to definition of appropriate hydro energy capability based on consideration of seasonally varying river flow.

The information for 1984 defines an annual load factor of 45.4 percent which means the maximum load is 2.2 times the annual average load. This relationship is used in this study to define peak annual load based on energy forecasts. INNEC energy forecasts are defined as fixed percentage annual growth based on actual requirements in 1985 of 1,780 MWh.

Keyes Point is a planned resort community located north of Nondalton on Lake Clark. Initial phases of development are presently beginning. The majority of the homes would be occupied part-time from May to October during fishing and hunting seasons. Light commercial development including lodges is also anticipated. Estimated energy requirements and timing of their occurrence are somewhat speculative at this time. Therefore, Keyes Point is considered only in the sensitivity case of "high" growth. The Keyes Point forecast is defined in Table 3.2.

Other communities in the area may at some time in the future join the existing intertied system. These include Port Alsworth, Pedro Bay, and Kakhonak. The loads are relatively small and the timing of any intertie work is undefined. Therefore, these three communities are not included in load forecasts for this study.

3.2 ENERGY FORECASTS

Three load growth forecasts are defined for this study. "Medium" growth is the design basis and "low" and "high" growth are sensitivity cases. In accordance with APA guidelines, it is assumed that after the last year of the planning period (2005) no further load growth occurs.

Load growth assumptions for INNEC are as follows:

Low growth: 1.5 percent per year
Medium growth: 3.0 percent per year
High growth: 3.0 percent per year plus Keyes Point

These three load forecasts are graphed for comparison in Figure 3.1. Table 3.2 shows the Keyes Point load growth forecast and the INNEC medium load growth forecast is listed in Table 3.3.

TABLE 3.1

MONTHLY PEAK DEMANDS

MONTH	RATIO OF MONTHLY PEAK TO ANNUAL PEAK*
January	0.74
February	0.79
March	0.70
April	0.67
May	0.63
June	0.49
July	0.55
August	0.55
September	0.86
October	0.88
November	0.97
December	1.00

*Based on INNEC records for 1984.

TABLE 3.2

KEYES POINT LOAD GROWTH FORECAST

YEAR	ENERGY USE, MWH*
1986	0
1987	128
1988	294
1989	552
1990	902
1991	1012
1992	1266
1993	1376
1994	1511
1995	1596
1996-2040	1681

* APA letter March 25, 1986

TABLE 3.3

MEDIUM LOAD GROWTH FORECAST

YEAR	ENERGY USE, MWH*
1986	1834
1987	1889
1988	1946
1989	2004
1990	2064
1991	2126
1992	2190
1993	2255
1994	2323
1995	2393
1996	2465
1997	2539
1998	2615
1999	2693
2000	2774
2001	2857
2002	2943
2003	3031
2004	3122
2005-2040	3216

*3 percent per year

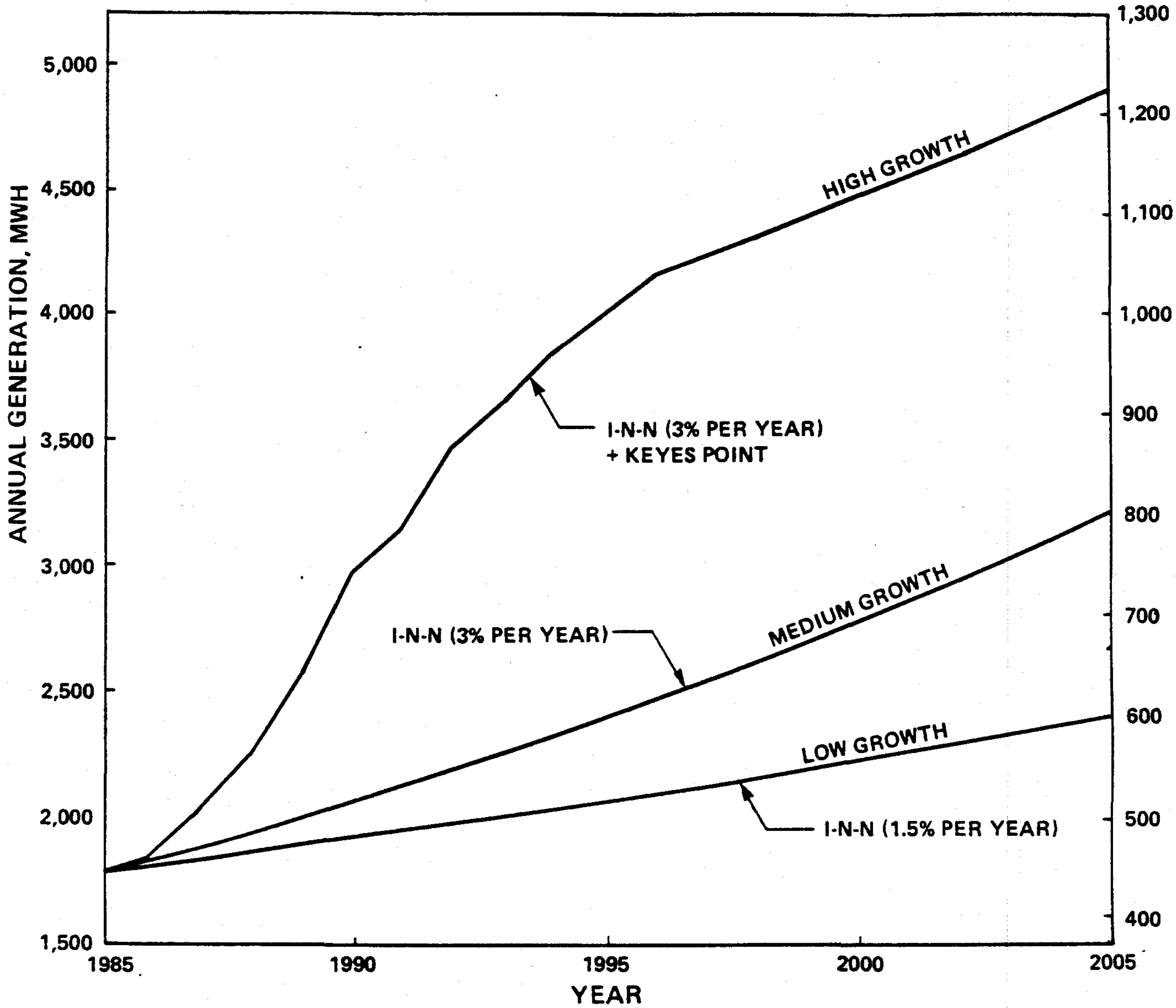

FIGURE 3.1
LOAD FORECASTS
TAZIMINA RIVER
HYDROELECTRIC PROJECT

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SECTION 4

HYDROLOGIC ANALYSIS

4.1 FLOW RECORDS

Available flow records on the Tazimina River are from a USGS gage 2.1 miles upstream of Tazimina Falls and the project site. There are 52 months of Tazimina River flow records from June 1981 to September 1985. Of these, 41 months (May 1982 to September 1985) are coincident with flow records for the Newhalen River. On the Newhalen River, 236 months of data are available from July 1951 to September 1967 and May 1982 to September 1985. Tazimina River flow records are included in Appendix A. The maximum discharge of record is 5,560 cfs on September 30, 1985.

4.2 METHODS

Average monthly flows are used in the hydrologic analysis to define correlations for estimating Tazimina River flows and to define flow duration curves. This is appropriate since the short term of Tazimina River flow records provides a limited basis for evaluation.

Previous work to analyze Tazimina River flows was done for the Interim Feasibility Assessment (IFA) of July 1982. At that time, due to lack of Tazimina River records, two methods using multiple regressions were defined for estimating Tazimina River flows. This work is documented in the 1982 Interim Feasibility Assessment, Volume 4, Appendix I, Hydrologic Evaluations - Tazimina River. For the current feasibility study, these two methods are reviewed and evaluated using available flow data. Then a third direct correlation is developed based on the available term of coincident Tazimina/Newhalen record. The three methods are then compared to actual records to determine the best method for estimating a longer term of Tazimina River flows.

Method 1 from 1982 relates Newhalen River flows to those on the Tazimina River. The relationship was derived from extension of Newhalen River flows by correlation to temperature and precipitation at Iliamna. Then by a second correlation, Newhalen River flows were related to Tanalian River flows and thus to the Tazimina River. The Tanalian drainage is directly north of the Tazimina River and the drainage area is of similar size. This method was tested by comparison to actual Tazimina River flows for the 41 coincident months.

Method 2 from 1982 relates temperature and precipitation at Port Alsworth to Tazimina River flow. Port Alsworth is on Lake Clark near the mouth of the Tanalian River. The relationship was derived from extension of Port Alsworth temperature and precipitation by correlation to temperature and precipitation at Iliamna. Then by a second correlation, Port Alsworth temperature and precipitation was related to Tanalian River flows and thus to the Tazimina River. This method was tested by comparison to the 52 months of existing Tazimina River records.

Method 3 of estimating Tazimina River flows was developed during the present study effort. Based on the 41 months of coincident record, a direct correlation was established between Newhalen River flows and Tazimina River flows. Two relationships were defined to account for seasonal effects during the year. One correlation relates to the "wet" season of June through October, the other applies to the "dry" or low flow season of November through May. By comparison to actual Tazimina River flows, this direct correlation provides the best estimate from the three methods.

4.3 FLOW DURATION CURVES

Using Method 3, the 236 average monthly flow values for the Newhalen River are used to estimate Tazimina River monthly flows. Average discharge ranges from over 100 cfs in March and April to nearly 2100 cfs in July and August. This is depicted in Figure 4.1. Annual and seasonal flow duration curves are also developed as shown in Figure 4.2. This shows the significant difference in flow regime in each of the two seasons. During the high flow season, discharges exceed 1000 cfs. In the low flow season, discharge is significantly reduced to affect hydro capability. Monthly flow duration curves are defined for November through May as shown in Figures 4.3 through 4.9, respectively. This allows proper consideration in the power study of water shortfall for hydro generation to meet energy requirements defined on a monthly basis.

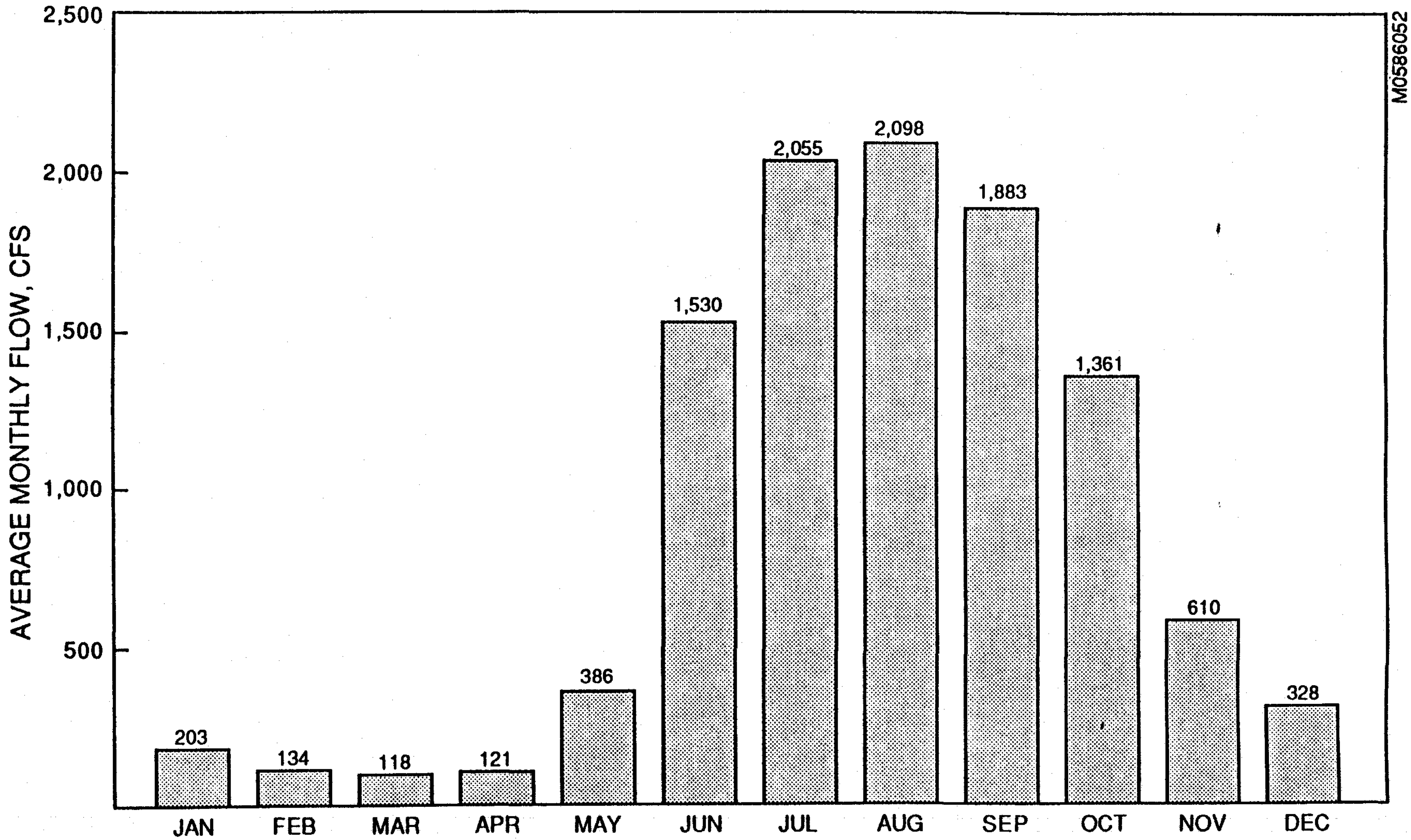

FIGURE 4.1

ESTIMATED AVERAGE MONTHLY FLOWS
TAZIMINA RIVER, 2.1 MILES UPSTREAM OF FALLS

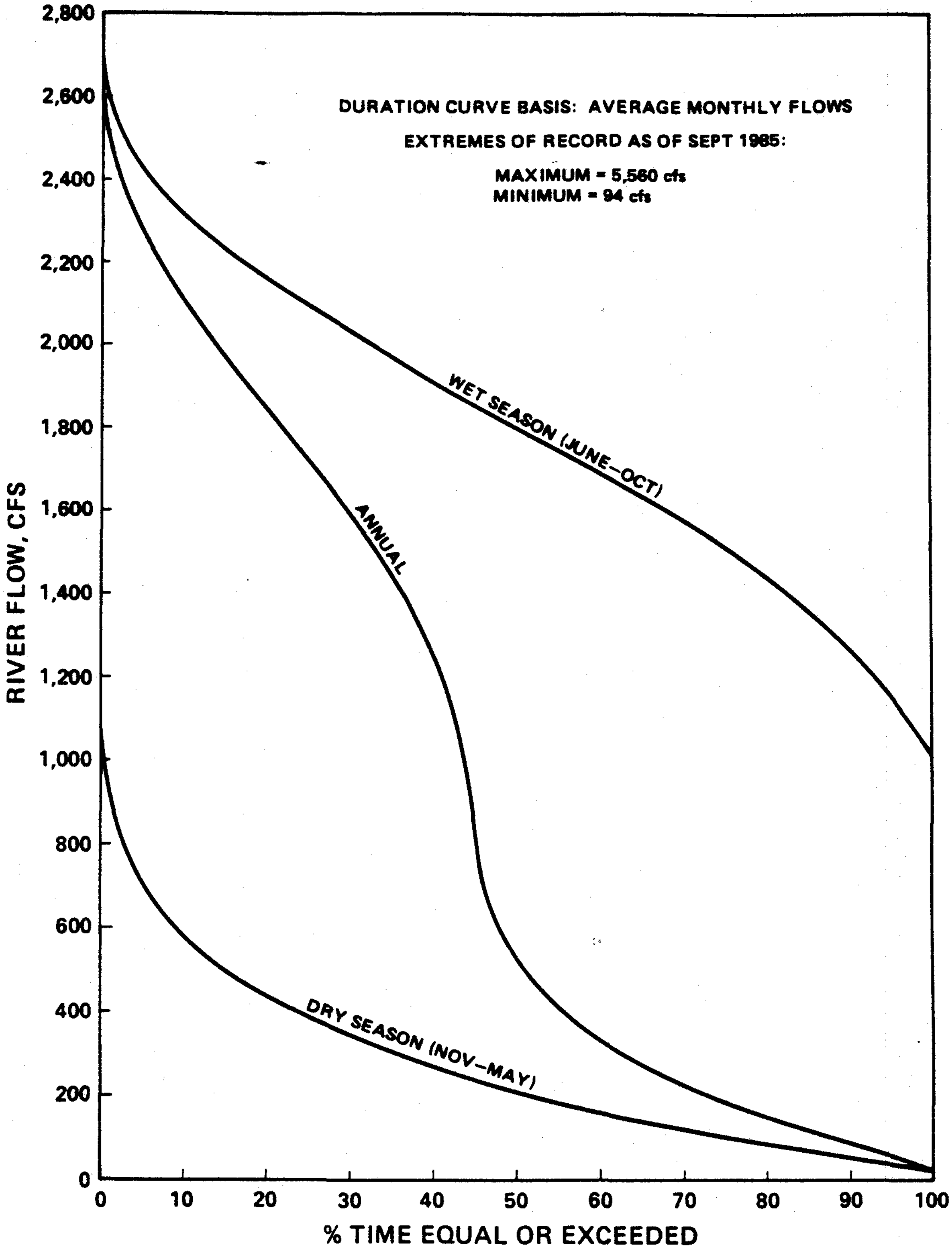

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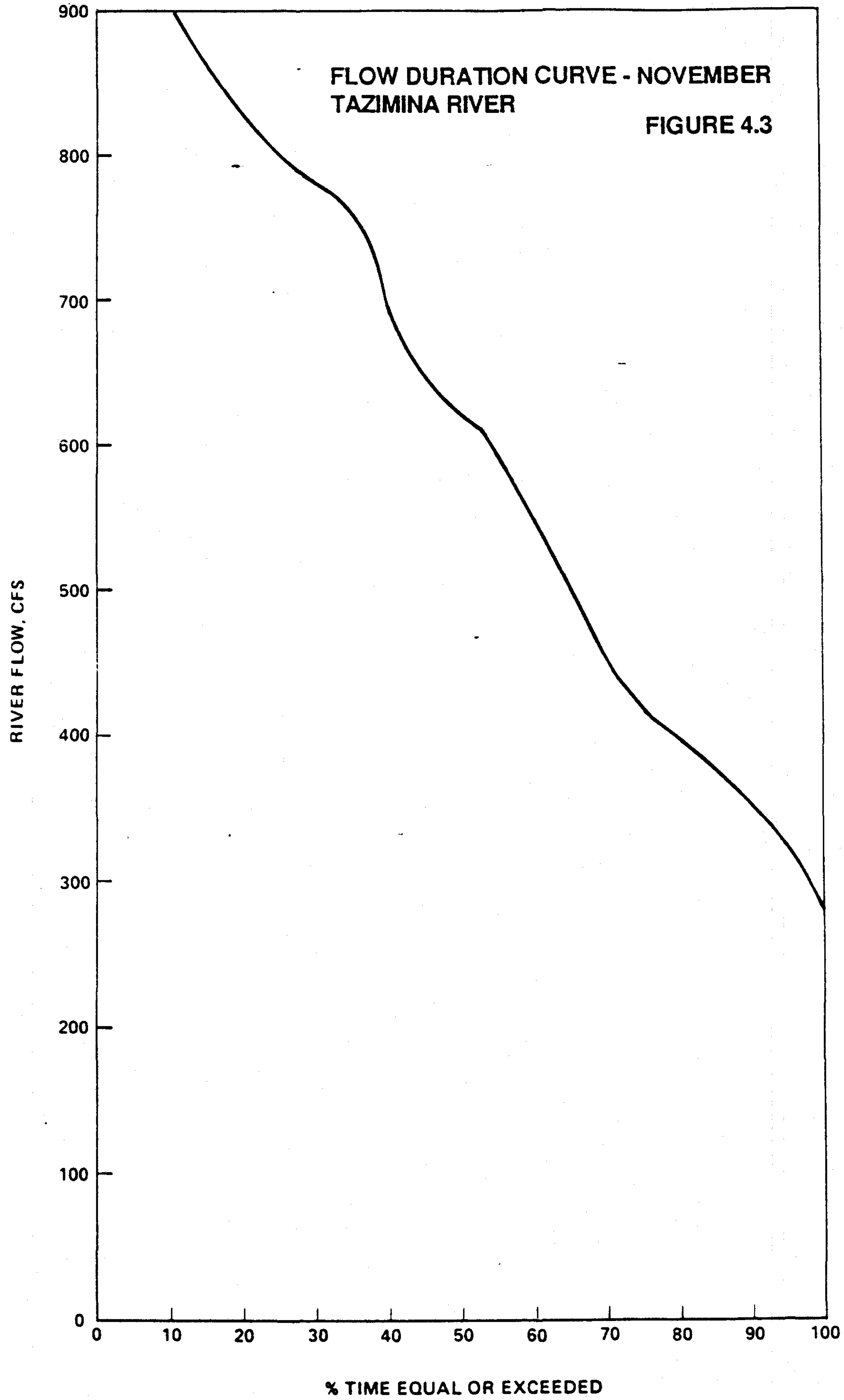
FIGURE 4.2

ANNUAL FLOW DURATION CURVE
TAZIMINA RIVER, 2.1 MILES
UPSTREAM OF FALLS


FLOW DURATION CURVE - NOVEMBER
TAZIMINA RIVER
FIGURE 4.3
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED

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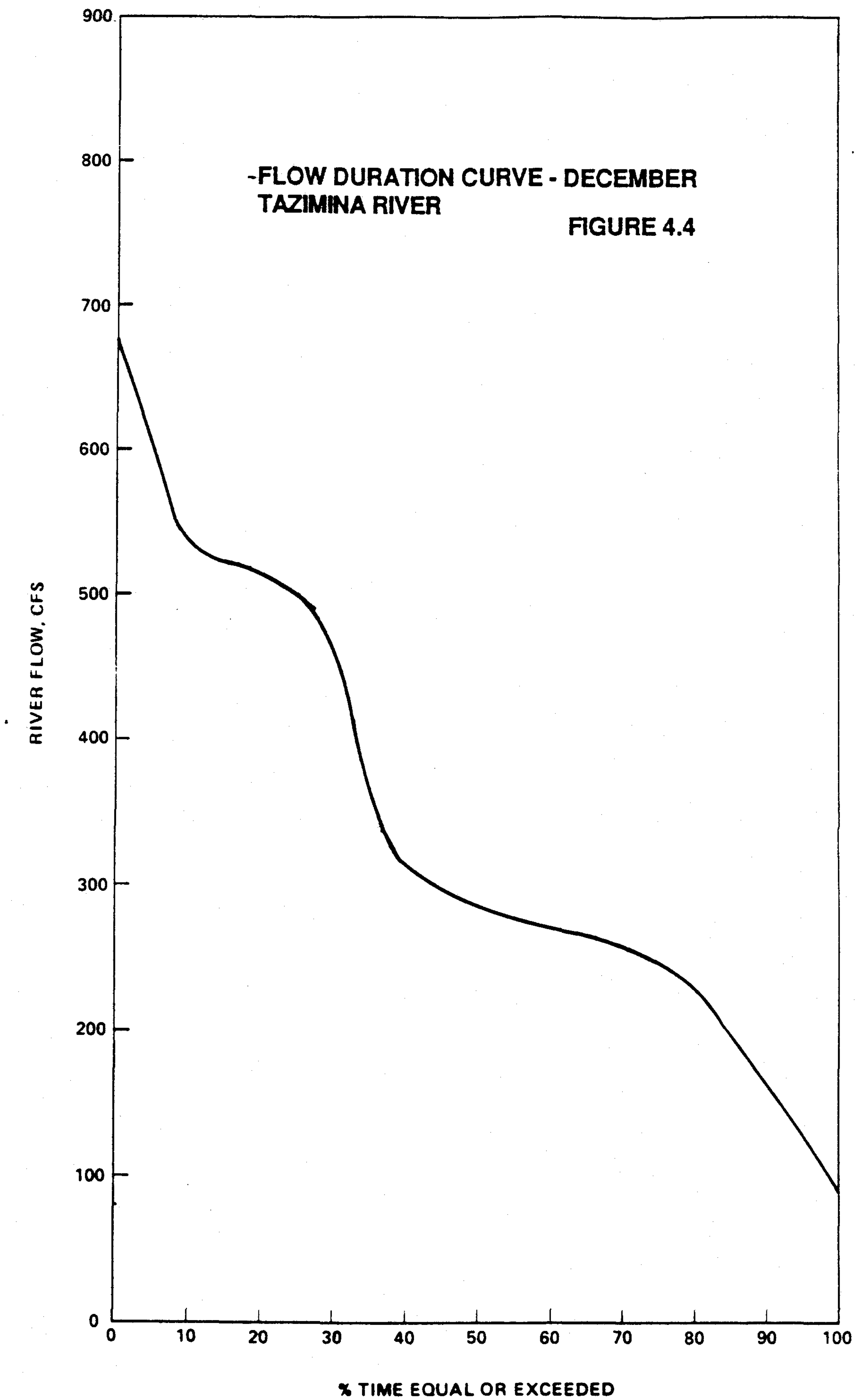
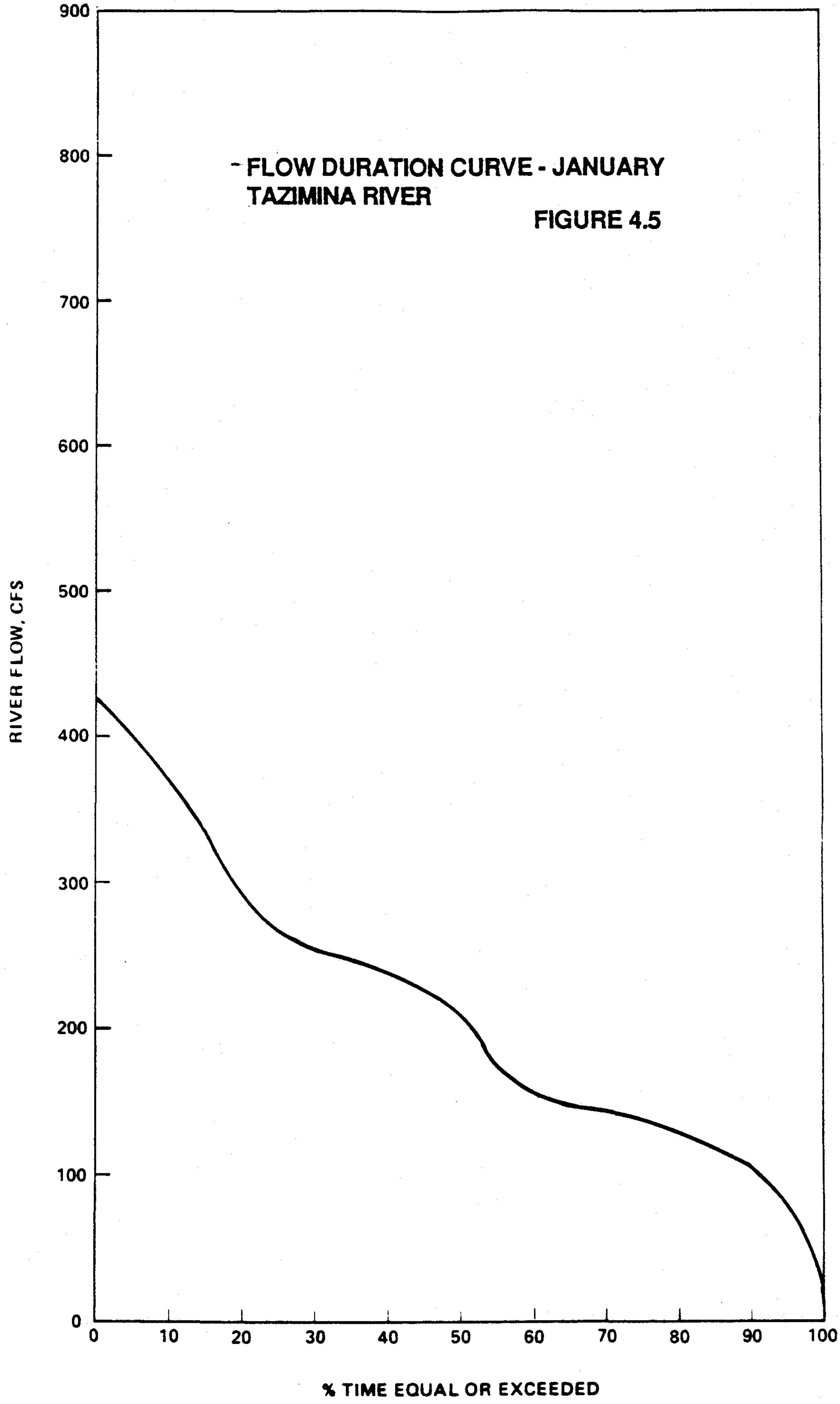

-FLOW DURATION CURVE - DECEMBER
TAZIMINA RIVER
FIGURE 4.4
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED


FLOW DURATION CURVE - JANUARY
TAZIMINA RIVER
FIGURE 4.5
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED

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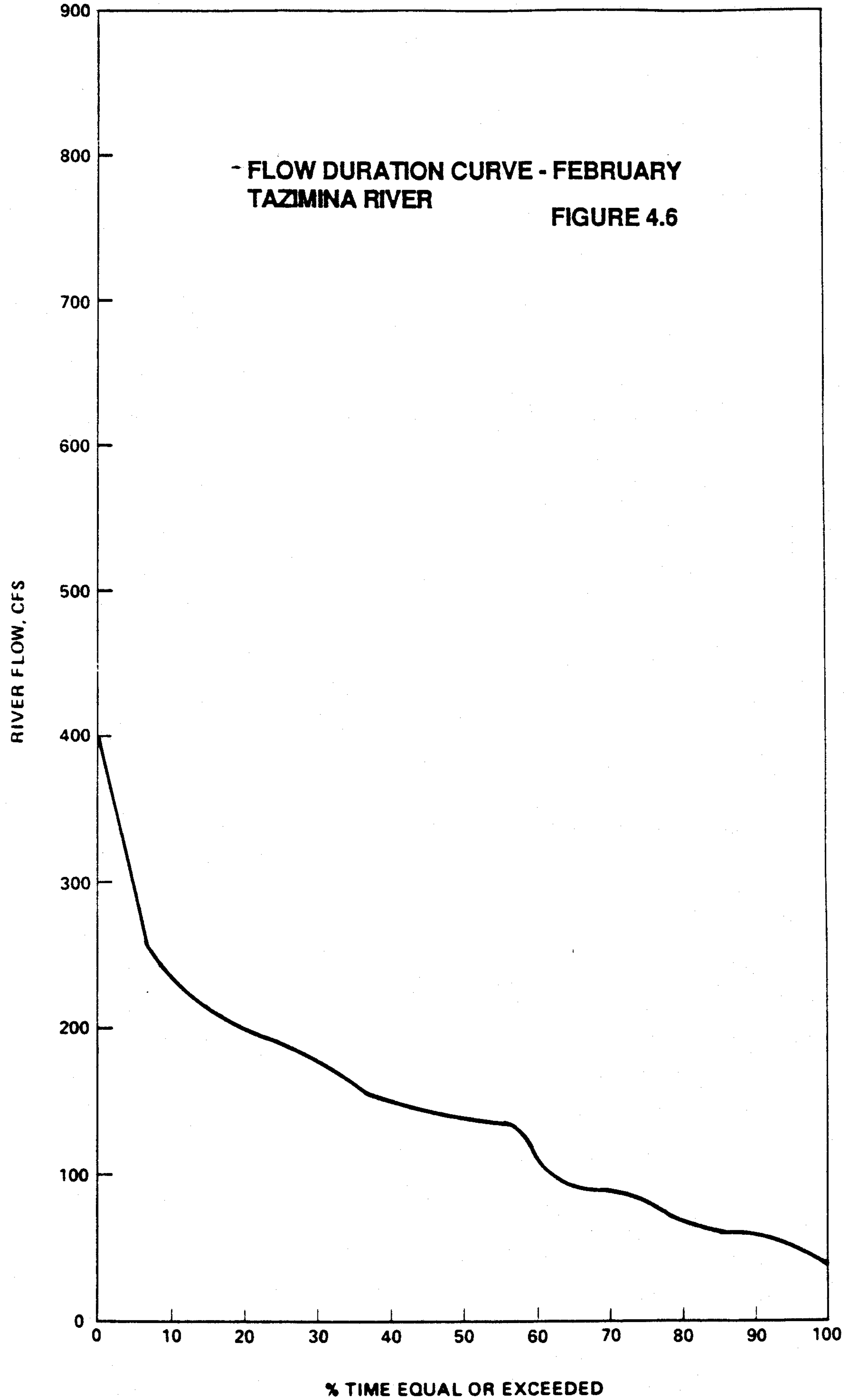
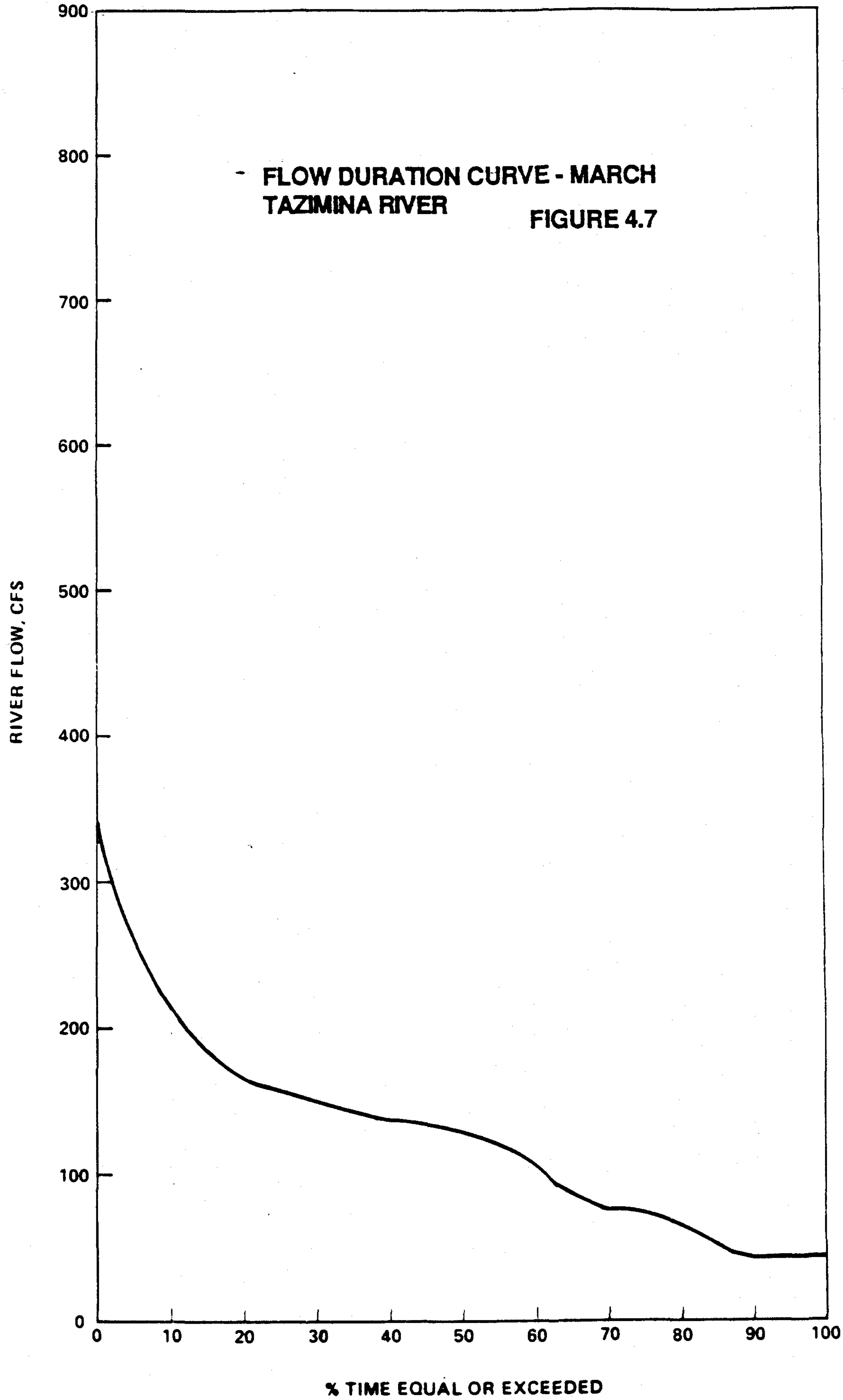

FLOW DURATION CURVE - FEBRUARY
TAZIMINA RIVER
FIGURE 4.6
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED


FLOW DURATION CURVE - MARCH
TAZIMINA RIVER
FIGURE 4.7
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED

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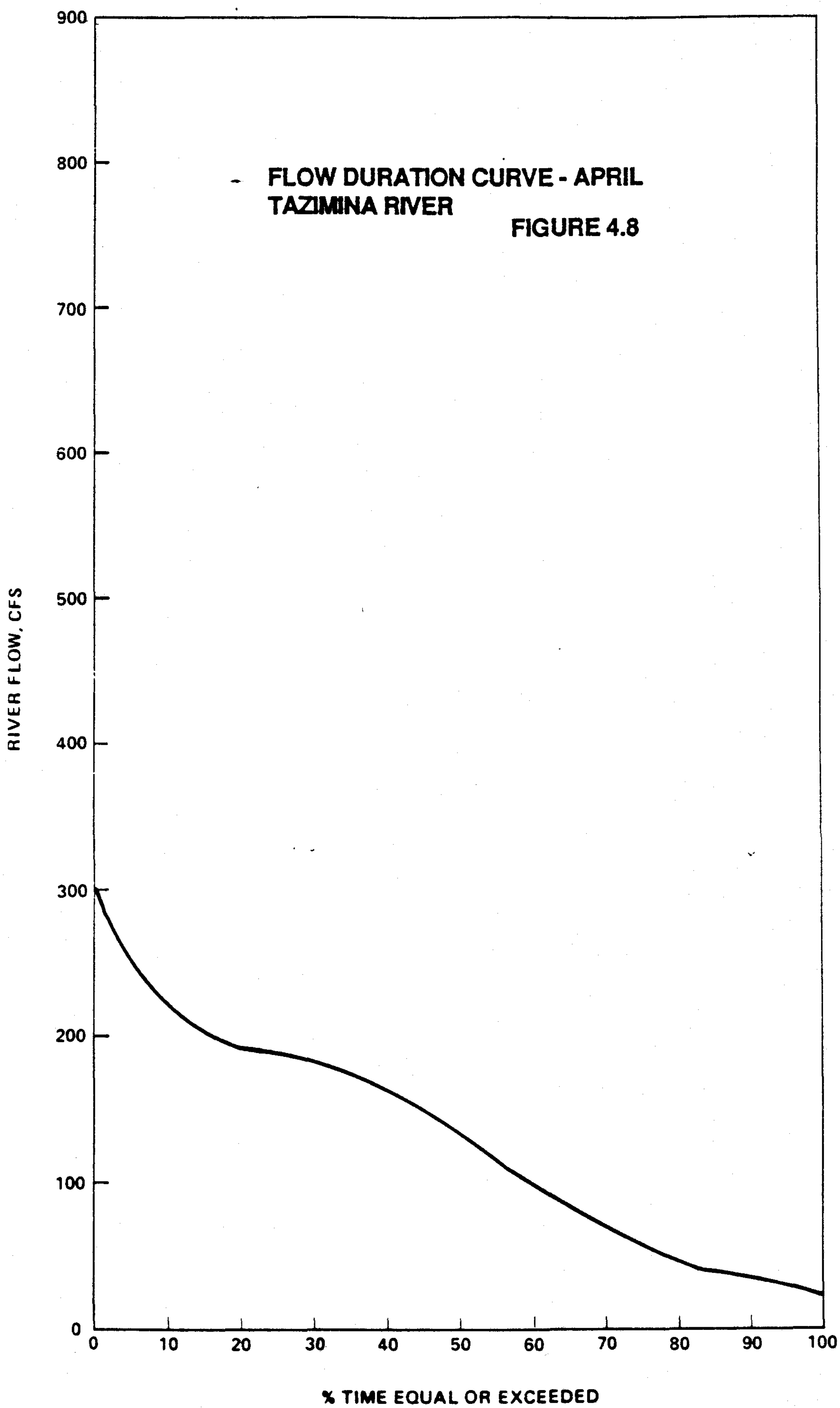
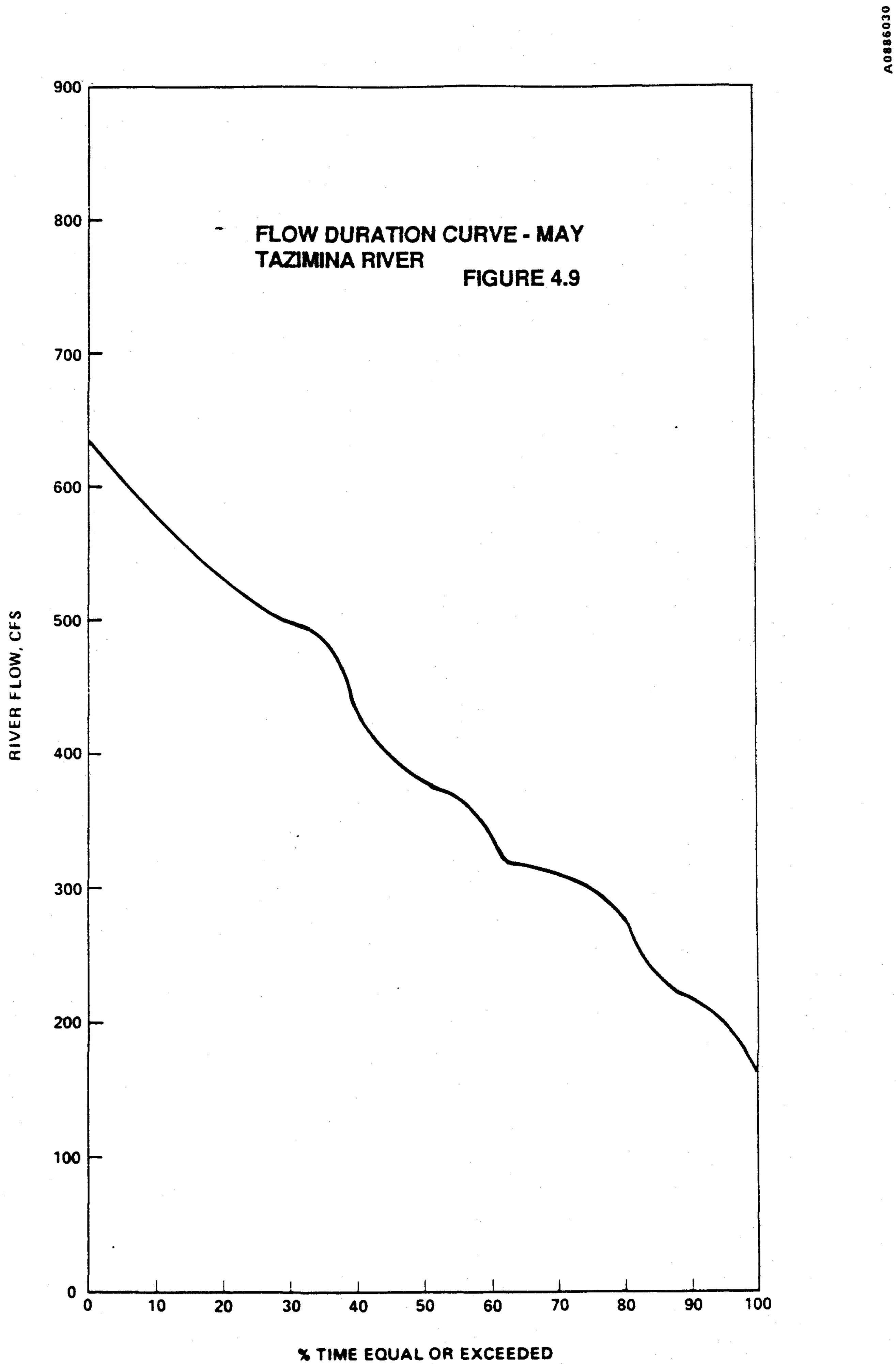

FLOW DURATION CURVE - APRIL
TAZIMINA RIVER
FIGURE 4.8
RIVER FLOW, CFS
% TIME EQUAL OR EXCEEDED
0
100
200
300
400
500
600
700
800
900
0
10
20
30
40
50
60
70
80
90
100
A086028


FLOW DURATION CURVE - MAY
TAZIMINA RIVER
FIGURE 4.9
RIVER FLOW, CFS
900
800
700
600
500
400
300
200
100
0
0
10
20
30
40
50
60
70
80
90
100
% TIME EQUAL OR EXCEEDED
A0886030

SECTION 5

POWER STUDY

The purpose of the power study is to trial-size the hydroelectric installation and to develop and evaluate a formulation to define dependable hydro capability. Initial sizing of the hydro installation is based on consideration of the peak and minimum demands for initial operation in 1991 and the ultimate demand as forecasted for 2005 for medium load growth. The objective is to provide sufficient capacity toward meeting peak demands while not sacrificing capability to operate in lower load ranges. Analysis of various installed capacities shows that the incremental expenditure for higher capacity turbine-generator equipment is offset by the benefit of increased hydro generation through the years.

Once trial sizes of hydro development are identified, it is necessary to evaluate hydro generation capability of a particular scheme. In this study, three types of turbine equipment are considered as discussed in Section 7.4. They are horizontal Francis, crossflow, and TKW units. Purely on the basis of energy production, crossflow units are beneficial because of the ability to operate over a wide range. The definition of hydro capability is affected by deficiency to meet peak demands, deficiency to operate at low loads, and inability to generate due to lack of river flow. Consideration of these factors gives an accurate estimate of dependable hydro generation. The three factors are systematically evaluated on a monthly basis for each trial capacity. The evaluation is based on load requirements, available river flow, installed capacity, and turbine characteristics. The formulation for evaluating hydro capability is shown in the sample worksheet in Table 5.1. A constant net head of 100 ft is used in this study. Variation in net head is insignificant for power estimates at this site and is neglected.

Referring to Table 5.1, columns 2-7 and 16 analyze peak demand. Monthly system peaks are defined on the basis of data in Table 3.1. Columns 8-15 evaluate river flow deficiency. The monthly flow duration curves for November through May, as defined in Section 4, are used. Columns 17-22 analyze low load capability. The estimate of hydro generation, or capability, is in Column 26. This includes an additional 2 percent reduction for downtime of the hydro plant. For this example, the year is 1991 as defined by the peak annual load of 534 kW. For this year, the hydro generation capability is 1,971 MWh. This calculation is just for one year. A separate calculation is needed for the varying load of each year of the 20-year planning period.

The hydro capability evaluation is incorporated as a subprogram into the economic evaluation present-worth computer worksheet discussed in Section 10. This allows flexibility to provide appropriate hydro generation input to any hydro scheme to be economically evaluated.

The sample hydro generation evaluation in Table 5.1 depends on the type of turbine equipment considered and the corresponding equipment characteristics of overall efficiency and operating range. Turbine-generator characteristics used in this study are summarized in Table 5.2. This data is derived from manufacturers' information.

The power study defines hydro generation on the basis of load demands. The results are input to the economic evaluation. Economics decide the optimum installed hydro capacity by identifying the hydro scheme which has the lowest total present worth cost. The optimum installed capacity is identified in Section 10 as two TKW units at 350 kW each. The annual hydro generation varies through the planning period as the load grows. Hydro generation is 1,971,000 kWH in the first year of operation in 1991 and levels off at 3,025,000 kWH in 2005.

TABLE 5.1

SAMPLE HYDRO CAPABILITY EVALUATION (YEAR = 1991)

TAZIMINA RIVER HYDROELECTRIC PROJECT

PEAK ANNUAL LOAD (KW)=	534	MIN HYDRO=	0.1	NET HEAD=	100
INSTALLED CAPACITY (KW)=	700	UNIT SIZE,KW	350	OVERALL EFF=	0.79

MONTH	PEAK RATIO	SYSTEM PEAK kW	HYDRO PEAK kW	SYSTEM GEN MWH	HYDRO % SYS PK %	HYDRO % SYS GEN %	ASSN'D HYDRO GEN MWH	AVG ASSN'D HYDRO LOAD kW	REQ'D PLANT Q CFS	% TIME Q AVAIL %	Q(100) CFS	AVG DEFICIENT Q CFS	% TIME DEFICIENT %	DEFICIENT HYDRO GEN MWH	DIESEL PK GEN MWH	SYSTEM MIN KW	HYDRO MIN % SYS PK %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
JAN	0.737	394	394	166.9	100.0	100.0	166.9	228.6	34.1	99.2	20	27.1	0.8	1.1	0.0	98.4	35.6
FEB	0.789	421	421	182.1	100.0	100.0	182.1	249.4	37.3	98.5	31	34.1	1.5	2.4	0.0	105.3	33.2
MAR	0.697	372	372	162.8	100.0	100.0	162.8	223.0	33.3	100.0	42	0.0	0.0	0.0	0.0	93.0	37.6
APR	0.671	358	358	150.1	100.0	100.0	150.1	205.7	30.7	92.1	20	25.4	7.9	9.8	0.0	89.6	39.1
MAY	0.632	337	337	149.7	100.0	100.0	149.7	205.0	30.6	100.0	159	0.0	0.0	0.0	0.0	84.4	41.5
JUN	0.487	260	260	143.4	100.0	100.0	143.4	196.5	29.3	100.0	1000	0.0	0.0	0.0	0.0	65.0	53.8
JUL	0.553	295	295	141.7	100.0	100.0	141.7	194.1	29.0	100.0	1000	0.0	0.0	0.0	0.0	73.8	47.4
AUG	0.553	295	295	156.9	100.0	100.0	156.9	214.9	32.1	100.0	1000	0.0	0.0	0.0	0.0	73.8	47.4
SEP	0.855	457	457	192.3	100.0	100.0	192.3	263.4	39.3	100.0	1000	0.0	0.0	0.0	0.0	114.1	30.7
OCT	0.882	471	471	217.6	100.0	100.0	217.6	298.1	44.5	100.0	1000	0.0	0.0	0.0	0.0	117.7	29.7
NOV	0.974	520	520	227.7	100.0	100.0	227.7	311.9	46.6	100.0	265	0.0	0.0	0.0	0.0	130.0	26.9
DEC	1.000	534	534	234.4	100.0	100.0	234.4	321.1	48.0	100.0	87	0.0	0.0	0.0	0.0	133.5	26.2
TOTAL				2125.6			2125.6							13.3	0.0		

TABLE 5.1, cont'd.

TAZIMINA RIVER HYDROELECTRIC PROJECT

% TIME OF HYDRO MIN % 19	AVG DEFICIENCY KW 20	% TIME DEFICIENT % 21	CAPABILITY DEFICIENCY MWH 22	WATER DEFICIENCY MWH 23	PEAK DEFICIENCY MWH 24	GROSS HYDRO GEN MWH 25	ACTUAL HYDRO GEN MWH 26
91.2	119.2	8.8	7.7	1.1	0.0	158.2	155.0
93.2	122.7	6.8	6.1	2.4	0.0	173.5	170.0
89.5	116.5	10.5	8.9	0.0	0.0	153.9	150.8
88.3	114.8	11.7	9.8	9.8	0.0	130.5	127.9
86.3	112.2	13.7	11.2	0.0	0.0	138.4	135.6
76.0	102.5	24.0	18.0	0.0	0.0	125.5	122.9
81.3	106.9	18.7	14.6	0.0	0.0	127.1	124.6
81.3	106.9	18.7	14.6	0.0	0.0	142.3	139.5
95.3	127.1	4.7	4.4	0.0	0.0	187.9	184.2
96.1	128.9	3.9	3.7	0.0	0.0	213.9	209.6
98.4	135.0	1.6	1.6	0.0	0.0	226.1	221.6
99.0	136.8	1.0	1.0	0.0	0.0	233.4	228.7
			101.5	13.3	0.0	2010.7	1970.5

TABLE 5.2

TURBINE - GENERATOR CHARACTERISTICS

TURBINE TYPE	MINIMUM HYDRO CAPABILITY, PERCENT OF DESIGN OUTPUT	OVERALL UNIT EFFICIENCY, PERCENT
Horizontal Francis	40	83
Crossflow	10	76
TKW vertical turbine	40	79

SECTION 6

GEOTECHNICAL ANALYSIS

6.1 AVAILABLE INFORMATION

The general area of the Upper Tazimina River was previously investigated to support consideration of a regional Tazimina project for the 1982 Interim Feasibility Assessment (IFA). Shannon & Wilson performed field work from August to October 1981. The emphasis was on potential dam sites a few miles upstream of Tazimina Falls. Work included geologic mapping, seismic refraction studies, test drilling, digging test pits, and topographic surveying. The results of this work are documented in IFA Volume 3, Appendix E, Geotechnical Studies - Tazimina River. Only three seismic lines are in the vicinity of Tazimina Falls and these are not at specific locations of proposed Tazimina River Project components.

Additional field work was performed in August 1985 to obtain site-specific information at the immediate project site directly above and below the falls. R&M Consultants, Inc. (R&M) completed seismic refraction work and SWEC engineers were at site for reconnaissance. R&M's seismic work is documented in their October 1985 report included herein as Appendix B.

6.2 SITE GEOLOGY

Detailed information on area geology is presented in Sections 4 and 5 of IFA, Appendix E. Specific input at the falls site is included in Section 5.7 thereof. Based on available information, the following observations are made.

1. The general surficial geologic conditions at Tazimina Falls and the deep canyon gorge immediately downstream are glacial till and/or glacio-fluvial outwash and terrace debris overlaying bedrock. The gorge is cut into bedrock. The bedrock is megascopically classified as tuff and/or andesite. Geologic features are mapped on Figure 6.1.

2. Seismic refraction work by R&M correlates well with previous work by Shannon & Wilson. Three lines run on the left bank at and about 600 ft upstream of the falls indicate depths of unconsolidated materials and/or highly weathered rock in the 10-40 ft range. This correlates well with Shannon & Wilson work in nearby, but not identical, locations.

3. Bedrock seismic velocities are 12,000-14,000 fps for both surveys. This suggests normally fractured rock below the terraces at the general elevation of the top of the falls. This is in contrast to the closely jointed and moderately to severely weathered condition of outcrops in the canyon. It is inferred from these observations that significant weathering does not extend to depths greater than 10 to 15 feet.

4. A number of aerial photo lineaments, aligned generally perpendicular to the course of the Tazimina River, cross the canyon. These are particularly prevalent in the area from the falls to about 1000 ft downstream. In some cases, these lineaments can be identified in thick glacial outwash as well as in bedrock and thin glacial deposits. These features probably represent zones of very close jointing and/or shearing.

5. The canyon walls must, in general, be considered unstable. The walls consist of rock spires and numerous scree slopes. Bent tree trunks are observed on more vegetated portions. Therefore, high potential exists for rockfall in outcrop areas and creep and landslides in soil-filled gullies.

6. Potential powerhouse sites in the canyon appear to be located in areas of shallow bedrock covered with thin, sometimes discontinuous, deposits of alluvial cobbles and boulders.

7. No unusual conditions are anticipated in the area to be traversed by the access road. Most soils appear to be silty sands and gravels, probably of glacial outwash and/or ground moraine origin.

Localized bogs and kettle lakes are common. A high groundwater table should be anticipated throughout the area.

6.3 GEOTECHNICAL CONSIDERATIONS

The steep, rugged terrain and the jointed, weathered exposed rock in the canyon complicate the technical factors of siting the hydro project at Tazimina Falls. The following items were considered in developing the project alternatives defined in Section 7.

1. Surface powerhouse locations within the Tazimina River canyon would be subject to continuous rockfall unless extensive slope protection/stabilization is installed above the location.

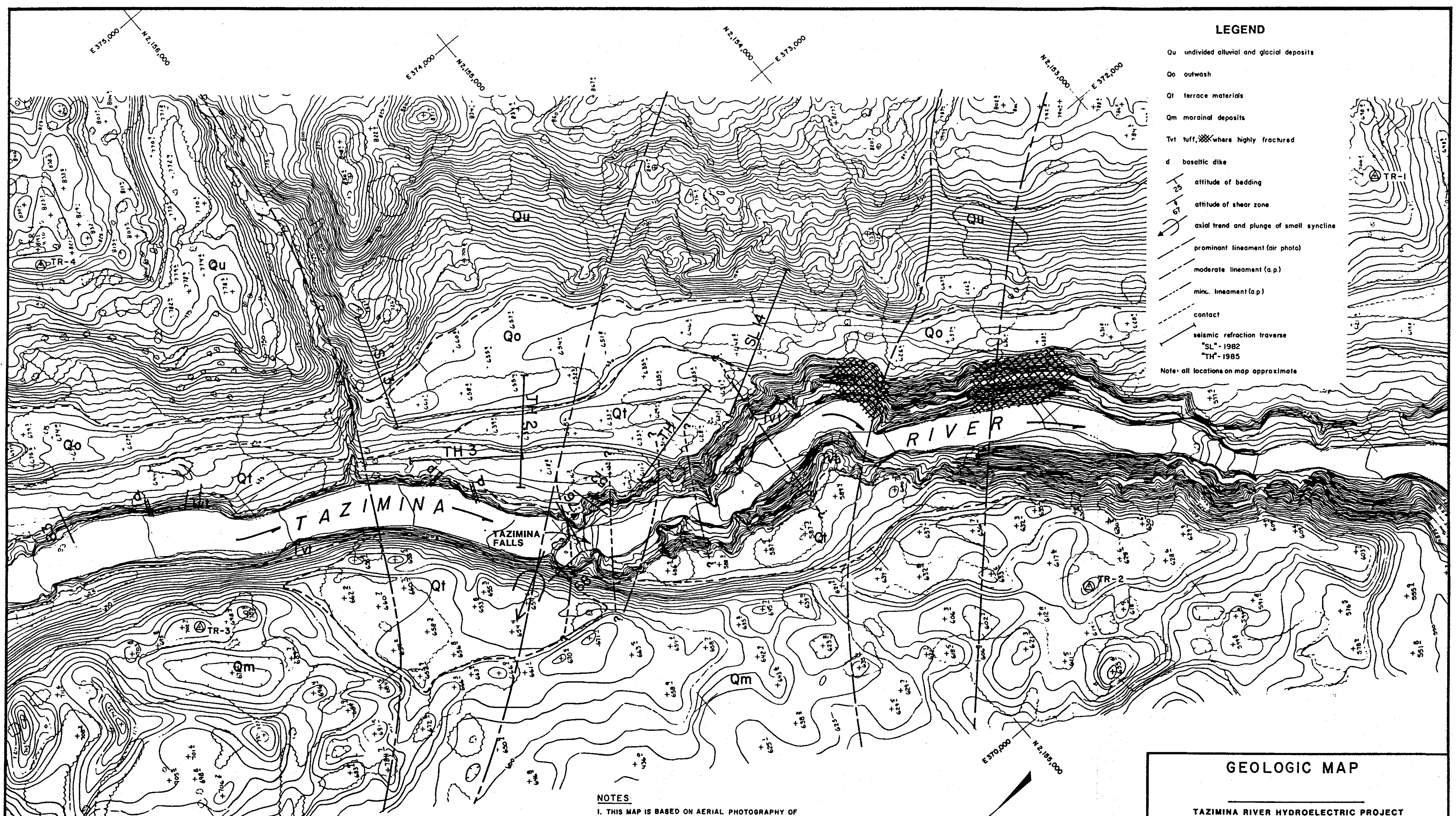
2. Powerhouse locations should avoid any of the lineaments identified on the geologic map. Blocky, fragmented, and/or squeezing ground could be encountered in such areas. An underground powerhouse probably requires at least roof support and possibly a full lining. Rock bolts, mesh, and shotcrete should provide adequate protection for access openings.

3. It is considered highly inadvisable to incorporate any scheme which would involve a conduit located on the wall of the Tazimina River canyon. It would be extremely difficult to adequately anchor such a conduit and the subsequent installation would be subject to continuous rockfall.

4. Any road built on the wall of the canyon would require extensive cuts and slope stabilization and would probably still require continuous maintenance due to rockfall.

5. For the major portion of the access road, the main consideration is to avoid, as much as possible, bogs and areas of seasonal standing water. Such areas can be accommodated in road construction, but only with increased cost. It is also possible that localized pockets of permafrost might be encountered.

6. It should be possible to develop suitable gravel sources almost anywhere in the area to be traversed by the access road. It is likely that constraints other than geologic/geotechnical will determine the location of a gravel borrow area.



NOTES

1. THIS MAP IS BASED ON AERIAL PHOTOGRAPHY OF SEPTEMBER 20, 1985.
2. THE BASIS OF HORIZONTAL AND VERTICAL CONTROL IS TRILATERATION STATION ROADHOUSE AZ 2. THE BASIS OF AZIMUTH ORIENTATION IS THE BEARING BETWEEN ROADHOUSE AZ 2 AND TRIANGULATION STATION PICK.
3. THIS MAP IS A TRANSVERSE MERCATOR PROJECTION BASED ON ALASKA STATE PLANE COORDINATE SYSTEM, ZONE 5, NAD 27.
4. ALL DIMENSIONS SHOWN ARE IN FEET.

CONTROL POINT COORDINATE LIST

STATION	NORTHING	EASTING	ELEVATION
ROADHOUSE AZ 2	2140823.50	377994.17	3231.88
PICK	2177995.30	382273.99	2211.53
TR-1	2152213.09	370886.28	701.06
TR-2	2154365.63	370298.29	630.37
TR-3	2157508.01	372713.46	703.80
TR-4	2157015.65	374413.42	830.75
1/4 CORNER	2143972.90	371246.03	2570.97

GEOLOGIC MAP

TAZIMINA RIVER HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

PREPARED BY:
R&M CONSULTANTS, INC.
ANCHORAGE, ALASKA

PREPARED FOR:
STONE & WEBSTER ENGINEERING CORPORATION
DENVER, COLORADO

DRAWING NUMBER: 551130-T-1 of 1
DRAWING NUMBER:

Figure 6.1

Prepared By NORTH PACIFIC AERIAL SURVEYS INC. & R&M CONSULTANTS, INC. MRMH/OEP 4/9/86

SECTION 7

PROJECT DESCRIPTION

7.1 GENERAL

The Tazimina River project is a run-of-river development. There is no forebay dam or structure for water storage. The components of the project are an intake, penstock, powerhouse, transmission line, and access road. The relative location of the intake, penstock, and powerhouse at the falls is shown on Figure 7.1. The project features are discussed in detail in this section of the report. This includes various alternatives considered during the study, as defined below.

<u>Alternative 1</u> - Well scheme with turbine and lineshaft assembly in a drilled hole.

<u>Alternative 2</u> - Canyon powerhouse with access and penstock routing down canyon wall.

<u>Alternative 3</u> - Underground powerhouse with access and penstock routing in vertical shaft.

<u>Alternative 4</u> - Canyon powerhouse with vertical shaft.

<u>Alternative 5</u> - Downstream canyon powerhouse with vertical shaft.

7.2 INTAKE

The layout of the intake and river channel features are shown on Figure 7.1. The intake structure is defined on Figure 7.2. The shoreline intake structure is approximately 250 ft upstream of the falls on the left bank, at a naturally occurring riffle extending toward mid-channel from the left bank. The trashrack is submerged below minimum water level to avoid ice problems, and it is sized for 2 ft/sec to avoid ice entrainment. Provisions are included for a stationary fish screen, to be installed if necessary, to exclude adult char and grayling. Velocities are limited to 2 ft/sec through the open area of the screen surface. If used, the stationary screen would be removed in winter. Hoist equipment is provided at the intake to handle the shutoff slide gate or the stationary screen panels, if necessary. The slide gate is normally open, but can be closed to isolate the penstock.

Excavation will be required in the stream bed in front of the intake to assure adequate water flow to the intake. The excavation will be concrete lined as indicated in Figure 7.2. A concrete sill approximately flush with the existing bed level will extend from the right bank across the stream for about 85 ft or one-half the channel width. This sill will avoid degradation of the right side of the stream bed which could adversely affect flow of water into the intake structure. A buried pipe extends downstream from in front of the intake to sluice away sediment deposition.

7.3 PENSTOCK

The 4 ft diameter penstock extends from the intake structure to the powerhouse and is buried in the left bank. The penstock length is 270 ft to the powerhouse. It is routed along the terrace roughly adjacent to the river to avoid increased burial depths at higher ground away from the river. As discussed in Section 6, it is not advisable to route the penstock along the canyon wall to the powerhouse because the weathered rock makes anchoring difficult and continuing rockfall could damage the installed pipe. The pipe is fiberglass reinforced (FRP) which is significantly lighter in weight than steel. This should be beneficial in reducing costs for shipping, handling, and installation. The difference in elevation of the intake invert versus the surface elevation on the left bank downstream near the powerhouse area is significant. Substantial cut and fill is required with burial depths at some portions of the alignment exceeding 30 ft for gravity arrangement of the flow line.

The powerhouse location for Alternatives 2 and 4 is further downstream. The penstock extends an additional 230 ft for a total length of 500 ft. This penstock extension is costly since large cuts and fills continue.

Burial depth exceeds 40 ft for gravity flow. Raising the vertical alignment of the penstock extension for siphon operation was considered to reduce cut and fill quantities. About one-half of the total 500 ft alignment can be raised approximately 18 ft. The siphon system reduces the total capital cost estimate of the hydro scheme by about $400,000 or 5 percent. However, a siphon penstock increases operational complexity and maintenance due to requirements for a priming system, valves and controls. Although a siphon system may be considered in further design work on the project, for the purposes of this study, further consideration of a siphon penstock was dropped in favor of the operational simplicity of the gravity system.

7.4 POWERHOUSE

The steep ruggedness of the canyon limits options for powerhouse siting to obtain reasonable access for construction and for normal operations. Cutting a road for access into the canyon is not an acceptable option because extensive cuts and slope stabilization would be required. Civil costs for viable powerhouse concepts are the dominant factor in defining total capital cost of the hydro project. Thus, the preferred hydro alternative is one which reduces the civil capital costs and provides the lowest total present worth as defined in Section 10. Several powerhouse alternatives, identified in Section 7.1, were investigated in order to select a preferred alternative for the feasibility study.

7.4.1 Preferred Scheme

The preferred hydro scheme (Alternative 1) uses a vertical turbine/generator arrangement. This allows the machine to be set at the proper elevation relative to tailwater by lowering turbine, water column, and shaft down a drilled hole (see Figure 7.3). The shaft length from generator down to turbine runner is about 150 ft. This is similar to a pump in a well. The shaft with lineshaft bearings is proven pump technology. This alternative is referred to as the "well scheme". For the purposes of this study, we have considered TKW turbines by Byron Jackson, although similar equipment from other manufacturers may be available. The

TKW unit is not just a pump running in reverse. It is a turbine with adjustable wicket gates which is needed to meet the widely varying load requirements. This vertical arrangement allows the "powerhouse" to be at the surface on the left abutment and provides easy operational access. Maintenance on the turbine will require piece-by-piece removal of water column and shaft. As the assembly is pulled from the hole the turbine equipment is removed at the top of the hole and is thus accessible within the powerhouse.

The installation is two units for a total installed capacity of 700 kW. The 900 rpm turbine is coupled through the lineshaft to the generator mounted at the surface on the floor of the powerhouse. Individual generator output is 350 kW at full gate turbine operation. At full output, the total hydraulic capacity of the two units is about 100 cfs. The net head is considered constant for this study at 100 ft. Load requirements are much less than the potential energy output of the site. Energy generation varies to meet load requirements. Estimated hydro generation is initially 1,971 MWh in 1991 and 3,025 MWh at the end of the planning period.

Wicket gates and turbine speed are controlled by a governor. Accessory installation includes electrical controls and protection equipment. The hydro plant will be operated remotely from the existing diesel station in Newhalen. Supervisory control and data acquisition (SCADA) equipment is provided. A powerhouse crane is provided to handle the generators and lineshaft assemblies. Electrical equipment includes switchgear and a 480v - 25 kV three-phase step-up transformer rated 1000 KVA.

7.4.2 Turbine Equipment

Three types of turbine units are considered for this study: horizontal Francis, crossflow, and the TKW unit. Alternative 1 is a unique solution for the hydro scheme using the TKW turbine-generator units. The remaining alternatives, discussed below, have the normal powerhouse arrangement. Any of the three types of generating equipment can be used. Crossflow units offer the benefit of a wide operating range. The present worth analysis in

Section 10 indicates that the installed capacity is 700 kW. This is provided by two TKW units at 350 kW each for Alternative 1. Alternatives 2 through 5 have one crossflow unit at 700 kW.

7.4.3 Alternatives

The second least costly concept (Alternative 3), is an underground scheme as defined in Figure 7.5. This provides personnel access and penstock routing in a vertical shaft. The 15 ft diameter of the shaft is the minimum constructible size. Increased costs for the shaft excavation and for the powerhouse are significant. This scheme allows tailrace excavation material to be removed to the left abutment surface via the vertical shaft. This would reduce construction activities within the confines of the canyon.

Other alternatives with the powerhouse in the canyon were considered. Acceptable powerhouse sites within the canyon are somewhat downstream of the falls. The increased cost for additional buried penstock to these sites is significant and results in higher total project costs. Alternative 2 has a powerhouse in the canyon at the base of the rock wall downstream of the falls. The penstock is routed down the canyon wall in a notch excavated in the rock to remove undesirable weathered material. Extensive rock bolting is used to stabilize the rock face. Access to the powerhouse is by inclined elevator routed down the wall in the same notch. This scheme is shown in Figure 7.4. There are operational drawbacks to this arrangement. Access in and out of the canyon will be complicated by adverse weather conditions including ice effects from spray from the falls. Also, personnel moving within the canyon, as well as the powerhouse structure therein, are subject to the possibility of falling weathered rock from the canyon walls above. Furthermore, the excavation on the canyon wall will result in increased aesthetic impact.

As a modification to the underground scheme, Alternative 4 was considered which moved the powerhouse out into the canyon at the base of the wall, and retained the vertical shaft for access. The resulting tunnel from the bottom of the shaft to the powerhouse is costly. Alternative 5, a variation of Alternative 4, sites the powerhouse 400 ft further downstream. This alternative is shown on Figure 7.6. The buried routing of the penstock for an additional 400 ft adds further to the total project cost.

7.5 ACCESS ROAD AND TRANSMISSION LINE

The project access road is routed along the alignment shown on Figure 7.7 from the existing Newhalen-Nondalton road to the project site at the falls. The road is 6.7 miles long with a 16 ft wide gravel surface. Appropriate cross drainage is provided by 24 in diameter culverts. As indicated in Section 6, it is anticipated that gravel sources in the area are adequate for road construction. The primary intent in routing the road is to avoid aquatic impacts at stream crossings. There are no stream crossings in the chosen route. This is not possible for any alignments south of Alexcy Lake.

The transmission line is a 24 kV system buried along an alignment immediately adjacent to the access road. Its length is likewise 6.7 miles to a point of tie-in to the existing line running north to Nondalton. Telephone line will be buried in the trench with the transmission cable. This telephone line will be the remote control link to the unmanned hydroelectric plant from the operational control point at the existing diesel station in Newhalen. The width of clearing for the access road/transmission line corridor is approximately 60 ft. The alignment is shown in more detail on photo mosaics in Figures 7.8-7.11.

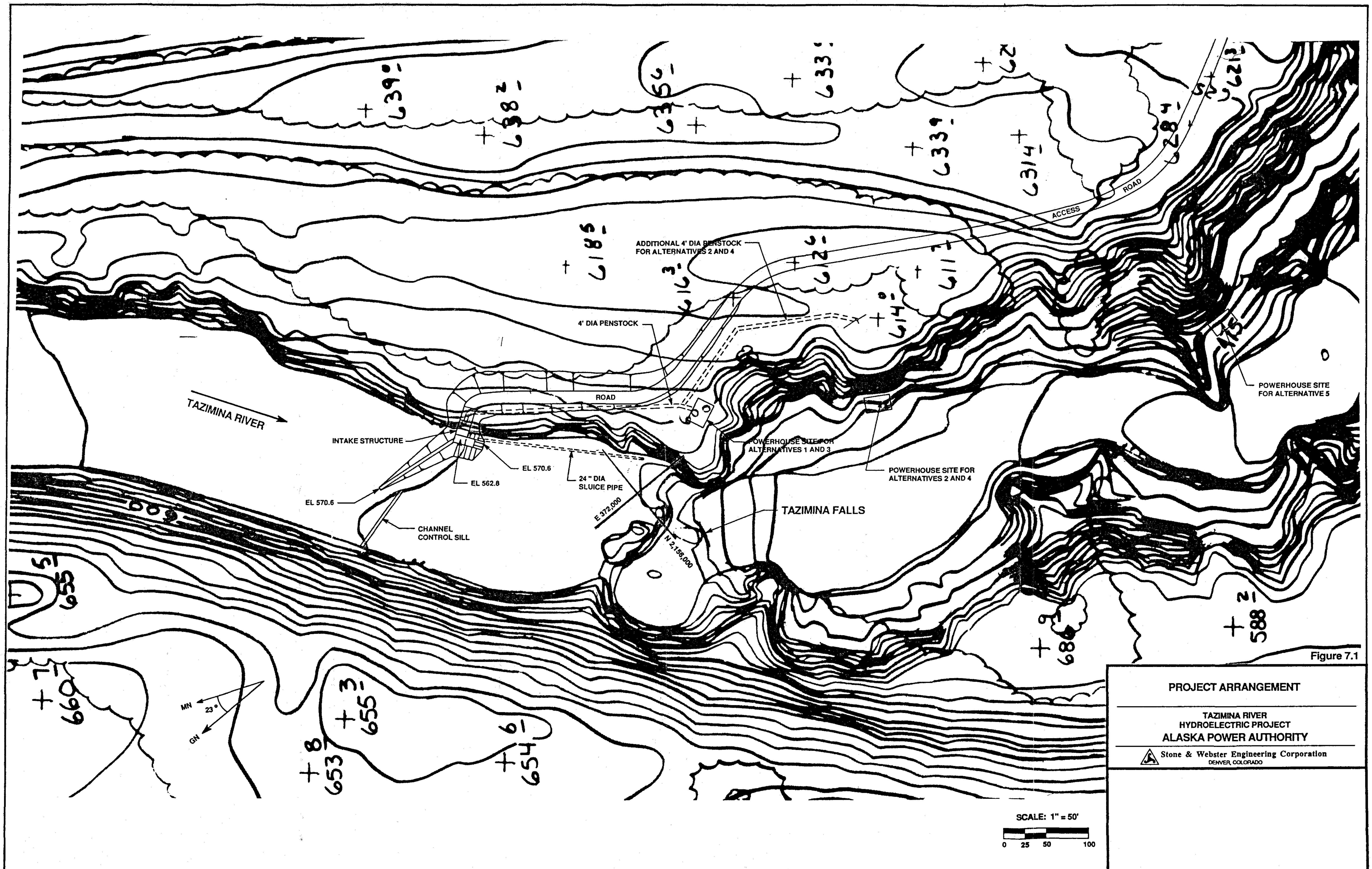


Figure 7.1

PROJECT ARRANGEMENT

TAZIMINA RIVER
HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO

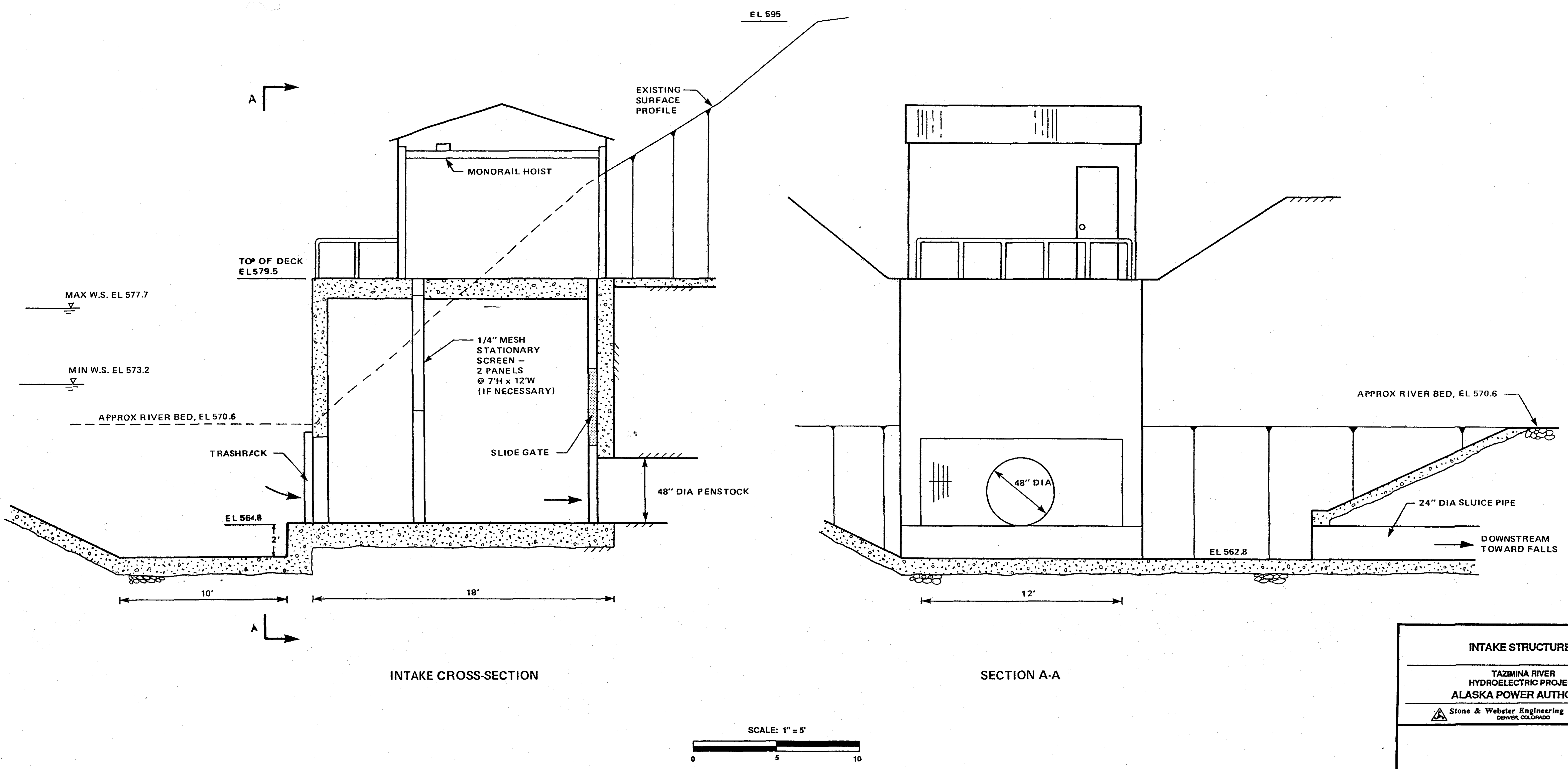


Figure 7.2

INTAKE STRUCTURE

TAZIMINA RIVER
HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO

B088013

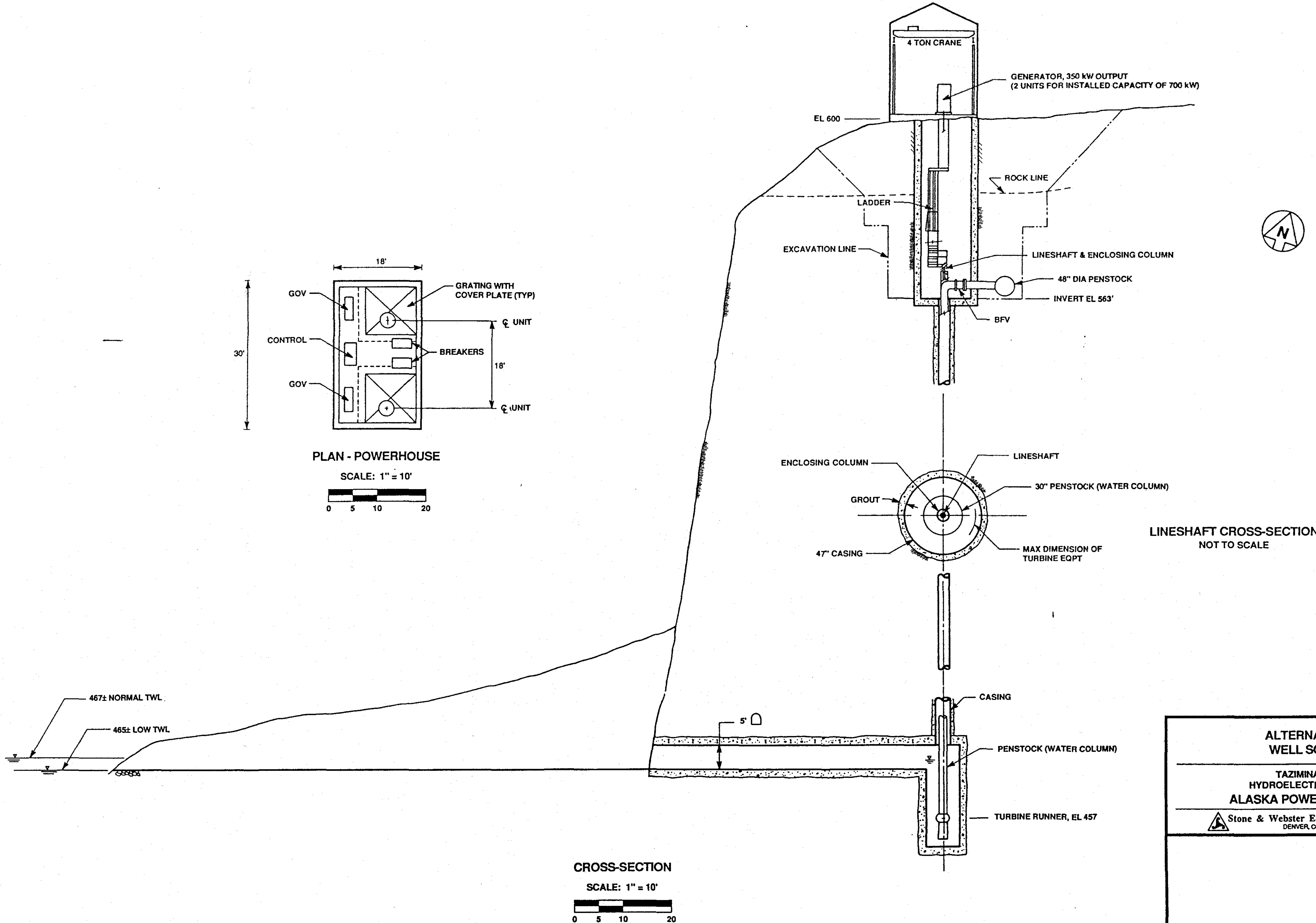


Figure 7.3

ALTERNATIVE 1
WELL SCHEME

TAZIMINA RIVER
HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO

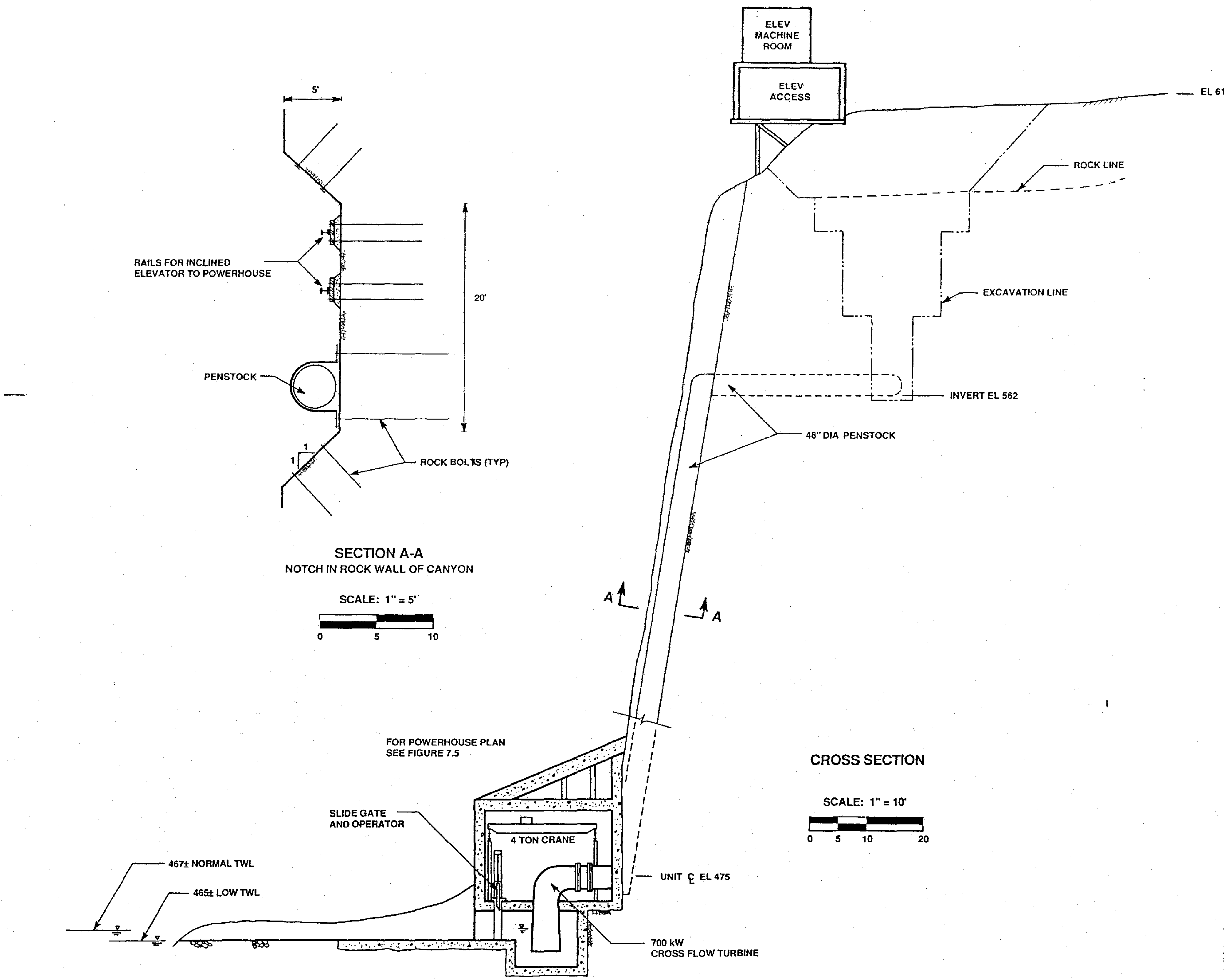


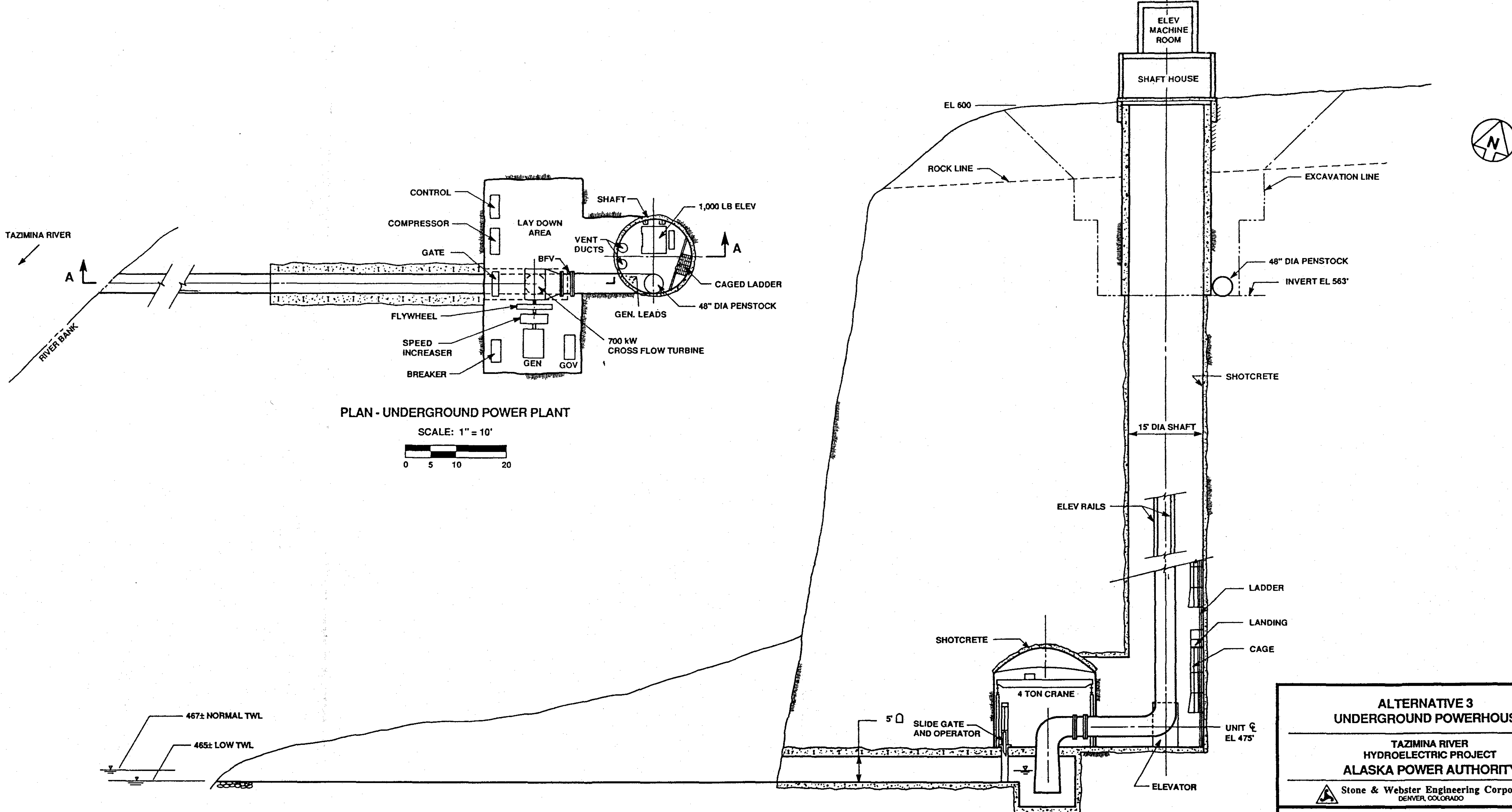
Figure 7.4

ALTERNATIVE 2
CANYON POWERHOUSE WITH ACCESS DOWN CANYON WALL

TAZIMINA RIVER
HYDROELECTRIC PROJECT

ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO



PLAN - UNDERGROUND POWER PLANT

SCALE: 1" = 10'

0 5 10 20

SECTION A-A

SCALE: 1" = 10'

0 5 10 20

Figure 7.5

ALTERNATIVE 3
UNDERGROUND POWERHOUSE

TAZIMINA RIVER
HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO

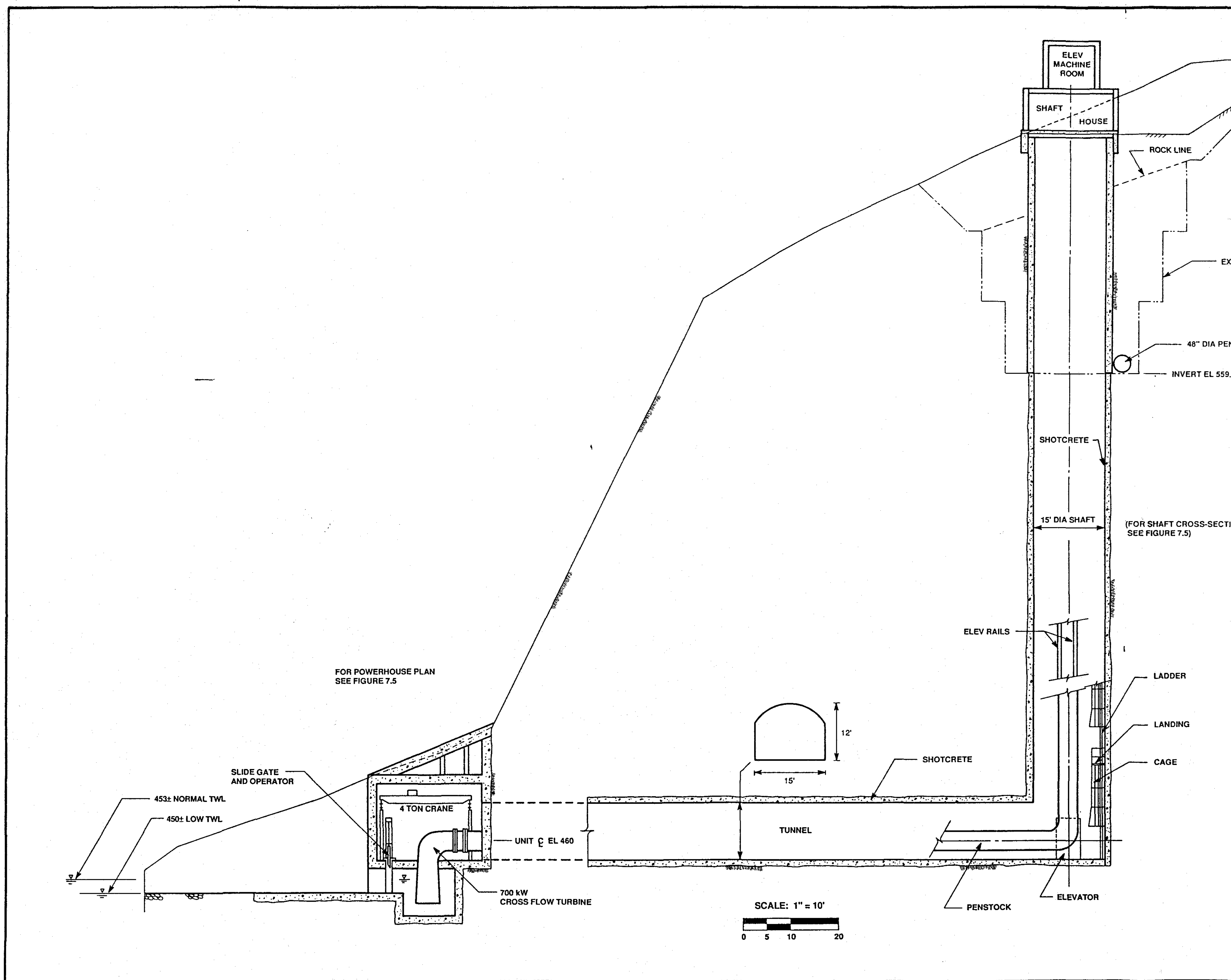


Figure 7.6

ALTERNATIVE 5
DOWNSTREAM CANYON POWERHOUSE
WITH VERTICAL SHAFT

TAZIMINA RIVER
HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY

Stone & Webster Engineering Corporation
DENVER, COLORADO

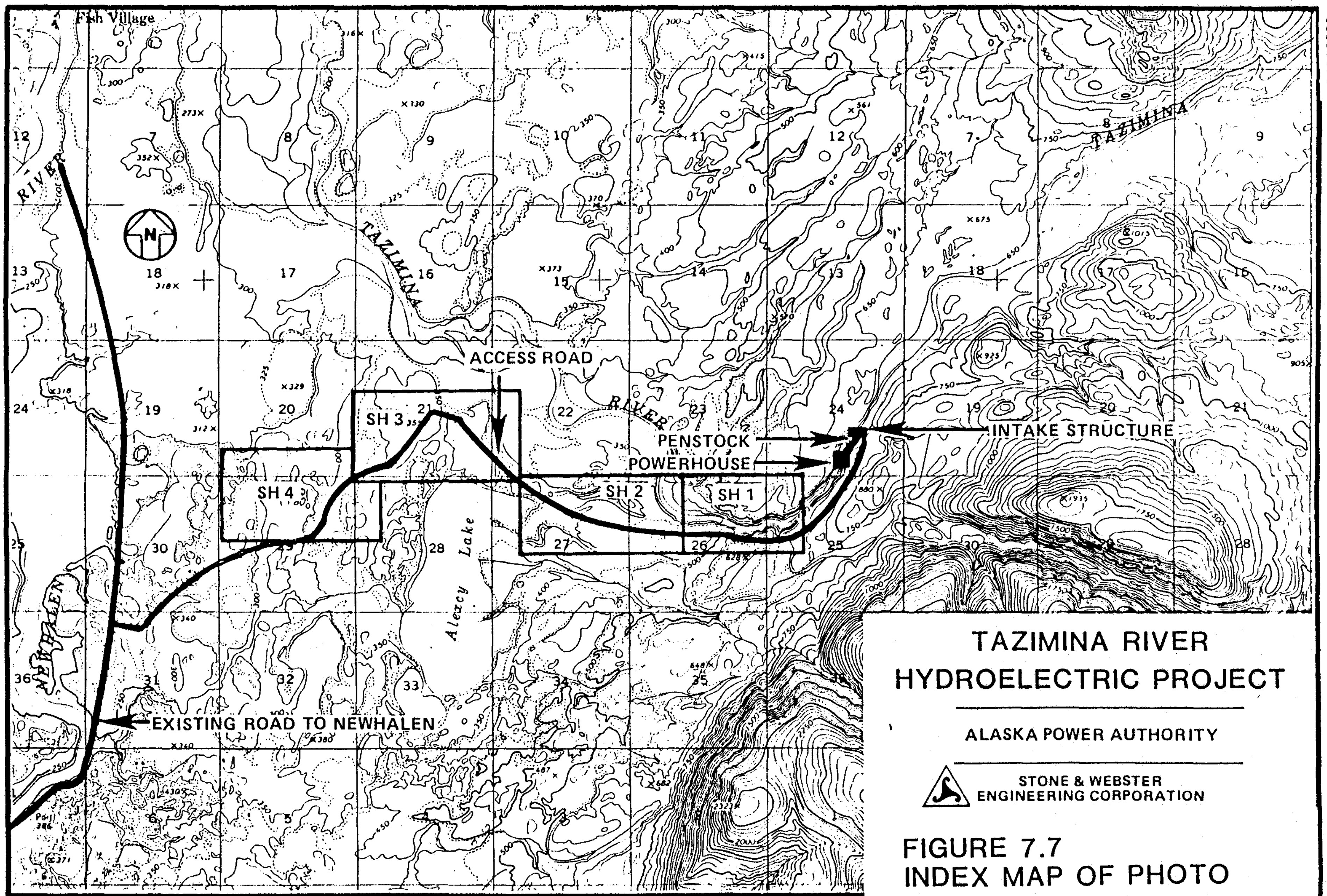


FIGURE 7.7
INDEX MAP OF PHOTO
MOSAIC COVERAGE
(FIGURES 7.8 - 7.11)

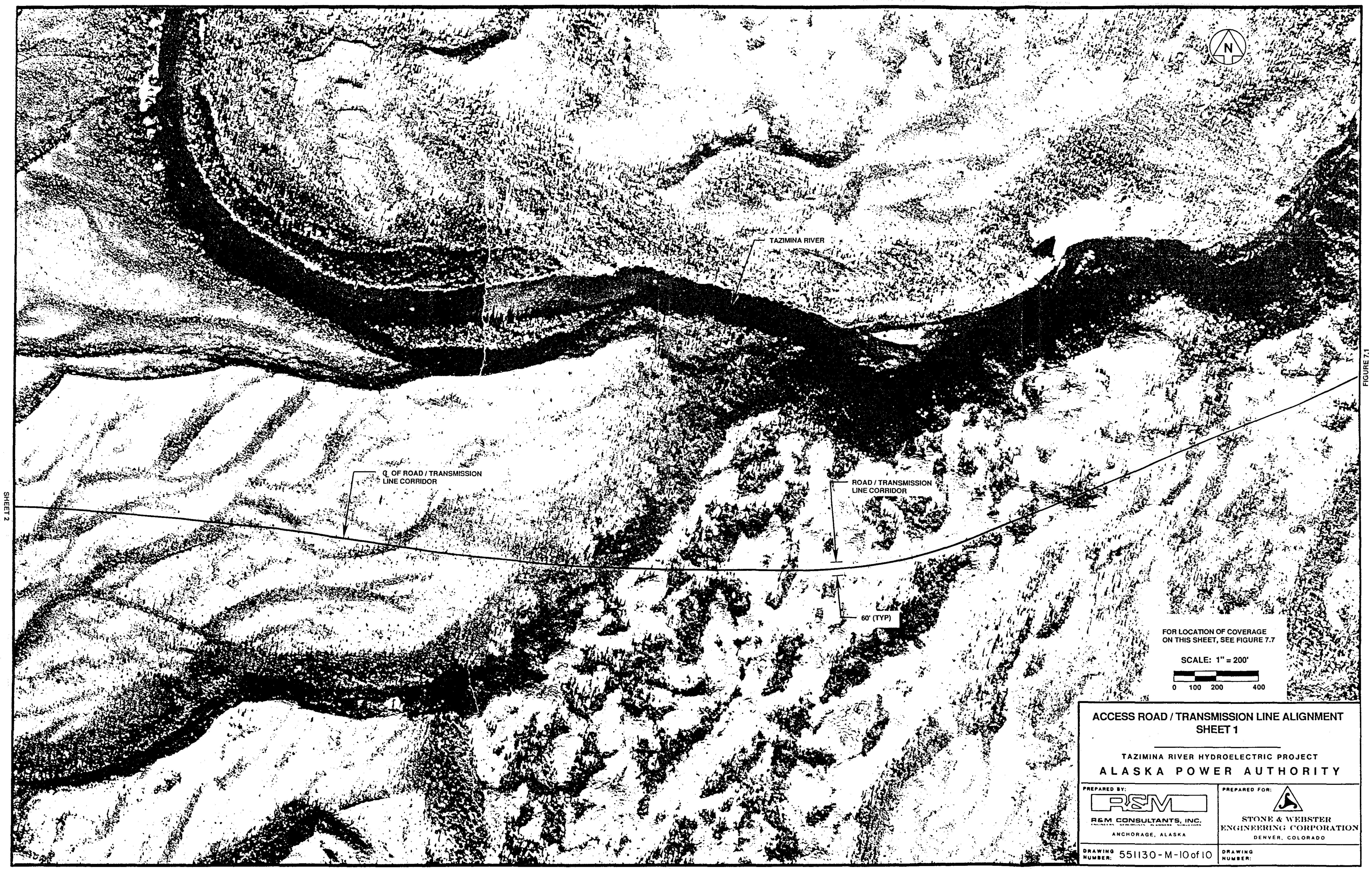
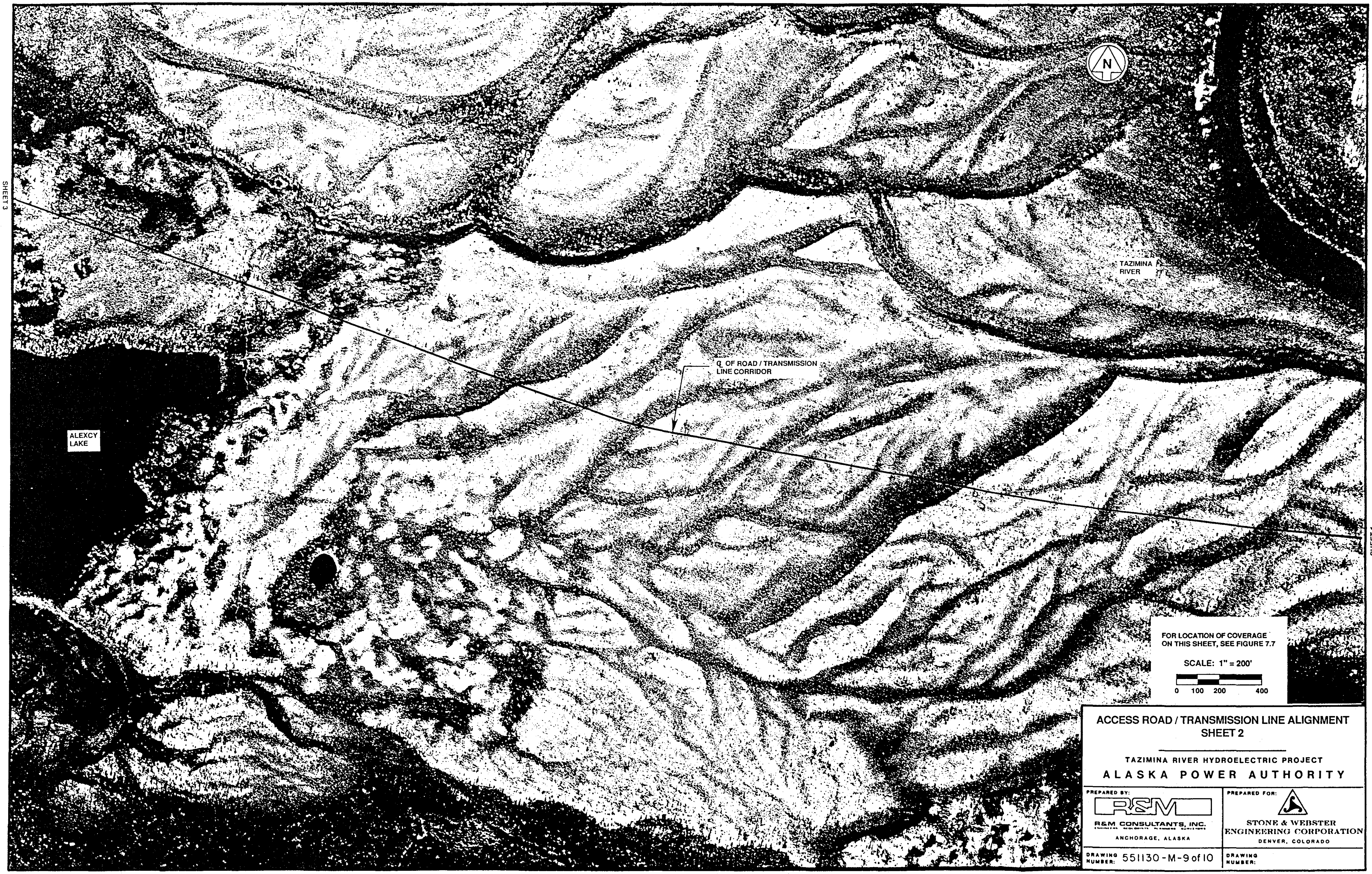

N
TAZIMINA RIVER
℄ OF ROAD / TRANSMISSION
LINE CORRIDOR
ROAD / TRANSMISSION
LINE CORRIDOR
60' (TYP)
SHEET 2
FIGURE 7.1
FOR LOCATION OF COVERAGE
ON THIS SHEET, SEE FIGURE 7.7
SCALE: 1" = 200'
0 100 200 400
ACCESS ROAD / TRANSMISSION LINE ALIGNMENT
SHEET 1
TAZIMINA RIVER HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY
PREPARED BY:
R&M
R&M CONSULTANTS, INC.
ANCHORAGE, ALASKA
PREPARED FOR:
STONE & WEBSTER
ENGINEERING CORPORATION
DENVER, COLORADO
DRAWING NUMBER: 551130-M-10 of 10
DRAWING NUMBER:

Figure 7.8



ACCESS ROAD / TRANSMISSION LINE ALIGNMENT
SHEET 2

TAZIMINA RIVER HYDROELECTRIC PROJECT

ALASKA POWER AUTHORITY

PREPARED BY: R&M CONSULTANTS, INC. ANCHORAGE, ALASKA

PREPARED FOR: STONE & WEBSTER ENGINEERING CORPORATION DENVER, COLORADO

DRAWING NUMBER: 551130-M-9 of 10

DRAWING NUMBER:

Figure 7.9

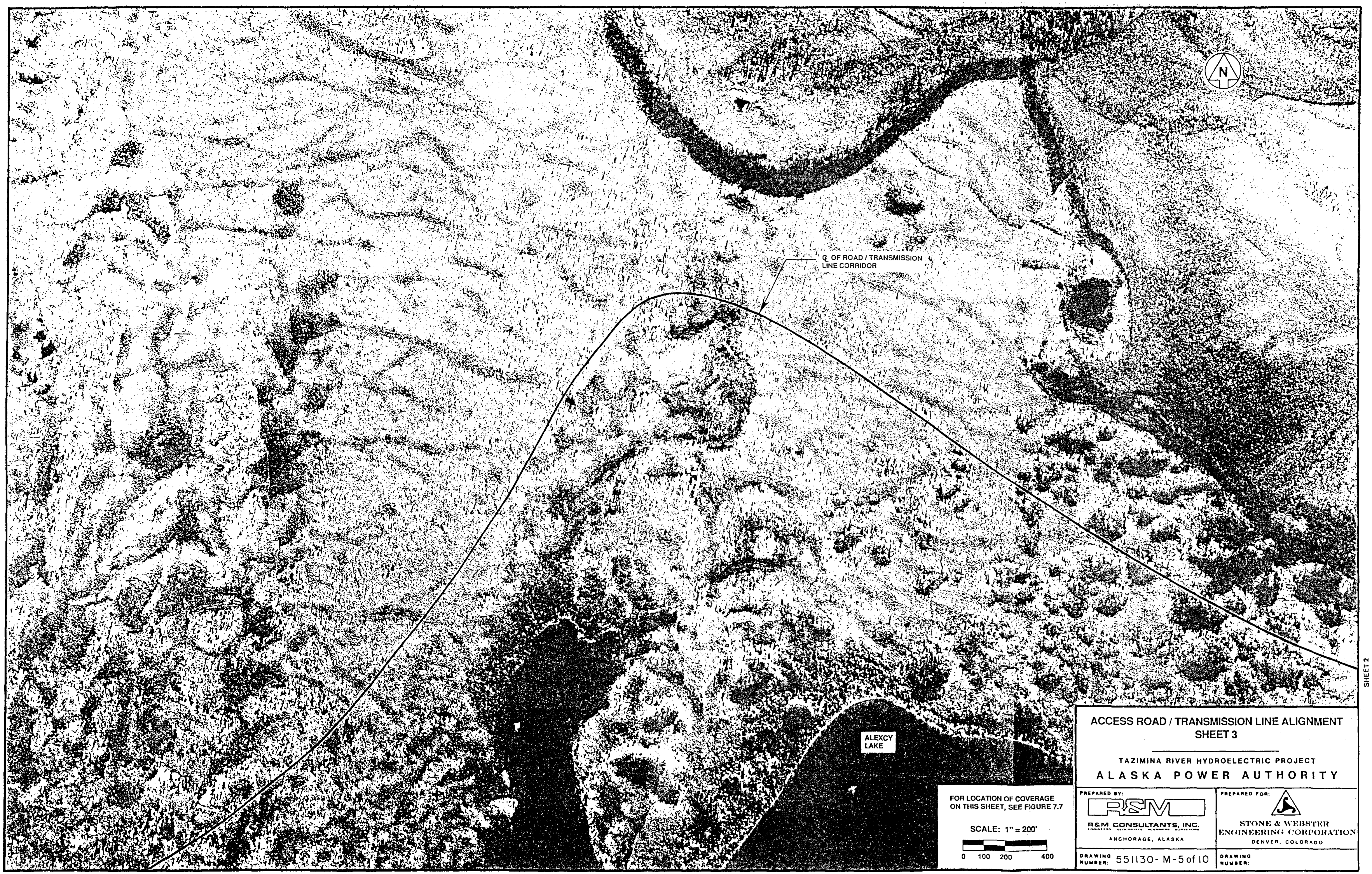
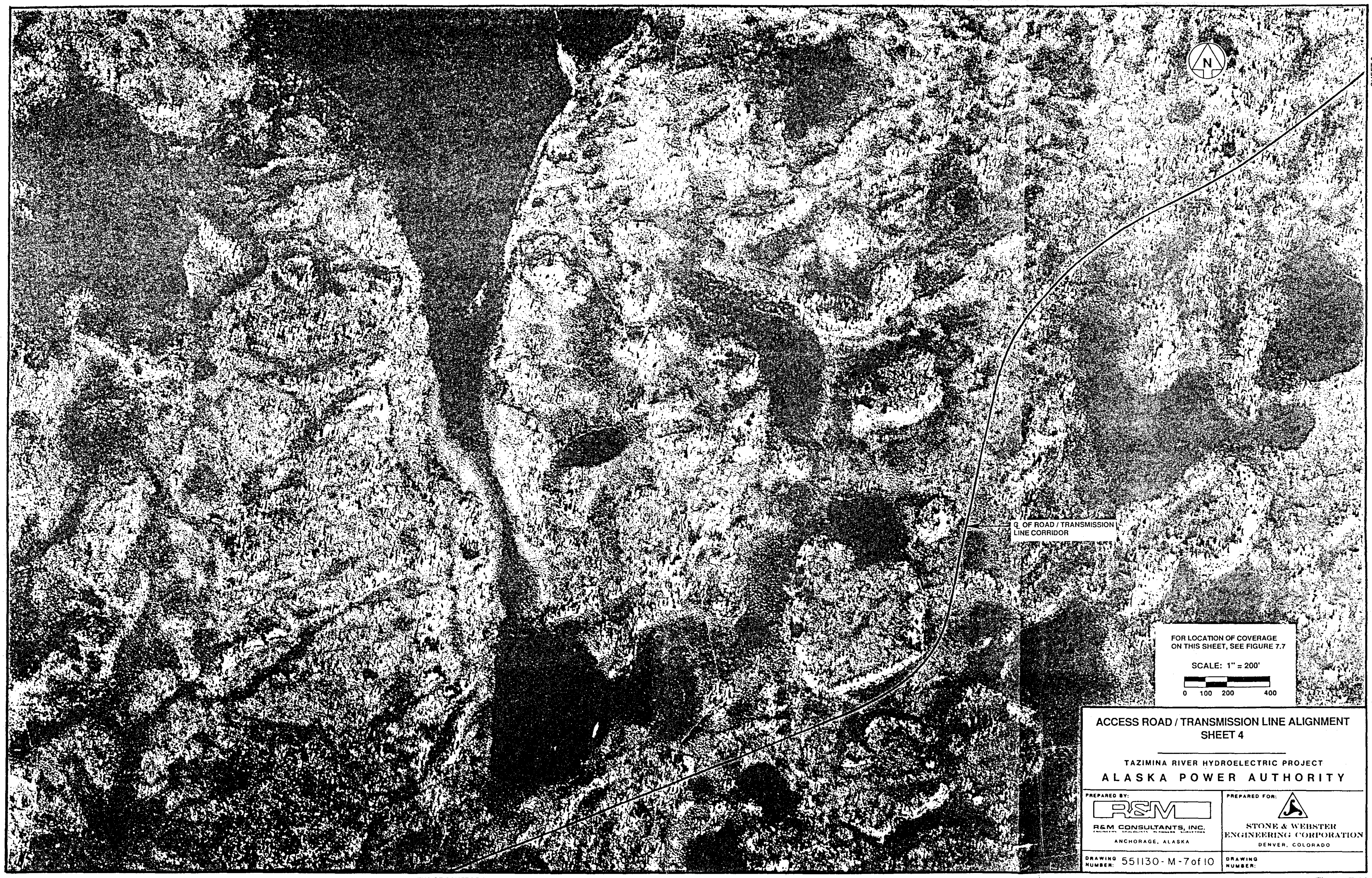

N
℄ OF ROAD / TRANSMISSION
LINE CORRIDOR
ALEXCY
LAKE
SHEET 2
ACCESS ROAD / TRANSMISSION LINE ALIGNMENT
SHEET 3
TAZIMINA RIVER HYDROELECTRIC PROJECT
ALASKA POWER AUTHORITY
FOR LOCATION OF COVERAGE
ON THIS SHEET, SEE FIGURE 7.7
SCALE: 1" = 200'
0 100 200 400
PREPARED BY:
R&M
R&M CONSULTANTS, INC.
ANCHORAGE, ALASKA
PREPARED FOR:
STONE & WEBSTER
ENGINEERING CORPORATION
DENVER, COLORADO
DRAWING NUMBER: 551130- M-5 of 10
DRAWING NUMBER:

Figure 7.10



END OF COVERAGE

Figure 7.11

SECTION 8

ENVIRONMENTAL ASSESSMENT

8.1 GENERAL

The development of a small hydroelectric plant at Tazimina Falls will involve an intake, penstock, and powerhouse immediately at the falls. There is no forebay dam or structure for water storage. Water surface elevations in the river will not be increased. Access to the site will be by a new access road from the existing Newhalen-Nondalton Road. Power generated at the plant will be transmitted to the existing Iliamna-Newhalen-Nondalton Electric Cooperative (INNEC) system via a 24 kV transmission line which will be buried beside the access road.

Meetings have been held with affected federal, state, and local agencies and organizations to discuss concerns and potential impacts related to the proposed project. These consultations have identified fishery resource related impacts as the major issue concerning hydro development in the area[1]. Enhanced access to the uninhabited area of Alexcy Lake and Tazimina Falls could alter natural resource use and affect recreational wilderness experience. Yet, the way of life in surrounding communities should be essentially unchanged. Existing sport and subsistence use of the area's fish and wildlife resources can continue. At the same time, customers of INNEC will enjoy less expensive electrical energy production from hydro. Thus, overall project impact is expected to be minimal.

The Tazimina River drainage was previously investigated for environmental considerations to support study of a regional Tazimina project for the 1982 Interim Feasibility Assessment (IFA). Dames & Moore performed field work which is documented in IFA Volume 4, Appendix G, Environmental Report.

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[1] Letter from U.S. Fish and Wildlife Service to Alaska Power Authority, August 14, 1985.
Letter from Alaska Dept. of Fish and Game to Alaska Power Authority, August 20, 1985.

As part of the present feasibility study, additional field work has been performed in 1985 and 1986 to address site specific aquatic and archeological issues. This additional field work is specifically discussed in Sections 8.2 and 8.5, below. In general the following discussion of project environmental issues is based on the details in the 1982 IFA as supplemented by input from 1985/1986 field work.

If a FERC license application is prepared, this environmental assessment will be the basis for development of Exhibit E, Environmental Report. Exhibit E would include documentation of agency consultations in accordance with regulatory requirements.

8.2 AQUATIC ECOLOGY

8.2.1 Fishery Resources

Four species of fish are found in the Tazimina River in the area of the proposed hydro project. A discussion of habitat follows.

1. The Kvichak River drainage, of which the Tazimina River is tributary, is the largest producer of sockeye salmon (Oncorhynchus nerka) in the Bristol Bay Management Area. Sockeye spawning has been documented in the Tazimina River upstream from the Newhalen River confluence to Tazimina Falls. Sport, commercial, and subsistence utilizations of sockeye comprise major roles in the socioeconomic viability of Iliamna, Newhalen, and Nondalton. Impacts to the life cycle of the sockeye salmon and its habitat are a most important factor in assessing hydro development.

2. Although not fished commercially, the Tazimina River population of rainbow trout (Salmo gairdneri) supports guiding and sport fishing opportunities. Access to these fish is gained by air transportation, riverboat travel from local villages, and float trips on the Tazimina below the falls. Relatively large numbers of rainbow trout exist in the Iliamna watershed because they are not overexploited. Although the designation of the Bristol Bay Wild

Trout zone has focused angler attention on these large resident rainbows, area remoteness, inaccessibility, and management considerations have limited sport harvesting. Terminal gear restrictions, spawning fish protection, and catch and release fishing promotions are actions instituted by the Alaska Board of Fisheries to maintain vigorous rainbow populations. The rainbow trout feed on all life stages of aquatic insects, small fish, and salmon eggs. As rainbows follow spawning sockeye salmon, the magnitude of the salmon runs may affect the juvenile rainbows survivability and the adult rainbows winter condition. Any adverse impact to sockeye salmon may contribute to the detriment of the rainbow trout in the Tazimina drainage.

3. Characteristically found in clear water, Arctic grayling (Thymallus arcticus) are common in the Tazimina River drainage. As such, they are susceptible to man-made habitat changes such as pollution, stream siltation, and abrupt variances in water temperature. Additionally, their slow growth and ease of capture render these populations susceptible to overharvesting which might occur with increased accessibility to the area.

4. Char (Salvelinus spp.) occur throughout the Tazimina drainage, both above and below the falls. Detailed migration and spawning patterns have not been determined in this watershed. The economic value of char in terms of subsistence and sport fishing is unknown.

8.2.2 Field Investigations

Dames & Moore made five field trips to the Tazimina River from late July to mid-October in 1981 to support the regional effort for the Bristol Bay IFA. The study area extended from the mouth of the river upstream to Upper Tazimina Lake. This 1981 effort provided a general definition of fishery habitat and resources in the river. Tazimina Falls is at River Mile (RM) 9.5 and the mouth of the canyon is downstream at RM 8.5.

The main 1981 study focus was from the mouth of the river to the mouth of the canyon and was on sockeye salmon. The other study focus area in 1981 was from the vicinity of the USGS gage station to Upper Tazimina Lake and was on resident fish. The river area from the mouth of the canyon (RM 8.5) up to the USGS gage (RM 11.5) was not studied in any detail in 1981. Based upon limited 1981 observations and personal communications from Pat Poe (now with University of Alaska, Juneau), the canyon area below the falls (RM 9.5 to RM 8.5) is occupied seasonally by rainbow trout, grayling, and char. In most years, relatively few adult sockeye salmon enter the canyon area to spawn. In large escapement years, more individual sockeye adults enter this area but this is still a relatively small part of the entire run. A cascade at RM 9 is a partial barrier to upstream migration. However, some sockeye adults have been seen all the way up to the base of the main falls (Poe, personal communications). Sockeye salmon eggs have been seen in back eddies in the canyon during spawning, suggesting the substrate and or density of spawners to available substrates results in many eggs being lost. Visual observations of most of the river substrate in the canyon indicates it is solid rock or large boulders with little gravel. Small rainbow trout taken in the lower canyon suggest some spawning may take place in that area. Solid rock substrate and high river velocities in many areas of the canyon limit available fish habitat there.

In the spring of 1982 (May 22-24), Dames & Moore made a field investigation to provide specific information about conditions immediately upstream of the falls. Limited resident fish habitat, characterized by high velocities and hard substrates, persisted over a distance at least 500 ft. above the falls. Gillnet, electro-shocking, seining, and angling operations failed to capture any fish. Some cottids were sighted. No grayling, rainbow trout, or char were seen by foot or helicopter within the first mile above the falls.

To supplement information on conditions at the immediate project area and to assess low-flow habitat, Dames & Moore made field trips to the site on July 1-7 and August 18-19, 1985. Findings are documented in their report dated September 24, 1985 (see Appendix C). During these survey periods, flow conditions were unusually high which frustrated efforts to sample in the immediate vicinity of the falls. River flows ranged from 3,500 cfs to

4,100 cfs. Under the observed flow conditions, fish habitat is severely limited within approximately 600 ft. of the top of the falls. However, minnow trapping efforts within 300 ft. of the falls did demonstrate the presence of cottids in both early July and late August, as well as the presence of small char in late August.

ADF&G personnel conducted a fish habitat survey at the falls on May 14 and 15, 1986. The purpose was to assess rainbow trout spawning below the falls and to determine the need to screen the intake above the falls. This survey was timed to coincide with the peak period of rainbow trout spawning in the river. Their findings are documented in a letter report to the Power Authority dated June 25, 1986 (see Appendix D). Visual observations, electrofishing, hook and line fishing, minnow traps, and gillnet were used. Two char and five sculpins were collected below the falls. Two char were caught above the falls.

Surveys also addressed aquatic impacts of access road alignments. This was investigated during the field trips in July/August 1985 and on May 13-16, 1986. Routes to the north and south of Alexcy Lake were evaluated. The findings of the 1985 work are documented in Appendix C. The report for the 1986 work is in Appendix D.

8.2.3 Findings

Observations indicate that little if any successful spawning occurs in the canyon near the falls (Appendix D). During construction and operation of the hydro project measures will be implemented to mitigate impacts. These will include adherence to Title 16 permit requirements and APA best management practices for erosion and sediment control and handling fuel and hazardous materials. Based on these considerations, the powerhouse and tailrace should not have a negative impact upon spawning, rearing, or migration of fish in the Tazimina River (Appendix D).

The May 1986 field work also addressed the need to screen the intake. Information from this and other surveys indicate that low numbers of resident grayling and char occur at the intake site (Appendix D).

Furthermore, the project design does not alter the stream in a manner that would attract fish to the intake site. Therefore, provisions are for a stationary screen with a mesh size of 0.25 inch to exclude fish from entering the system. These screens will be used if required by final agency resolution of this issue. If used, the stationary screen would be removed in winter.

The Alexcy Lake system with its associated inlet and outlet streams is used by sockeye salmon spawners. It constitutes the second largest drainage, after the Tazimina River, tributary to the Newhalen River downstream of Sixmile Lake. Access road alignments south of Alexcy Lake cross significant tributaries feeding the lake. Field observations indicate the presence of sockeye salmon, char, and cottids. The chosen alignment of the road north of Alexcy Lake does not cross any streams or ponds. This avoids any direct impact on fish habitat. The only sensitive consideration is proximity to Alexcy Lake. This will be mitigated by control of erosion and runoff.

The construction of the access road to the project site will improve human access to the area. This will result in increased fishing pressure on resources in the lower Tazimina River, Alexcy Lake area, and Tazimina Lakes region. This is perhaps the greatest impact of the project. Access might be controlled by gating the road.

8.3 TERRESTRIAL ECOLOGY

The access road/transmission line corridor is the major consideration for terrestrial impacts. The transmission line is routed immediately adjacent to the access road in the same 6.7 mile-long corridor. Terrestrial habitat along the road varies from open low scrub and lichen communities to a sparse, white spruce woodland (cover 10-25 percent). Essentially, the area is interspersed by short, stunted white spruce which appear to be dominant but overall cover is generally less than 10 percent. This vegetation type extends over most of well drained upland areas adjacent to the Tazimina River and extending to the project site. The access road/transmission line corridor will require the clearing of approximately 50 acres.

Wildlife in the project area include brown bear, moose, fox, beaver and caribou. Wetlands and riparian areas south and east of Alexcy Lake provide important habitat. Moose and brown bear attract many resident and non-resident hunters. Because of relatively easy access from the communities of Iliamna, Newhalen, Port Alsworth, and Nondalton, moose in the area are a highly prized subsistence resource. Brown bear is relatively common in the area.

The transmission line will be buried to avoid raptor impact. The location of the access road avoids wildlife habitat areas south and east of Alexcy Lake. The primary impact on wildlife will be increased hunting pressure resulting from improved access to the area.

8.4 WATER USE AND QUALITY

The project area of the Tazimina River drainage is uninhabited and no water alteration to natural watershed characteristics has occurred. The primary use of the Tazimina River is related to fish resources. Recreational fishing occurs during the open water months with heaviest use on the lower Tazimina River and lighter use of the upstream lake area. Subsistence fishing by residents of the Sixmile Lake area also concentrates on the lower river. The substantial run of sockeye salmon contributes to sport, subsistence, and commercial fisheries that occur downstream and in Bristol Bay.

The water quality in the Tazimina River is pristine, and is characteristically clear, highly oxygenated, very soft, and low in alkalinity. Mineralization is low and nutrient concentrations are low to moderate. The project is not expected to have any adverse impact on water quality except during construction when soil erosion and sedimentation is possible. These construction related impacts will be mitigated by management practices as discussed in Section 8.2.3. Furthermore, it is anticipated that in-stream work at the intake area will be within containments (dikes, cofferdams) which will mitigate sedimentation effects and maintain local streambed stability.

River flows will not be altered except immediately at the falls. Generating flows will be diverted through the shoreline intake above the falls and discharged back into the canyon at the base of the falls. Discharge over the falls could be greatly reduced during the low flow months of January through April. At times the diversion could nearly equal total streamflow and essentially dry up the falls.

8.5 HISTORIC AND ARCHEOLOGICAL RESOURCES

Previous work relating to historical and archeological resources was conducted in the Tazimina River-Tazimina Lakes area in 1981 in conjunction with studies for a regional hydroelectric project. A literature search and preliminary field reconnaissance of the area were done. The results of these efforts are documented in the Interim Feasibility Assessment, July 1982, Appendix G - Bristol Bay Regional Power Plan Environmental Report, Section 5.0 - Historic and Archeological Resources. The following discussion summarizes the findings therein. The literature search revealed that there are no previously known cultural resources in the area. A surface survey was conducted at two previously considered powerhouse sites on the Tazimina River in T.3S, R.32W, Section 26, approximately one mile downstream from the presently proposed powerhouse location. No evidence of cultural resources was found at either site. An aerial reconnaissance of the shoreline around Lower Tazimina Lake was also completed. Discoveries were limited to two recent campsites. Surface inspection of these campsites indicated that neither appeared archeologically significant.

A more site specific archeological survey of the project area was done on May 14 and 15, 1986 by Cultural Resource Consultants. Their findings are documented in a report dated May 21, 1986 (see Appendix F). The only cultural remains located during the survey were a fragment of a microblade core and a retouched flake. Both were found exposed on the surface along the edge of the river terrace northeast of Alexcy Lake on the access road alignment. The river terrace above the Tazimina, especially the section of the terrace which separates the northeast corner of Alexcy Lake and the river valley, has a very high archeological potential. The project site at the falls has no archeological potential. Prior to construction, the river terrace area should be further surveyed and tested. This is not expected to be a significant impact on project feasibility. It is anticipated that there are no extremely large sites along the terrace edge. Minor adjustments to access road alignment should avoid any sites.

8.6 AESTHETIC RESOURCES

Facilities at the falls would constitute an intrusion into an otherwise undisturbed area of special scenic values. People come into the area to observe the falls and canyon. The intake structure will be set back into the terrace along the left bank. The powerhouse building will be on the left bank immediately adjacent to the falls. Within the canyon, the tailrace outlet will be visible. These features are of a size and /or layout which affords relatively minimal visual impact compared to the scale of natural features at the canyon setting.

Project features will present intrusion when viewed from the air. This is especially true of the access road. It will be visible to sports persons flying into the area and it will degrade the wilderness experience. The intrusion of transmission line structures is avoided by burial of the cable.

SECTION 9

PROJECT COSTS

9.1 INPUT AND ASSUMPTIONS

Quantities are developed from layouts for each hydroelectric alternative. Site-specific unit costs were applied to estimate direct costs. The estimates include costs for turbine-generator equipment from written budgetary quotes from manufacturers. Each estimate includes allowance for indeterminates (AFI) at 10 percent of direct costs. Also included are the indirect costs of engineering and design, construction management, and interest during construction (IDC). The construction period is assumed to be May 1989 to December 1990 (see Section 11, Project Schedule). The allowance for IDC is $500,000 which might not be appropriate if the work is undertaken by the Power Authority. Mobilization/demobilization is estimated to be $400,000. Cost of land is not included in the estimates.

9.2 RESULTS

The total estimated capital cost of each hydroelectric alternative is given below.

Alternative	Description	Total Estimated Capital Cost* ($000)
1	Well Scheme	7,400
3	Underground PH with vertical shaft	7,900
2	Canyon PH with access down canyon wall	8,500
4	Canyon PH with vertical shaft	8,900
5	D/S Canyon PH with vertical shaft	10,200

*Includes AFI and indirects (engineering/design, construction management, and IDC).

Civil costs are a significant majority of the direct costs for any hydro scheme at Tazimina Falls. Major items are cut and cover of the penstock at relatively large depth and construction of 6.7 miles of access road.

Although penstock lengths vary, these two items are common to all alternatives. Differences are seen in varying powerhouse locations and arrangements. Alternative 1 has the lowest cost because drilled shafts for the TKW units replace powerhouse construction. Furthermore, this concept allows the "powerhouse" to be located adjacent to the falls. This significantly reduces penstock length. Alternative 3 is $500,000 more than the well scheme. As for Alternative 1, the powerhouse location adjacent to the falls significantly reduces penstock length compared to Alternatives 2, 4, and 5. Alternative 3 incurs the increased expense of underground excavation for the powerhouse and the vertical shaft. The unique cost item for Alternative 2 is rock excavation and rock bolting on the canyon wall. Alternative 4 has a higher total cost due to the vertical shaft and horizontal tunnel to the powerhouse. Alternative 5 has the highest estimated cost because of penstock costs to the furthest downstream powerhouse site.

For the preferred scheme (Alternative 1) the breakdown of the estimate by FERC line items is given in Table 9.1.

TABLE 9.1

COST ESTIMATE - HYDRO ALTERNATIVE 1

Well Scheme: 2 TKW Units @ 350 KW (700 KW)

FERC ACCT	DESCRIPTION	ESTIMATED COST
330	Land and Land Rights	(Not Included)
331	Powerplant	659,000
332	Waterways	1,483,000
333	Turbines and Generators	556,000
334	Accessory Electrical Equipment	300,000
335	Miscellaneous Power Plant Equipment	115,000
336	Roads	1,500,000
352/353	Substation and Switching Station	50,000
354	Transmission	500,000
	Mobilization and Demobilization	400,000
		5,563,000
	Allowance for Indeterminates	537,000
	Direct Cost	$6,100,000
	Engineering and Design	500,000
	Construction Management	300,000
	Interest During Construction (allowance)	500,000
	Total Cost	$7,400,000

SECTION 10

ECONOMIC EVALUATION

10.1 METHOD OF ANALYSIS

10.1.1 Installed Hydro Capacity

The purpose of the economic evaluation is to identify the optimum installed hydro capacity and to analyze the economic feasibility of the chosen hydro scheme. In order to compare the economic rating of hydro project schemes, a consistent, systematic evaluation method is used. The present worth of all costs and differential benefits associated with each scheme is the basis for economic comparisons. The schemes are compared with each other in terms of their ability to supply power at the lowest total cost by comparing present worth. The scheme with the lowest total present worth cost is the least costly alternative on a life-cycle basis and is the preferred hydro installation. By evaluating different schemes of varying unit size and number, installed hydro capacity is selected for Alternatives 1 and 3.

10.1.2 Economic Feasibility

To analyze hydro economic feasibility, the preferred hydro scheme is compared to the diesel base case on a total present worth cost basis. The base case is the continuation of diesel power generation. Additional diesel capacity as required on the basis of load and energy demand forecast is installed at intervals through the study. Comparison is by present worth ratio (PWR). Present worth ratio is obtained by dividing the present worth of the hydro scheme into the present worth for the diesel base case. A ratio greater than 1.0 indicates the amount by which the diesel case present worth cost exceeds the present worth cost of hydro. Ratios less than 1.0 indicate the savings in diesel case present worth compared to hydro.

Present worth ratios are affected by variations in input parameters. The sensitivity of PWR is analyzed with respect to these variations using "low" and/or "high" values of input parameters. The low and high values are defined by the Power Authority for this study.

10.2 INPUT AND ASSUMPTIONS

The base year for the economic analyses is 1986 with a 55-year analysis period. The length of the analysis period results from the assumed initial operation of the hydro plant in 1991 which, when combined with a 50-year hydroelectric lifetime, extends the analysis from the base year of 1986 through the year 2040.

In accordance with APA's procedures for economic analyses, inflation is assumed to be zero. All costs and present worths are expressed in terms of 1986 dollars. A discount rate of 3.5 percent is used to calculate the present worth of annual costs.

The economic parameters used in all analyses to calculate present worth costs are given in Table 10.1. This includes sensitivity values for parameters. Also, in Table 10.1 is the definition of economic lifetimes for equipment. It is assumed that any equipment items that reach the end of their economic lifetimes during the period of analysis are replaced with identical units. Thus, the initial capital cost of a given equipment item is incurred at the completion of each lifetime cycle and reflected as appropriate replaced capacity. Salvage values consider credit for capital costs of equipment whose economic lifetime is not completed at the end of the study period.

Diesel fuel base cost is from current 1986 prices and is escalated accordingly to reflect changing fuel prices through the economic study period. The fuel price is applied to fuel usage based on diesel generation to give annual fuel costs. The 1986 cost of diesel fuel at Naknek is $0.82 per gallon. Transportation costs to Newhalen are about $0.28 per gallon. The resulting base price of fuel used in this study is $1.10 per gallon. Diesel fuel escalation, as defined by the Power Authority, is 2.8 percent per year from 1987 through 2005. This results in a fuel price in 2005 of

$1.86 per gallon. It is assumed that fuel costs remain constant with no further price escalation in the remaining years of the economic analysis.

Other assumptions used in present worth analyses are given below.

1. Diesel fuel usage is calculated using a fuel rate of about 12 Kwh/gallon.

2. Existing installed diesel capacity is 990 kW (3 units at 330 kW each).

3. The installed cost of diesel equipment is $800 per kW.

4. For hydro with diesel backup or for the diesel base case, the installed capacity meets the annual peak demand with the largest unit out of service.

5. Costs developed in this study represent bus bar costs and do not include all costs that would comprise the true consumer cost. For example, cost allowances are not made for administration, taxes, depreciation, insurance, etc. The present worth of consumer costs would be significantly higher than the present worth of bus bar costs determined in this study. However, the inclusion of the additional consumer costs would not affect comparison of alternatives since the cost would be common to all cases.

10.3 RESULTS

10.3.1 Preferred Scheme

Alternatives 1 and 3 were evaluated in present worth analyses to determine hydro installed capacity. These alternatives have the two lowest capital costs. Alternative 1 has the unique TKW vertical turbine-generator units. Alternative 3 represents the more conventional powerhouse arrangement of the other alternatives. Economic evaluation shows that the total present worth of Alternatives 1 and 3 is at a minimum in the range of 600 to 800 kW installed capacity. Furthermore, in this range present worth costs are insensitive to unit size variations. Present worth varies by about one percent. Therefore, it is appropriate to use an installed hydro capacity of 700 kW. This installed capacity is provided by two TKW units at 350 kW each for Alternative 1. Alternatives 2 through 5 have one 700 kW cross flow unit.

The present worth comparison of Alternatives 1 and 3 is given below. These results are based on design basis ("medium") parameters including a discount rate of 3.5 percent and diesel fuel escalation of 2.8 percent between 1987 and 2005.

Alternative	Hydro Present Worth Cost ($000)	Diesel Base Present Worth Cost ($000)	Present Worth Ratio* (PWR)
No. 1 - Well Scheme with 2 TKW units @ 350 kW (700 kW)	11,181	12,510	1.12
No. 3 - Underground powerhouse 1 crossflow @ 700 kW	11,768	12,510	1.06

$$*PWR = \frac{\text{Base Case Present Worth}}{\text{Alternative Present Worth}}$$

Alternative 1 is the preferred hydro scheme because it has the lower total present worth cost. Furthermore, the PWR of 1.12 shows that the hydro scheme is economically attractive in comparison to diesel generation. Hydro Alternatives 1 and 3 are significantly different concepts, yet the evaluated cost of Alternative 3 is about the same as for Alternative 1. Both alternatives could be considered in more detail during project design.

A sample computer worksheet showing the calculation of present worth for Alternative 1 is in Appendix G. This worksheet is representative of the detailed input and timing of costs which are the basis for present worth analysis.

Figures 10.1 and 10.2 show the break down of total present worth cost into the categories of capital, O & M, and fuel costs. These figures illustrate the weight of capital costs in the hydro scheme. Conversely, the major factor in the base case is diesel fuel.

Figure 10.3 shows cumulative present worth versus time for hydro and diesel. This illustrates relative rate of expenditures through the analysis period.

10.3.2 Sensitivity Cases

The results of sensitivity cases for Alternative 1 are given below. This includes analysis of a 1000 kW hydro development to meet the high load growth forecast. The installed capacity of two TKW units at 500 kW each is defined on the basis of lowest total present worth cost.

Parameter Variation	Hydro Alternative 1 Present Worth Cost ($000)	Diesel Base Present Worth Cost ($000)	Present Worth Ratio (PWR)
2 TKW Units at 350 kW (700 kW)			
Low Load Growth (1.5%)	10,800	10,283	0.95
High Load Growth (with Keyes Point)	13,491	18,300	1.36
Zero Fuel Escalation	10,963	9,498	0.87
High Discount Rate (4.5%)	10,154	10,085	0.99
2 TKW Units at 500 kW (1000 kW)			
High Load Growth (with Keyes Point)	13,059	18,300	1.40
Medium Load Growth Sensitivity (3.0%)	11,866	12,510	1.05

This shows that the 700 kW hydro scheme has an advantage over diesel for high load growth when the benefit of additional hydro generation is realized. For variation in other parameters, diesel generation is less costly. The 1,000 KW hydro development shows a slight advantage with a PWR of 1.05. It has a substantial advantage over the diesel base case in meeting high load growth requirements. Figure 10.4 shows change in PWR with load growth.

Figures 10.5 through 10.10 show cumulative present worth versus time for variation in a given parameter for hydro and diesel. They illustrate how parameters vary the growth of present worth through the analysis period to give the total present worth costs which define PWR's.

Results of the economic evaluation are sensitive to diesel fuel cost. The 1986 cost of fuel is relatively low compared to recent years. Using the current fuel cost of $1.10 per gallon, the hydroelectric development has some economic advantage over the base case. As shown in Figures 10.11 and 10.12, future change in diesel fuel prices could bring a more favorable advantage to development of the hydroelectric project.

TABLE 10.1

SUMMARY OF ECONOMIC ANALYSIS PARAMETERS AND INPUT

1. Base year: 1986

2. Planning period, load growth: 20 years, 1986-2005
   diesel fuel escalation: 20 years, 1986-2005

3. Load growth rate : 3 percent/year (Sensitivity: "low growth" at 1.5 percent/year and "high growth" with Keyes Point)

4. Diesel fuel escalation rate: 0 percent for 1986, 2.8 percent/year for next 19 years (Sensitivity: 0 percent for 20 years)

5. Economic analysis period: 55 years, 1986-2040

6. Inflation rate: 0 percent (all costs expressed in 1986 dollars)

7. Real discount rate: 3.5 percent (Sensitivity: 4.5 percent)

8. Diesel fuel base cost (1986): $1.10/gal.

9. Economic lifetimes for major equipment

   Diesel generators

   Primary units: 20 years
   Reserve units: 30 years

   Hydroelectric: 50 years
   Transmission line: 30 years

10. Initial installed diesel capacity: 3 x 330 = 990 kW

11. Diesel fuel consumption: 0.0836 gal./kWh

12. Diesel installed cost: $800/kW

13. Diesel O&M cost:

    Primary operation: $60,000 + $0.0175/kWh
    Reserve operation: $0.0175/kWh, but not less than $20,000/year

14. Hydroelectric O&M cost: $60,000 + $0.015/kWh, except first year add $75,000 for initial manned operation

15. Hydroelectric startup date: 1991

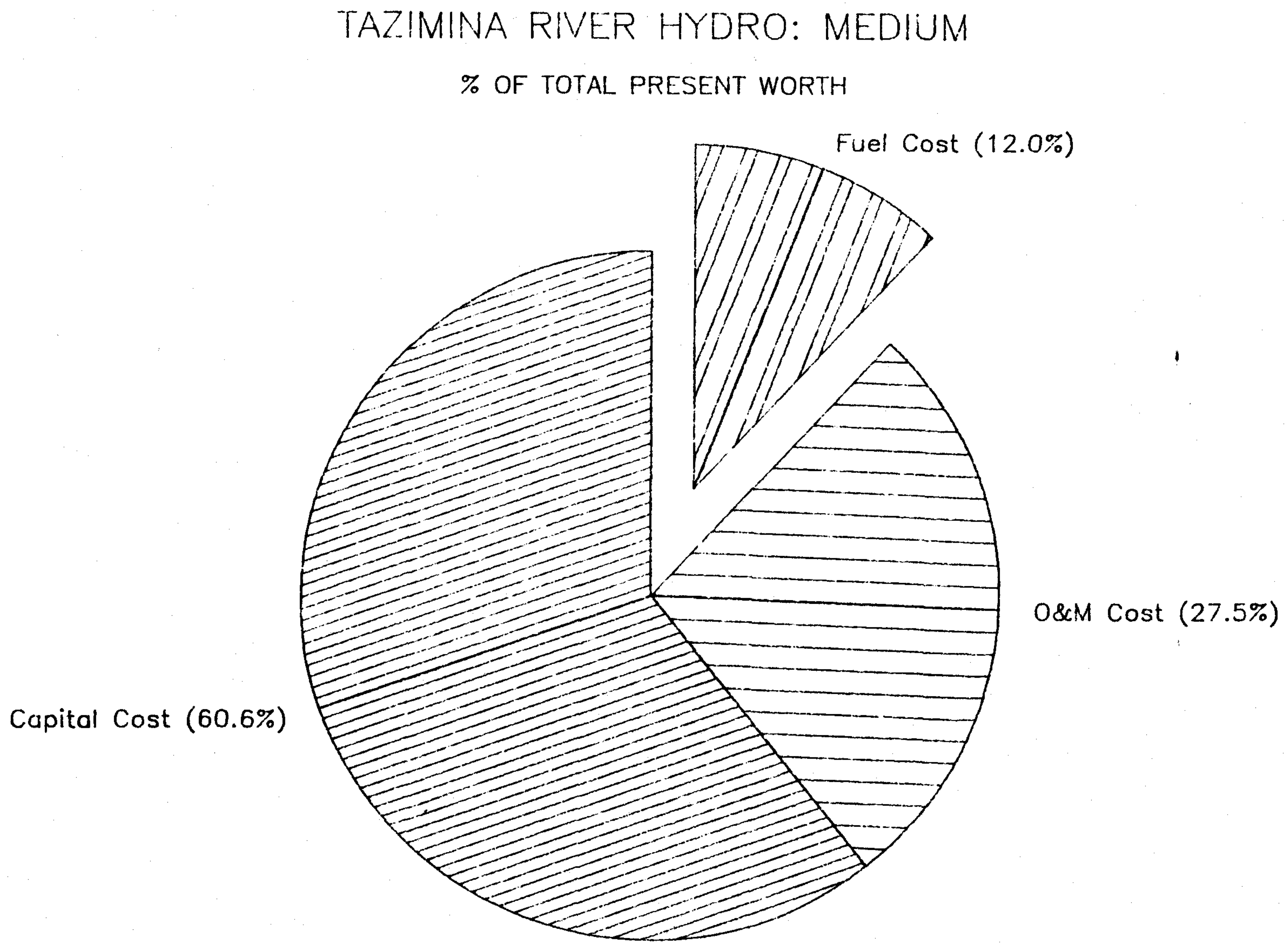

TAZIMINA RIVER HYDRO: MEDIUM
% OF TOTAL PRESENT WORTH
Fuel Cost (12.0%)
O&M Cost (27.5%)
Capital Cost (60.6%)

Figure 10.1

DIESEL BASE: MEDIUM

% OF TOTAL PRESENT WORTH

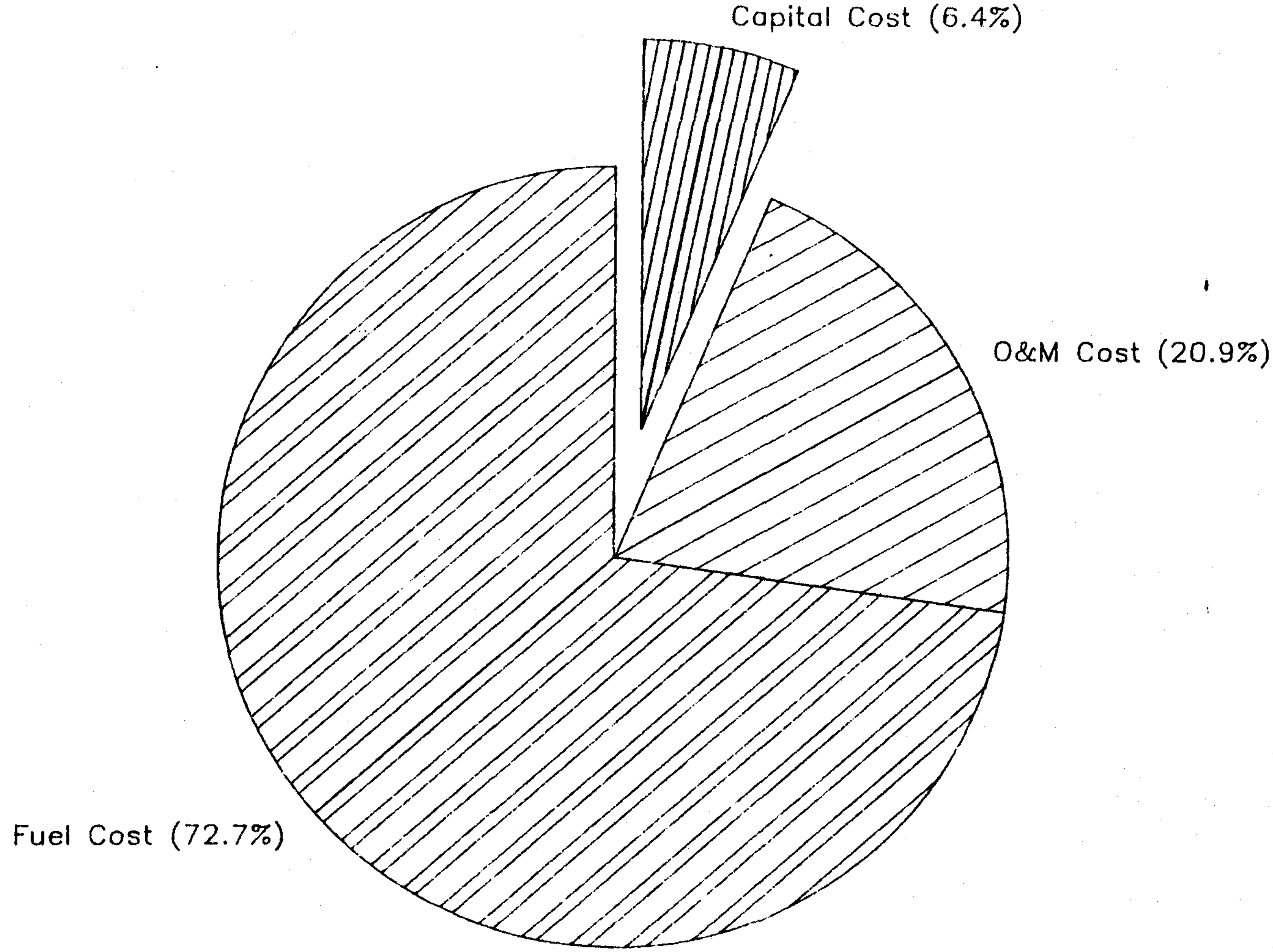


Figure 10.2

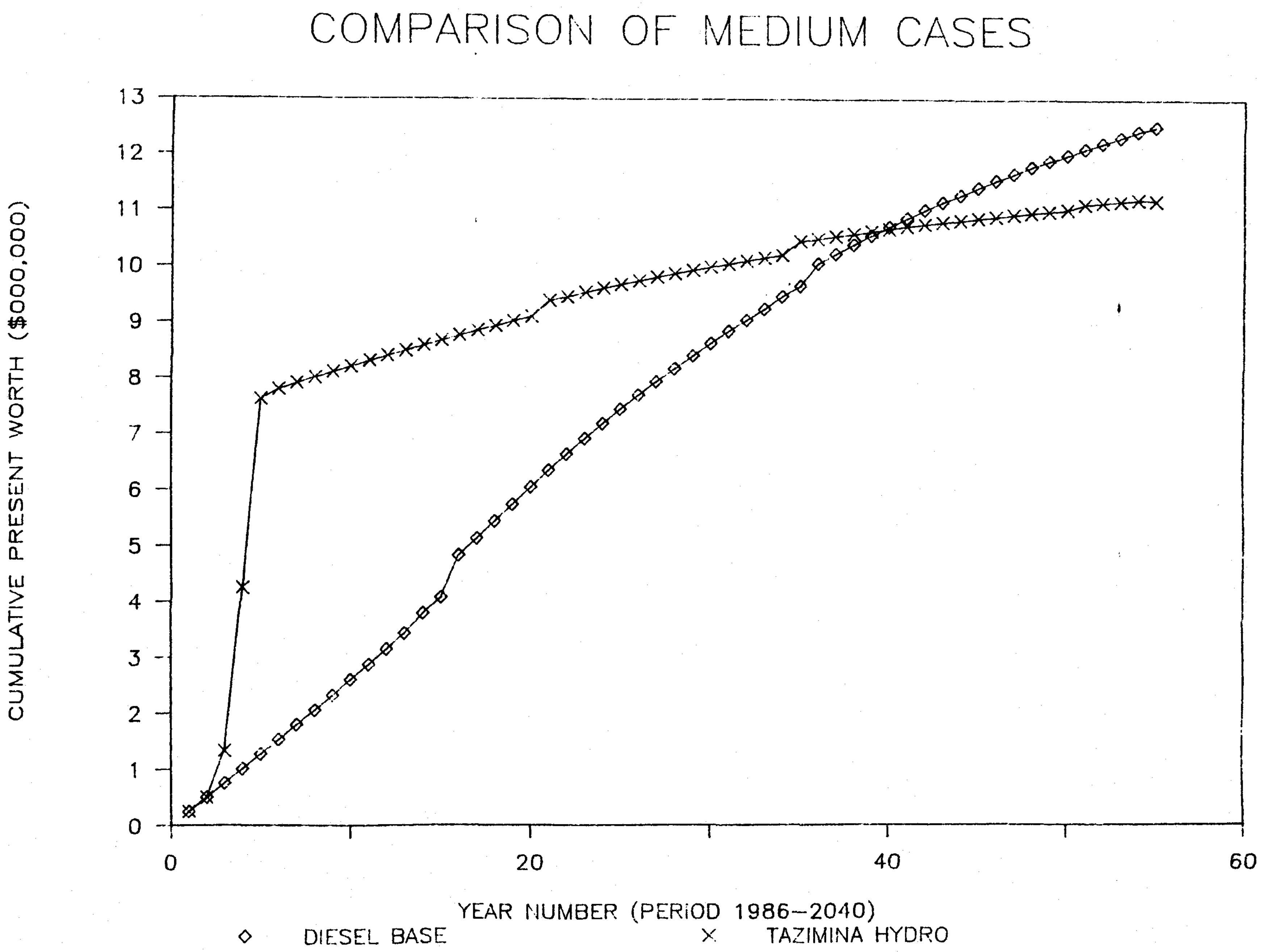

COMPARISON OF MEDIUM CASES
CUMULATIVE PRESENT WORTH ($000,000)
YEAR NUMBER (PERIOD 1986–2040)
DIESEL BASE
TAZIMINA HYDRO
0
1
2
3
4
5
6
7
8
9
10
11
12
13
20
40
60

Figure 10.3

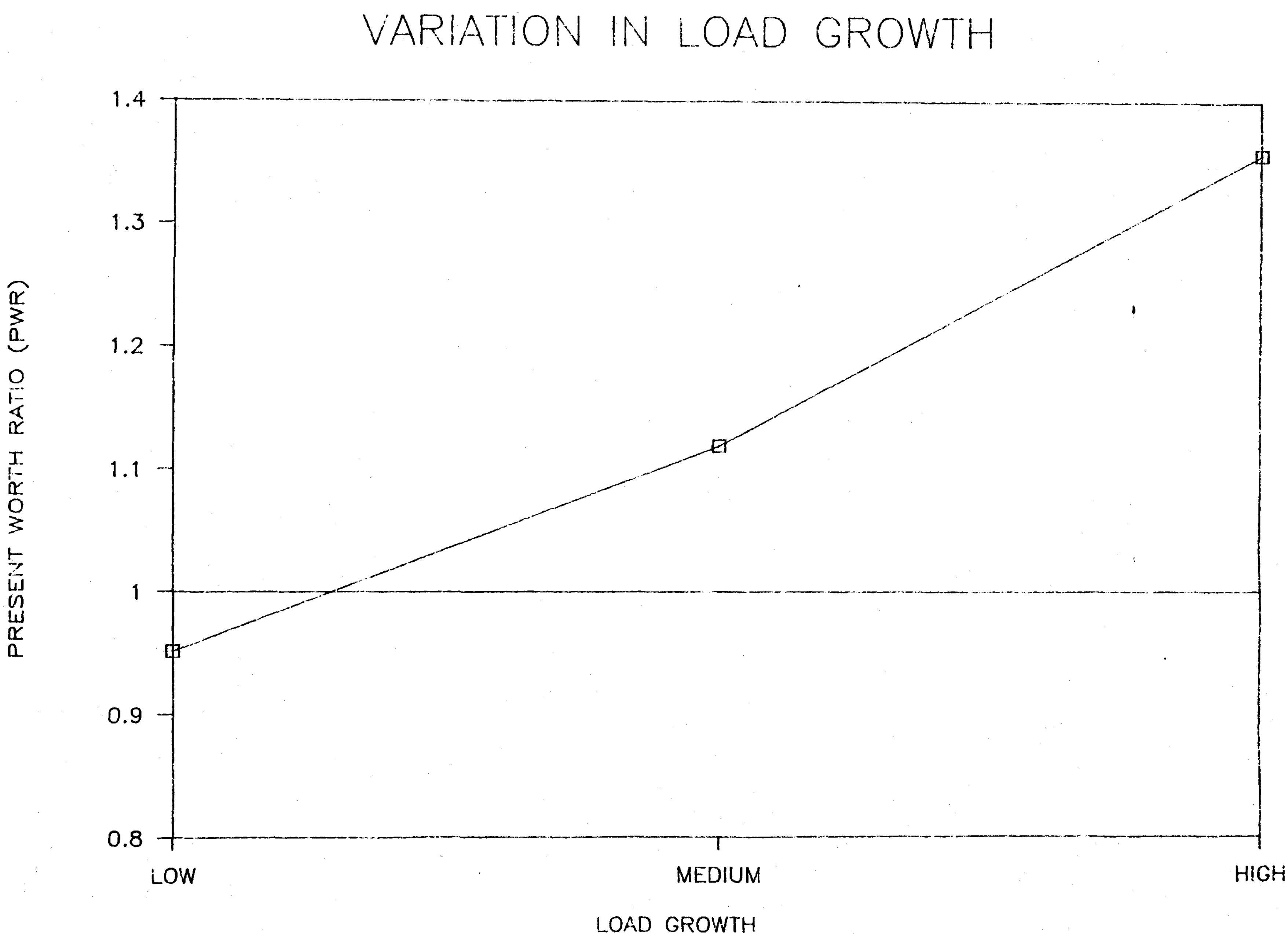

VARIATION IN LOAD GROWTH
PRESENT WORTH RATIO (PWR)
1.4
1.3
1.2
1.1
1
0.9
0.8
LOW
MEDIUM
HIGH
LOAD GROWTH

Figure 10.4

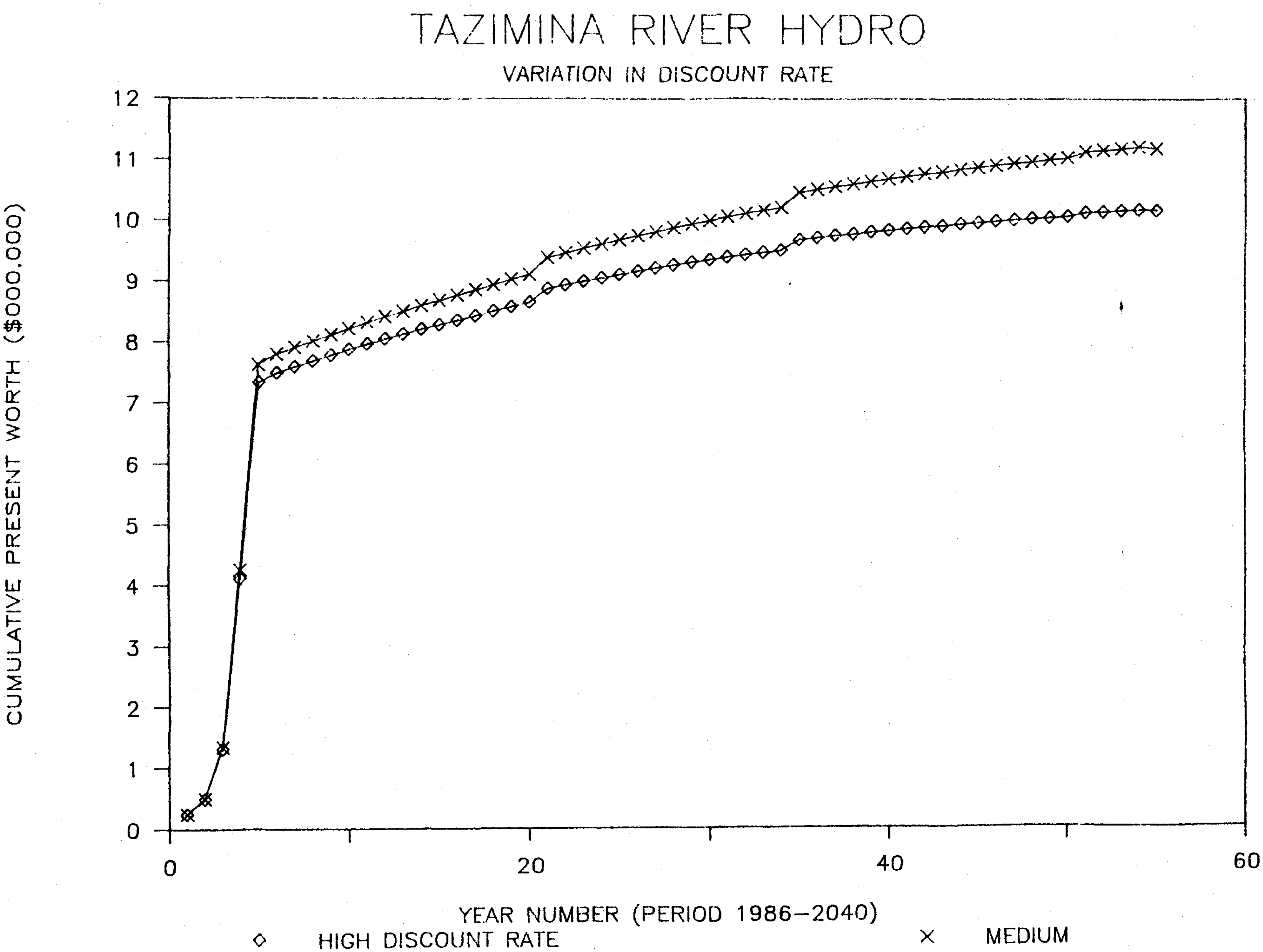
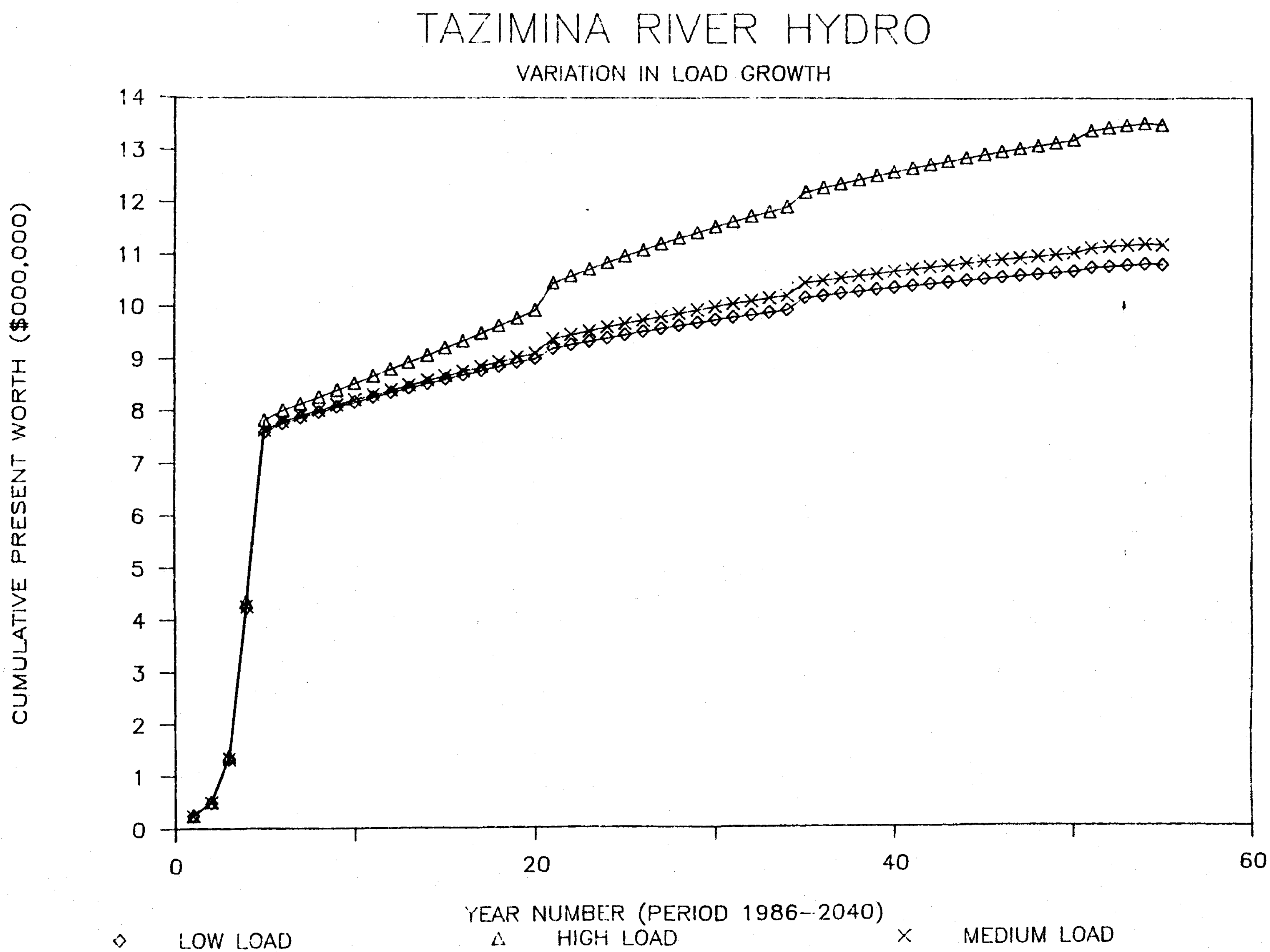

TAZIMINA RIVER HYDRO
VARIATION IN DISCOUNT RATE
CUMULATIVE PRESENT WORTH ($000,000)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
20
40
60
YEAR NUMBER (PERIOD 1986–2040)
◇ HIGH DISCOUNT RATE
× MEDIUM

Figure 10.5



TAZIMINA RIVER HYDRO
VARIATION IN LOAD GROWTH
CUMULATIVE PRESENT WORTH ($000,000)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
0
20
40
60
YEAR NUMBER (PERIOD 1986-2040)
◇ LOW LOAD
Δ HIGH LOAD
× MEDIUM LOAD

Figure 10.6

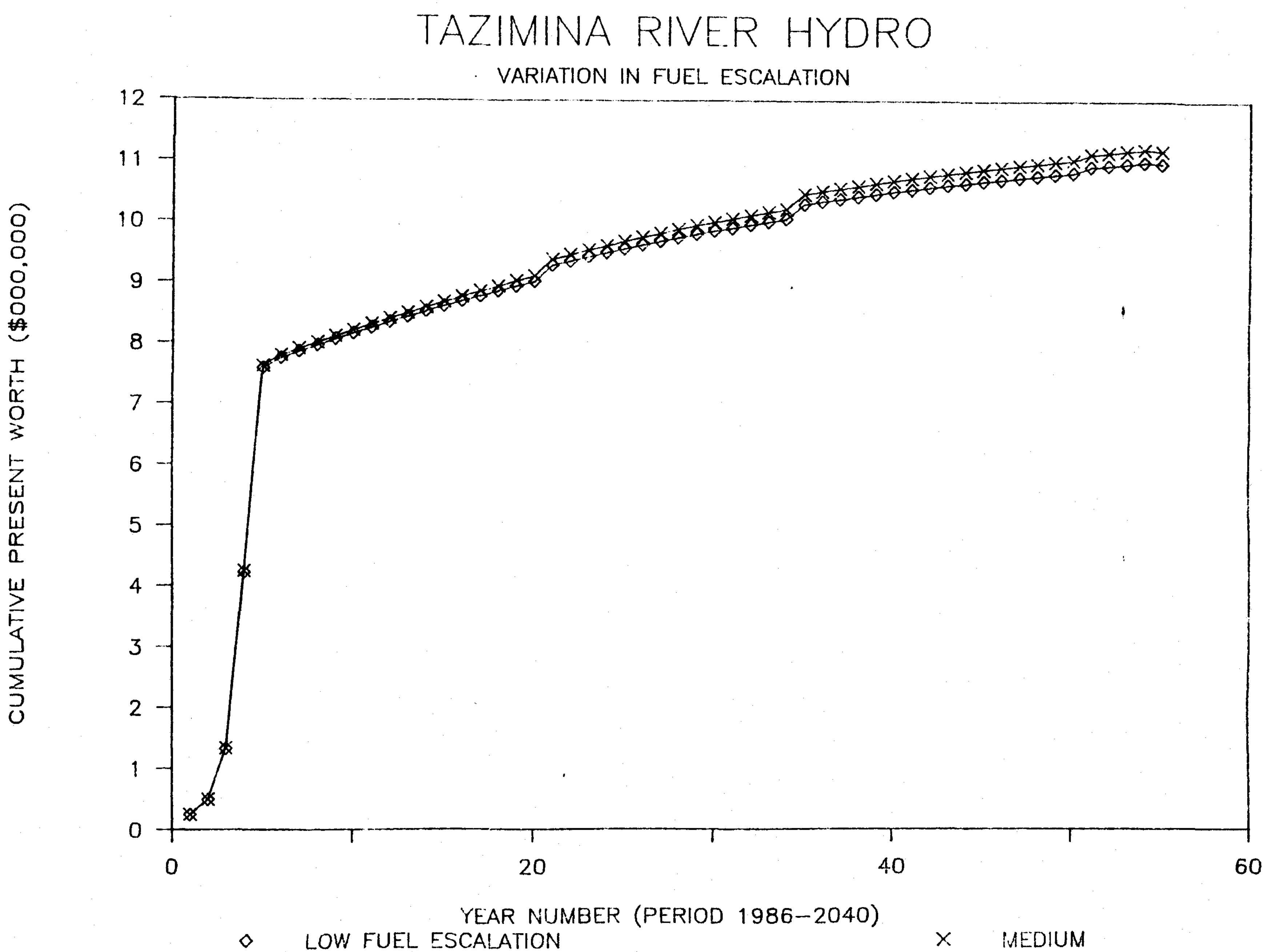

TAZIMINA RIVER HYDRO
VARIATION IN FUEL ESCALATION
CUMULATIVE PRESENT WORTH ($000,000)
0
1
2
3
4
5
6
7
8
9
10
11
12
0
20
40
60
YEAR NUMBER (PERIOD 1986-2040)
LOW FUEL ESCALATION
MEDIUM

Figure 10.7

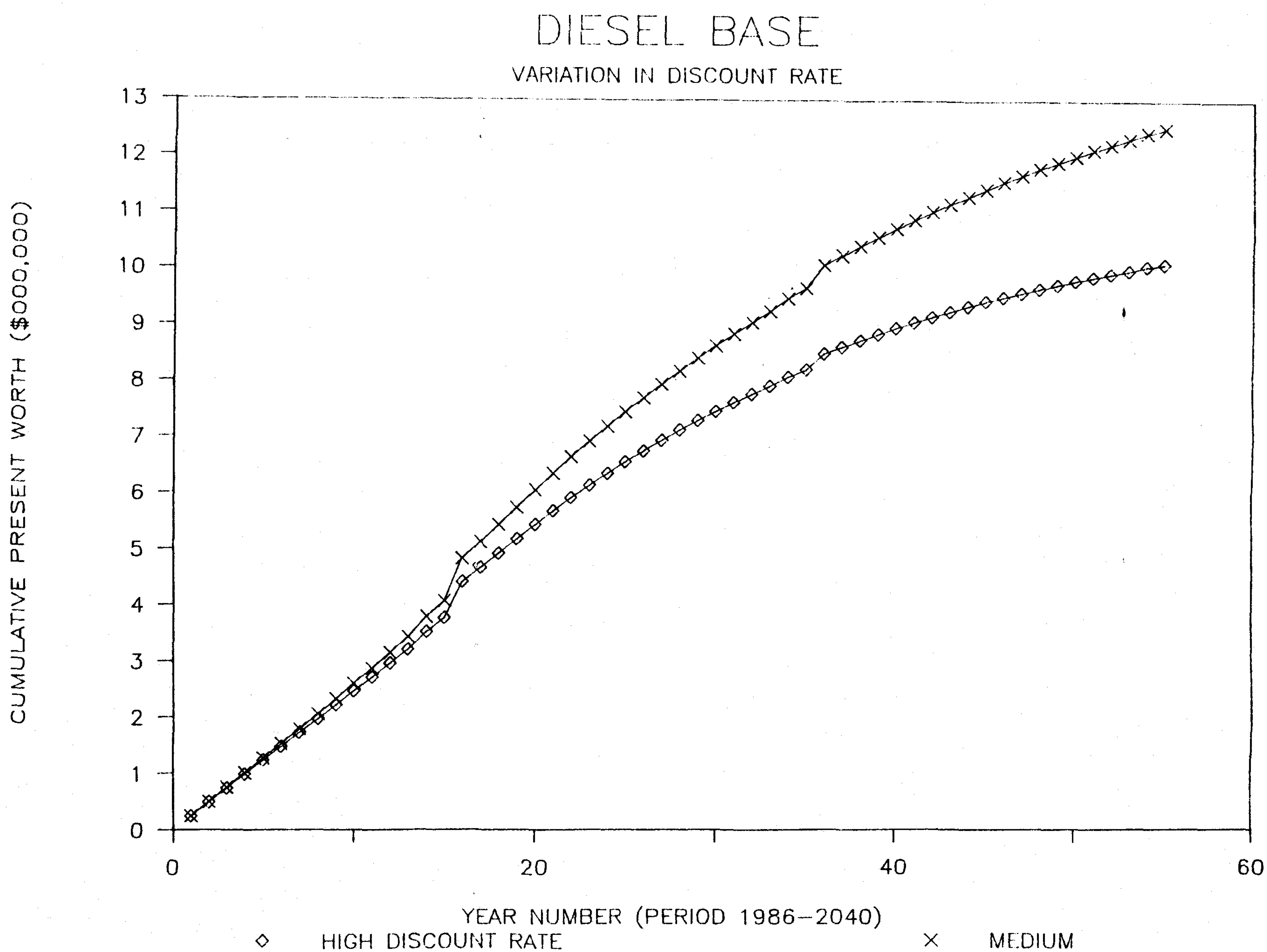

DIESEL BASE
VARIATION IN DISCOUNT RATE
CUMULATIVE PRESENT WORTH ($000,000)
YEAR NUMBER (PERIOD 1986–2040)
HIGH DISCOUNT RATE
MEDIUM
0
1
2
3
4
5
6
7
8
9
10
11
12
13
20
40
60

Figure 10.8

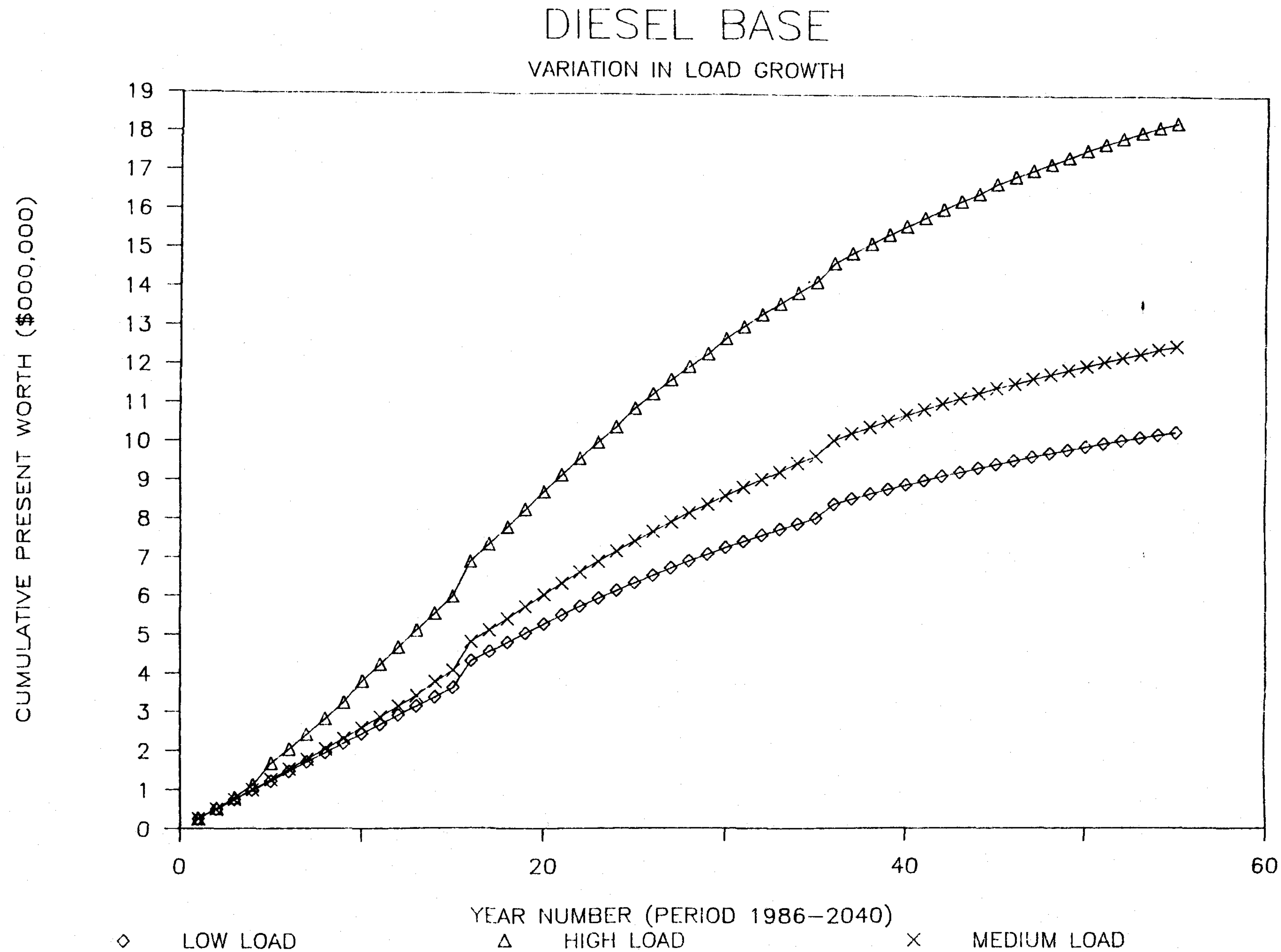
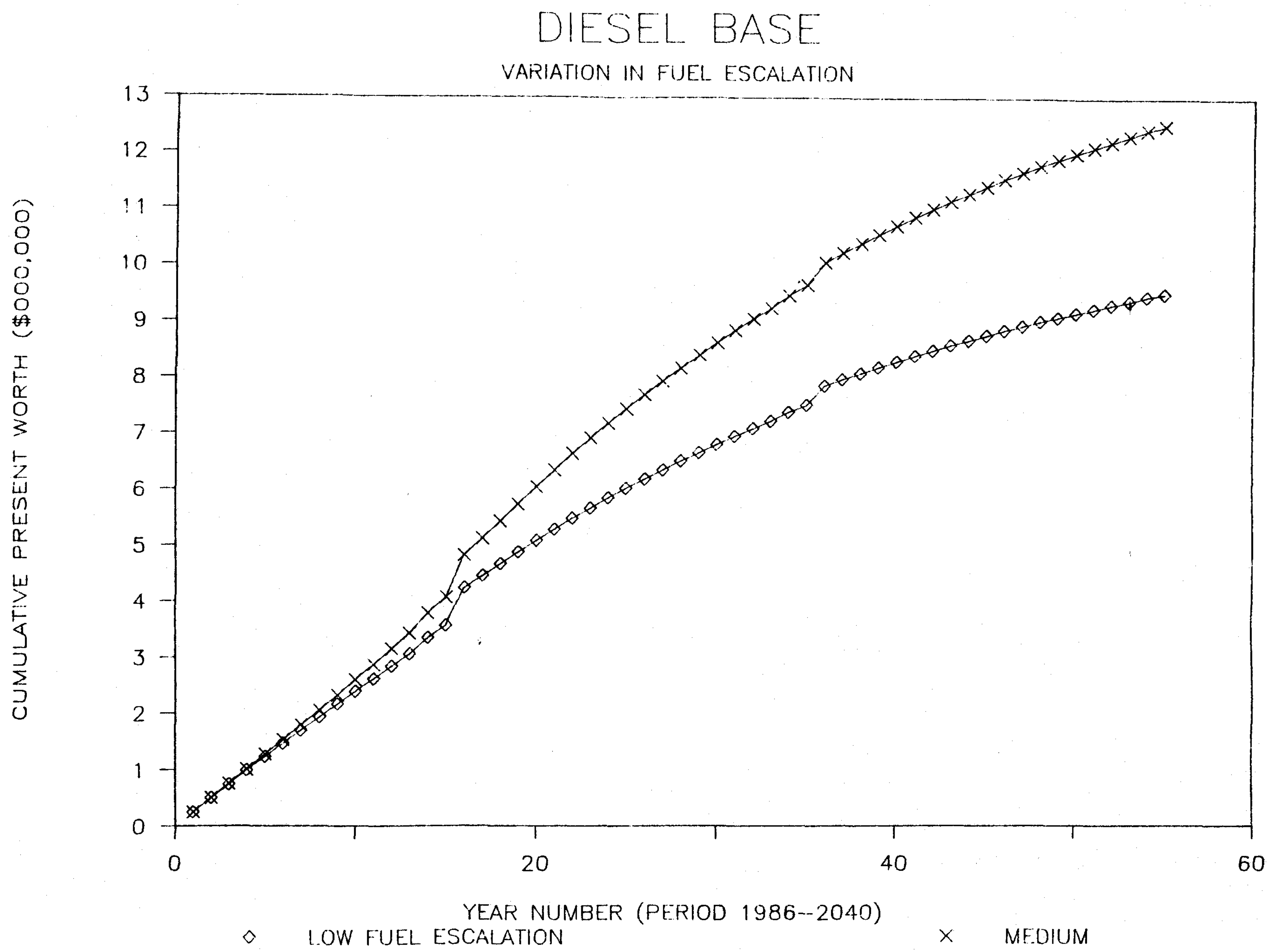
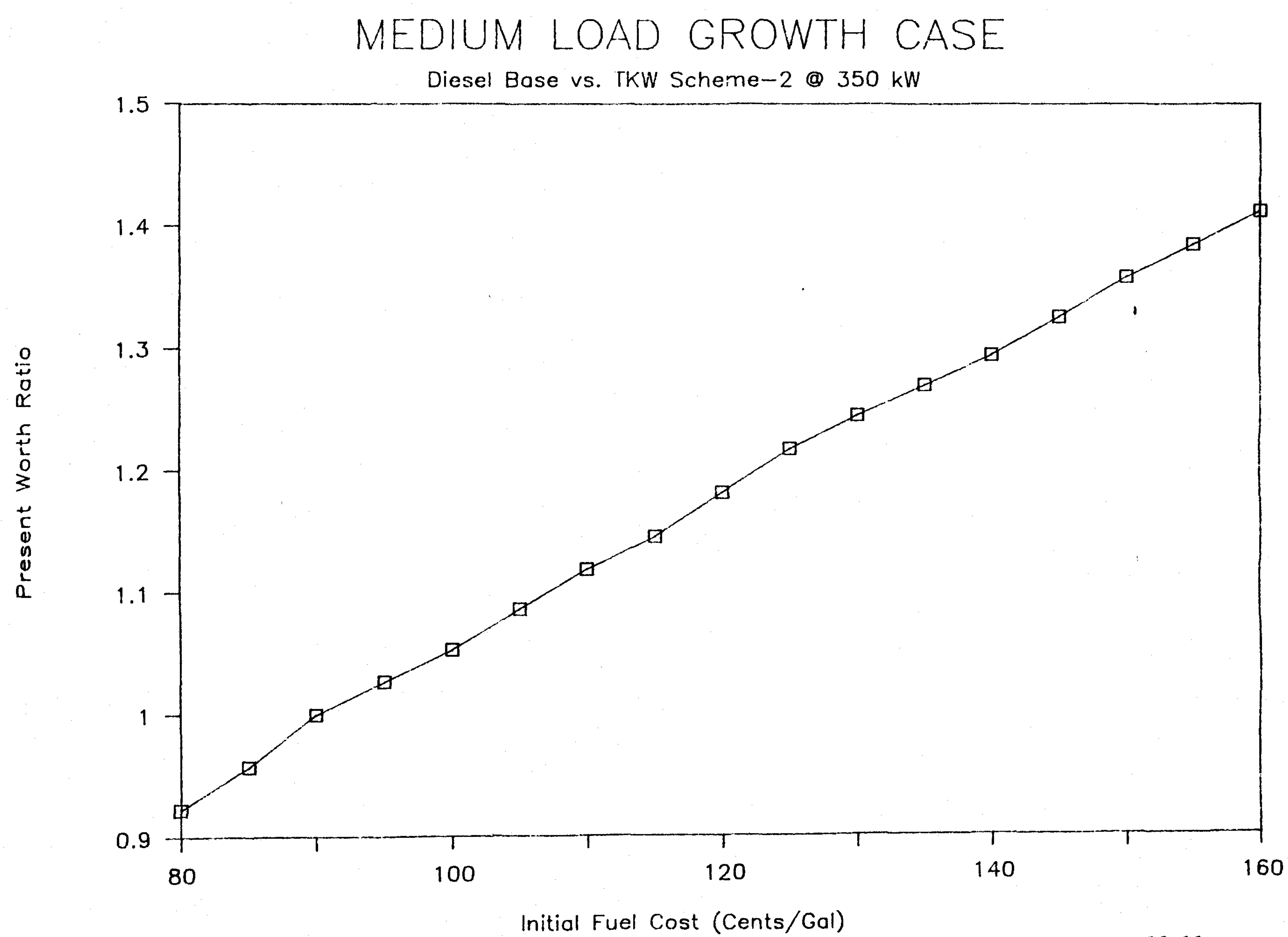

DIESEL BASE
VARIATION IN LOAD GROWTH
CUMULATIVE PRESENT WORTH ($000,000)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
0
20
40
60
YEAR NUMBER (PERIOD 1986–2040)
◇ LOW LOAD
Δ HIGH LOAD
× MEDIUM LOAD

Figure 10.9



DIESEL BASE
VARIATION IN FUEL ESCALATION
CUMULATIVE PRESENT WORTH ($000,000)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
0
20
40
60
YEAR NUMBER (PERIOD 1986--2040)
LOW FUEL ESCALATION
MEDIUM

Figure 10.10


MEDIUM LOAD GROWTH CASE
Diesel Base vs. TKW Scheme-2 @ 350 kW
Present Worth Ratio
1.5
1.4
1.3
1.2
1.1
1
0.9
80
100
120
140
160
Initial Fuel Cost (Cents/Gal)
Figure 10.11

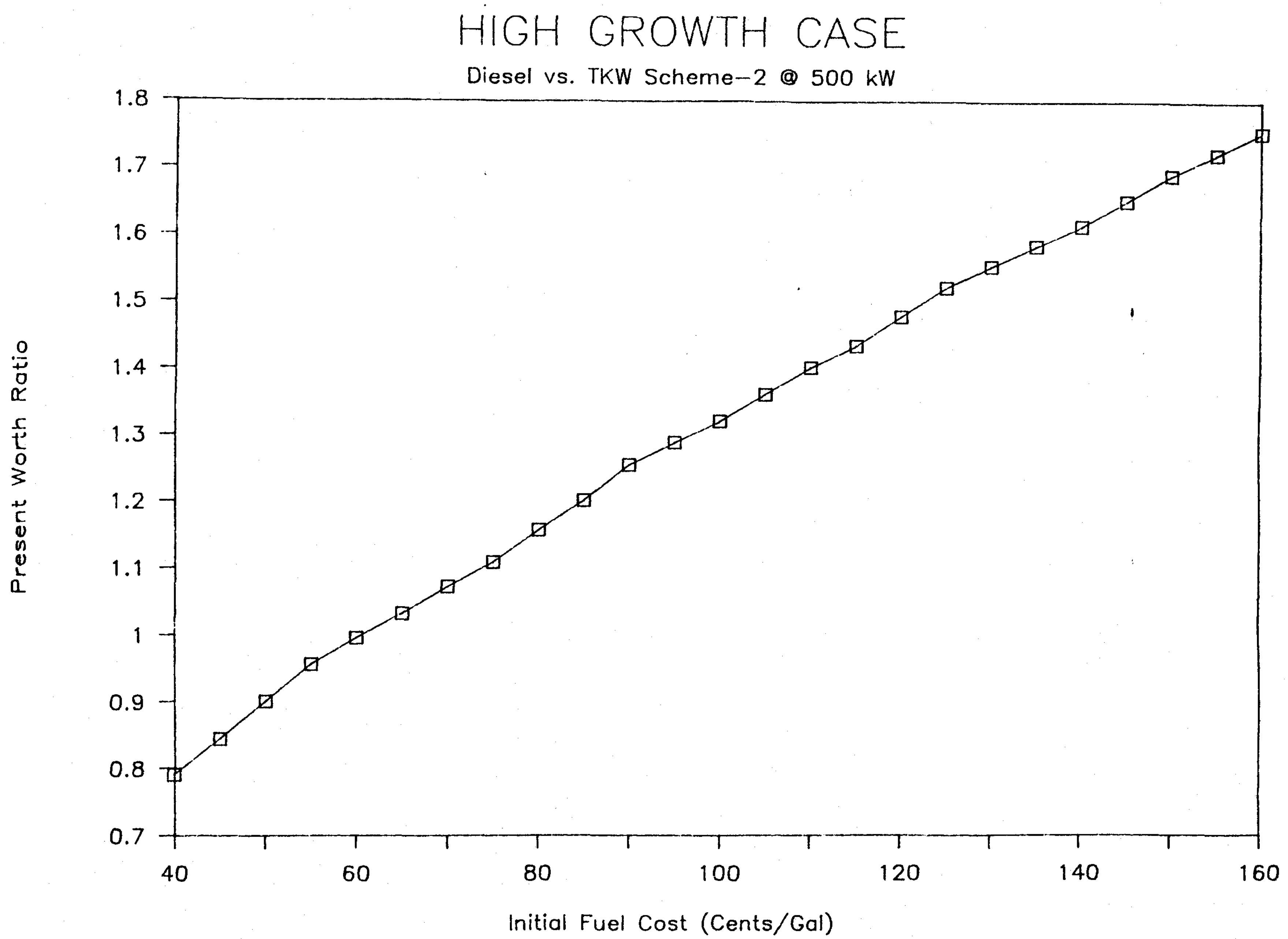

HIGH GROWTH CASE
Diesel vs. TKW Scheme-2 @ 500 kW
Present Worth Ratio
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
40
60
80
100
120
140
160
Initial Fuel Cost (Cents/Gal)

Figure 10.12

SECTION 11

PROJECT SCHEDULE

A project schedule has been formulated for the principal project activities of licensing, design, construction, and turbine - generator equipment. It is shown on Figure 11.1. The project on-line date is December 31, 1990.

The schedule allows 18 months for the FERC process from submittal of the license application to issuance of the license. The construction effort starts in May 1989. It is anticipated that work through the 1989/1990 winter season would be minimal or entirely suspended. Award of the turbine-generator contract is scheduled to support project design in a timely manner.

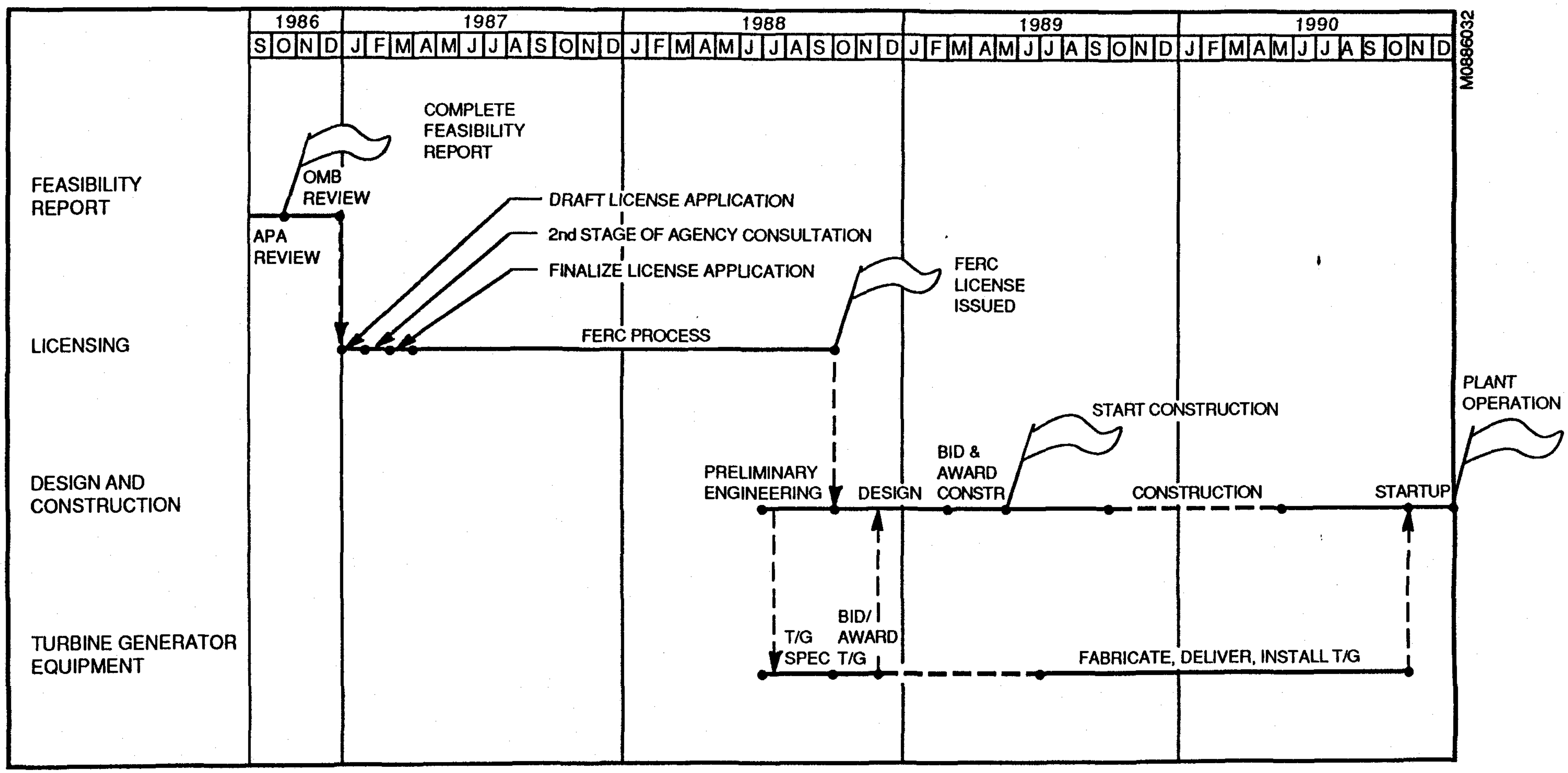


Figure 11.1
PROJECT SCHEDULE

SECTION 12

CONCLUSIONS

This feasibility study evaluates the technical, environmental, and economic aspects of the run-of-river Tazimina River Hydroelectric Project. The following conclusions are derived from the work effort.

1. Annual "medium" energy requirements for INNEC are forecast at 1834 MWh in 1986 and increasing to 3216 MWh in 2005. This excludes the potential development at Keyes Point. Including Keyes Point, the forecast increases to 4900 MWh in 2005.

2. Tazimina River summer flows substantially exceed the foreseeable energy requirements of the INNEC system. Flows peak in July and August with a monthly average discharge of nearly 2100 cfs, while project requirements are only about 100 cfs. River flows are significantly reduced from November through May. These months are critical for appropriate definition of hydro generation capability.

3. The power study indicates that optimum plant capacity for the "medium" growth scenario is 700 kW. For "high" growth projection including Keyes Point the plant capacity is increased to 1000 kW.

4. The Tazimina Falls site is technically suitable for several project arrangements. However due to the steep topography and the ruggedness of the canyon, relatively costly civil works are required to construct the hydro project. The preferred and most economical arrangement uses a vertical turbine/generator with lineshaft assembly in a drilled hole on the left bank adjacent to the falls. All feasible alternatives employ a shoreline intake approximately 250 ft upstream of the falls, a relatively short penstock of varying length to the turbine, and a tailrace just downstream of the falls.

5. The environmental assessment which considered aquatic, terrestrial, archeological, water use, and aesthetic factors found no impacts from

the project that would preclude its development. Although initial consultation has occurred with State and Federal regulatory agencies, review of this study and further consultation with appropriate agencies will be required if a FERC license application is to be prepared. Further archeological investigations along the access road alignment may be required prior to or during construction.

6. The preferred project arrangement is estimated to cost $7.4 million including allowance for indeterminates, engineering and design, construction management, and interest during construction. Cost of land is not included in the estimate.

7. The discounted cash flow economic analysis shows that on the basis of total life cycle present worth costs, using the Alaska Power Authority's 1986 economic criteria, the Tazimina River Hydroelectric Project is about 12 percent less costly than continuing with diesel generation for the "medium" load growth case. For the "high" load growth case with Keyes Point included, the project is 36 percent less costly than diesel. On the other hand, for "low" load growth projections and low diesel fuel escalation, diesel generation is less costly.

8. The economic analyses are sensitive to diesel fuel cost. The 1986 cost of fuel is relatively low compared to recent years. Future change in fuel prices could bring a more favorable advantage to development of the hydro project.

In summary, the Tazimina River Hydroelectric Project is found to be technically and environmentally feasible. It is also economically feasible based on "medium" criteria. However, its economic feasibility is sensitive to assumptions regarding future load growth in the area and future cost of diesel fuel.

APPENDIX A

TAZIMINA RIVER FLOW RECORDS

15299900 TAZIMINA RIVER NEAR NONDALTON

LOCATION.--Lat 59°55'05", long 154°34'34", in SE¼NE¼ sec.18, T.3 S., R.31 W., Hydrologic Unit 19040002, on left bank at small lake outlet, 2.1 mi (3.4 km) upstream of large waterfall, 7.5 mi (12.1 km) southeast of Nondalton, and 14.5 mi (23.3 km) northeast of Illiamna.

DRAINAGE AREA.--327 mi² (847 km²).

PERIOD OF RECORD.--June to September 1981.

GAGE.--Water-stage recorder. Altitude of gage is 610 ft (186 m), from topographic map.

REMARKS.--Records good.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 3,260 ft³/s (92.3 m³/s) Aug. 3, gage height, 3.93 ft (1.198 m); minimum, during period June to September, 577 ft³/s (16.3 m³/s) Sept. 30, gage height, 1.61 ft (0.491 m); a discharge of 224 ft³/s (6.34 m³/s) was measured on Apr. 8.

DISCHARGE, IN CUBIC FEET PER SECOND, JUNE TO SEPTEMBER 1981
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1					---		---		---	3050	2050	1280
2					---		---		---	2930	2690	1240
3					---		---		---	2740	3180	1200
4					---		---		---	2570	3190	1200
5					---		---		---	2400	3020	1180
6					---		---		---	2290	2810	1150
7					---		---		---	2240	2620	1110
8					---		≠224		---	2190	2430	1070
9					---		---		---	2240	2350	1040
10					---		---		---	2460	2390	1020
11					---		---		---	2840	2380	982
12					---		---		---	3000	2460	958
13					---		---		---	2980	2560	950
14					---		---		---	2820	2800	894
15					---		---		---	2840	3080	846
16					---		---		---	3000	3020	809
17					---		---		---	2990	2840	781
18					---		---		2170	2880	2680	767
19					---		---		2310	2800	2470	746
20					---		---		2520	2690	2330	753
21					---		---		2740	2590	2170	767
22					---		---		2860	2460	2000	739
23					≠255		---		2780	2380	1820	711
24					---		---		2690	2360	1700	711
25					---		---		2620	2400	1620	704
26					---		---		2530	2400	1570	690
27					---		---		2460	2320	1530	684
28					---		---		2390	2190	1500	678
29					---		---		2380	2130	1450	660
30					---		---		2800	2080	1390	642
31					---		---		---	1980	1350	---
TOTAL					---		---		---	79240	71450	26962
MEAN					---		---		---	2556	2305	899
MAX					---		---		---	3050	3190	1280
MIN					---		---		---	1980	1350	642
CFSM					---		---		---	7.82	7.05	2.75
IN.					---		---		---	9.01	8.13	3.07
AC-FT					---		---		---	157200	141700	53480

≠ Result of discharge measurement.

15299900 TAZIMINA RIVER NEAR NONDALTON

LOCATION.--Lat 59°55'05", long 154°34'34", in SE¼NE¼ sec.18, T.3 S., R.31 W., Hydrologic Unit 19040002, on left bank at small lake outlet, 2.1 mi (3.4 km) upstream of large waterfall, 7.5 mi (12.1 km) southeast of Nondalton, and 14.5 mi (23.3 km) northeast of Iliamna.

DRAINAGE AREA.--327 mi² (847 km²).

WATER-DISCHARGE RECORDS

PERIOD OF RECORD --June 1981 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 610 ft (186 m), from topographic map. Prior to Oct. 1, 1981 at datum 3.00 ft (0.914 m) higher.

REMARKS.--Records good except those for Oct. 30 to Mar. 26, which are poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 4,950 ft³/s (140 m³/s) Sept. 17, 1982, gage-height, 7.92 ft (2.414 m); minimum, 140 ft³/s (3.96 m³/s) Apr. 20-22, 1982, but may have been less during period of ice effect.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 4,950 ft³/s (140 m³/s) Sept. 17, gage height, 7.92 ft (2.414 m); minimum, 140 ft³/s (3.96 m³/s) Apr. 20-22, but may have been less during period of ice effect.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1981 TO SEPTEMBER 1982
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	624	880	470	260	330	200	175	180	1090	2540	2380	1240
2	594	840	450	260	350	200	175	179	1240	2300	2200	1280
3	588	810	440	260	360	200	175	180	1390	2100	2030	1270
4	582	800	420	260	370	200	175	182	1500	1910	1860	1230
5	570	800	410	260	370	200	165	189	1710	1740	1720	1300
6	546	790	400	250	370	190	165	211	2620	1630	1600	1730
7	522	780	390	250	360	190	165	242	3160	1550	1510	2160
8	500	760	380	250	350	190	165	275	2880	1630	1440	2350
9	485	740	380	250	350	190	165	358	2720	1730	1370	2410
10	465	720	350	250	330	190	155	415	2720	1780	1320	2380
11	500	700	350	250	320	190	155	420	2790	1820	1460	2280
12	546	680	350	250	300	190	154	425	2730	1870	1540	2160
13	564	660	350	250	290	190	152	410	2580	1840	1530	2210
14	564	630	350	250	280	190	150	410	2350	1780	1490	2180
15	570	610	350	250	260	190	148	420	2150	1710	1480	2370
16	606	590	320	250	250	185	146	435	1980	1700	1460	3760
17	636	570	320	250	240	185	146	445	1860	1780	1420	4760
18	636	560	320	250	235	185	144	460	1820	1840	1390	4800
19	618	550	320	250	235	185	141	460	1850	1800	1340	4490
20	612	540	320	250	250	185	141	460	1900	1740	1280	4080
21	690	530	300	250	245	185	140	470	1970	1720	1230	3790
22	760	520	300	250	217	185	140	495	1980	1760	1170	3860
23	830	520	300	250	203	185	143	516	1930	1850	1120	3640
24	893	520	300	250	200	185	151	528	1920	2080	1100	3250
25	972	520	300	250	200	185	158	546	1980	2350	1070	2880
26	1020	520	280	260	200	185	162	582	2100	2760	1070	2620
27	1030	520	280	260	200	185	166	648	2230	2840	1030	2450
28	1020	520	280	260	200	177	171	739	2490	2760	988	2270
29	988	510	280	260	---	175	175	788	2840	2620	996	2210
30	950	490	280	280	---	175	179	837	2760	2600	1040	2190
31	900	---	280	310	---	175	---	948	---	2540	1170	---
TOTAL	21381	19180	10620	7930	7865	5822	4742	13853	65240	62670	43804	79600
MEAN	690	639	343	256	281	188	158	447	2175	2022	1413	2653
MAX	1030	880	470	310	370	200	179	948	3160	2840	2380	4800
MIN	465	490	280	250	200	175	140	179	1090	1550	988	1230
CFSM	2.11	1.95	1.05	.78	.86	.58	.48	1.37	6.65	6.18	4.32	8.11
IN.	2.43	2.18	1.21	.90	.89	.66	.54	1.58	7.42	7.13	4.98	9.06
AC-FT	42410	38040	21060	15730	15600	11550	9410	27480	129400	124300	86890	157900

WTR YR 1982 TOTAL 342707 MEAN 939 MAX 4800 MIN 140 CFSM 2.87 IN 38.99 AC-FT 679800

NOTE.--No gage-height record Oct. 30 to Feb. 17 and Feb. 24 to Mar. 26.

15299900 TAZIMINA RIVER NEAR NONDALTON

LOCATION.--Lat 59°55'05", long 154°39'34" (revised), in SE¼NE¼ sec.18, T.3 S., R.31 W., Hydrologic Unit 19040002, on left bank at small lake outlet, 2.1 mi upstream of large waterfall, 7.5 mi southeast of Nondalton, and 14.5 mi northeast of Illiamna.

DRAINAGE AREA.--327 mi².

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1981 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 610 ft, from topographic map. Prior to Oct. 1, 1981 at datum 1.00 ft higher

REMARKS.--Records good except those for Oct. 23 to Jan. 2, which are fair, and those for Jan. 3 to May 30, which are poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 4,950 ft³/s Sept. 17, 1982, gage-height, 7.92 ft; minimum recorded, 124 ft³/s Apr. 1, 1983, but may have been less during period of ice effect.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 2,140 ft³/s Oct.1, stage falling, peak occurred Sept. 17,1982; maximum peak discharge, 2,110 ft³/s June 9, gage height, 6.20 ft; minimum recorded, 124 ft³/s, gage height, 2.96 ft, Apr. 1, from range in stage, but may have been less during period of ice effect.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1982 TO SEPTEMBER 1983
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	2100	558	310	330	140	140	140	300	1790	1860	858	624
2	2030	570	310	321	140	140	140	320	1940	1870	851	612
3	1930	552	300	300	140	140	140	330	2020	1860	830	624
4	1810	516	300	290	140	140	145	340	2070	1800	830	648
5	1700	495	290	270	140	140	145	360	2040	1730	900	654
6	1580	480	290	240	140	140	150	380	1990	1670	924	648
7	1470	475	280	220	140	140	150	400	1990	1650	940	636
8	1370	485	280	200	140	140	150	420	2040	1640	1080	618
9	1280	470	270	180	140	140	155	440	2080	1600	1280	606
10	1190	450	270	170	140	140	155	460	2080	1540	1410	594
11	1120	460	260	160	140	140	160	480	2010	1480	1450	570
12	1080	455	260	150	140	140	165	510	1920	1420	1430	552
13	1010	465	250	150	140	140	170	540	1850	1360	1380	594
14	964	470	245	145	140	140	170	570	1800	1370	1320	672
15	932	445	242	140	140	140	175	600	1790	1410	1240	704
16	932	425	232	140	140	140	180	630	1800	1410	1150	704
17	940	410	228	140	140	140	185	670	1780	1400	1090	684
18	893	400	219	140	140	140	190	710	1760	1370	1020	672
19	916	390	217	140	140	140	195	750	1800	1320	879	660
20	900	375	213	140	140	140	200	790	1850	1260	886	672
21	837	366	213	140	140	140	210	850	1860	1190	872	690
22	746	350	215	140	140	140	220	900	1840	1130	858	725
23	594	362	210	140	140	140	225	950	1820	1080	823	746
24	570	362	210	140	140	140	230	1000	1870	1020	802	746
25	570	350	210	140	140	140	240	1050	1920	988	767	725
26	570	338	210	140	140	140	250	1150	2020	972	725	718
27	570	330	207	140	140	140	260	1200	1960	948	697	718
28	564	324	223	140	140	140	270	1300	1960	908	672	711
29	558	318	292	140	---	140	280	1350	1920	879	642	746
30	558	318	334	140	---	140	290	1450	1900	858	636	865
31	552	---	334	140	---	140	---	1520	---	851	630	---
TOTAL	32836	12764	7924	5506	3920	4340	5735	22720	57470	41844	29872	20138
MEAN	1059	425	256	178	140	140	191	733	1916	1350	964	671
MAX	2100	570	334	330	140	140	290	1520	2080	1870	1450	865
MIN	552	318	207	140	140	140	140	300	1760	851	630	552
CFSM	3.24	1.30	.78	.54	.43	.43	.58	2.24	5.86	4.13	2.95	2.05
IN.	3.74	1.45	.90	.63	.45	.49	.65	2.58	6.54	4.76	3.40	2.29
AC-FT	65130	25320	15720	10920	7780	8610	11380	45070	114000	83000	59250	39940

CAL YR 1982 TOTAL 345050 MEAN 945 MAX 4800 MIN 140 CFSM 2.89 IN 39.25 AC-FT 684400
WTR YR 1983 TOTAL 245069 MEAN 671 MAX 2100 MIN 140 CFSM 2.05 IN 27.88 AC-FT 486100

NOTE.--No gage-height record Mar. 11 to May 30.

SOUTHWEST ALASKA

15299900 TAZIMINA RIVER NEAR NONDALTON

LOCATION.--Lat 59°55'05", long 154°39'34", in SE¼NE¼ sec.18, T.3 S., R.31 W., Hydrologic Unit 19040002, on left bank at outlet of small lake, 2.1 mi upstream of large waterfall, 7.5 mi southeast of Nondalton, and 14.5 mi northeast of Iliamna.

DRAINAGE AREA.--327 mi².

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1981 to current year.

GAGE.--Water-stage recorder. Altitude of gage is 610 ft, from topographic map. Prior to Oct. 1, 1981 at datum 3.00 ft higher.

REMARKS.--Records good except those for Jan. 2 to Mar. 13, which are poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 4,950 ft³/s Sept. 17, 1982, gage-height, 7.92 ft; minimum recorded, 124 ft³/s Apr. 1, 1983, but may have been less during period of ice effect.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 3,500 ft³/s Oct. 13, gage-height, 7.12 ft; minimum recorded, 189 ft³/s Apr. 19, but may have been less during period of ice effect.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1983 TO SEPTEMBER 1984
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	1000	726	1270	300	210	210	255	327	893	2370	1020	1860
2	1180	711	1350	290	210	210	255	338	900	2270	1000	1660
3	1260	711	1340	280	210	210	250	334	940	2150	988	1500
4	1270	678	1310	280	210	250	245	327	1020	1980	980	1360
5	1260	631	1250	270	210	330	245	321	1120	1930	964	1240
6	1310	600	1170	260	210	390	245	321	1250	1910	972	1140
7	1310	636	1090	260	210	400	240	324	1380	1920	964	1060
8	1270	876	1000	250	210	410	238	330	1540	1930	948	997
9	1350	947	909	250	210	410	228	334	1650	1920	932	941
10	1710	924	852	240	210	400	221	346	1740	1860	908	880
11	2630	886	809	240	210	380	215	358	1790	1800	971	837
12	3340	851	756	240	210	360	215	366	1790	1720	980	795
13	3490	809	712	240	210	340	211	374	1810	1630	940	788
14	3270	754	680	230	210	327	211	386	1900	1590	900	767
15	2950	714	630	230	210	300	209	398	1970	1520	865	746
16	2630	704	597	230	210	290	207	425	2050	1440	830	725
17	2350	690	564	230	210	288	203	450	2230	1370	795	704
18	2100	666	534	230	210	283	203	470	2420	1370	816	697
19	1890	624	505	220	210	275	195	490	2450	1370	864	690
20	1740	606	500	220	210	270	195	522	2370	1370	886	690
21	1600	624	505	220	210	268	201	564	2300	1340	900	666
22	1470	618	475	220	210	265	207	612	2250	1280	1020	648
23	1360	594	450	220	210	260	203	660	2210	1250	1160	642
24	1260	547	430	220	210	255	201	710	2250	1210	1410	648
25	1140	528	410	220	210	250	195	759	2390	1180	2130	648
26	1040	522	390	210	210	250	197	802	2570	1130	3160	630
27	981	505	380	210	210	263	221	837	2610	1100	3370	624
28	917	557	360	210	210	265	279	858	2520	1080	3120	636
29	859	793	340	210	210	263	290	879	2440	1060	2790	666
30	816	1060	328	210	---	260	303	886	2420	1040	2420	666
31	774	---	309	210	---	258	---	893	---	1020	2110	---
TOTAL	51527	21092	22205	7350	6090	9190	6783	16001	57173	48110	42113	26551
MEAN	1662	703	716	237	210	296	226	516	1906	1552	1358	885
MAX	3490	1060	1350	300	210	410	303	893	2610	2370	3370	1860
MIN	774	505	309	210	210	210	195	321	893	1020	795	624
CFSM	5.08	2.15	2.19	.73	.64	.91	.69	1.58	5.83	4.75	4.15	2.71
IN.	5.86	2.40	2.53	.84	.69	1.05	.77	1.82	6.50	5.47	4.79	3.02
AC-FT	102200	41840	44040	14580	12080	18230	13450	31740	113400	95430	83530	52660

CAL YR 1983 TOTAL 286369 MEAN 785 MAX 3490 MIN 140 CFSM 2.40 IN 32.58 AC-FT 568000
WTR YR 1984 TOTAL 314185 MEAN 858 MAX 3490 MIN 195 CFSM 2.62 IN 35.74 AC-FT 623200

SOUTHWEST ALASKA

15299900 TAZIMINA RIVER NEAR NONDALTON

LOCATION.--Lat 59°55'05", long 154°39'34", in SE¼NE¼ sec.18, T.3 S., R.31 W., Hydrologic Unit 19040002, on left bank at outlet of small lake, 2.1 mi upstream of large waterfall, 7.5 mi southeast of Nondalton, and 14.5 mi northeast of Iliamna.

DRAINAGE AREA.--327 mi².

Preliminary Report
Subject to Revision

WATER-DISCHARGE RECORDS

PERIOD OF RECORD.--June 1981 to current year.

GAGE.--Water-stage recorder. Elevation of gage is 610 ft above National Geodetic Vertical Datum of 1929, from topographic map. Prior to Oct. 1, 1981 at datum 3.00 ft higher.

REMARKS.--Estimated daily discharges: Nov. 25-27, 29, 30, Dec. 7, Dec. 9 to Apr. 19, Apr. 27, 28, July 1-29, and Aug. 1-3. Records good except for periods of no gage-height record, July 1-29 and Aug. 1-3, which are fair, and period with ice effect, Dec. 12 to Apr. 19, which is poor.

EXTREMES FOR PERIOD OF RECORD.--Maximum discharge, 5,560 ft³/s, Sept. 30, 1985, gage-height, 8.23 ft; minimum, 94 ft³/s, Mar. 31, 1985, result of freezeup.

EXTREMES FOR CURRENT YEAR.--Maximum discharge, 5,560 ft³/s, Sept. 30, gage-height, 8.23 ft; minimum, 94 ft³/s, Mar. 31, result of freezeup.

DISCHARGE, IN CUBIC FEET PER SECOND, WATER YEAR OCTOBER 1984 TO SEPTEMBER 1985
MEAN VALUES

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	672	346	195	170	155	150	150	130	2550	3500	1540	1600
2	733	324	195	170	155	150	150	133	2450	4000	1470	1530
3	751	300	197	170	155	150	150	135	2390	4100	1410	1580
4	745	288	195	170	155	150	150	139	2510	4100	1380	1540
5	809	293	201	170	155	150	150	141	2700	3900	1340	1480
6	809	300	193	165	155	150	150	150	2760	3700	1350	1410
7	802	307	195	165	155	150	150	163	2700	3500	1440	1340
8	781	288	195	165	155	150	150	159	2630	3300	1550	1300
9	760	273	193	165	155	150	150	175	2550	3100	1690	1290
10	739	265	191	165	155	150	150	180	2460	3000	1920	1300
11	718	253	189	165	155	150	150	160	2370	2900	2150	1280
12	690	243	190	160	155	150	150	182	2340	2900	2610	1270
13	665	240	190	155	155	150	150	165	2440	2800	3390	1220
14	636	238	185	155	155	150	150	193	2490	2800	3690	1270
15	600	245	185	155	155	150	150	209	2470	2700	3810	1460
16	588	253	183	150	155	150	150	243	2450	2500	4150	1660
17	564	230	180	150	155	150	150	305	2390	2400	4250	2140
18	540	243	180	150	155	150	150	369	2310	2300	3930	2340
19	516	235	180	150	155	150	150	439	2250	2300	3520	2480
20	485	240	180	150	155	150	156	460	2250	2300	3240	2490
21	470	248	180	150	150	150	150	485	2240	2200	3010	2320
22	485	243	180	150	150	150	147	357	2160	2200	2520	2150
23	480	235	180	150	150	150	147	647	2160	2100	2580	2100
24	455	225	175	150	150	150	151	773	2200	2000	2370	2060
25	430	215	175	150	150	150	147	895	2250	1900	2200	1990
26	348	207	175	155	150	150	133	1080	2450	1900	2030	1940
27	378	200	175	155	150	150	133	1270	2750	1900	1860	2160
28	358	203	175	155	150	150	130	1590	3010	1800	1740	3670
29	346	225	175	155	---	150	128	1960	3330	1700	1730	4690
30	346	199	170	155	---	150	128	2270	3640	1710	1670	5390
31	346	---	170	155	---	150	---	2540	---	1640	1620	---
TOTAL	15191	7614	5730	5030	4300	4650	4410	18371	75690	83450	73460	6065
MEAN	490	254	185	162	154	150	147	593	2523	2692	2370	202
MAX	809	346	201	170	155	150	156	2540	3640	4100	4250	539
MIN	346	199	170	155	150	150	128	130	2160	1640	1340	122
CFSM	1.79	.78	.57	.50	.47	.46	.45	1.81	7.72	8.23	7.25	6.1
IN.	2.07	.87	.65	.57	.49	.53	.50	2.09	8.61	9.49	8.36	6.9
AC-FT	30130	15100	11370	9980	8530	9220	8750	36440	150100	165500	145700	12030

CAL YR 1984 TOTAL 250886 MEAN 685 MAX 3370 MIN 170 CFSM 2.10 IN 28.54 AC-FT 497600
WTR YR 1985 TOTAL 361555 MEAN 991 MAX 5390 MIN 128 CFSM 3.03 IN 41.13 AC-FT 717100

APPENDIX B

SEISMIC REFRACTION SURVEY REPORT

4/38 1

SEISMIC REFRACTION SURVEY
FOR THE
TAZIMINA RIVER HYDROELECTRIC PROJECT

Prepared For:

Stone & Webster Engineering Corporation
Denver Operations Center
Denver, Colorado

Prepared By:

R&M Consultants, Inc.
Anchorage, Alaska

OCTOBER 1985

R&M
R&M CONSULTANTS, INC. 5024 CORDOVA • BOX 6087 • ANCHORAGE, ALASKA 99502 • PH. 907-561-1733
ENGINEERS
GEOLOGISTS
PLANNERS
SURVEYORS

October 8, 1985 R&M No. 551130

Stone & Webster Engineering Corporation
Denver Operations Center
P.O. Box 5406
Denver, Colorado 80217-5406

Attention: Mr. D.L. Newman

Re: Contract No. 14007-0014, Seismic Refraction Study, Tazimina River Hydroelectric Project

Dear Mr. Newman:

R&M Consultants, Inc. was contracted by Stone & Webster Engineering Corporation (SWEC) to perform a seismic refraction study for the Tazimina River Hydroelectric Project. The general study area is shown on Figure 1. We have recently completed the subject work and the results are contained herein. This work was authorized by your letter of August 16, 1985 and was conducted under the terms of Contract No. 14007-0014.

Location and General Site Conditions

The Tazimina River lies north of Illiamna Lake and flows from its headwaters in the Aleutian Range west south westward to Six Mile Lake and the Newhalen River (Figure 1). The variable river profile includes two large and several small lakes, an approximately 100 foot high waterfall and a gorge with rapids. The steep gradient of the waterfall portion of the river is interpreted to have significant hydroelectric power generating potential.

Wahrhafting has identified the Tazimina drainage as lying within the Alaska-Aleutian Range physiographic province which consists of high rugged glaciated peaks and broad U-shaped valleys. The bedrock geology of the project area is dominated by early Jurassic granitic batholiths intruding highly deformed Paleozoic and Mesozoic volcanic and sedimentary rocks deposited in an early Mesozoic magmatic arc. Outcrops near the project facilities investigated by this study have been mapped as volcanic tuff and andesite (Shannon & Wilson, 1982).

The entire project area was repeatedly glaciated during the Pleistocene and displays classic geomorphology including horns, arete ridges and broad U-shaped valleys. Most of the lower side slopes and valley bottoms are mantled with unconsolidated glacial drift including outwash, till, alluvium, colluvium and probably a thin discontinuous blanket of loess. The

ANCHORAGE ALASKA   FAIRBANKS ALASKA   JUNEAU ALASKA   SALT LAKE CITY UTAH

surficial materials in the area of the R&M seismic lines have been mapped as outwash and terrace deposits (Shannon & Wilson, 1982). Sporadic to discontinous permafrost occurs throughout the project area. Preliminary studies related to the Tazimina River Hydroelectric project have been conducted and/or sponsored by the U.S. Department of Energy, Alaska Power Authority, U.S. Geological Survey, Retherford Associates, Stone & Webster Engineering Corporation, Shannon & Wilson, Inc., and C.C. Hawley, Inc.

Vegetation consists of white spruce and birch on the well drained soils and black spruce in poorly drained areas. A thick organic mat covers much of the ground surface in the low elevation portions of the project area including the R&M seismic line locations.

Project Description

Several different project facility configurations have been investigated in the past. The present arrangement being considered is a run-of-river project which includes a gated intake structure above Tazimina Falls and a penstock leading from the intake around the falls to a powerhouse in the canyon below the falls. Additional project facilities include an access road, switchyard, and transmission line.

Scope

As described in the Stone & Webster request for proposals and R&M's subsequent proposal, the original scope of work identified five seismic lines totaling approximately 1,800 feet. Project facilities to be investigated by this work included the intake structure, penstock route, powerhouse area (canyon rim), powerhouse site (bottom of canyon) and an alternate powerhouse site. Adverse field conditions forced a modification of the field program (ie., two seismic lines in the Tazimina River Canyon were inaccessible due to high water). The modified program consisted of three 520 foot seismic refraction lines, located at the intake structure, penstock route, and powerhouse area on the rim of the Tazimina River Canyon. Stone & Webster field personnel at the site observed work, provided technical direction, and determined the seismic line locations.

Methodology

R&M Consultants employed standard seismic refraction survey techniques as described in "Seismic Refraction Exploration for Engineering Site Investigations (Redpath, NTIS, 1973)" and numerous other texts. Initial site work consisted of laying out, clearing and topographically surveying the three 520 foot lines. These lines are located on the southeast bluff above the Tazimina River canyon as shown on Figure 2.

The seismic refraction survey was performed on August 21, 1985 using a Geometrics Model 1210F seismograph and a string of 12 geophones spaced at 20 foot intervals. Geophones were set into the mineral soil beneath an average of one foot of organic mat where possible. Charges were set one to two feet into the soil. One half pound explosive charges were used as the energy source with one shot 20 feet from each end of the geophone string and one at the center of each string. For each 520 foot line, six shots were recorded allowing a more accurate interpretation. Printed records were collected and read in the field to ensure the quality was adequate for interpretation.

The printed records were interpreted to extract the first arrival times for compressional waves. Plotting the arrival times against distance allowed the determination of soil and rock velocities and time intercepts. This data was used in computer-aided analysis to determine the thicknesses of, depth to, and undulations in various soil and rock layers. Additionally, the velocity data may be used to estimate rippability and blasting characteristics.

Limitations

The R&M seismic refraction data has an interpreted accuracy of approximately ±10% in terms of material velocity and layer depth/thickness. Note that velocities and thicknesses probably show variation throughout the investigated site, and that seismic refraction work has well documented limitations in identifying slow velocity layers underlying faster layers and thin hidden layers. Most of any error in the R&M data is probably contributed by varying thicknesses of very slow surficial organics. Also, note that the seismic interpretations were not corroborated by test holes located on the seismic lines.

Results

The results of the R&M seismic refraction survey are presented on Figures 3, 4, and 5 in the form of time-distance plots and seismic velocity profiles (velocity cross-sections). Each line was interpreted as a three layer situation, with a low velocity (800 fps to 1,100 fps) surficial layer; a middle layer with velocities ranging from 3,500 fps to 6,000 fps; and a high velocity lower layer ranging from 12,000 fps to 14,000 fps. The high velocity layer is interpreted to be bedrock (probably the tuff and/or andesite mapped by Shannon & Wilson). The middle layer overlying bedrock may include glacial till of the Newhalen Stade and/or glacio-fluvial outwash and terrace debris as mapped by Shannon & Wilson. The thickness of the materials varies along each line with a general depth to bedrock ranging from about 10 feet to almost 40 feet. Along R&M seismic lines the unconsolidated materials overlying bedrock appear to be thinner closer to the river. Details concerning depths and thickness are best scaled from Figures 3, 4 and 5. These data appear consistent with the previous seismic refraction work.

If you have any questions or desire additional information please contact R&M at your convenience.

Very truly yours,

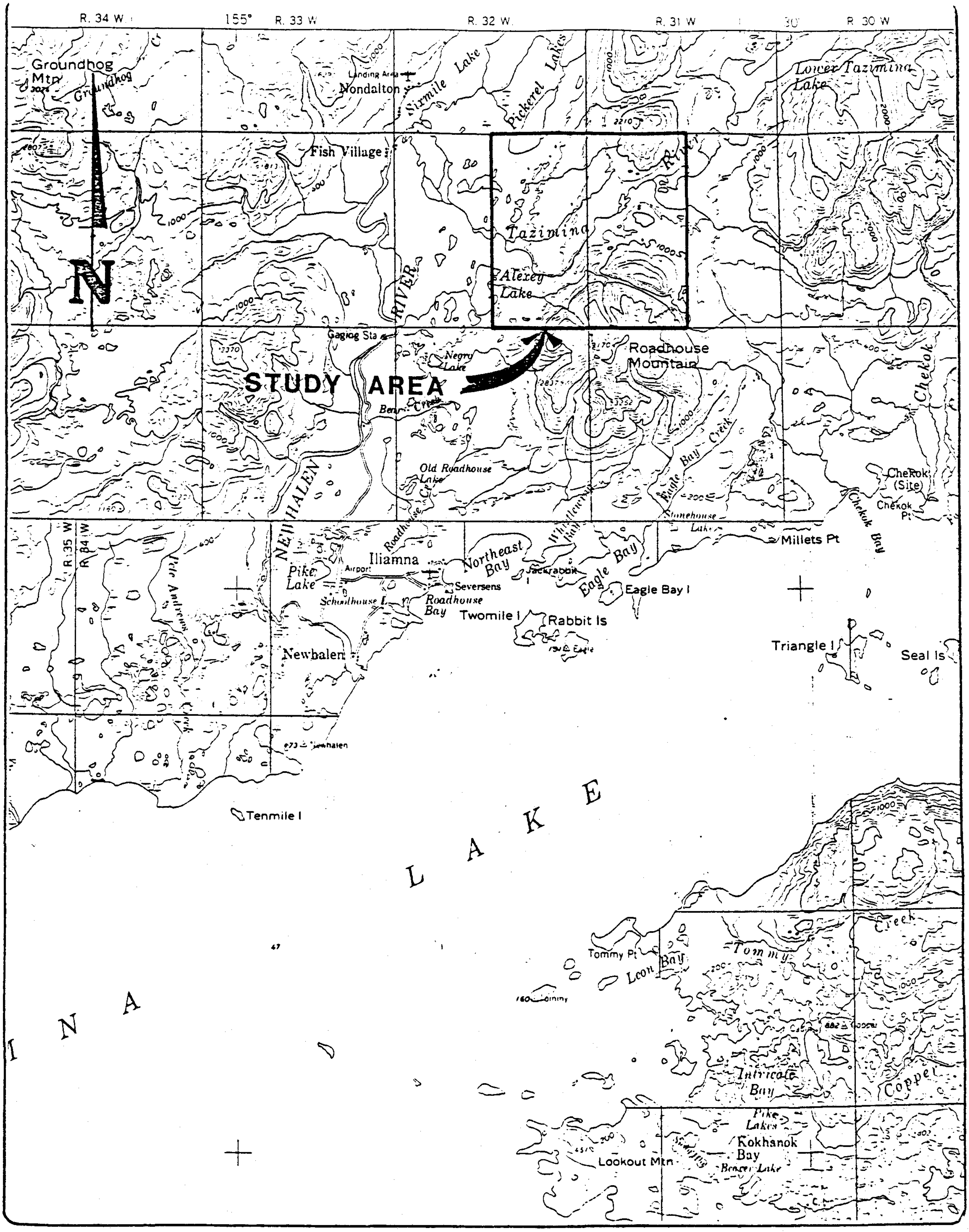
R&M CONSULTANTS, INC.

Kelly S. Merrill

for Gerald Williams
Senior Geologist/Geophysicist

Lawrence J. Acomb, C.P.G.
Senior Geologist

CHR:KSM;bje



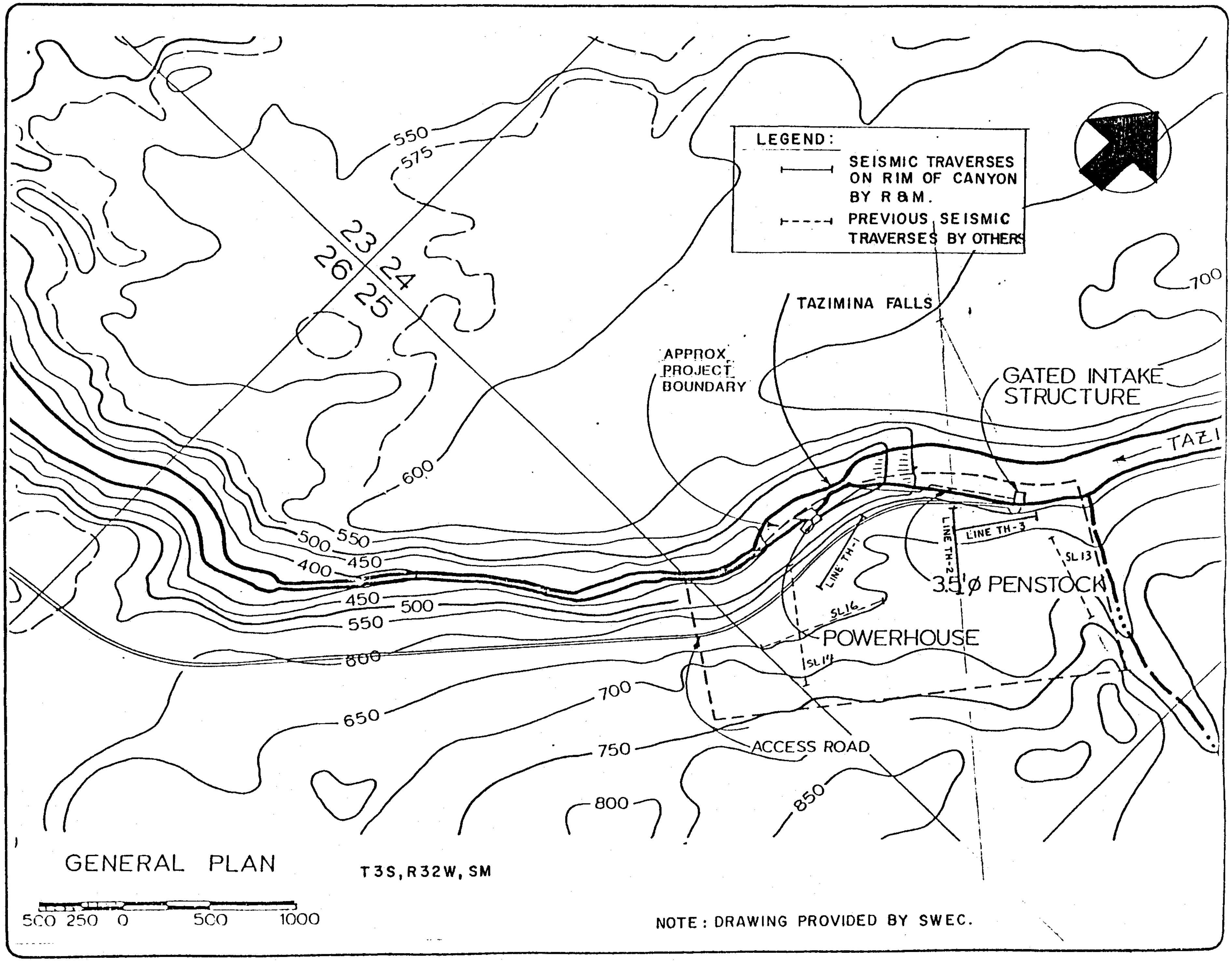
DWN	OEP
CKD	KSM
DATE	SEPT. 1985
SCALE	1: 250 000

R&M

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

SITE LOCATION MAP
TAZIMINA HYDRO PROJECT
Prepared For:
Stone & Webster Engineering Corp.

FB.	
GRID.	
PROJ. NO.	551130
FIGURE	1

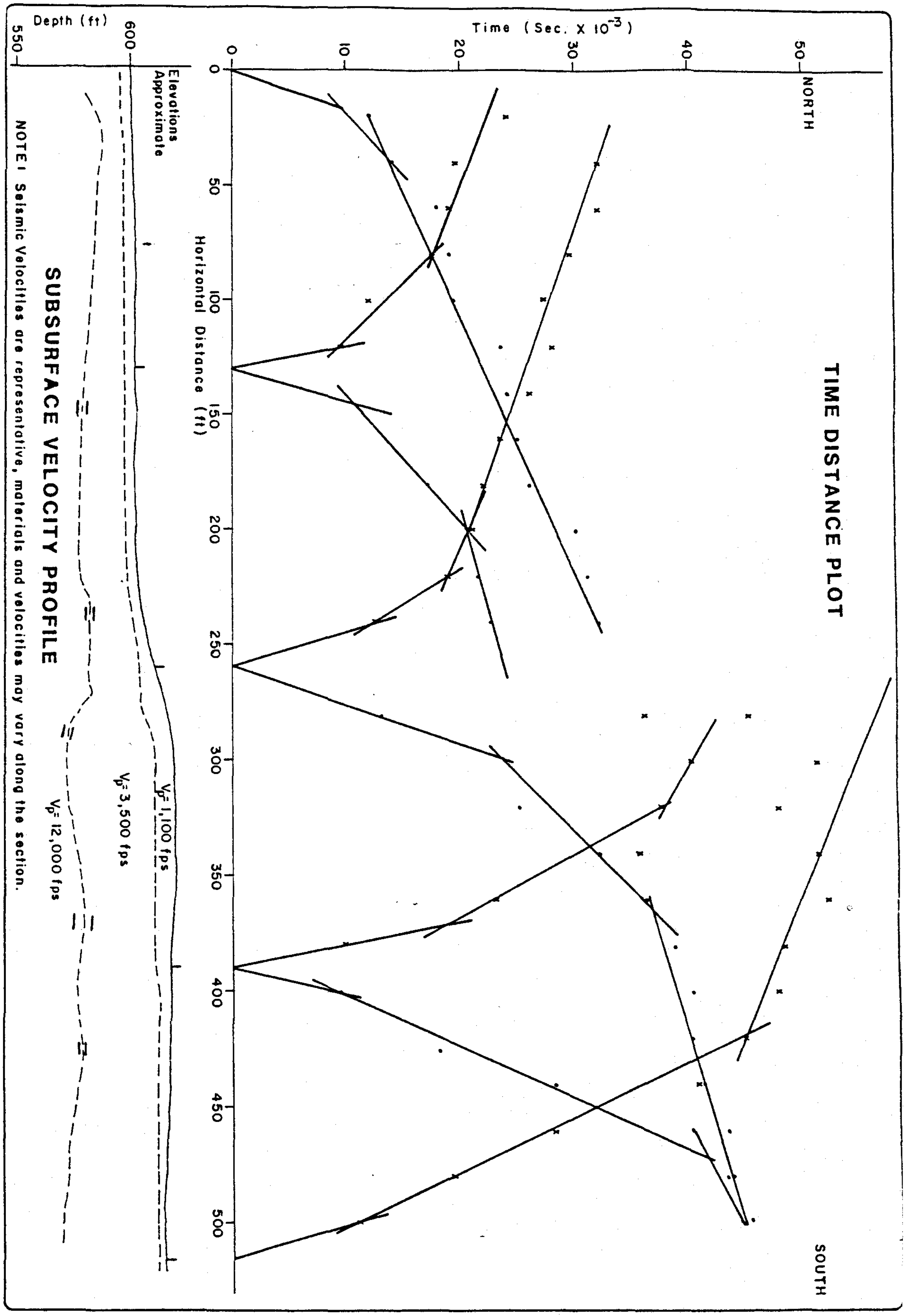


DWN OEP
CKD KSM
DATE SEPT. 1985
SCALE SHOWN

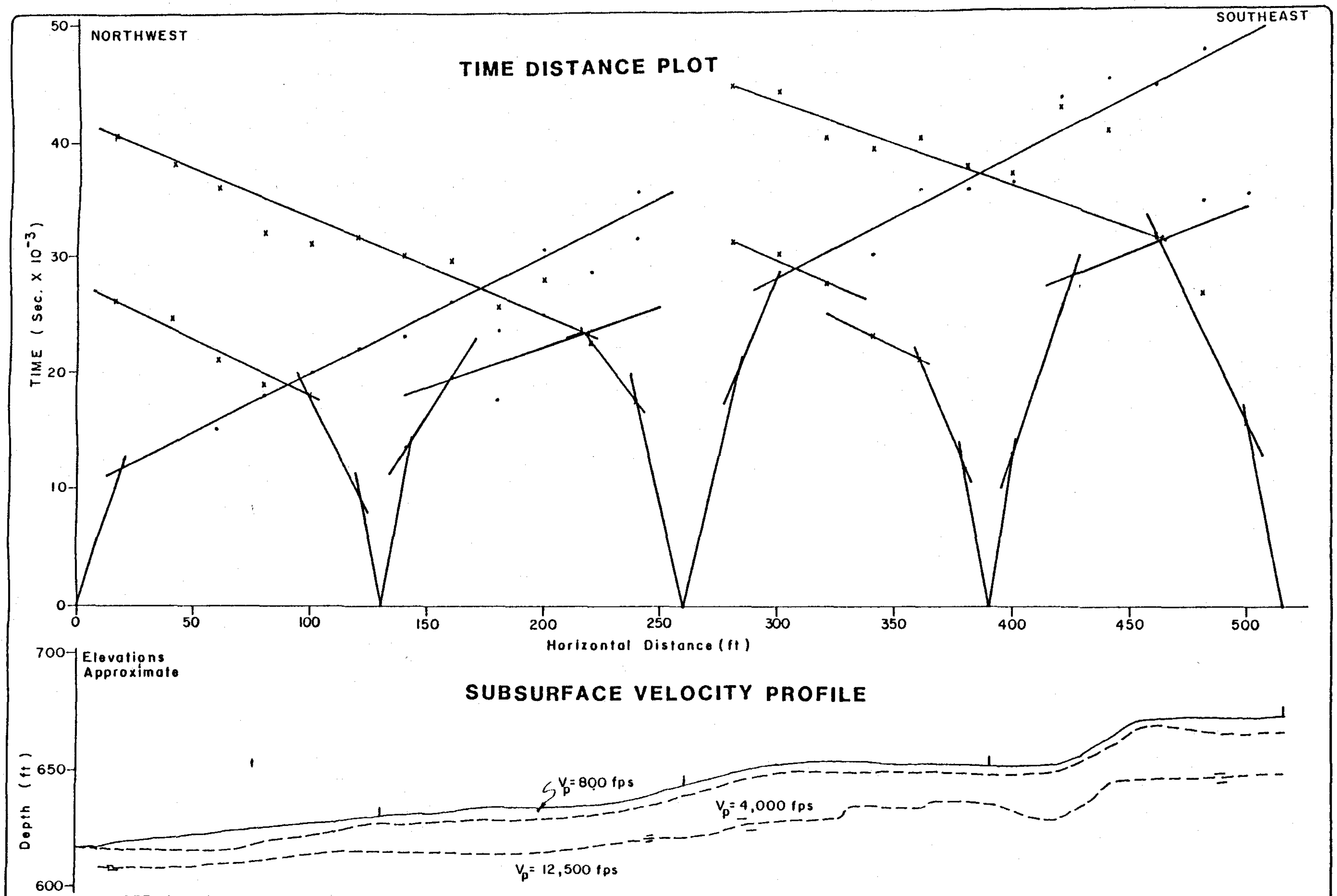
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

LINE LOCATION MAP
TAZIMINA HYDRO PROJECT
Prepared For:
Stone & Webster Engineering Corp.

F.B.
GRID.
PROJ.NO. 551130
FIGURE 2



DWN: OEP	R&M CONSULTANTS, INC. ENGINEERS GEOLOGISTS PLANNERS SURVEYORS	LINE TH-1	FB:
CKD: KSM		TAZIMINA HYDRO PROJECT	GRID:
DATE: SEPT. 1985		Prepared For:	PROJ. NO: 551130
SCALE: SHOWN		Stone & Webster Engineering Corp.	FIGURE 3



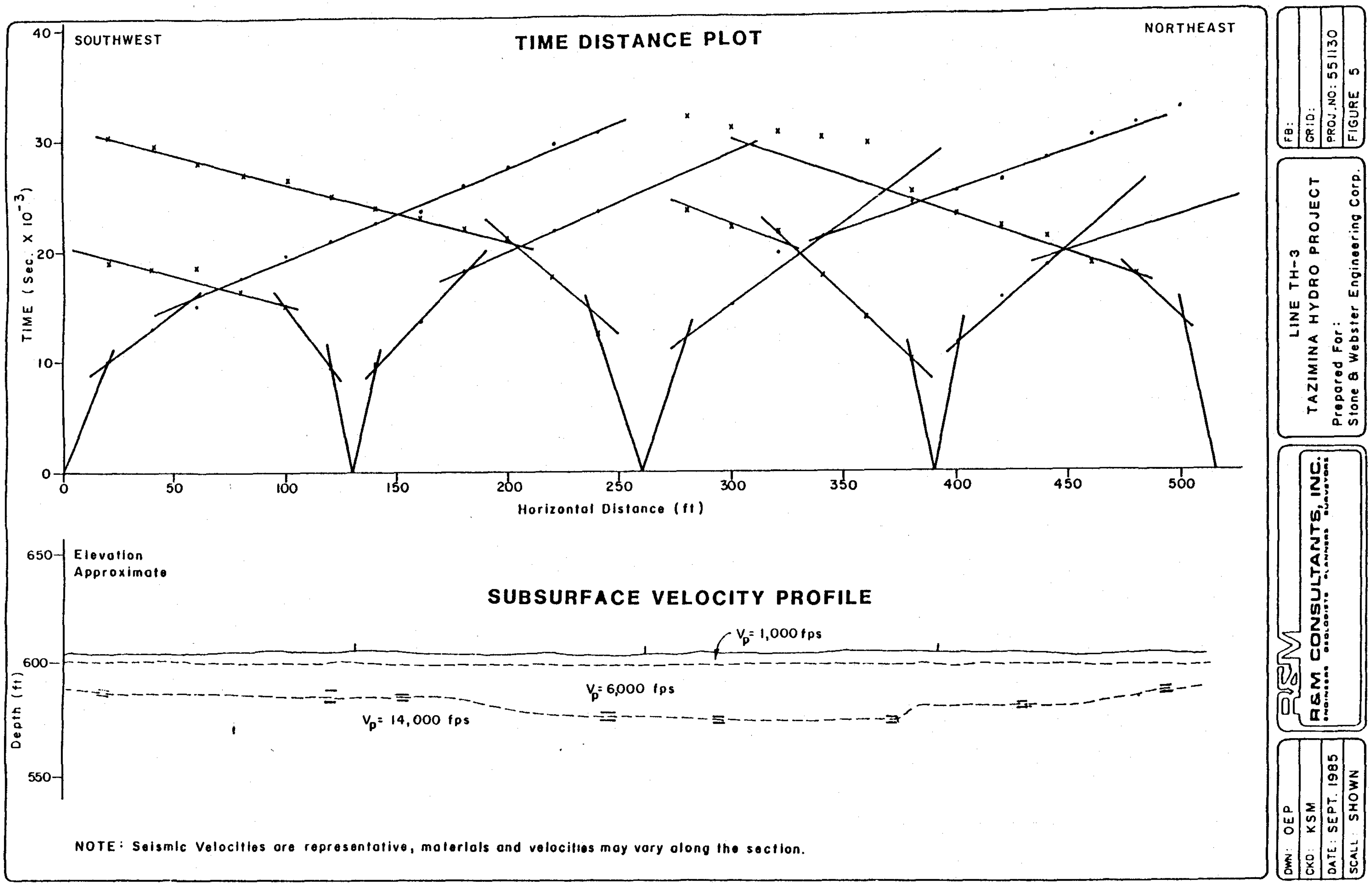
NOTE: Seismic Velocities are representative, materials and velocities may vary along the section.

DWN:	OEP
CKD:	KSM
DATE:	SEPT. 1985
SCALE:	SHOWN

R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS

LINE TH-2
TAZIMINA HYDRO PROJECT
Prepared For:
Stone & Webster Engineering Corp.

FB:
GRID:
PROJ. NO: 551130
FIGURE 4



TIME DISTANCE PLOT
SOUTHWEST
NORTHEAST
TIME (Sec. X 10⁻³)
Horizontal Distance (ft)
0
10
20
30
40
0
50
100
150
200
250
300
350
400
450
500
SUBSURFACE VELOCITY PROFILE
Elevation
Approximate
Depth (ft)
650
600
550
Vp= 1,000 fps
Vp= 6,000 fps
Vp= 14,000 fps
NOTE: Seismic Velocities are representative, materials and velocities may vary along the section.
FB:
GRID:
PROJ. NO: 551130
FIGURE 5
LINE TH-3
TAZIMINA HYDRO PROJECT
Prepared For:
Stone & Webster Engineering Corp.
R&M CONSULTANTS, INC.
ENGINEERS GEOLOGISTS PLANNERS SURVEYORS
DWN: OEP
CKD: KSM
DATE: SEPT. 1985
SCALE: SHOWN

APPENDIX C

1985 ENVIRONMENTAL RECONNAISSANCE - DAMES & MOORE

FINAL REPORT PREPARED FOR
STONE & WEBSTER ENGINEERING CORPORATION

ENVIRONMENTAL RECONNAISSANCE OF POTENTIAL ROAD ROUTES TO THE PROPOSED TAZIMINA RIVER HYDROELECTRIC PROJECT

FOR
ALASKA POWER AUTHORITY

SEPTEMBER 24, 1985
12023-023-020

Dames & Moore

Dames & Moore

800 Cordova, Suite 101
Anchorage, Alaska 99501
(907) 279-0673
Telex: 090-25227 Cable address: DAMEMORE

September 24, 1985

Stone & Webster Engineering Corporation
P.O. Box 5406
Denver, Colorado 80217

Attention: Mr. Donald Matchett

Dear Don:

Enclosed please find three copies of our report of the Environmental Reconnaissance of Potential Road Routes to the Proposed Tazimina River Hydroelectric Project. This report has been expanded from the July 26 version to incorporate results from our late summer field trip.

Please call if you have any questions or need any further information.

Sincerely,

DAMES & MOORE

By Jonathan Houghton

Jonathan P. Houghton, Ph.D.
Associate

JPH/lav

ENVIRONMENTAL RECONNAISSANCE OF POTENTIAL ROAD ROUTES TO THE PROPOSED TAZIMINA RIVER HYDROELECTRIC PROJECT (REVISED SEPTEMBER 1985)

1.0 INTRODUCTION

Field investigations were conducted during early July and late August 1985 to evaluate fish habitat and resources near the diversion and tailrace areas (at Tazimina Falls) and along several alternative road access routes to the powerhouse location for the proposed Tazimina River Hydroelectric Project. Specific objectives of this reconnaissance were to:

- Obtain low altitude videotape coverage of alternative routes from a helicopter.
- Conduct a ground reconnaissance of potential route crossings of streams, noting hydraulic, topographic and biological features of each.
- Recommend and justify a biologically-preferred route from the two primary alternatives given; suggest and justify minor reroutes to further reduce impacts to aquatic resources.
- Suggest mitigation measures to reduce aquatic impacts of access road construction.
- Build on existing knowledge (especially under low flow conditions) of fish habitat and use of areas in the immediate vicinity of the major falls (Tazimina Falls) that would provide the head for the proposed project .

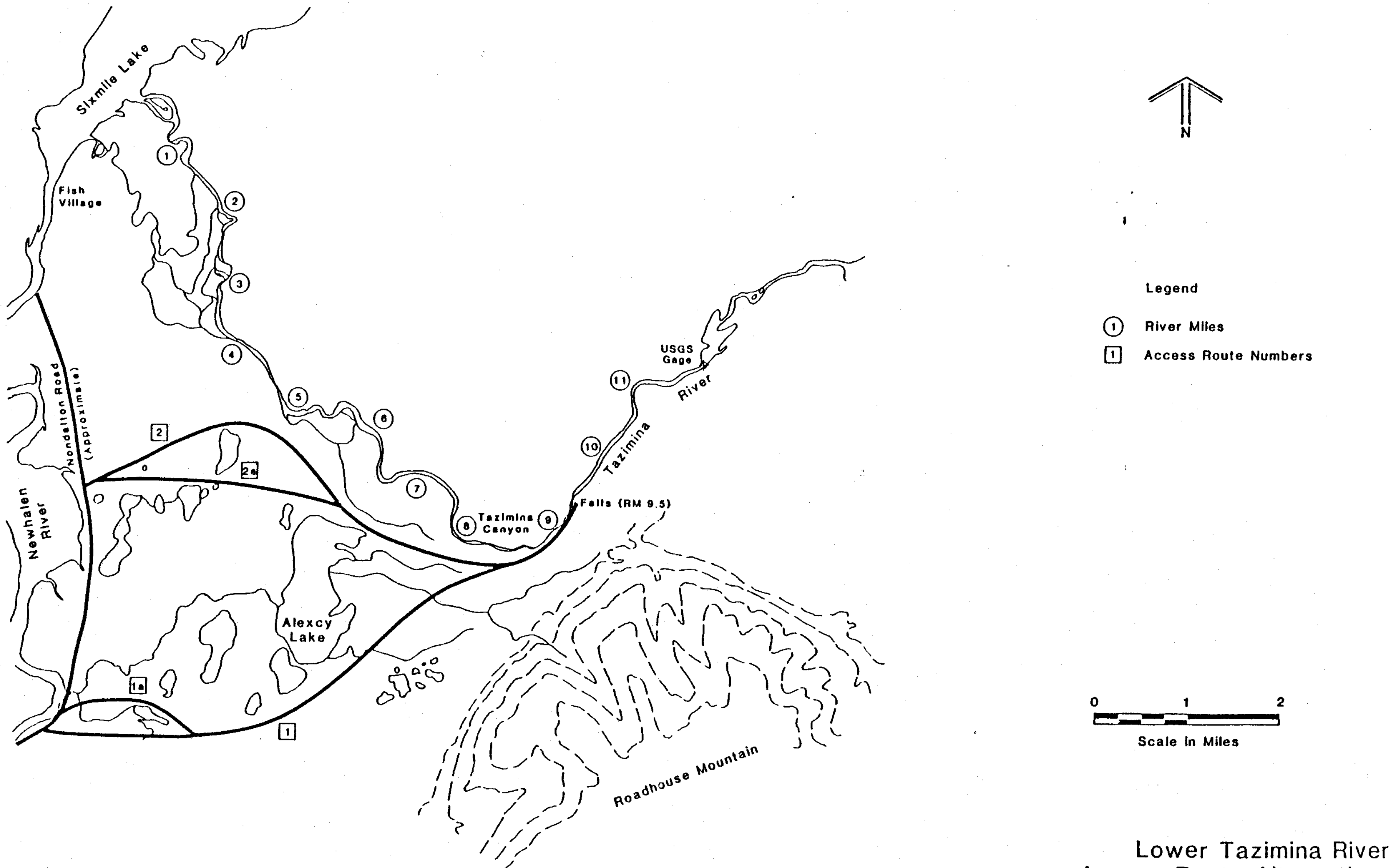
The surveys were conducted by Dr. Jonathan Houghton, Senior Fishery Biologist with Dames & Moore, with the assistance of biologists from the University of Washington, Fisheries Research Institute (FRI).

2.0 BACKGROUND

The Tazimina River is the major tributary of the Newhalen River below Lake Clark. The Newhalen River is the largest river entering Lake Iliamna and, within the Kvichak system, the largest spawning tributary for sockeye salmon (*Oncorhynchus nerka*)--the major economic resource in the Bristol Bay region. The Tazimina River provides a significant proportion of the stream spawning habitat for sockeye in the Newhalen system with spawning escapements of as many as 500,000 fish in some years (Poe and Mathisen 1982). The fish resources of the Tazimina River (along with other pertinent environmental characteristics of the area) have been previously reported by Dames & Moore (1982a,b) using data from a series of surveys conducted during the late summer and fall of 1981 and in late spring 1982. Based on this earlier work, the primary fish usage of the area immediately above and below the falls is by resident fish, primarily grayling (*Thymallus arcticus*), rainbow trout (*Salmo gairdneri*), and char (*Salvelinus alpinus* or *S. malma*). Relatively few sockeye spawners have been documented in the canyon, which extends for about a mile below the falls. A lower falls or cascade about midway up the canyon probably constitutes a significant barrier to upstream migrations.

Access to the powerhouse just below the falls would be gained from the newly constructed Newhalen-to-Nondalton Road, via one of several alternative routes eastward across a broad rolling plane in the Alexcy Lake area (Figure 1). The alternative routes join just south of the mouth of the Tazimina River canyon and ascend more steeply to the east and then to the northeast along the south rim of the canyon. None of the road route alternatives considered crosses any tributaries of the Tazimina River itself.

Next to the Tazimina River, the Alexcy Lake system with its associated inlet and outlet streams constitutes the second largest drainage tributary to the Newhalen River downstream of Sixmile Lake. Fish usage of the Alexcy Lake system has been documented with approximately 20 years of sockeye salmon spawner counts by FRI (e.g., Poe and Mathisen 1982).



Lower Tazimina River
Access Route Alternatives

Dames & Moore

Job No. 12023-023

Figure 1

However, these published records do not specify use of stream areas in question for this project; therefore, the Alaska Power Authority authorized this effort to evaluate aquatic conditions along these access routes.

3.0 METHODS

An A-Star helicopter, chartered from ERA Helicopters, Inc. of Anchorage was used for flying the low altitude video taping routes and for transportation to all other study areas during the July survey. Video equipment was provided by the Power Authority and all tapes have been delivered directly to them. A Jet Ranger, chartered from Trans-Alaska Helicopters, Inc. of Anchorage provided transportation during the August survey.

Aerial surveys of Alexcy Lake tributaries and of the Tazimina River were conducted to document the general nature and extent of aquatic habitats of concern as well as the distribution and abundance of spawning sockeye salmon (late summer only). Ground surveys were conducted on tributaries that would be crossed by any access alternative. These tributaries, and the Tazimina River near the falls were also sampled by baited minnow traps and by electrofishing with a Smith-Root Type XI battery-powered backpack electroshocker.

4.0 RESULTS AND DISCUSSION

4.1 VIDEO TAPING

The video tape delivered to the Power Authority contained the following sequences:

- The lower Newhalen River near the falls below River Mile (RM) 7.
- Scenes of outmigrant sampling at RM 7, including both the large and the small inclined-plane traps.
- Scenes of fish sampling on tributaries to Alexcy Lake.

- The southernmost access alternative from the area of the Tazimina River canyon mouth flying southwest and then west to the Nondalton Road (Route 1 on Figure 1).

- An alternative alignment of the westernmost portion of this route (Route 1A) from east to west.

- The northernmost access alternative (Route 2) from the Nondalton Road east to near the mouth of the canyon.

- An alternative alignment of the western part of the northern route (Route 2A) from the Nondalton Road east to just past the northern end of Alexcy Lake.

- Scenes of the Tazimina canyon, Tazimina Falls, and the area around and immediately upstream of the falls.

Time was not available to review this tape prior to submittal to the Power Authority and some portions were not recorded due to low camera batteries.

4.2 FISH HABITAT ALONG ALTERNATIVE ACCESS ROUTES

ROUTE 1

As shown on Figure 1, access Route 1 crosses two significant tributaries feeding into Alexcy Lake. The southernmost of these is by far the smaller with an estimated 0.06 to 0.12 cubic meters per second (2 to 4 cubic feet per second cfs) of flow in early July. At the crossing location shown, the stream forks several times receiving flow from the numerous small ponds to the east as well as from some springs in the area. Electroshocking in the area just below these forks and springs did not produce any salmonids but several cottids (probably *Cottus cognatus*) were taken. However, the habitat appeared very suitable for small resident salmonids with a good mixture of riffles, pools, and low-velocity glides. It is likely that more exhaustive sampling would demonstrate their presence--at least seasonally. Visual surveys in July near the mouth of this stream revealed numerous spawned-out sockeye salmon carcasses from the fall 1984 run. Sockeye fry (29 to 35 mm) were also abundant in quiet eddies and shallows of this lower reach as demonstrated by electrofishing. Run size cannot be estimated at this time but is probably on the order of scores or a few hundreds of fish (cf., thousands) based on the limited extent of habitat available. Only about 400 meters of stream habitat above the lake are likely to be accessible to adult sockeye. Extremely poor weather conditions during the August sampling prevented enumeration during the spawning period, but some adults were present, both in the creek and in the lake near the creek mouth. Lake spawning of sockeye was observed along the east shore of Alexcy Lake.

The confirmation of sockeye runs in these Alexcy Lake tributaries (see below) will greatly heighten sensitivity of the regulatory agencies to upstream disturbances.

In addition to sockeye salmon and cottids, small resident char (140 to 150 mm) were also taken in minnow traps near the mouth of this tributary in July. A school of about 25 large fish (e.g., 400 mm plus) was seen from the air off the mouth of this stream. These may have been either northern pike (Esox lucius) preying on sockeye fry as they entered the lake from the creek or an early school of adult sockeye waiting to spawn in the creek.

The northern tributary entering Alexcy Lake is considerably larger than the southern tributary and drains a majority of the northwest quadrant of Roadhouse Mountain. This stream flows through a dense willow/cottonwood thicket in contrast to the much more open vegetation at the southern tributary. At the crossing, the gradient is moderately high, and the stream flows in a U-shaped channel with few gravel bars. Stream velocities were very swift (e.g., greater than 2 meters per second); flow appeared to be near a seasonal high in early July and was estimated to be on the order of 1.4 to 2.3 cubic meters per second (50 to 80 cfs). As a result, fish habitat was very poor and no fish were taken in electroshocking of the few limited areas of lesser flow velocity. At lower flows or in other reaches of the stream where the gradient is lower, it is likely that this stream supports salmonids and thus, for regulatory purposes would be treated as a fish stream.

As the northern tributary approaches Alexcy Lake, its gradient drops considerably and the stream splits into several distributaries. Like the smaller tributary to the south, this area is used for spawning by sockeye, as evidenced by the abundance of carcasses and fry seen in July. Because of the larger size and swollen state of this tributary during our visits, it was not possible to estimate how far upstream adults might spawn.

A third aquatic habitat on access Route 1 lies in the vicinity of a pond in the northeast 1/4 of Sec. 6 (T. 4 S, R. 32 W). Smaller ponds lying to the southeast of this pond are shown on the U.S.G.S. 15-minute quadrangle as isolated. However, they are actually connected by a shallow arm of the larger pond that would require bypassing. Since the larger pond is connected by a small outlet stream to the main outlet of Alexcy Lake, it is likely that this pond contains fish. It was not sampled during our surveys, however.

ROUTE 1A

A variation that would eliminate the need to cross the pond area described in the previous paragraph (and uneven ground to the west) is shown as Route 1A in Figure 1. This route would, however, require crossing of the small outlet stream from the pond. Although it was not surveyed, it can be assumed that this stream does contain fish.

ROUTE 2

The northernmost of the route alternatives considered (Route 2 on Figure 1) does not cross any surface waters and would therefore have no direct impacts on fish habitat. The route would pass very close to Alexcy Lake's northeast corner, where care would be required to avoid the potential for runoff from disturbed areas entering the lake. A small draw in this area may have at one time been an outlet from the lake to the Tazimina Lake. However, at present, there is a divide in this draw; the southern 200 m (approximately) of the draw drain south into the lake while north of this point drains north toward a small creek which flows to the river.

ROUTE 2A

An alternative to Route 2 that would reduce the distance to be traveled is shown as Route 2A on Figure 1. The aquatic impacts of this route would not differ greatly from those of Route 2 except that a wet area south of the lake occupying the northeast quarter of Sec. 20 (T. 3 S, R. 32 W.) would require crossing. This could have minor associated engineering and aquatic impacts. Neither category of impact would present unusual problems, but both can be avoided by Route 2.

4.3 THE PREFERRED ROUTE

From the standpoint of avoiding impacts on aquatic resources, the preferred route is clearly Route 2, which has no crossings of streams or significant wetlands. Since 2A is shorter than 2 and would thus have less potential for construction area runoff problems, this route would be slightly preferable to 2 were it not for the small wetland area described above. The major aquatic impact of either of these routes (assuming use of standard practices to control erosion and runoff) would be the aesthetic impact on sport anglers using either the Tazimina River or Alexcy Lake.

Either of the Route 1 alternatives would cross the two major tributaries of Alexcy Lake, both of which are known spawning streams for sockeye salmon. While these crossings could certainly be constructed in a manner that would not have a long-term effect on the system's productivity, the short-term construction impact and the potential for long-term disturbance by humans of spawning in the lower reach of the smaller stream would be avoided by selection of either of the northern routes.

4.4 MITIGATIVE MEASURES

Regardless of route selected, the major impact will be aesthetic. While not typically considered an aquatic impact, we have placed aesthetics in the realm of an aquatic consideration because the primary human use of this area at present is for fishing, usually by guided parties who fly, or fly and boat, in for a "wilderness fishing experience." Subsistence use of the area, especially by Nondalton residents is also significant. Construction and subsequent presence and use of the proposed access road would severely degrade the feeling of wildness and undisturbed natural beauty that can now be gained in the area. The road will be a significant man-made visual feature in an area that currently has none east of the Nondalton Road. As an additional indirect effect, the road will encourage motor vehicle access to the Alexcy Lake area and to much of the Tazimina valley. This will further degrade the enjoyment of those seeking "wilderness" and may greatly alter the way natural resources (fish and wildlife) are utilized in the area.

To mitigate the full extent of these impacts will not be possible; those flying in to Alexcy Lake or the Tazimina River or lakes will know that the road is there. However, there are certainly measures that can be applied to make the visual impact far less severe than is the case for the Nondalton Road. Width of the disturbed area can be kept to the minimum actually required for construction; alignment can be adjusted to minimize the extent of cuts and fills; to minimize the duration of maximum disturbance, disturbed areas can be revegetated as soon as work is complete in the area. In the Alexcy Lake area, the alignment can be kept largely out of view of boaters on the lake by staying on the Tazimina side of the crest of the low ridge north of the lake (assuming Route 2 or 2A). Taller trees along the lower Tazimina River should largely shield the road from the view of anglers on the stream (cf., those flying in).

To exclude unofficial traffic by cars or trucks, thereby reducing traffic, it might be possible to gate the road. However, there likely would be considerable local pressure to leave it open to all. Road control will need to be resolved by the group owning and operating the proposed facility.

The potential for direct impacts on aquatic habitats from construction of all access alternatives would be reduced by use of the best practicable methods to:

- Minimize the extent of surface area disturbed.

- Control runoff from disturbed areas (e.g., by mulching, reseeding, and/or use of fabrics; construction of retaining ponds in drainage ways).

- Minimize the angle and extent of cuts and fills.

- Maintain a-100-m buffer between the route and the nearest surface water wherever possible.

- Minimize construction activity in the canyon.

In addition, on the southern routes (1 and 1A), care would be required to design and construct stream crossings that conform to Alaska Department of Fish & Game and Alaska Power Authority standards. At this point it would be necessary to assume that both tributaries of Alexcy Lake are fish streams. Culvert design to allow fish passage both up and down stream would therefore be required along with associated bed and bank protection to prevent erosion at each installation.

4.5 TAZIMINA RIVER HABITAT

To supplement data gathered in previous surveys and provide data for assessment of impacts in the vicinity of the proposed water diversion and the project tailrace, an evaluation of fish habitat just above and just below the falls in the Tazimina River was desired. High flows during both field periods limited efforts in this area as the river was nearly bank full. Access to the first mile below the falls was impossible even with a helicopter. Above the falls, the waters' edge could be approached at only two points within the first 400 m of the falls.

Viewing the river from the limited available vantage points, however, served to confirm the general concensus from our earlier (Dames & Moore 1982a, b) studies: fish habitat within 100 to 200 m of the falls is severely limited by high velocities and hard substrates (boulder/bedrock).

At the observed flows, there would be very few resident fish in areas immediately above the falls that would be affected by the low diversion berm planned (assumed to be within 200 m of the falls). July electroshocking of the two accessible streambank areas in this reach failed to take any fish. Three days of effort with baited minnow traps took only three cottids (87 - 100 mm) in July; one day of trapping in August produced one char (147 mm) and one cottid (96 mm).

In contrast, similar trapping effort at the U.S.G.S. gauge at RM 12 produced 20 small char (98 - 164 mm) in July and 6 (91 - 155 mm) in August. July electrofishing in this area took one char (165 mm) while angling in each survey took several small grayling (280 - 350 mm). Clearly, the slower water in the gauge vicinity is excellent fish habitat compared to that immediately above the falls.

In spring (May) of 1982 Dames & Moore biologists surveyed the area immediately above the falls in some detail under low flow conditions that permitted wading the entire width of the stream (Dames & Moore 1982b). Gillnet, electroshocking, and seining operations failed to capture any fish, although some cottids were seen during electrofishing (J. Isakson, Dames & Moore, personal observation). It remains to be seen if surveys under similar flow conditions in late summer or fall would show similar low fish usage.

At the flow conditions encountered in these surveys, extreme turbulence and high velocities would virtually eliminate use by both anadromous and resident fish in much of the reach immediately downstream of the falls. The mid-canyon falls or rapids at about RM 9.3 would likely discourage upstream passage of fish.

Aerial surveys of spawning sockeye salmon in August showed that several schools, each containing several hundred adults, were distributed in the limited slow-water eddies throughout the canyon below this barrier. None were seen above it, although a few adults have been reported to spawn in the reach up to the base of the main falls (P. Poe, University of Alaska, Juneau, personal communication).

July electrofishing in slower water areas adjacent to an island near the entrance to the canyon (RM 8.5, the closest landing site to the base of the falls) produced no fish. Five days of minnow trapping in the same area in July and 2 days effort in August also took no fish. In August, a school of about a hundred sockeye adults was holding in the lee of the island. It is likely that with lower late summer flows these areas may be used by fish moving up from the lower river, perhaps to feed on eggs shed by the sockeye. Electroshocking under much lower flow conditions in 1981, Dames & Moore (1982a) captured young-of-the-year rainbow trout at RM 8.8 and large adult rainbow trout were reported well up in the canyon.

Concern has been expressed that the intake diversion berm for the project might interrupt bedload movement of gravels essential to the maintenance of important sockeye and rainbow spawning habitat below the canyon. A very large gravel bank at RM 11 is the only potential source for such gravels above the falls. There are numerous scree slopes in the canyon and a large gravel bank at RM 8 just below the canyon that, along with the extensive glacial deposits along the lower river are far more important in the lower river's gravel budget than sources above the falls. It is our opinion that the diversion berm contemplated will not affect spawning habitat in the lower Tazimina River.

5.0 ADDITIONAL STUDIES

Summer 1985 surveys were disappointing in that flow conditions remained unusually high, frustrating efforts to sample in the immediate vicinity of the falls. The single char taken just above the falls (cf., the absence of salmonids in July 1985 and in May 1982) may be indicative of increased use of this area later in the summer-fall season. To more fully understand the potential impacts of the proposed project on fish resources of the area, we recommend a follow-up, fall survey to document the following:

- Habitat availability in areas of concern under low flow conditions.
- Fall fish usage of these areas.
- Potential fall downstream movement of fish above the falls.

6.0 REFERENCES

Dames & Moore. 1982a. Bristol Bay regional power plan, preliminary environmental report. Prepared for Stone & Webster Engineering Corporation, Inc. and the Alaska Power Authority, February.

______. 1982b. Study of fish habitat as related to potential impacts of the Tazimina run-of-the-river hydroelectric concept. Appendix C. In Bristol Bay-regional power plan, interim feasibility assessment. By Stone & Webster Engineering Corporation, Inc. for the Alaska Power Authority, July.

Poe P. H., and Mathisen. 1982. 1981 Newhalen River sockeye escapement studies. Fisheries Research Institute, University of Washington. FRI-UW-8211. Final Report to Alaska Department of Fish & Game, Contract No. 81-827.

APPENDIX D

RESULTS OF FISH HABITAT SURVEY, MAY 1986 - ADF&G

STATE OF ALASKA

BILL SHEFFIELD, GOVERNOR

DEPARTMENT OF FISH AND GAME

333 RASPBERRY ROAD
ANCHORAGE, ALASKA 99502-2392

267-2342

June 25, 1986

Eric Marchegiani
Project Manager
Alaska Power Authority
P.O. Box 190869
Anchorage, Alaska 99519-0869

Dear Mr. Marchegiani:

Re: Results of Fish Habitat Survey, Tazimina Falls Hydro Site.

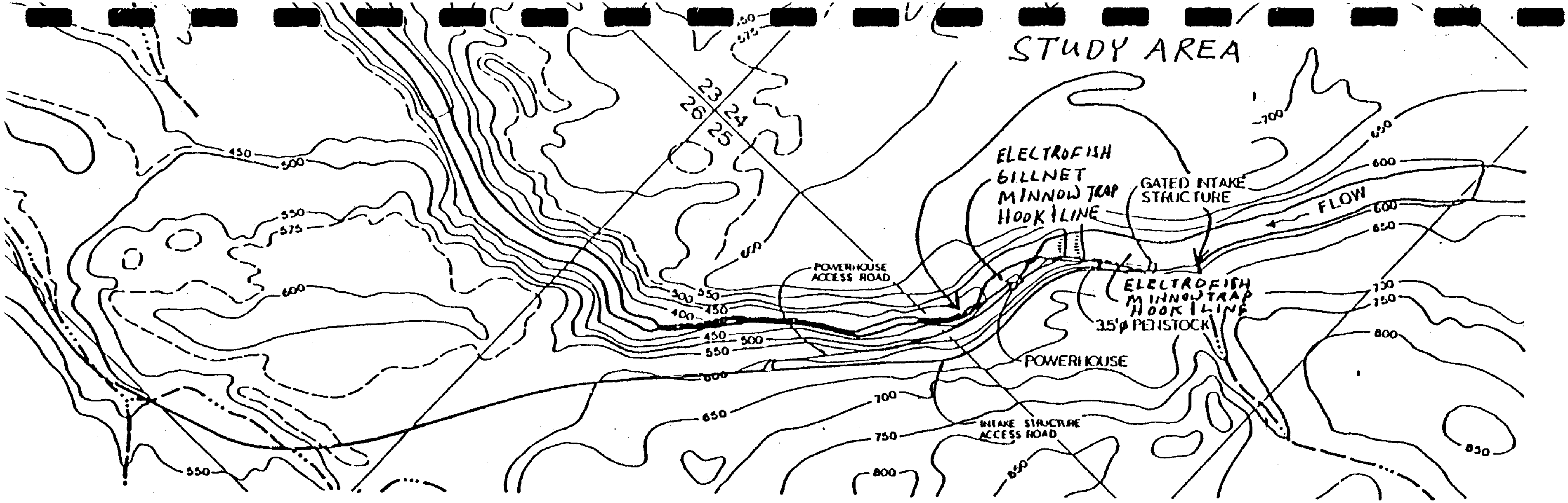
On May 14-15, 1986, Kim Sundberg and Denby Lloyd, both Habitat Biologists on my staff, accompanied you to Iliamna to conduct a fish habitat survey at the proposed Tazimina Falls Hydroelectric Project site. The purpose of the survey was: (1) to ascertain the fish habitat values at the base of falls where a powerhouse and tailrace would be constructed, especially as this might effect potential spawning habitat in the lower Tazimina River and (2) to survey the fish resource and habitat above the falls in the vicinity of the project intake to determine the need for screening to prevent fish entrainment or impingement in the intake. The survey was timed to coincide with both ice-free low water conditions and with the peak of rainbow trout spawning in the lower Tazimina River.

Study Area and Methods

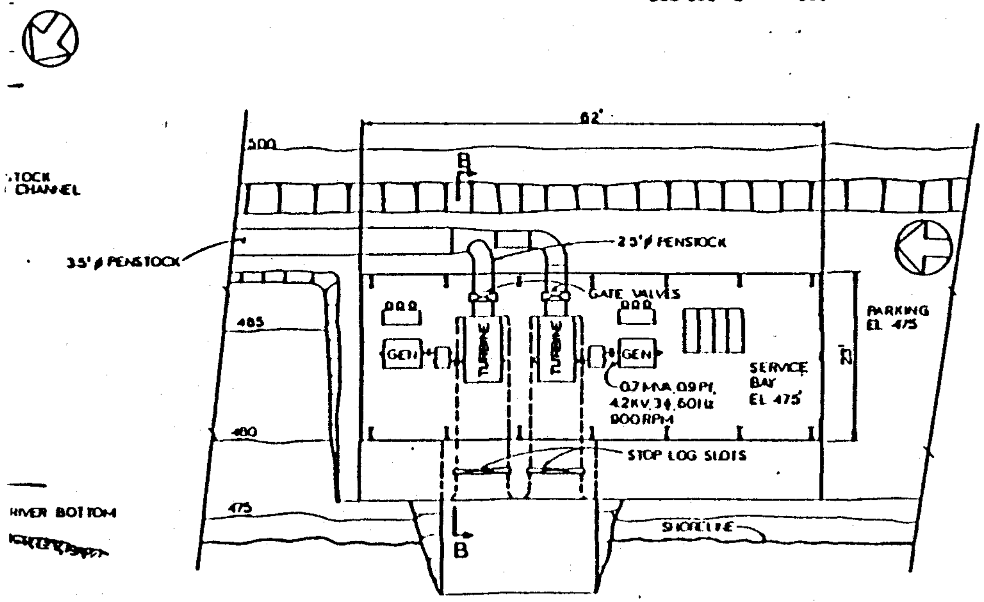
The study area was defined at the lower end by a series of low falls approximately 400 feet downstream from Tazimina Falls and at the upper end by a gully on the southwest bank approximately 500 feet upstream from falls (Figure 1). The study area encompassed all proposed inwater construction locations for the project. Five sampling techniques were employed in the survey:

1. Visual observations with polarized glasses on the ground and from a helicopter of all potential fish habitat.

2. Electrofishing of all wadable areas (approximately 40 percent of the study area) using a backpack shocker (Smith-Root Model 11-A).



GENERAL PLAN
SCALE: 1" = 500'
500 250 0 500 1000



PLAN - POWERHOUSE
SCALE: 1" = 10'
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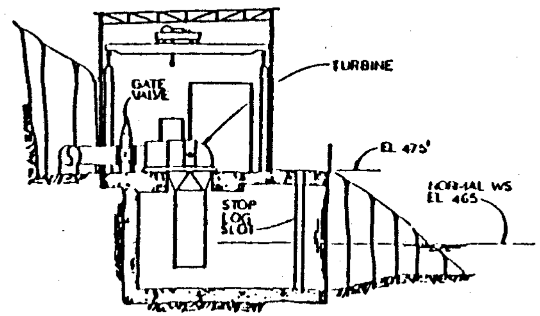

B - B
SCALE: 1" = 10'
10 5 0 10 20

TAZIMINA RIVER DEVELOPMENT
LOCAL POWER PROJECT

BRISTOL BAY REGIONAL POWER PLAN

ALASKA POWER AUTHORITY

STONE & WEBSTER ENGINEERING CORPORATION
DENVER, COLO.
J.O. 14007 JAN 1982

FIGURE 1

3. Hook and line fishing using single hooks baited with salmon eggs or Mepps spinners.

4. Minnow traps baited with salmon eggs and soaked overnight (approximately 18 hours).

5. A variable mesh gillnet (0.5 to 2.0 inch stretched mesh) set across the lower end of the plunge pool below the falls.

Results

1. Visual observations below falls. Approximately 6.0 observer hours were spent in visual observations below the falls. No fish were observed in the study area.

   Visual observations above falls. Approximately 4.0 observer hours were spent in visual observations above the falls. No fish were observed in the study area.

2. Electrofishing below the falls. The entire south side of the river including the tailrace site was sampled with a backpack shocker. The total shocking time was 520 seconds. Because of low conductivity, the shocker was set at 1,000 V.D.C. at a pulse frequency of 90 Hz. At this setting, the approximate region of galvanotaxis was one meter from the anode. Three sculpins (Cottus sp.) were collected below the falls.

   Electrofishing above the falls. Both sides of the river were shocked including all wadable portions and the proposed intake site. The total shocking time was 296 seconds. No fish were collected by shocking above the falls.

3. Hook and line fishing below the falls. Approximately 4.5 angler hours of effort were expended in fishing below the falls. No fish were caught on hook and line.

   Hook and line fishing above the falls. Approximately 3.0 angler hours of effort were expended in fishing above the falls. No fish were caught on hook and line.

4. Minnow trapping below falls. Seven baited minnow traps were set within the study area below the falls. Two char (Salvelinus sp., fork length = 121 mm, 146 mm) and two sculpin (Cottus sp.) were caught.

   Minnow trapping above falls. Three baited minnow traps were set within the study area above the falls. Two char (fork length = 108 mm, 89 mm) were caught.

5. Gillnet below falls. Approximately 60 feet of variable mesh gillnet was set across the lower end of the plunge pool below the falls. The net was in the river for approximately

0.5 hours. The net was fished by hauling the free end across the river and alternately stretching it taut perpendicular to the flow and then relaxing the free end and allowing it to drift downstream with the current. No fish were caught in the net.

6. Birds. Birds observed in the study area included dipper, common merganser, harlequin, goldeneye (probably Barrows) and sharp-shinned hawk. We did not observe any feeding activity by diving ducks.

Temperature. The water temperature below the falls on May 15, 1986 was 39°F. The air temperature was 44°F.

Substrate. The bed and bank material below the falls consisted primarily of cobble-sized talus, angular boulders, bedrock shelves and small pockets of gravel and sand. The substrate composition is substantially similar above the falls except that the cobbles and boulders are less angular and more water worn. Accumulations of coarse sand were found on top of the remnant snow and ice on the banks below the falls. This sand may be deposited by anchor ice carried over the falls at breakup.

Discussion

The lower Tazimina River supports very valuable sockeye salmon and rainbow trout resources. Previous studies by Poe and Mathisen, 1982 noted that during years of large escapements, sockeye salmon (*Oncorhynchus nerka*) can be found up to the base of the Tazimina Falls. However Poe (pers. comm.) felt that because of the scarcity of suitable spawning habitat in the Tazimina Canyon, little if any successful spawning and incubation could occur there. Concerns had been raised that there could be rainbow trout spawning near the base of the falls where the project outlet and tailrace would be constructed. Our May 14-15 survey was timed to coincide with the peak period of rainbow trout spawning in the river. Observations of rainbow trout in the lower Tazimina River confirmed that spawning was occurring further downstream during the time of our survey. The failure to collect or observe rainbow trout within the study area strongly suggests that it was not used for spawning this year. A low series of falls approximately 400 feet downstream of the Tazimina Falls may discourage fish from ascending into the project area. Moreover, our observations of substrate indicates that there is very little suitable spawning habitat within the study area. These observations would support previous investigators' speculation that little if any successful spawning occurs in the vicinity of the falls. If contractors closely adhere to the terms and conditions of the Title 16 permit that will be required for the portion of the project below the falls as well as APA's Best Management Practices for Erosion and Sediment Control and for Handling Fuel and Hazardous Materials, the construction and operation of the powerhouse and tailrace should not have a negative impact upon spawning, rearing, or migration of fish in the Tazimina River.

The question of whether screening is necessary to prevent fish entrainment or impingement in the project intake is also an issue. The available information indicates that low numbers of resident grayling and char occur at the intake site. Because no salmon can migrate above the Tazimina Falls, screening the intake to protect anadromous fish is not an issue.

The Bristol Bay Area Plan (BBAP) Guideline No. 6 to Prevent Fish Habitat Alteration and Destruction and the draft Bristol Bay Coastal Management Program (BBCMP) Policy No. 10.4 both require the following:

> Tideland permits or leases, water appropriations, and/or Title 16 permits for water intake pipes used to remove water from fish bearing waters will require that the intake be surrounded by a screened enclosure to prevent fish entrainment and impingement. Pipes and screening will be designed, constructed, and maintained so that the maximum water velocity at the surface of the screen enclosure is not greater than 0.1 foot per second. Screen mesh size will not exceed 0.04 inch unless another size has been approved by ADF&G. Other technology and techniques which can be demonstrated to prevent the entrainment and impingement of fish may also be utilized.

Deviation from this guideline requires that (1) no fish use the intake waters, or (2) that alternate technology or techniques provide adequate protection for fish. Information collected during this and other surveys (Grabacki, 1982) suggests that there is no migration of fish through or into the project area. Some of the fish that occur in the vicinity of the intake site are likely swept over the falls and lost from the Upper Tazimina River system. Given that fish use of the intake site appears to be very low, and the project design does not appear to alter the stream in a manner that would attract fish to the intake site, there seems to be little benefit in designing a screening system for the intake specifically to prevent fish entrainment or impingement. We suggest that instead you incorporate measures into the location and design of the intake and trash screens which would minimize the likelihood of fish entering the system. Fish exclusionary screens with a mesh size of 0.25 inch would adequately protect the adult char and grayling that use the site. The feasibility and cost of installing and maintaining 0.25 inch mesh screens at the intake should be determined before the screening issue can be finally resolved. This analysis should be accomplished in order to determine the consistency of the project with the BBAP and the BBCMP.

Finally, during aerial observations and video taping of the preferred access route (Route No. 3) we did not note any streams or other flowing water that could support fish. It appears that no Title 16 permits will be required for road crossings associated with Access Route No. 3. However, Alexey Lake and Alexey Creek are in the vicinity of the road and they are important for salmon spawning and rearing. Contractors should be advised that any work affecting Alexey Lake and its tributary streams, including water pumping, will require a Title 16 permit from ADF&G.

Based upon this survey and our review of other pertinent project information, we believe that with continued close coordination between ADF&G and the developer, and close adherence to all biological stipulations on Title 16 and other permits, this project can be constructed and operated with minimal impact to the environment.

If you have any questions concerning this report please contact Kim Sundberg (267-2334). Thank you for the opportunity to work with APA on this project.

Sincerely,

Lance L. Trasky
Regional Supervisor
Region IV
Habitat Division

cc: Jim Hemming, Dames & Moore
Don Matchett, Stone & Webster
Dick Russell, ADF&G, King Salmon
Hank Hosking, USFWS-WAES
Tim Hostetler, Bristol Bay CRSA
Bob Arce, Iliamna Natives, Ltd.
Brad Smith, NMFS

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Grabacki, S.T. 1982. Study of fish habitat as related to potential impacts of the Tazimina run-of-river hydroelectric concept. Dames & Moore. in Volume 4, Bristol Bay Regional Power Plan Detailed Feasibility Analysis. Alaska Power Authority Contract No. CC-08-2108. July, 1982.

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APPENDIX E

ENVIRONMENTAL RECONNAISSANCE, MAY 1986 - DAMES & MOORE

ENVIRONMENTAL RECONNAISSANCE
OF AN ALTERNATE ROAD ROUTE
TO THE PROPOSED
TAZIMINA RIVER HYDROELECTRIC PROJECT

by

David E. Erikson
DAMES & MOORE

1.0 INTRODUCTION

A reconnaissance level field survey was conducted on May 13-16, 1986, of a proposed alternate road alignment which bypasses the lower two and a half miles of the Tazimina access road. This alternate alignment separates from the old route approximately 3 miles south of the proposed powerhouse site and travels southwest to intersect with the Iliamna-Nondalton Road one mile above the landing on the Newhalen River (Figure 1). The specific objectives of this survey were to:

- Conduct a ground survey of the new route documenting any crossings of streams and survey each for anadromous fish.
- Assess the overall biological features of this area including wetlands and waterfowl habitat and identify sensitive areas.
- Note any obvious sources of gravel near the road route.
- Photograph the proposed location of the intake structure above the Tazimina falls.

This survey was conducted by Dave Erikson, staff ecologist with Dames & Moore and by Mike Yarborough, an archeologist with Cultural Resources Consultants. The environmental survey was done in conjuction with an archeological survey of each route.

The old access road route from the proposed powerhouse location to the Iliamna-Nondalton road was previously surveyed for stream crossings in the summer of 1985 (Dames & Moore, 1985). More detailed environmental baseline studies of the Tazimina drainage were conducted in 1981 (Dames & Moore, 1982).

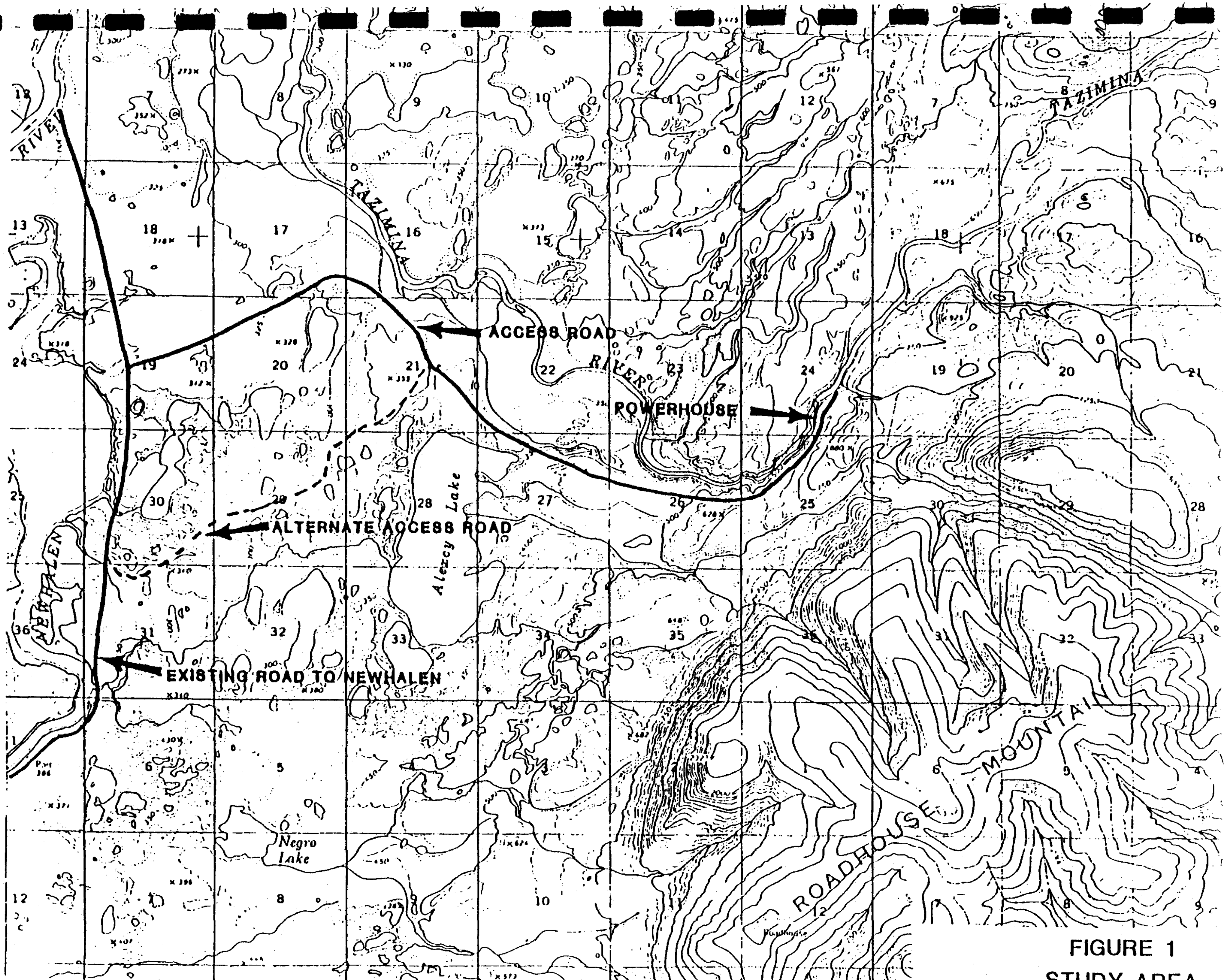

FIGURE 1
STUDY AREA

2.0 METHODS

In order to document fish stream crossing and assess overall habitat conditions along the proposed road routes, each route was walked by the field party. Lakes and ponds adjacent to the road routes were surveyed with binoculars for waterfowl activity and general notes and photographs were taken of habitat features. The starting point of the ground survey was the ridge between Alexcy Lake and Tazimina River.

A Jet Ranger helicopter, chartered from Trans Alaska Helicopters, Inc. of Anchorage, provided transportation to the sites and was also used for low-level aerial surveys of the road routes and to survey adjacent lakes for waterfowl.

The material site survey was conducted at the same time as the biological survey, but the ground was still frozen so only surface deposits of gravel were noted along the routes. Areas of exposed gravel were photographed and marked on the map.

3.0 RESULTS

3.1 Upland Habitats

Terrestrial habitat along alternate road route varies from open low shrub and lichen communities dominated by narrow-leafed laborador tea (Ledum decumbens), crowberry (Empetrum nigrum) dwarf birch (Betula nana) and willow (Salix sp.) and by several species of lichen (Cetraria sp., Sterocaulon sp., Cladonia sp.), to a sparce, white spruce woodland (cover 10-25%). Essentially, all of this area is interspersed by short, stunted white spruce which appear to be dominant but overall cover is generally less than 10% (the minimum required to classify it as a woodland vegetation type).

This vegetation type extends over most of well drained upland areas adjacent to the Tazimina River and occurs throughout most of the area traversed by both road routes. There appears to be no significant difference in the upland vegetation between the two routes.

3.2 Wetlands

The proposed alternate access road route passes through an area of well-drained soils and does not intersect any significant areas of wetlands. Minor re-alignment around some small potholes could easily avoid all wetland habitats. This is similar terrain to the old road route which also crosses no wetlands.

Wetland areas adjacent to the road route occur in conjunction with small ponds and lakes, some of which have little open water with mostly emergent vegetation. The development of the access road should have no effect on these areas.

3.3 Fish Habitat

The proposed alternate road alignment would not cross any areas of surface water and thus would not have any effect on fish habitats. The small lakes and ponds along the route are isolated from other waterbodies, so would not likely support significant fish resource which could be affected by road construction.

3.4 Waterfowl

All of the lakes and small ponds along the alternate road route and the present road route were surveyed for any waterfowl concentrations. The lake with the most activity was Alexcy Lake. Red-brested mergansers were common with smaller numbers of common mergansers observed. A few pintails, mallards, and green-winged teal were flushed from the edges of the lake.

The smaller isolated potholes and lakes adjacent to the lower access road and the alternate route supported only a small number of diving ducks (Barrow's goldeneye, red-brested mergansers), that probably nest in the area. Many of the ponds had no waterfowl present during either the aerial or ground survey. Overall waterfowl density in the area adjacent to both routes appeared to be low.

A pair of tundra swans were located in a small pond north of the existing access road route during aerial survey but no nesting activity was observed on that pond. They may be using any one of the other ponds or lakes in the area but no nest site was not found. It did not appear that these ponds and lakes support more than one pair of swans. No geese were seen in any of the areas surveyed.

3.5 Gravel Sources

The terrain along the proposed alternate appears to be part of an old glacial moraine with many small ridges and depressions, a few of these depressions support small isolated ponds. Many of these ridges have large, exposed area of unvegetated gravel which suggests much of the parent material may be suitable for road construction. Since the ground was still frozen, it was not determined how far below the surface the gravel went, but there appeared to be no shortage of gravel, especially along the alternate road route.

Typical examples of these exposed gravel deposits are given in the attached photomosaic and locations of these sites along the alternate route are given in Figure 2.

TABLE 1

LOCATIONS OF POTENTIAL DEPOSITS FROM
LORAN C. COORDINATES

Site Number*	Latitude	Longitude
1	N 59 53 30	W 154 47 06
2	N 59 53 54	W 154 47 30
3	N 59 53 30	W 154 48 30
4	N 59 53 36	W 154 49 00
5	N 59 53 30	W 154 49 00
6	N 59 53 30	W 154 49 12
7	N 59 53 18	W 154 49 24

*Site numbers correspond to the map in Figure 2.

3.6 Intake Area

Two photomosaics of the area intake structure above the falls and are included as attachments to this report. These photos cover approximately 150 m of the south side above the falls of the Tazimina River taken from the opposite side.

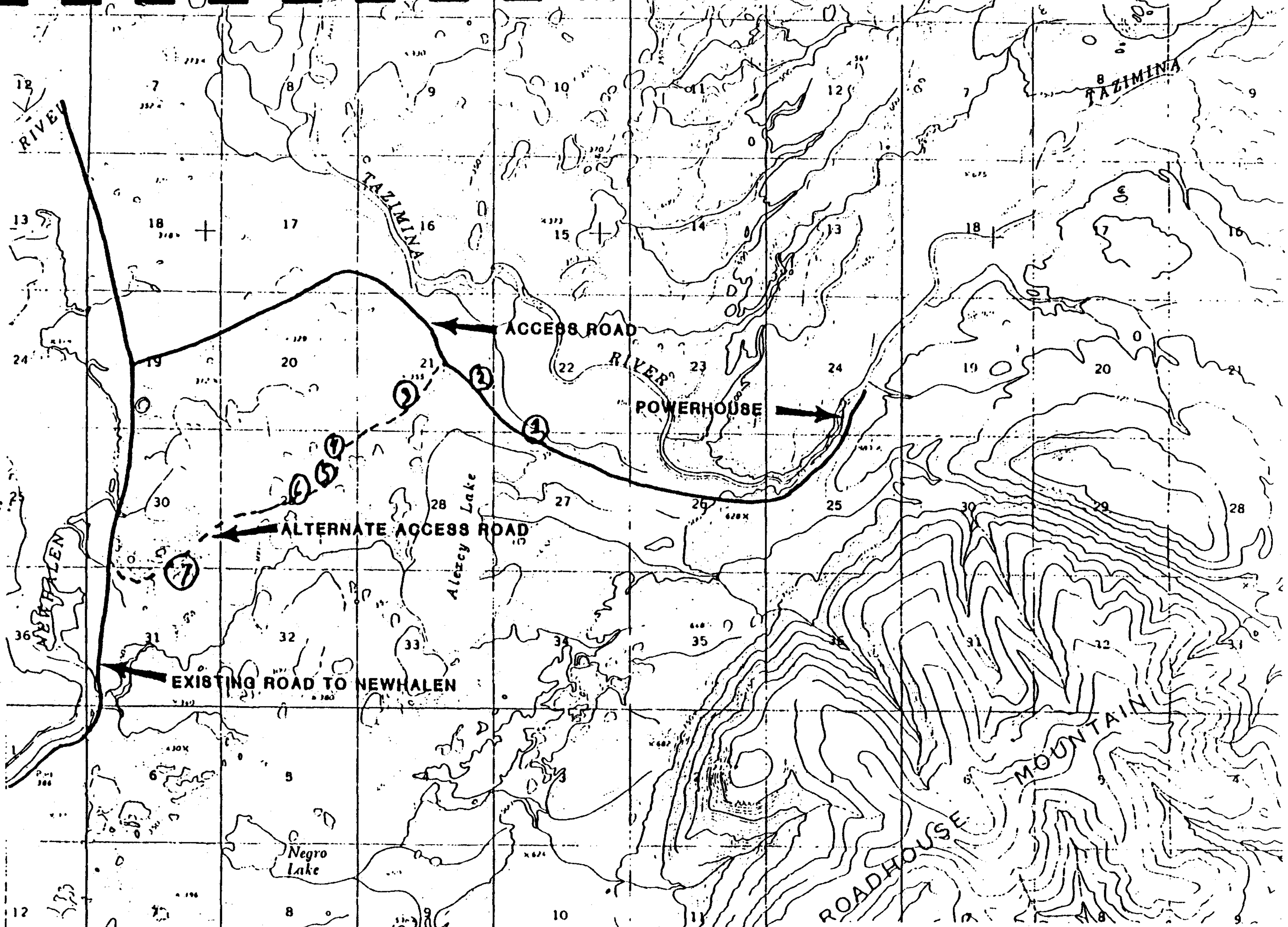

FIGURE 2
LOCATION OF POTENTIAL MATERIAL SI
ALONG ALTERNATE ACCESS ROAD

4.0 DISCUSSION

4.1 Overall Comparison of Road Routes

After walking both the old proposed route and the alternate road alignment it would appear there is no significant biological difference between the two routes. Neither route crosses any area of surface water such as streams or ponds and the vegetation community types are very similar between the two routes. The area of surface disturbance would also be very comparible since both routes would be the same length. Although both routes do pass by lakes and ponds, these habitats appear to have only marginal waterfowl use. A small amount of disturbance would be expected during construction of the road. Swans do nest in the general area, but only one pair were observed using the ponds adjacent to the northern route. There were no indications of any concentrated nesting activity.

No ecologically sensitive or unique habitats were identified along either road route which would be affected by the development of an access road from the proposed powerhouse site to the Iliamna-Nondalton road.

5.0 REFERENCES

Dames & Moore. 1982. Bristol Bay Regional Power Plan, Environmental Report. Prepared for Alaska Power Authority. Anchorage, Alaska.

Dames & Moore. 1985. Environmental Reconnaissance of Potential Road Routes to the proposed Tazimina River Hydroelectric project. Prepared for the Alaska Power Authority. Anchorage, Alaska.

APPENDIX F

ARCHEOLOGICAL SURVEY, MAY 1986

Archeological Survey of Two Access Road Routes and the Proposed Sites of a Powerhouse and Penstock for the Tazimina River Local Power Project

by

Michael R. Yarborough

Submitted to

Dames and Moore Consulting Engineers

May 21, 1986

Cultural Resource Consultants

Anchorage, Alaska

Introduction

The following report describes an archeological survey of two possible access road routes and the proposed sites of a powerhouse and penstock associated with the Tazimina River Local Power Project. This work was conducted on the 14th and 15th of May, 1986, by Michael R. Yarborough of Cultural Resource Consultants.

Project Areas

The prefered access route to the site of the powerhouse and penstock would run northeast from the Newhalen Road, through a convoluted terrain of discontinuous glacial ridges, knolls and small lakes without outlet streams, to a point just south of the edge of the terrace above the Tazimina River (Figure 1). From here the road swings back away from the terrace edge for approximately four-tenths of a mile before running along the northern edge of a ridge that separates the northeastern corner of Alexcy Lake and the Tazimina River valley. East of Alexcy Lake the road would again turn away from the terrace edge across a wind-swept plateau.

All of the glacial features along the first portion of this route are marked with extensive patches of exposed gravel. There are also numerous barren areas along the edge of the river terrace. Portions of the route back from the terrace edge were covered with unbroken alpine tundra.

The first segment of the alternate route, from the existing Newhalen Road to the southwest shore of a lake along the southern margin of Section 17, Township 3 S, Range 32 W, would run through an area of flat tundra dotted with white spruce. From the lake, the route crosses a rolling terrain of discontinuous ridges, knolls and hummocks before turning to the southeast to the edge of the terrace above the Tazimina River. The road would then roughly parallel the edge of the terrace for approximately nine-tenths of a mile to where it joins the prefered route.

In the vicinity of the lake in Section 17 and to the southeast of where the alternate road joins the prefered route there are numerous and extensive areas of exposed gravel. Other areas of the alternate route are covered with tundra.

The powerhouse will be located in the river canyon below the falls, while the penstock will be above the falls in the bed of the river. In this area, the river runs through a narrow canyon with high, vertical, rock walls. Along the eastern edge of the river, upstream from the falls, are a series of low terraces rising above the rim of the canyon. Here, except for a series of holes left by seismic testing, there are few areas of exposed soil.

Previous Archeological Surveys

The only previous archeological work in the project area was done in September of 1981 by Kathy Arndt. She conducted a surface survey of two potential powerhouse sites on the Tazimina River and an aerial reconnaissance around the perimeter of Lower Tazimina Lake. Two recent campsites were the only cultural remains found during this survey. Her report (Dames and Moore 1982) contains a detailed summary of the prehistory, history, and ethnography of the Tazimina Lake area.

Field Research

Both the prefered access route, from the Newhalen Road to approximately the common boundary between Sections 26 and 27, and the alternate route were inspected from the air and surveyed on-the-ground. The proposed sites of the powerhouse and penstock were also looked at from the air, and the terraces on the eastern side of the river were walked for a distance of approximately 100 meters (m) upstream from the falls.

During the surface survey, the approximate routes of the access road and the alternate, as depicted on a 1:63,360 U.S.G.S. map, were followed using landmarks and compass bearings for direction. Areas of exposed gravels, which were numerous, were inspected for cultural material. Except in the vicinity of the lake in Section 17, the ground in the project area was frozen just under the cover of moss and lichens. The latitude and longitude of the two artifacts found during the survey were determined using the helicopter's Loran navigation system.

Field Results

The only cultural remains located during this survey were a fragment of a microblade core and a retouched flake. Both were found exposed on the surface along the edge of the river terrace northeast of Alexcy Lake (Figure 1). The core fragment, measuring 18.6 by 7.9 by 10.5 mm, is from a patch of exposed gravel approximately 12 m back from the edge of the terrace in the northwest corner of Section 27 (latitude 59 53'30" N, longitude 154 46'54" W). It is made of a fine-grained, dark red chert covered with small black spots. The fragment includes a portion of the core's fluted face and striking platform. Numerous hinged flake scars and some crushing on the platform attest to the attempted removal of front-struck rejuvenation flakes from the platform surface. Only one blade scar is present on the face of the core. This piece is apparently from a wedge-shaped core which fractured along several flaw lines in the material.

Wedge-shaped microblade cores are a characteristic artifact of the American Paleo-arctic tradition. Assemblages of this tradition have been previously found on the Alaska Peninsula at Ugashik Narrows, Igiugig, and Graveyard Point at the mouth of the Kvichak River. The assemblage at Ugashik Narrows dates between 7,700 and 9,000 B.P., while that at Graveyard Point dates to 7,800 to 7,900 B.P. (Smith and Shields 1977:23-24, 36). The site at Igiugig is undated. In addition to wedge-shaped cores, artifacts recovered from these sites have included microblades, core rejuvenation flakes, large and small projectile points, scrapers and bifaces.

The retouched flake was found along the edge of the terrace approximately 250 meters to the west (latitude 59 53'36" N, longitude 154 47'6" W) of the core fragment. It is a large, 33.1 by 43.1 by 11.6 mm, flake of fine-grained chert with bifacial retouch along both lateral margins.

Conclusions and Recommendations

One of the recommendations from Arndt's 1981 work was that "terraces above the present river bed" be tested, since "prehistoric sites have been found high above present day rivers and lakes in the Iliamna-Lake Clark region..." (Dames and Moore 1982:5-12). This conclusion is supported by the results of this second survey of the project area. The river terrace above the Tazimina, especially the section of the terrace which separates the northeast corner of Alexcy Lake and the river valley, has a very high archeological potential. The terrace offers a convenient route of travel and an excellent vantage of the Tazimina River valley. The river and Alexcy Lake are rich in both anadromous and fresh water species of fish, and beaver and waterfowl are found around the lake.

Other portions of the prefered and alternate routes, away from the edge of the terrace, have a much lesser archeological potential. The prefered route crosses numerous glacial ridges and knobs, but, because of the convoluted nature of the terrain, no single feature offers much of an advantage in terms of view. Much of the alternate route--the segment southwest of the lake in Section 17--is flat and featureless tundra. The lakes skirted by both routes are small and have no outlet streams. Indeed, neither route crosses any streams.

The sites of the penstock and powerhouse have no archeological potential. These locations are virtually inaccessible and offer no advantage, other than scenic, over other more accessible areas further up- or downstream.

Based on the results of this survey, it is recommended that, once an access route has been selected, the portion of the road that parallels the edge of the river terrace be intensively surveyed and tested. Barren patches within the road right-of-way should be checked for artifacts exposed on the surface, and vegetated areas tested for in situ cultural material. Given the number of "blowouts" examined during this survey, it can be reasonably predicted that there are no extremely large sites along the terrace edge. However, the isolated core fragment and retouched flake do suggest that there may be other small "chipping stations", "lookouts", or "hunting camps" overlooking the Tazimina River valley.

Bibliography

Dames and Moore
1982 *Bristol Bay Regional Power Plan Environmental Report*. Submitted to the Alaska Power Authority.

Smith, George S. and Harvey M. Shields
1977 *Archaeological Survey of Selected Portions of the Proposed Lake Clark National Park: Lake Clark, Lake Telaquana, Turquoise Lake, Twin Lakes, Fishtrap Lake, Lachbuna Lake and Snipe Lake*. Anthropology and Historic Preservation, Cooperative Parks Studies Unit, University of Alaska, Fairbanks.

Legend

Figure 1- Project Area Map

1. Prefered access road alignment
2. Alternate access road alignment
3. Falls and site of penstock and powerhouse
4. Microblade core fragment
5. Retouched flake
6. Approximate eastern limit of access road survey

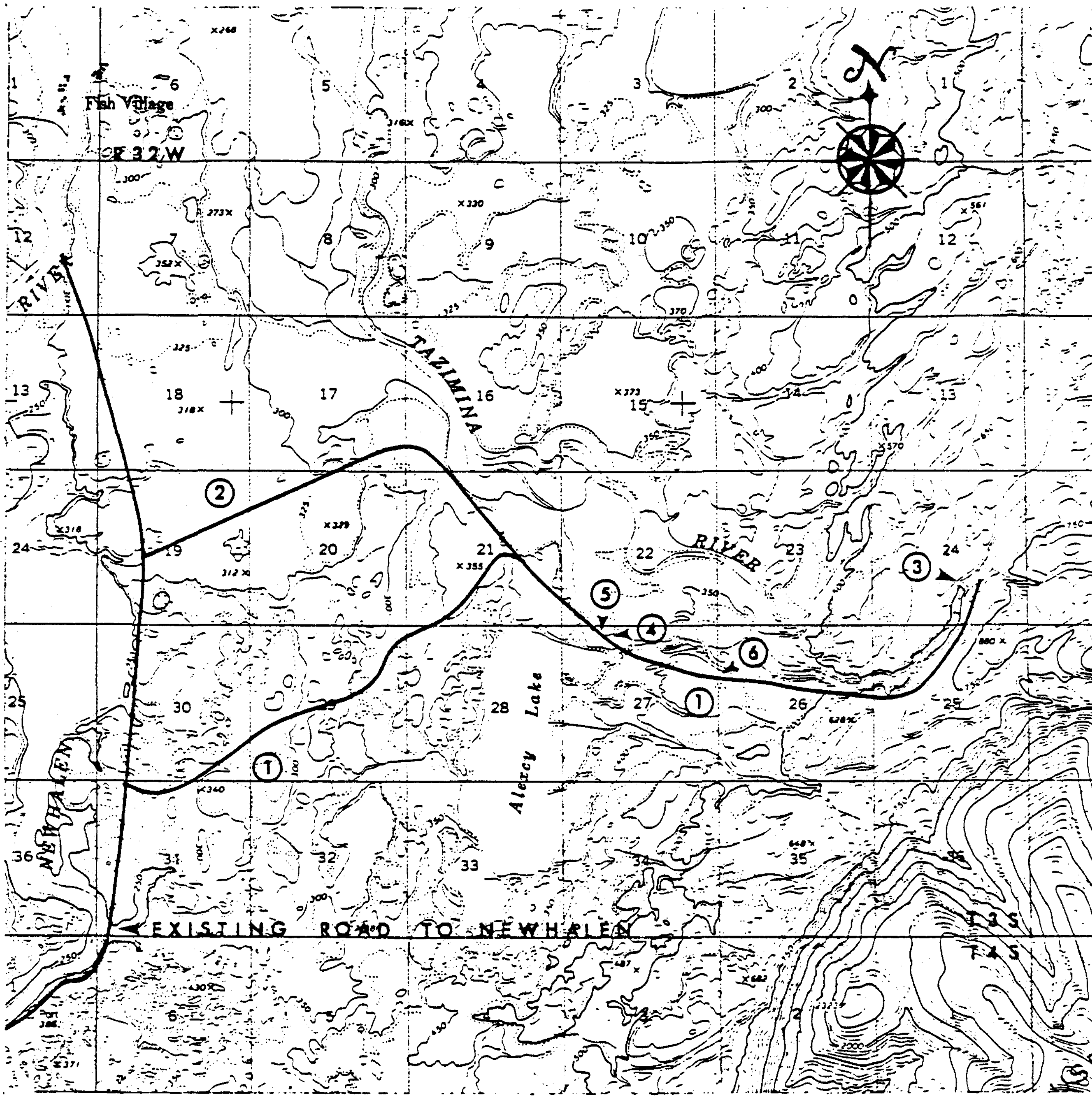

FIGURE 1

PROJECT AREA MAP

APPENDIX G

SAMPLE PRESENT WORTH PRINTOUT

DISCOUNTED CASH FLOW ANALYSIS
FEASIBILITY STUDY
TAZIMINA RIVER HYDROELECTRIC PROJECT
BRISTOL BAY REGIONAL POWER PLAN
ALASKA POWER AUTHORITY

Discount Rate (%)	3.5
Diesel Fuel Base Cost (Cents/Gal)	110
Diesel Fuel Consumption (Gal/kWh)	0.0836
Load Growth Rate (%)	3
Diesel O&M Variable Cost ($/kWh)	0.0175
Hydro O&M Variable Cost ($/kWh)	0.015

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
	1	2	3	4	5	6	7	8	9	10
ELECTRICITY GENERATION										
Peak Demand (kW)	461	474	489	503	518	534	550	566	583	601
Annual Energy Use (MWh)	1834	1889	1946	2004	2064	2126	2190	2255	2323	2393
DIESEL GENERATION										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Replaced Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	990	990	990	990	990	990	990	990	990	990
Energy Generation (MWh)	1834	1889	1946	2004	2064	155	151	147	144	139
Diesel Fuel Escalation Rate (%)	0.0	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Diesel Fuel Cost (Cents/Gal)	110	113	116	119	122	125	129	133	137	141
Diesel Fuel Used (Gal 000)	153	158	163	168	173	13	13	12	12	12
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	92	93	94	95	96	20	20	20	20	20
Fuel Cost ($000)	169	178	189	199	211	16	16	16	16	16
Debt Service ($000)	0	0	0	0	0	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	261	271	283	294	307	36	36	36	36	36
HYDROELECTRIC										
Added Capacity (kW)	0	0	0	0	0	700	0	0	0	0
Installed Capacity (kW)	0	0	0	0	0	700	700	700	700	700
Percent of Annual Generation (%)	0	0	0	0	0	93	93	93	94	94
Energy Generation (MWh)	0	0	0	0	0	1971	2039	2108	2179	2254
Capital Cost ($000)	0	0	650	3050	3050	0	0	0	0	0
O&M Cost ($000)	0	0	0	0	0	165	91	92	93	94
Subtotal ($000)	0	0	650	3050	3050	165	91	92	93	94
TRANSMISSION										
Capital Cost ($000)	0	0	0	0	650	0	0	0	0	0
O&M Cost ($000)	0	0	0	0	0	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	0	0	0	0	650	10	10	10	10	10
SUMMARY										
Total Cost ($000)	261	271	933	3344	4007	211	137	138	139	140
Discounted Cost ($000)	252	253	841	2914	3373	171	108	105	102	99
Cumulative Present Worth ($000)	252	505	1346	4261	7634	7806	7913	8018	8120	8220

CUMULATIVE DISCOUNTED VALUES

CAPITAL COST ($000)	6771
O&M COST ($000)	3073
FUEL COST ($000)	1337
TOTAL PRESENT WORTH ($000)	11181

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	11	12	13	14	15	16	17	18	19	20
ELECTRICITY GENERATION										
Peak Demand (kW)	619	638	657	676	697	718	739	761	784	808
Annual Energy Use (MWh)	2465	2539	2615	2693	2774	2857	2943	3031	3122	3216
DIESEL GENERATION										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Replaced Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	990	990	990	990	990	990	990	990	990	990
Energy Generation (MWh)	136	132	130	146	149	155	165	173	182	191
Diesel Fuel Escalation Rate (%)	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8	2.8
Diesel Fuel Cost (Cents/Gal)	145	149	153	157	161	166	171	176	181	186
Diesel Fuel Used (Gal 000)	11	11	11	12	12	13	14	14	15	16
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	20	20	20	20	20	20	20	20	20	20
Fuel Cost ($000)	16	16	17	19	20	22	24	25	28	30
Debt Service ($000)	0	0	0	0	0	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	36	36	37	39	40	42	44	45	48	50
HYDROELECTRIC										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	700	700	700	700	700	700	700	700	700	700
Percent of Annual Generation (%)	94	95	95	95	95	95	94	94	94	94
Energy Generation (MWh)	2329	2407	2485	2547	2625	2702	2779	2858	2940	3025
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	95	96	97	98	99	101	102	103	104	105
Subtotal ($000)	95	96	97	98	99	101	102	103	104	105
TRANSMISSION										
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	10	10	10	10	10	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	10	10	10	10	10	10	10	10	10	10
SUMMARY										
Total Cost ($000)	141	143	144	147	149	152	155	158	162	165
Discounted Cost ($000)	97	94	92	91	89	88	87	85	84	83
Cumulative Present Worth ($000)	8316	8411	8503	8594	8683	8771	8857	8942	9027	9110

	2006 21	2007 22	2008 23	2009 24	2010 25	2011 26	2012 27	2013 28	2014 29	2015 30
ELECTRICITY GENERATION										
Peak Demand (kW)	808	808	808	808	808	808	808	808	808	808
Annual Energy Use (MWh)	3216	3216	3216	3216	3216	3216	3216	3216	3216	3216
DIESEL GENERATION										
Added Capacity (kW)	-490	0	0	0	0	0	0	0	0	0
Replaced Capacity (kW)	500	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	500	500	500	500	500	500	500	500	500	500
Energy Generation (MWh)	191	191	191	191	191	191	191	191	191	191
Diesel Fuel Escalation Rate (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel Fuel Cost (Cents/Gal)	186	186	186	186	186	186	186	186	186	186
Diesel Fuel Used (Gal 000)	16	16	16	16	16	16	16	16	16	16
Capital Cost ($000)	400	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	20	20	20	20	20	20	20	20	20	20
Fuel Cost ($000)	30	30	30	30	30	30	30	30	30	30
Debt Service ($000)	0	0	0	0	0	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	450	50	50	50	50	50	50	50	50	50
HYDROELECTRIC										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	700	700	700	700	700	700	700	700	700	700
Percent of Annual Generation (%)	94	94	94	94	94	94	94	94	94	94
Energy Generation (MWh)	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	105	105	105	105	105	105	105	105	105	105
Subtotal ($000)	105	105	105	105	105	105	105	105	105	105
TRANSMISSION										
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	10	10	10	10	10	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	10	10	10	10	10	10	10	10	10	10
SUMMARY										
Total Cost ($000)	565	165	165	165	165	165	165	165	165	165
Discounted Cost ($000)	274	77	75	72	70	67	65	63	61	59
Cumulative Present Worth ($000)	9384	9461	9536	9608	9678	9746	9811	9874	9935	9994

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	31	32	33	34	35	36	37	38	39	40
ELECTRICITY GENERATION										
Peak Demand (kW)	808	808	808	808	808	808	808	808	808	808
Annual Energy Use (MWh)	3216	3216	3216	3216	3216	3216	3216	3216	3216	3216
DIESEL GENERATION										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Replaced Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	500	500	500	500	500	500	500	500	500	500
Energy Generation (MWh)	191	191	191	191	191	191	191	191	191	191
Diesel Fuel Escalation Rate (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel Fuel Cost (Cents/Gal)	186	186	186	186	186	186	186	186	186	186
Diesel Fuel Used (Gal 000)	16	16	16	16	16	16	16	16	16	16
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	20	20	20	20	20	20	20	20	20	20
Fuel Cost ($000)	30	30	30	30	30	30	30	30	30	30
Debt Service ($000)	0	0	0	0	0	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	50	50	50	50	50	50	50	50	50	50
HYDROELECTRIC										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	700	700	700	700	700	700	700	700	700	700
Percent of Annual Generation (%)	94	94	94	94	94	94	94	94	94	94
Energy Generation (MWh)	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	105	105	105	105	105	105	105	105	105	105
Subtotal ($000)	105	105	105	105	105	105	105	105	105	105
TRANSMISSION										
Capital Cost ($000)	0	0	0	0	650	0	0	0	0	0
O&M Cost ($000)	10	10	10	10	10	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	10	10	10	10	660	10	10	10	10	10
SUMMARY										
Total Cost ($000)	165	165	165	165	815	165	165	165	165	165
Discounted Cost ($000)	57	55	53	51	245	48	46	45	43	42
Cumulative Present Worth ($000)	10051	10105	10159	10210	10454	10502	10548	10593	10636	10678

	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
	41	42	43	44	45	46	47	48	49	50
ELECTRICITY GENERATION										
Peak Demand (kW)	808	808	808	808	808	808	808	808	808	808
Annual Energy Use (MWh)	3216	3216	3216	3216	3216	3216	3216	3216	3216	3216
DIESEL GENERATION										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Replaced Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	500	500	500	500	500	500	500	500	500	500
Energy Generation (MWh)	191	191	191	191	191	191	191	191	191	191
Diesel Fuel Escalation Rate (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diesel Fuel Cost (Cents/Gal)	186	186	186	186	186	186	186	186	186	186
Diesel Fuel Used (Gal 000)	16	16	16	16	16	16	16	16	16	16
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	20	20	20	20	20	20	20	20	20	20
Fuel Cost ($000)	30	30	30	30	30	30	30	30	30	30
Debt Service ($000)	0	0	0	0	0	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	50	50	50	50	50	50	50	50	50	50
HYDROELECTRIC										
Added Capacity (kW)	0	0	0	0	0	0	0	0	0	0
Installed Capacity (kW)	700	700	700	700	700	700	700	700	700	700
Percent of Annual Generation (%)	94	94	94	94	94	94	94	94	94	94
Energy Generation (MWh)	3025	3025	3025	3025	3025	3025	3025	3025	3025	3025
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	105	105	105	105	105	105	105	105	105	105
Subtotal ($000)	105	105	105	105	105	105	105	105	105	105
TRANSMISSION										
Capital Cost ($000)	0	0	0	0	0	0	0	0	0	0
O&M Cost ($000)	10	10	10	10	10	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	0	0	0	0	0	0
Subtotal ($000)	10	10	10	10	10	10	10	10	10	10
SUMMARY										
Total Cost ($000)	165	165	165	165	165	165	165	165	165	165
Discounted Cost ($000)	40	39	38	36	35	34	33	32	31	30
Cumulative Present Worth ($000)	10718	10757	10795	10831	10866	10900	10933	10964	10995	11025

	2036	2037	2038	2039	2040
	51	52	53	54	55
ELECTRICITY GENERATION					
Peak Demand (kW)	808	808	808	808	808
Annual Energy Use (MWh)	3216	3216	3216	3216	3216
DIESEL GENERATION					
Added Capacity (kW)	0	0	0	0	0
Replaced Capacity (kW)	500	0	0	0	0
Installed Capacity (kW)	500	500	500	500	500
Energy Generation (MWh)	191	191	191	191	191
Diesel Fuel Escalation Rate (%)	0.0	0.0	0.0	0.0	0.0
Diesel Fuel Cost (Cents/Gal)	186	186	186	186	186
Diesel Fuel Used (Gal 000)	16	16	16	16	16
Capital Cost ($000)	400	0	0	0	0
O&M Cost ($000)	20	20	20	20	20
Fuel Cost ($000)	30	30	30	30	30
Debt Service ($000)	0	0	0	0	0
Salvage Value ($000)	0	0	0	0	200
Subtotal ($000)	450	50	50	50	-150
HYDROELECTRIC					
Added Capacity (kW)	0	0	0	0	0
Installed Capacity (kW)	700	700	700	700	700
Percent of Annual Generation (%)	94	94	94	94	94
Energy Generation (MWh)	3025	3025	3025	3025	3025
Capital Cost ($000)	0	0	0	0	0
O&M Cost ($000)	105	105	105	105	105
Subtotal ($000)	105	105	105	105	105
TRANSMISSION					
Capital Cost ($000)	0	0	0	0	0
O&M Cost ($000)	10	10	10	10	10
Salvage Value ($000)	0	0	0	0	108
Subtotal ($000)	10	10	10	10	-98
SUMMARY					
Total Cost ($000)	565	165	165	165	-143
Discounted Cost ($000)	98	28	27	26	-22
Cumulative Present Worth ($000)	11122	11150	11177	11202	11181