JUNE 26, 1995

CHIGNIK LAGOON HYDROELECTRIC FEASIBILITY STUDY

FINAL REPORT

prepared for the

CHIGNIK LAGOON TRIBAL COUNCIL

CHIGNIK LAGOON, AK

prepared by

POLARCONSULT ALASKA

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1. FINDINGS

A hydroelectric power plant constructed at Packers Creek is technically and economically feasible as long as the construction costs are kept within reasonable limits. The recommended plant will use a low height diversion, a de-sanding structure, 2,300 feet of High Density Polyethylene (HDPE) pipe, 2,200 feet of Polyvinylchloride (PVC) pipe, and a 200 kW impulse turbine. The system will be constructed mostly with local labor. The general layout of the system as well as details of the intake and powerhouse are shown in the drawings in Appendix F.

The following is a summary of the conclusions that were drawn from the feasibility analysis.

- The cost to construct the plant will be $572,925.
- The highest feasible capacity of the plant will be approximately 200 kW.
- The plant will generate an average of 1,170,217 kWh per year.
- The hydro energy will need to be augmented by 84,711 kWh of diesel energy during low water periods (approximately January through April).
- A FERC license will not be needed to build the recommended project.

Basic characteristics of the recommended plant are provided below:

General Data:	
Installed Capacity	200 kW
Number of Units	1
Type of Turbine	Impulse
Basin Area	1.14 square mi
Average Annual Energy Produced	1,170,217 kWh
City's Annual Power Needs	650,000 kWh
Estimated Annual Usable Energy	565,289 kWh
Design Flow	8 cfs
Gross Head	390 feet
Net Head at Full Flow	357 feet
Penstock Diameter	16 & 14 inches
Penstock Length	4,500 feet
Diversion Structure Height	4 feet
Economic Data (0 to 30 yrs):	
Project Construction Cost	$572,925
Average Annual Project Cost	$95,326
Annual Fuel Displaced	43,484 gallons
Average Savings per year	$35,508
Total Savings, present worth	$804,710
Excess Energy, present worth	$1,194,825

2. INTRODUCTION

This report provides an analysis of the feasibility of hydroelectric power production from Packers Creek at Chignik Lagoon, Alaska. Authorization for this study was given by the Chignik Lagoon village council. Funding was provided by the Department of Energy.

Chignik Lagoon is located on the Alaska Peninsula (See Figure 1 in Appendix F) within the Lake & Peninsula Borough with a population of about 88 people during the winter months and increasing during the summer.

Currently, Chignik Lagoon is without a central power generating and distribution system. Each individual in the community is responsible for providing their own power. This is likely to change in the near future as the community recently received a design for a diesel power plant and distribution system.

This study is based on the economic and practical comparison of the costs and benefits of constructing a hydroelectric plant in addition to building the diesel plant. It is assumed in this study that the costs for building the diesel plant are as estimated in the Electrical Distribution and Generation Feasibility and Design report dated April 12, 1994.

The scope of this study includes the installation of a recorder to monitor stream flow near the location of the proposed intake structure, a preliminary layout of the pipeline based on surveyed elevation information and visual inspection of terrain, an analysis of streamflows with estimations for optimum turbine size, a cost estimate for design and construction, and an economic evaluation of the benefits of constructing the hydroplant. The initial site visit, performed on January 19, 1995 is detailed in the field trip report, a copy of which is in Appendix E. A second field trip was conducted on June 8, 1995 to download data from the stream gauge and to get another stage discharge reading. This information is included in Appendix G.

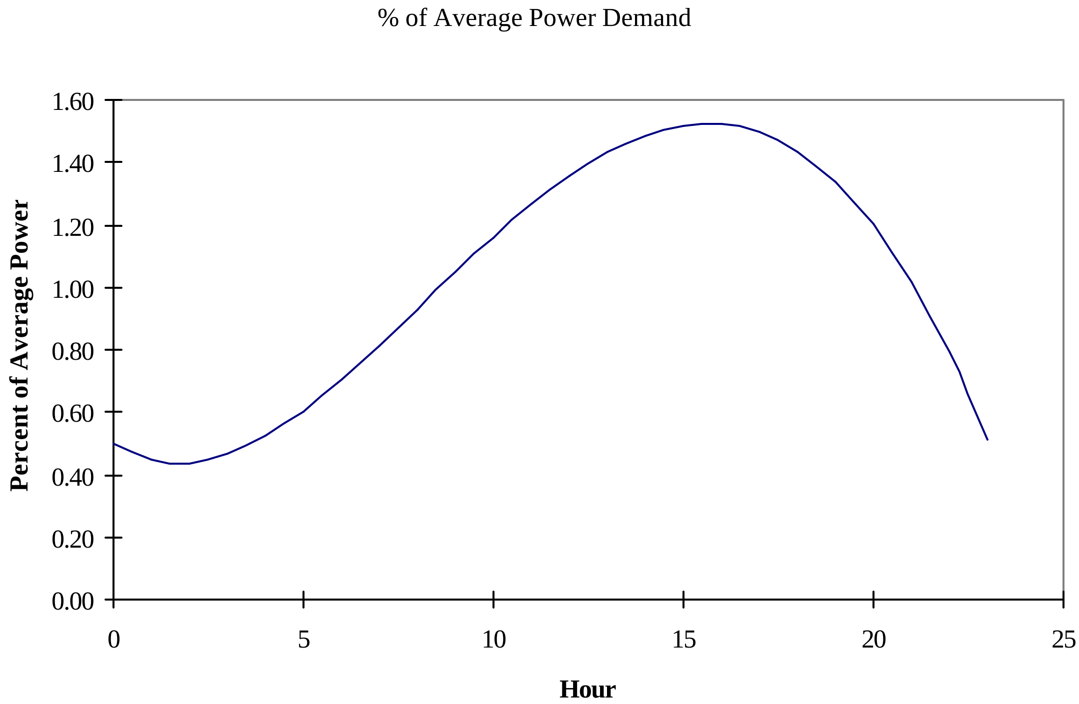
3. CHIGNIK LAGOON ELECTRICAL REQUIREMENTS

Generally the amount of electricity used in a community is a function of population, cost of electricity, cost of alternative energy and earnings of the population. Currently, Chignik Lagoon does not have a central power generating system. Each user has their own generator and must supply their own fuel.

In order to assess the feasibility of the hydro plant, an assumption needs to be made regarding the city's power usage. This is a significant factor that determines the economic feasibility of installing a hydroelectric plant because the viability of the hydro plant is directly related to how much diesel fuel it can displace.

The City's needs were estimated by using known power usage from a similar sized community in a similar location. This was done in the previous electrical design report. Given a population of 88 people during the winter, the average power needs amount to 74 kW. During the summer, the population increases but the assumed use of electricity remains constant. This is a conservative assumption that favors the diesel option but without knowing the actual power usage it is better to error on the conservative side.

A daily demand curve was also generated to show the daily fluctuations in power needs. This fluctuation was taken into account for the amount of diesel makeup needed to substitute hydro power. Using the daily multiplier, the peak power usage is 113 kW. The following is the daily fluctuation curve that was used for Chignik Lagoon.



4. HYDROLOGY AND POWER

4.1 PRECIPITATION AND STREAMFLOW

One of the critical factors for a hydroelectric power plant is the availability of water. Packers Creek is a stream without records. There are several methods of obtaining and/ or estimating stream flow information when there isn't a recorded history for the stream. But any estimate should be checked with actual stream gauging. A stream gauge was recently installed by Polarconsult. This gauge will remain in place for approximately one year.

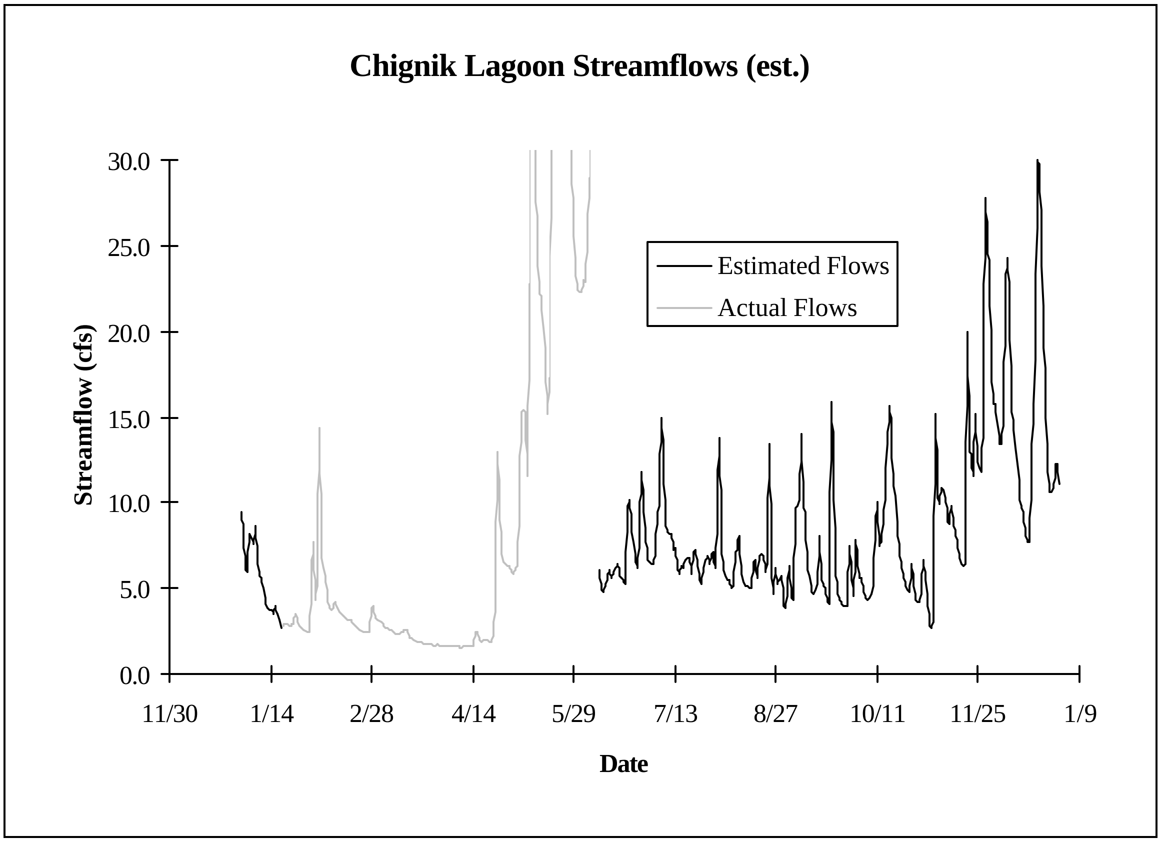
Initially, the streamflows in Packers Creek were estimated without the benefit of stream gauging. This was accomplished using rainfall records for the Alaska Peninsula and streamflow data from Russell Creek and two creeks near Sand Point. The streamflows used consisted of approximately 8 months of data from two streams in Sand Point and several years of data from Russell Creek all scaled by basin size.

The streamflow data has been adjusted to more accurately match the recorded measurements using the gauging information from January 19 through June 8.

Rainfall records from Sand Point and Cold Bay indicated a mean yearly rainfall of 35.8 inches and 36 inches respectively. This is consistent with the streamflows in the above mentioned creeks. The streamflows observed in Packers Creek suggest a rainfall of about 100 inches. It could be that this year has an unusually high amount of snow which is skewing the streamflow data. However, a hydropower feasibility report for Chignik done in July of 1984 by the US

Army Corps of Engineers gives a mean rainfall of 107.9 inches over a 12 year period (Appendix G).

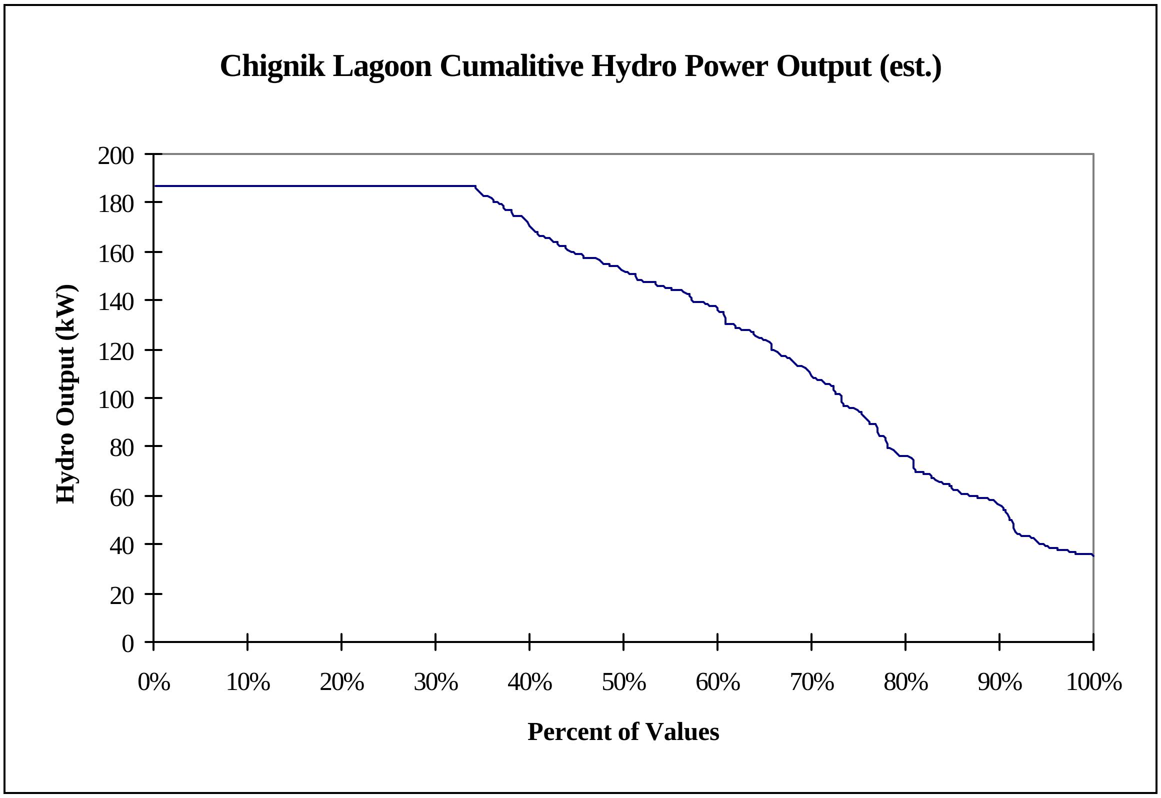
For estimating purposes, the streamflows used in this study correlate with approximately 100 inches of rainfall. The following chart shows the yearly streamflows - actual and estimated.



4.2 AMOUNT OF POWER GENERATED

The amount of power generated is dependent on the pressure and flow of the water along with the efficiency of the turbine, generator, and electrical equipment. This analysis is based on a water to wire efficiency of 0.77. The energy available in the water is converted to electrical energy units and multiplied by this efficiency.

Based on the streamflow information, the cumulative power output of the plant can be estimated. This represents the amount of time that the plant will produce power at a given output level. The following cumulative distribution of hydro output shows how much of the time the power is less than or equal to the city's needs. As the chart shows, approximately 80% of the time the hydro can provide all of the City's needs on average. Where the hydro output is less than the City's demand (about 20% of the time on average), diesel makeup will be needed to provide the City with all of the power it needs.



4.3 EXCESS ENERGY

Energy in excess of the community's traditional needs will be produced by the hydro plant. This energy can be wasted but it also can be used. An inexpensive computer equipped module can be used which will determine by the frequency whether there is surplus energy. If there is an increase in frequency above sixty hertz, a relay is closed that sends the excess to an electric heater. Such a heater can be used to heat hot water for the school, community center, and provide heat to the buildings as well. It can also be used for greenhouses and adsorption refrigeration. The equivalent amount of fuel displaced by the excess hydro power will be dependent on water flows and the ways in which the excess power is used by Chignik Lagoon. It is estimated that the equivalent of 43,105 gallons of oil is available on average each year if all of the energy is usable. A realistic assumption is that one quarter of the energy can be put to useful purpose.

This study ignores the value of the excess power when determining the feasibility of the hydroplant. This is somewhat conservative but appropriate because excess power is essentially "free" when using a hydroplant. When there is excess power, the community will likely find a use for it but may also lower electrical rates at the same time so that the net income from power sales remains the same.

5. TYPICAL FEATURES

5.1 INTAKE

The intake for this project is a small diversion structure that simply raises the water high enough to allow it to enter the piping that will carry the water to the desander. Figures 3 and 4 in Appendix F are drawings of the proposed intake. The intake has to be built strong enough to withstand spring floods and ice buildup. It also has to be deep enough in the ground to prevent the flow of water under the intake so that as much water as possible enters the intake pipe.

It is proposed to use a reinforced concrete structure with removable stop logs for an intake. The removable stop logs will enable the water to flush out accumulated rocks and allow bypassing of the intake pipe for servicing of the desander. Stop logs also serve to control the maximum height that the water must be at for operation. Installing more stop logs raises the height of the water over the intake pipe.

On the downstream side of the diversion structure is a concrete pad that dissipates the energy of excess water falling over the stop log portion of the structure (spillway). Without this concrete pad the force of the water falling in the stream would eventually erode away the stream and undermine the concrete.

Before the intake, there will be a trash rack that consists of steel bars spaced closely enough together (about one pipe diameter) to prevent very large objects from entering the intake pipe and blocking it.

5.2 DE-SANDING AND SCREENS

The desander is one of the most important components for the operation of the turbine. Without it, sand and rocks can flow down the pipe and into the turbine causing excessive wear and shortened project life. It is very important that the de-sander be built and maintained properly.

The desander has a primary settling area for removal of gravel and other large material. In this portion is a flush gate that can be opened and closed manually or automatically. When the flush gate opens, the water flows through the primary settling area rapidly, thereby washing out accumulated gravel. When the gate is closed, water flows upward towards the screen. The water passes up through the screen which catches leaves. The water then continues up until it reaches the operating height in the desander and flows over the separating wall in the secondary settling basin.

When the gate in the initial settling portion of the desander opens, water briefly flows down through the screen. This water removes the buildup of leaves and other floatables and carries it on out through the gate as the primary settler drains.

The secondary settling basin is much larger than the primary basin. This causes the water to flow slowly through the basin. When the flow of water is slow, the sand and grit in the water are able to settle to the bottom. The water then flows through a backup screen and into the penstock. The backup screen is used in case the first screen fails.

5.3 PENSTOCK

The water conveyance system, or penstock, is one of the single most expense parts of a project such as this.

A combination of pipes will be used to convey the water to the turbine. High density polyethylene, HDPE, pipe weighs about 11 pounds per foot. A single forty foot section weighs about 440 pounds. The fusion machine for such a pipe weighs about 3,000 pounds.

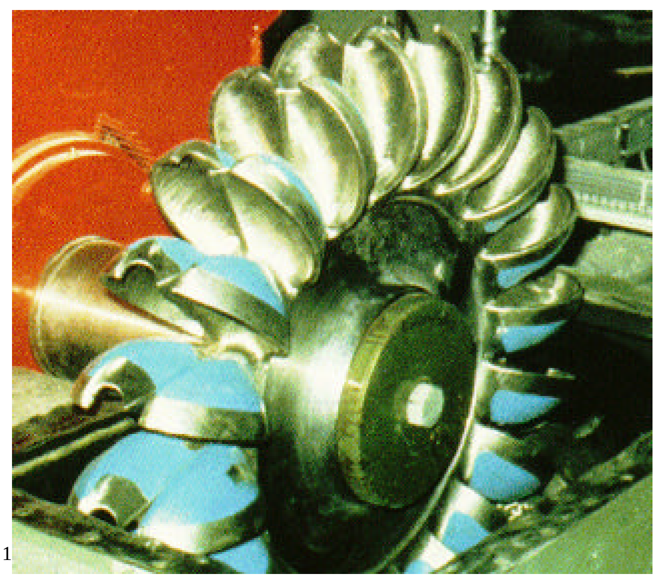
Polyvinyl Chloride, PVC, pipe also will be used. It comes in 20 foot lengths and has a bell and spigot joint. The weight would range from 32 to 40 pounds per foot depending on the wall thickness selected. PVC pipe is less expensive and the material is stronger than HDPE. However, when cold it is brittle and if shot with a bullet it will crack.

PVC pipe will have to be hauled in sections and connected together in the field. Rubber "O" ringed joint pipe, if used, will need to be restrained so the joints cannot pull apart.

5.4 POWERHOUSE

The powerhouse will house the turbine, generator, load governor and switch gear. A transformer will be located outside the powerhouse. The powerhouse will be located so the generator floor is above flood stage. The base of the powerhouse will be concrete. The walls and roof will be wood framing with T1-11 on the exterior and greenboard on the interior.

5.5 TURBINE



[1]

The turbine for this plant will be an impulse turbine. The turbine consists of one or more nozzles that shoot water at buckets positioned around the wheel. The water hits the buckets causing the wheel to spin which is connected to the generator. The figure at left shows the configuration of the buckets on an impulse turbine. The water stream is directed to the center of the bucket where the flow divides. This impulse wheel is connected directly to a generator.

The nozzles that directs the water at the buckets has needles inside that can be extended or retracted to control the amount of water

[1] Provided by Kvaerner Hydro Power, Inc.

that hits the turbine. These needles open and shut relatively slowly to prevent a water hammer effect. Between the nozzle and the turbine buckets is a movable deflector plate. This plate can be placed between the buckets and the nozzle to instantly prevent water from hitting the turbine. This plate prevents the turbine and generator from overspeeding when the needles can't close fast enough because of a sudden drop in power output (breaker tripping for instance).

5.6 GENERATOR

The proposed generator will produce a minimum of 200 kW at a 0.9 power factor. Electrically, it will be a three phase, 480 volt unit. It will have static excitation and will use a Basler or equivalent voltage regulator.

The generator for the turbine will come from the U.S., and will operate at 1,200 rpm. It will have ball bearings. The turbine may or may not be mounted on the generator shaft.

5.7 GOVERNOR

The generator rpm must be controlled to produce sixty cycles. In earlier hydroplants the speed of the turbine was controlled with a governor that controlled the amount of water the machine received, which in turn controlled the speed. There is another way to control the speed of the machine, and that is to add and subtract electrical loads so the output remains at 60 cycles. This can now be done electronically by a device called a "load governor". There are a number of load governors operating in Alaska, such as at Burnett Inlet on Alaska Aquaculture's project, Larsen Bay, Ouzinkie, Rainbow Creek, and more. An electronic load governor can be located anywhere on the three phase electrical distribution system. It takes power in excess of that being used and shunts it to resistance heaters. Resistance heater can be hot water heaters, hydronic heating systems, and electric air heaters that are located wherever heat is required. Loads are prioritized by the load governor. As an example, the governor can be programmed to supply excess electricity first to the school heating system, secondly to the school hot water, and then to the greenhouse or the city hall.

For a run of the river plant that has no storage, the amount of water that can be used at any moment cannot exceed the amount in the stream. If there is more water in the stream than the plant could use then that water is wasted energy. A stream fluctuates as does the demand for electricity. A 200 kW machine will rarely be used near peak capacity at Chignik Lagoon. Much of the time there will be excess water that can be used to operate the hydroplant at an output above the community's needs. The surplus electricity can produce heat that has value as it can be used to displace fuel and its associated costs. This provides added value to the plant and also is environmentally superior to burning carbon based fuels.

In addition to the load governor there is an electronic head level controller that opens or shuts the turbine needles based on the quantity of water available at the beginning of the penstock. It does this by reading the water pressure (depth) which in turn is converted to an electrical signal that is provided to a computer which directs the operation of a hydraulic pump that drives a cylinder controlling the flow of water to the turbine. If water is being used at a rate greater than its supply then the needles will close, if the rate is less than the supply the needles will open until they reach their limits of opening.

5.8 SWITCH GEAR

The switch gear will consist of several elements. One item will be the circuit breaker that will protect the plant if there is over-current. The electronic equipment can also be used to perform relaying to shut the plant off if there is over or under voltage or frequency. In addition, transducers can be provided, as was done at Larsen Bay, so it is possible to monitor the status of the plant from town. In a small plant such as this, the switch gear and the electronic controls for a load governor can be incorporated within a single enclosure thus saving space and costs.

5.9 TRANSMISSION

Different power line designs are possible. The most desirable one, considering aesthetics and damages, is buried cable. A second design would be bare overhead wire.

For this study, it is assumed that the transmission line will be buried line. It will be enclosed in conduit and buried beneath the road to the powerhouse.

6. COSTS

The value of hydropower is based on the alternative means of providing the same service. The only feasible alternative to hydro at Chignik Lagoon is diesel generation.

Another significant difference between the ‘diesel only’ and the ‘hydro and diesel’ options is the amount of maintenance that has to be done to equipment. The estimate for the diesel cost and the assumptions about diesel are outlined in more detail below.

6.1 DIESEL

6.1.1 FUEL COST

Fuel is the single most expensive component of generating power with diesel generating units. It is estimated that total plant expenditures are approximately $130,834. For a fuel cost of $1.25 per gallon, $62,500 dollars will be used to purchase the 50,000 gallons consumed. This represents almost half of the yearly cost of operating the diesel electric plant and distribution system.

The future cost of diesel fuel is uncertain because of the current international situation. There is no physical shortage of oil in the world nor will there be for some time. A conservative estimate of fuel costs for this analysis is that they will increase at 1.0% for the next 5 years and at 0.0% thereafter. Sources for such analysis include the "World Energy Outlook", dated 1990, produced by the Chevron Corporation. The sensitivity analysis in Appendix C shows the value of the hydro plant for different fuel price increase scenarios.

6.1.2 EQUIPMENT AND LABOR COST

The Electrical Distribution and Generation Feasibility and Design report done for Chignik Lagoon in April 1994 outlines the costs for installing a centralized power system. The costs that were used in that document have also been used for this analysis.

When considering the hydro plant the amount of time the diesel is used as a backup is a large factor in determining the economic advantage of the hydro. For instance, because the diesels won't be running nearly as much when there is a hydro, the village can invest in lower cost 1800 rpm machines instead of the higher cost 1200 rpm machines. The 1200 rpm machine is estimated to last about 30,000 hours before overhaul. The 1800 rpm machines should last about 18,000 hours. This analysis assumes that when building the hydro the diesel generators will be 1800 rpm engines instead of the 1200 rpm machines specified in the design. The cost for the power distribution system will not change.

Analysis shows that using 1200 rpm engines with the hydroplant decreases the net present value by about $35,000 which is equivalent to about $1,840 per year.

The maintenance costs for a diesel engine are also directly related to the hours of use. It is assumed in the electrical distribution report that the maintenance costs for the diesel plant would be $30,000 per year. This includes the overhaul costs which is why they are listed as $0 in the Economic Assumptions table in Appendix A. When using a hydro, the diesel is used only about 20% percent of what it would be without the hydro. Therefore, the parts costs are assumed to decrease by that same amount. However, salaries for workers will generally remain constant so this portion of the maintenance costs are not lowered.

6.1.3 FUEL REQUIRED

There will be times when there is not sufficient water to supply the demand or when the plant is down for maintenance reasons. During these times generation will be done by the diesel plant. As a result, an average of 6,516 gallons of diesel fuel will need to be purchased each year. This can vary as water flows vary for different years. Some years may not require any makeup fuel at all while others years will require more than the average.

6.2 HYDRO

6.2.1 EQUIPMENT AND LABOR COST

The hydro plant has a very high initial equipment cost. Given a high interest rate, this can make the project unattainable for a project that has a marginal economic advantage. This analysis assumes that the hydroplant can be funded by a loan with an interest of 3.5% above inflation. The State's revolving loan fund has money with interest of 0%. Any loan with interest below inflation plus 3.5% will increase the benefits. Other interest rates are used in the sensitivity analysis in Appendix C.

Once the plant is built no further equipment purchases need to be made. The hydroplant is designed to last 50 years.

Although a diesel electric power plant takes considerably more maintenance than a hydroelectric plant, the hydro is not maintenance free. This is especially true during the first year of operation when problems are most likely to occur.

Modern low cost electronic equipment can be installed to monitor the operation of a small hydroplant. For example there is an inexpensive device that connects to the telephone system that will call designated people if the temperature is too high or too low, or there is too much noise. This device also has contacts where a fire detector or other off/on devices may be connected. One can also call and listen to the sound level at the plant which is useful for periodic monitoring. The cost for this device is about $400. In addition, transducers can be installed in the switch gear that will enable the operator to determine what is happening electrically. This type of system was installed at Larsen Bay. It may also be possible to install a pair of the new video phones which will provide an inexpensive way of looking at the power house, intake, or other plant features. Since the operator will be living in town and the weather is not always conducive to inspecting the plant, these remote devices will be able to avoid field inspections that will save considerable time and effort. After the operator gains experience operating the plant, less observation will be needed. For example, the operator may find from experience that after a heavy rain the screens require cleaning, so the operator will not bother investigating the screens on a daily basis if the rains have been moderate. This means that the amount of time spent at the plant will decrease with time.

6.2.2 CONSTRUCTION

Project costs are one of the most important derivatives of an analysis such as this. Their accuracy, along with the demand, estimate of future alternative power generation costs, costs of money, and quantity of production are the important values that provide the information to make sound economic judgments.

It is important to assign values to each of these items that will result in a conservative realistic result. Too many contingencies have a multiplying effect and can result in unrealistically high costs. Many construction and operations costs can be predicted in a manner that will be conservative. These include demand, alternative power generation costs, and costs of money. The quantity of production is dependent on water flow and is not as easily predicted.

Project costs have received extra attention in the analysis. The extra attention has included more detail than is typical in a study of this type in the sizing of equipment. In addition, costs were analyzed on an item by item basis instead of a unit basis, such as dollars per square foot. This attention to detail increases the estimate's accuracy but it takes more time and as a result is more costly for the consultant.

Project costs are composed of two major elements. One element is material costs. These costs, if based on accurate quantities, can be fairly accurate. The second element is labor cost. This is the variable cost, and is hard to estimate accurately. As an example, heavy rain can reduce productivity to as low as 36% of dry conditions. However, if the work is mostly done during the months of June, July, and August and the weather is not unusually wet, productivity can be good. Labor costs are based on an estimate of the time to do the work, assuming a crew and supervision such as was used on the McRobert's Creek project that Polarconsult constructed.

Wages are based on information garnered from the City of Chignik Lagoon, force account work in other communities, and our construction of McRobert's Creek Hydro. For wages the following assumptions are made.

2 Skilled laborers	@ $15.00 per hour
2 laborers	@ $12.50 per hour
1 Foreman	@ $17.50 per hour
Average	@ $14.50 per hour
Use	@ $15.00 per hour

Fringes estimated as follows:

Workers Compensation	8.5%
Alaska Unemployment	3.1%
Employer Social Security	7.65%
Total	19.25%

Average rate per hour calculated is $17.88. Twenty dollars per hour is used in the estimates.

This is more than rates paid on McRobert's Creek which averaged $10 per hour plus fringes.

The project cost estimate is arranged to present the costs of material and labor in a detailed format so the City will be able to review costs and provide any bias or input to the figures based on local knowledge.

Itemized material costs are not as variable as their costs are fixed by quotation. Frequently quoted prices can be bettered when an order is placed. As a general rule, these quotations are rounded to higher values.

Freight costs are based on a single barge hauling in the majority of the material during one trip from Seattle. Because of scheduling, the turbine and generator are assumed to be shipped separately.

6.2.3 FORCE ACCOUNT

Force account is the only practical and cost effective way to construct a project such as this. Wage rates for Title 36, Little Davis Bacon, are high enough to make the project uneconomical. Force account optimizes the situation for local employment and avoids all of the added costs that contracting brings. Some of the added costs for contracting are the cost to bid, bonding costs, tighter plans and specifications resulting in more expensive engineering, better record keeping, greater overhead, and more detailed inspections. Additionally, higher worker’s compensation insurance rates and higher wages are required, since Little Davis Bacon rules are less flexible as they require overtime pay for working more than 8 hours per day. There is also greater contractor risk and added legal fees, resulting in increased costs and bids.

The major problem with community force account is management. In the best interests of the project, the manager generally should not be from the community. Tough personnel decisions are required during the execution of the project. If the project is brought in under budget then money can be returned to the workers as a bonus or to the rate payer. Management in force account can strike the balance between sensitivity for local feelings and needs, and the absolute need to complete the project on or under budget.

To build a quality plant with low cost, the philosophy of construction must be different for small hydro plants as compared to large ones. More of the decisions on routing and layout must be made in the field during construction. The project must be compatible with the terrain and not be required to move more rock and earth than is absolutely necessary, or pour added concrete to match lines drawn on paper as is done on larger scale projects. This requires a flexible mind and the ability to innovate in order to solve problems on the spot.

6.2.4 TITLE 36

Title 36 is enforced when a contractor or subcontractor performs work on public construction in Alaska. Title 36 requires that contractors be paid the prevailing wage in the locality. This prevailing wage is set by the Labor Department's Labor Standards and Safety Division. For Chignik Lagoon the wage plus the fringes will average near 30 dollars per hour. The overall cost increase for wages alone would exceed $40,000. Additionally, contractors have other costs that will further raise this amount.

7. ECONOMICS

The economics of the system are outlined below. A synopsis of the assumptions and results is presented below. The sensitivity analysis in the appendix gives results for different economic assumptions. Loan period and analysis period is for 30 years. The initial cost of the plant is $572,925.

Other assumptions are that current labor costs will remain constant. Although it is likely these costs can be reduced after the debugging period, this is a conservative approach that will retain the needed skills within the community.

All of the monetary values in this analysis have been adjusted to present value using the discount rate. This means that inflation is not taken into account. This gives clearer resolution of variations in the dollar quantities.

An explanation of some of the selected values follows:

- Interest rates: A system was selected that does not use standard interest rates which include assumed factors for inflation. Everything is reduced to the opportunity cost of interest which traditionally has been near 3.5%. This results in costs that are in today's dollars throughout the analysis period. This helps in achieving a more accurate understanding of the project costs.
- Power demand: A conservative figure is 0.0% growth. More growth favors the hydro over the diesel.

- Loan Period: The loan period is typical for a small hydroplant and again is conservative as compared to 50 year periods used for governmental projects.

In addition there are other economic values for the project that have not been quantified. Some of these values are as follows:

- Retaining money within the community. When oil is purchased most of the money leaves the community and goes to the transporters, refiners, producers, and resource owners. The labor will result in employment for people in the community. Income from their wages will add new money to the community. The savings from lower costs for electricity will conserve dollars within the community for other uses.
- People will receive training in construction by doing the work. This training is valuable as it makes for salable skills, and fosters independence.
- Freedom from rate shock created by increasing oil prices is obtained. Should there be large excursions in oil prices then the communities electric costs will not be significantly affected.

In addition to benefits there are also potential negative aspects of the project which follow:

- The primary risk is from cost overruns during construction.
- The second risk is that a flood or mechanical events will result in reduced revenues. This risk can persist until the causes of the problems are corrected.
- Another disadvantage is that a project such as this could be conceived as increasing stress within the community because of the requirement to complete it on time and on budget. Further, if the community is divided on the project there is always a possibility of increased political disagreements between the anti's and the progressives.

8. ENVIRONMENTAL

8.1 FISH REQUIREMENTS

The hydro plant would discharge water upstream of any potential spawning grounds. Because of the significant number of flow contributions downstream of the intake, it is expected that there won't be any impact to fish in Packers Creek.

8.2 FERC

The Federal Energy Regulatory Commission (FERC) has jurisdiction over most of the hydro in the US. FERC's jurisdiction is when a hydroplant is on Federal land, is involved with Interstate Commerce, is on a Navigable River, or uses water from a Federal dam or Project.

The proposed project is not on Federal land, it is on Chignik Lagoon land. The project does not send power beyond State boundaries therefore, it is not involved in interstate commerce. Packers Creek is clearly not navigable where the project is located, and there is no federal dam or project on the river. As a result the commission can be petitioned for a waiver from FERC licensing. The petition, when granted, will save time and money and makes the project much easier to permit as the Federal agencies will not have jurisdiction.

9. PERMITS

9.1 PERMITS WILL BE REQUIRED AS FOLLOWS:

1. A water use permit will be required from the Alaska Department of Natural Resources (DNR). DNR will ask for comments by the Alaska State Department of Fish and Game (ADF&G), and Department of Environmental Conservation (DEC) in the review of these permits. It is unlikely but ADF&G may ask for special conditions, such as minimum stream flows.
2. Alaska Coastal Zone Management Consistency Review Compliance.
3. DEC Clean Water Certification (401) which is done in conjunction with DNR's review. This permit is required only if a Federal permit is needed. A typical Federal permit which will require a (401) is a (404) permit for action involving a wetland or fill in a stream. Without fill, a (404) permit will not be needed, therefore, a (401) permit will not be required either.
4. FERC confirmation of no jurisdiction.

With the possible exception of dealing with ADF&G, none of these permits will be difficult or expensive to acquire. DNR is behind in permit processing so their permit will take the most time, the agency cannot say how long, but perhaps 6 months.

10. CONCLUSIONS

Based on the analyses in this report, the conclusion is that a hydro plant is superior to the current diesel generation under almost all reasonable scenarios.

Hydro is superior to diesel generation in a conventional economic sense as the base project yields a present value of $804,710 for the difference between hydro and the diesel alternative.

In addition to being superior economically, the plant will be superior in an environmental sense as it will not discharge carbon dioxide nor nitrous oxides into the atmosphere. The new design of the plant in addition to reducing costs, fits into the terrain and requires the very minimum of earthwork. The generation facility is outside the community and will considerably reduce air and noise pollution in Chignik Lagoon, or anywhere for that matter.

There are a number of indications that the US, in an attempt to reduce payments to foreign interests, will create an increase in the costs of diesel fuel. With the hydroplant the use of diesel generation is reduced to about 20% of its current use so changes in the cost of diesel fuel will have no appreciable impact on the cost of power.

The hydroplant will provide employment for the community for much of one year. The community, instead of sending money out to pay for oil, will capture the labor portion of the project. This will have multiplier effects throughout the community, and should increase prosperity. The diesel plant will not provide these benefits.

11. RECOMMENDATIONS

There are a number of advantages that can accrue to the people of Chignik Lagoon if a hydroplant is constructed. If these advantages are to be acquired it is recommended that the following steps be undertaken.

- Ascertain whether the people believe it is in their best interest to build the plant. If pursuing the project is favorable, then the following additional steps be taken.
- Get a grant from the Legislature to design and construct a portion of the plant. King Cove has a grant which funds a large amount of their hydro plant's cost. The Railbelt has been granted money for Bradley Lake. The 4 dam pool has received great amounts of largess from the state. It would seem that equity should result in equal consideration for Chignik Lagoon. Governor Knowles likes to keep money within Alaska and philosophically supports the concept of the plant.
- Money can be borrowed from the revolving power loan fund at low interest from Alaska Industrial Development and Export Authority, Farmers Home Administration, Municipal Bond Bank or other sources.
- Only consider doing the work with force account, i.e. City employees. Be very careful with management of the project. Non-innovative construction people who are accustomed to high cost state government projects can ruin a small project like this. Paraphrasing Shumaker, think small. Give the project manager absolute authority to fire people who are not performing. There is no money for feather bedding.
- Plan to and execute methods of taking advantage of the excess energy that is available to reduce costs, decrease pollution, and improve the quality of life in the community.

APPENDIX A - HYDRO COST

ITEM	MATERIAL		LABOR		SUBTOTAL	SHIPPING			TOTAL
	Quantity Unit	Cost Per Unit	Labor Rate	Labor Hours	Labor And Material Cost	Volume	Wt	Shipping	
TURBINE	1 ea	$ 45,000	$ 20	48	$ 45,960		1,000	$ 150	$ 46,110
GENERATOR	1 ea	$ 27,400	$ 20	48	$ 28,360		1,500	$ 225	$ 28,585
PIPE								$ -	
Pipe 1 (16")	2300 ft	$ 10.00	$ 20	460	$ 32,200	3,271	24,150	$ 24,533	$ 56,733
Pipe 2 (14")	2200 ft	$ 16.00	$ 20	220	$ 39,600			$ -	$ 39,600
Trenching	4500 ft	$ 5.00	$ 20	680	$ 36,100			$ -	$ 36,100
Fusion Rental	7 wks	$ 250			$ 1,750	480	4,000	$ 3,600	$ 5,350
WIRING TO INTAKE								$ -	
Conduit	4500 ft	$ 0.60	$ 20	150	$ 5,700	300	1,350	$ 2,250	$ 7,950
Control Wire	4500 ft	$ 0.30	$ 20	150	$ 4,350		900	$ 135	$ 4,485
Power Wire	4500 ft	$ 0.60	$ 20	150	$ 5,700		900	$ 135	$ 5,835
INTAKE BOX								$ -	
Material	5200 lump	$ 1.00	$ 20	448	$ 14,160	267		$ 2,003	$ 16,163
DIVERSION								$ -	
Concrete	8.89 cu yd	$ 600	$ 20	576	$ 16,853		36,000	$ 5,400	$ 22,253
CONTROL EQUIPMENT								$ -	
Transformer	1 ea	$ 6,000	$ 20	20	$ 6,400		3,000	$ 450	$ 6,850
Load Governor	1 ea	$ 12,000	$ 45	20	$ 12,900	16		$ 120	$ 13,020
Switch Gear	1 ea	$ 7,000	$ 45	80	$ 10,600	128		$ 960	$ 11,560
Station Power	1 ea	$ 850	$ 20	15	$ 1,150	192		$ 1,440	$ 2,590
POWER WIRE					$ -			$ -	$ -
Wire	13500 ft	$ 1.40	$ 20	113	$ 21,150		10,800	$ 1,620	$ 22,770
Trenching	4500 ft	$ 3.33	$ 20	113	$ 17,235			$ -	$ 17,235
BUILDING									
Size, Width	20 ft				$ -			$ -	$ -
Length	20 ft				$ -			$ -	$ -
Height	10 ft				$ -			$ -	$ -
Slab Thickness	10 in				$ -			$ -	$ -
Slab Volume	12.35 cu yd	$ 15.00	$ 20	120	$ 2,585		50,000	$ 7,500	$ 10,085
Wall Area	800 sq ft	$ 3.50	$ 20	100	$ 4,800		8,000	$ 1,200	$ 6,000
Roof	400 sq ft	$ 5.00	$ 20	100	$ 4,000		6,000	$ 900	$ 4,900
Valve	1 ea	$ 1,500	$ 20	10	$ 1,700			$ -	$ 1,700
Piping	1 ea	$ 2,500	$ 45	60	$ 5,200			$ -	$ 5,200
ROAD	5500 lin ft	$ 6.00	$ 20	275	$ 38,500			$ -	$ 38,500
Sub Total									$ 409,574
Administrative	10%								$ 40,957
Field Inspection	$ 20,000								$ 20,000
Engineering	10%								$ 40,957
Contingency	15%								$ 61,436
TOTAL									**$572,925**

APPENDIX B - ECONOMIC ASSUMPTIONS AND YEARLY DATA

CHIGNIK LAGOON ECONOMICS

Discount Rate (%)	3.5%
Power demand growth (%)	0.0%
Fuel cost increase in 1st X years (%)	1.0%
X years	5
Fuel cost increase thereafter	0.0%
Length of study (yrs)	30
Price of Fuel ($/gal)	$1.25
diesel efficiency (kWh/gal)	13.0
Price per kWh ($/kWh)	$0.096

DIESEL

Yearly Maintenance cost	$30,000
Overhaul cost	$0
Overhaul frequency (kwh)	2,220,000
Replacement cost	$90,000
Replacement frequency (yrs)	10
payback period for replacement (yrs)	10
Debt payment for diesel purchase	10,822
power system payback period (yrs)	30
power system cost (grid)	506,000
power system payments	$27,512
Diesel parts cost per kwh	$0.000

HYDRO

Initial hydro cost (loan amount)	$572,925
Hydro loan payback time (yrs)	30
Hydro loan interest rate (%)	3.5%
Hydro yearly payments	($31,151)
Hydro O & M	$10,000
Diesel replacement cost when using hydro	$50,000
Debt payment for diesel purchase	$3,518
Diesel Overhaul Cost	$0
Diesel Overhaul Frequency (kWh)	1,332,000
Diesel O&M with hydro	$15,000
Diesel Replacement Freq with Hydro (yrs)	20

RESULTS

Net present cost of hydro	$2,033,719
Net present cost without hydro	$2,838,430
Net present value of excess power	$1,194,825
Total savings, present value	$804,710

Yearly Summary

			HYDRO										NO HYDRO		
Year	Average Flow	City Needs	Hydro Output	Hydro Debt	Hydro Maintenance	Total Hydro Cost	Diesel Makeup	Fuel Cost	Total Diesel Cost	Total Cost	Present Value	Excess Power Present Value	Diesel Usage	Total Diesel Cost	Present Value
	cfs	1,000 kWh	1,000 kWh	thousands	thousands	thousands	1,000 kWh		thousands	thousands	thousands	thousands	1,000 kWh	thousands	thousands
1995	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.250	$54.2	$95.3	$95.3	$53.9	650	$130.8	$130.8
1996	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.263	$54.3	$95.4	$92.2	$52.6	650	$131.5	$127.0
1997	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.275	$54.3	$95.5	$89.2	$51.4	650	$132.1	$123.4
1998	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.288	$54.4	$95.6	$86.5	$50.2	650	$132.7	$120.1
1999	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.300	$54.5	$95.7	$83.9	$49.2	650	$133.3	$117.0
2000	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$81.5	$48.1	650	$134.0	$114.0
2001	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$79.1	$46.8	650	$134.0	$110.7
2002	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$76.9	$45.4	650	$134.0	$107.6
2003	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$74.8	$44.2	650	$134.0	$104.7
2004	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$72.8	$43.0	650	$134.0	$101.9
2005	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$70.9	$41.9	650	$134.0	$99.2
2006	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$69.1	$40.8	650	$134.0	$96.7
2007	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$67.4	$39.8	650	$134.0	$94.3
2008	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$65.8	$38.9	650	$134.0	$92.1
2009	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$64.3	$38.0	650	$134.0	$89.9
2010	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$62.8	$37.1	650	$134.0	$87.8
2011	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$61.4	$36.3	650	$134.0	$85.9
2012	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$60.0	$35.5	650	$134.0	$84.0
2013	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$58.7	$34.7	650	$134.0	$82.2
2014	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$57.5	$34.0	650	$134.0	$80.5
2015	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$56.3	$33.3	650	$134.0	$78.8
2016	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$55.2	$32.6	650	$134.0	$77.2
2017	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$54.1	$32.0	650	$134.0	$75.7
2018	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$53.0	$31.3	650	$134.0	$74.2
2019	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$52.0	$30.7	650	$134.0	$72.8
2020	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$51.1	$30.2	650	$134.0	$71.4
2021	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$50.1	$29.6	650	$134.0	$70.1
2022	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$49.2	$29.1	650	$134.0	$68.9
2023	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$48.4	$28.6	650	$134.0	$67.7
2024	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$47.5	$28.1	650	$134.0	$66.5
2025	9.03	650	1170	$31.2	$10.0	$41.2	85	$1.313	$54.6	$95.7	$46.7	$27.6	650	$134.0	$65.3

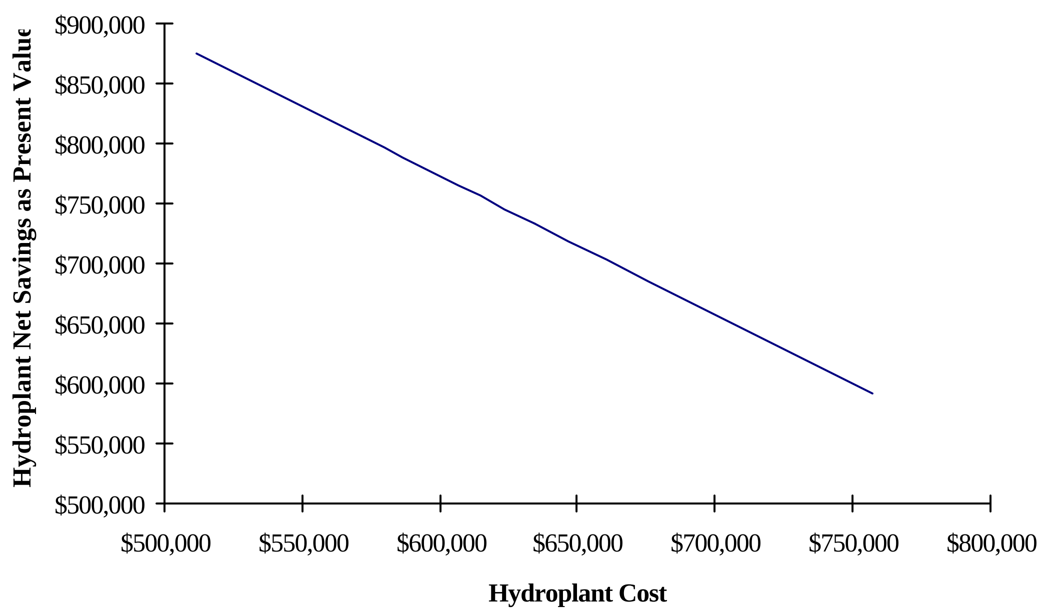
APPENDIX C - SENSITIVITY ANALYSIS

The sensitivity analysis gives an indication as to what are the most critical factors affecting the economic viability of the hydroplant project. This analysis focuses on the primary factors that determine the cost and feasibility of the project. These are:

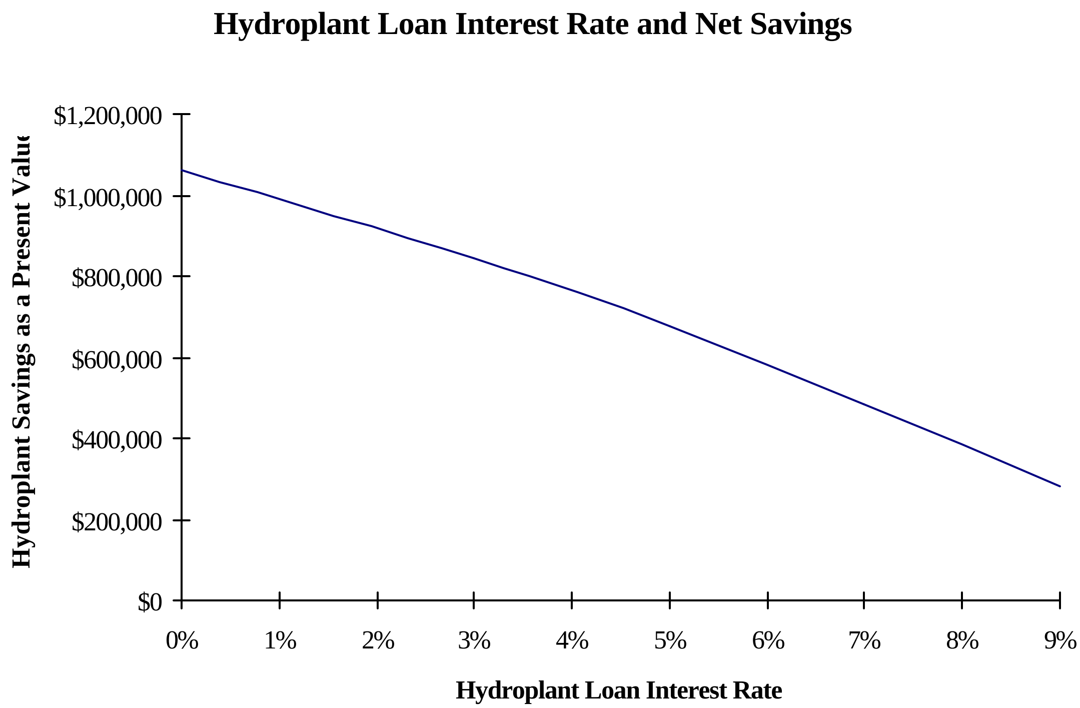
- Project construction costs.
- Hydroplant loan interest rate.
- Chignik Lagoon's electrical demand.
- Estimate of future diesel fuel costs.
- Quantity of hydro production based on variations in water flow.

The following charts and tables show the effect of each one of these variables on the economics. Only the stated variable is changed at one time while all the other variables are as those listed in Appendix B, Economic Assumptions.

Hydro Cost and Net Savings



As can be seen from the chart, the project would still be economically feasible for a considerable increase in the estimated construction cost. This only applies at the interest used for the loan in the base case. As the next graph shows, the loan interest rate has a significant affect on the feasibility of this project.



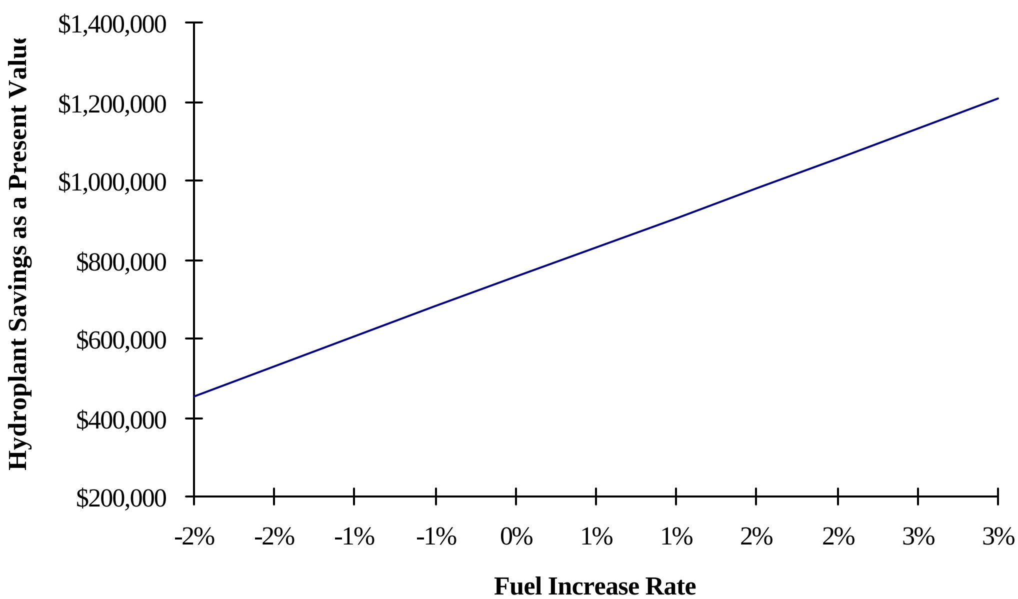
The City's power demand needs will affect the profitability of the hydroplant also. As the following graph illustrates, increases in the City's demand cause a significant increase in the net present value difference between the hydro and non hydro power generation. Similarly, decreases in the City's power needs will reduce the economic feasibility of the hydro project.

When combined with estimations for water flow the city's needs become even more important. For instance, using the current estimate for water flow there are a large number of days during the summer where the flow is less than 8 cfs and thus power output is less than 200 kW. If the population increase in the summer is such that the city uses over 150 kW daily, the hydroplant will have to be supplemented with diesel energy a significant amount of time.

Power Demand Growth and Net Savings

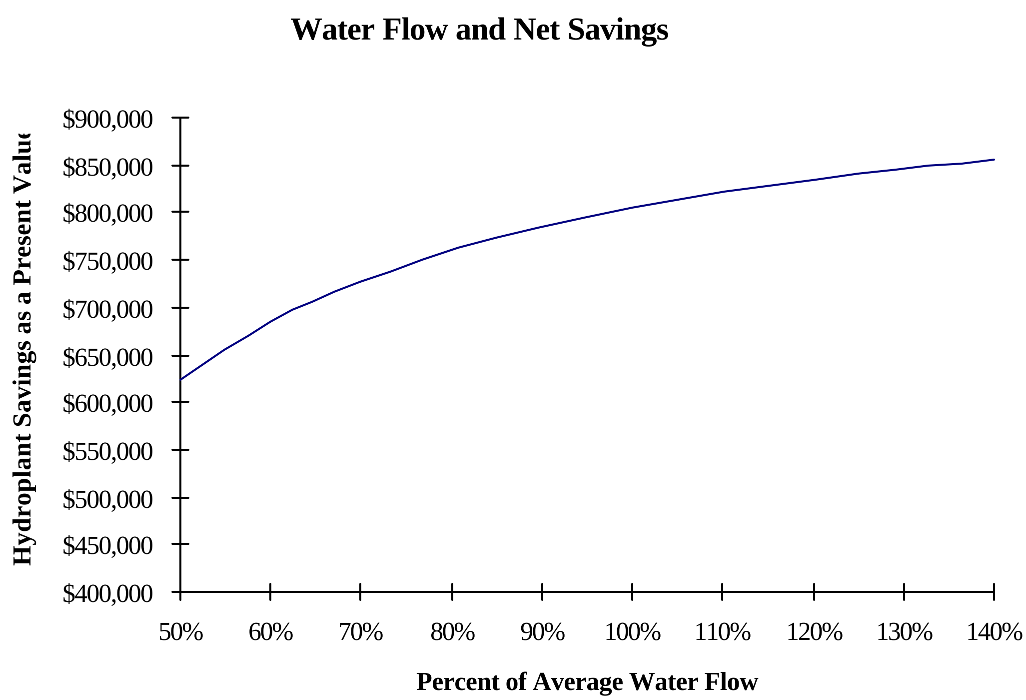
Fuel price increases, or even decreases, play a major part in the feasibility of the project. The following chart shows the sensitivity of the project to fuel prices. Of concern would be a decrease in the price of fuel. This is not a likely scenario, however.

Fuel Increases and Net Savings



One of the biggest factors in determining the output of the hydroplant, and thus it's profitability, is the amount of water available in the stream. As was mentioned in the report, there aren't any stream flow records for Packer's Creek. Micro climates can be very significant around mountains and inlets. For this reason, further stream gauging should be done along with input from the community as to rainfall, snowfall, and general streamflow conditions in the creek over the years.

The following graph illustrates the affect of streamflow on the feasibility of the project. As the flow decreases, the value of the project decreases rapidly because the flow rate is reaching the lower portions of the turbine efficiency curve. As the flow increases, there is a point of diminishing returns as the community cannot put to use the increase in the amount of power.



APPENDIX D - FIELD REPORT

JANUARY 30, 1995

CHIGNIK LAGOON HYDROELECTRIC FEASIBILITY STUDY

FIELD TRIP REPORT

prepared for the

NATIVE VILLAGE OF CHIGNIK LAGOON
P.O. BOX 57
CHIGNIK LAGOON, ALASKA 99565

prepared by

POLARCONSULT ALASKA

polarconsult alaska, inc.
ENGINEERS • SURVEYORS • ENERGY CONSULTANTS

Chignik Lagoon Hydroelectric Feasibility Field Trip Report

Polarconsult engineers Dan Hertrich and Dempsey Thieman traveled to Chignik Lagoon January 19, 1995 to obtain streamflow and geographic information on Packers Creek and surrounding area. At the time of the trip, there was approximately 2 feet of snow, which made traveling with survey and stream monitoring equipment difficult. The average temperature was 25 degrees. Overall, the area was determined to be favorable for a hydroelectric powerplant.

On January 20, a stream gage was installed, and depth and velocity data were recorded at approximately 470', near the potential stream diversion, (see photos page 4). The stream gage samples the water depth every 15 minutes, every two hours the data is averaged and stored in memory. The stream gage will record data for over three years before the batteries need to be replaced and data downloaded. The average stream depth was six inches. The average stream width was eight feet. The stream bed is eight feet wide and 2.5 feet deep, with a 30 foot wide flood plain. The stream was flowing at approximately 2.8 cubic feet per second. Elevations of potential diversion and turbine sites were determined using EDM surveying equipment, (see page 9).

Due to the canyon geography, it was concluded that the pipeline should be located on the north side of the creek. This will eliminate numerous gully crossings and result in a shorter pipeline, reducing cost and headloss. The pipeline would generally follow the contour of the land until the lower third of the pipeline, where it would lose most of its elevation. The vegetation of the area consists of small alder trees and bushes, very dense in some places, with tall grass. Examination of the cut stream bank shows the soil consists of mostly glacial till and should allow ready burial of the pipeline.

The stream diversion should be located at approximately 510' above sea level in order to climb out of the incised stream bed with enough elevation to reach a small saddle while maintaining minimum slope, (see photos page 3, 4). The large gully near the top of the pipe run (see photo on page 5) can be crossed by burying the pipeline a few feet deeper than usual in order to avoid potential erosion problems. The pipeline could divert the significant flow of water flowing in this large gully as well, increasing the hydro output, which is especially important during the winter season. The pipeline would then follow a small ridge on the side of the mountain, a few hundred feet from the creek, (see photo on page 5, 6). As the ridge drops away from the mountain, the pipeline would maintain minimum slope and cross one more small gully. The pipeline would then turn down the mountain to the turbine, located near the stream bed. The turbine should be located at approximately 110' above sea level, as the creek bed levels out below this elevation. This would provide 400' of gross head for electrical production. The pipeline will be approximately 3,800 feet long. The pipeline material can be high density polyethylene in the upper portion and steel in the lower, higher pressure portion of the pipeline. A small

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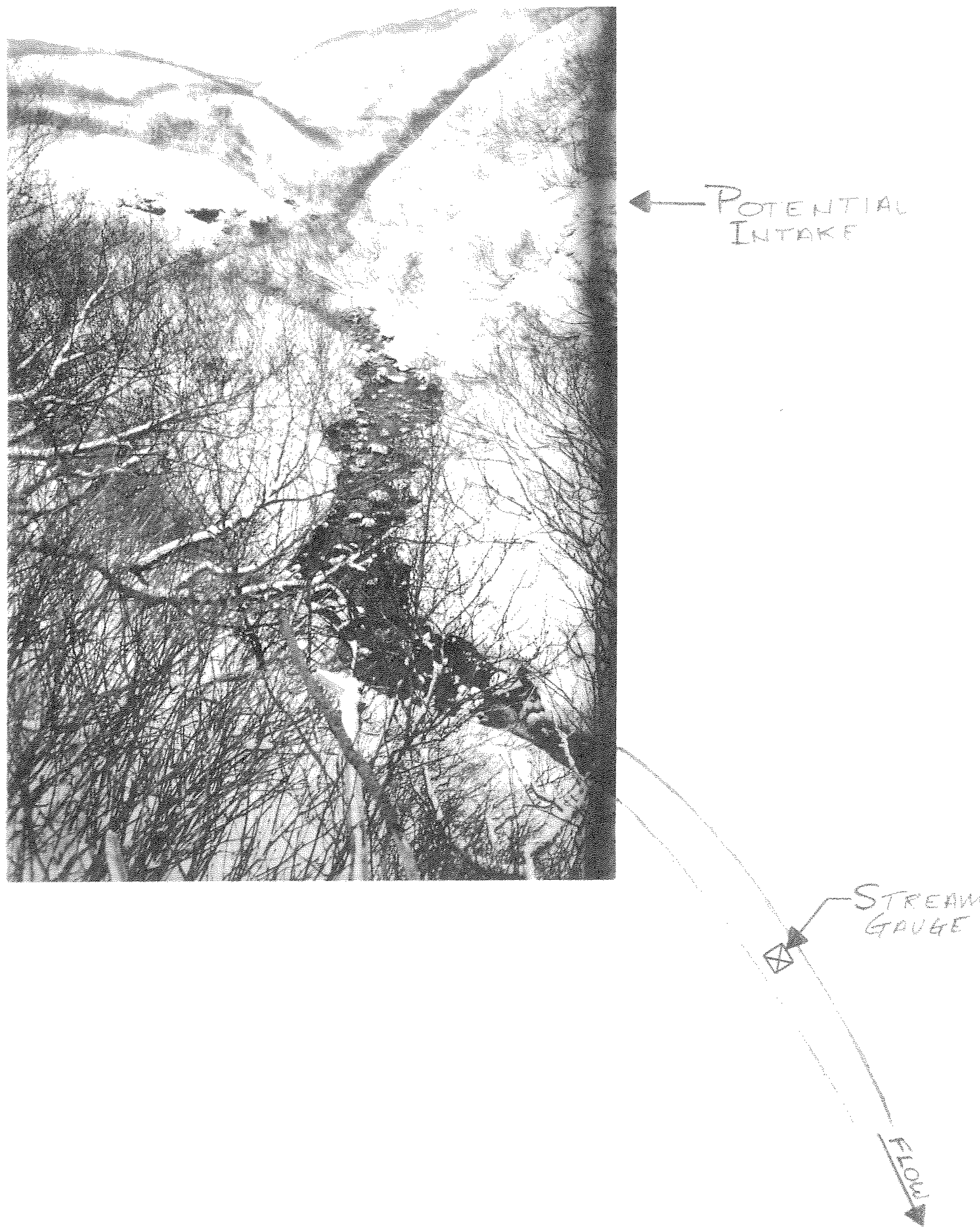
road would be cut to allow access to the powerhouse. A buried powerline in the road would connect the powerhouse to the village distribution lines.

The terrain, geography, soil type and stream flow are all very favorable conditions for a hydroelectric powerplant which could provide electricity to the village of Chignik Lagoon.

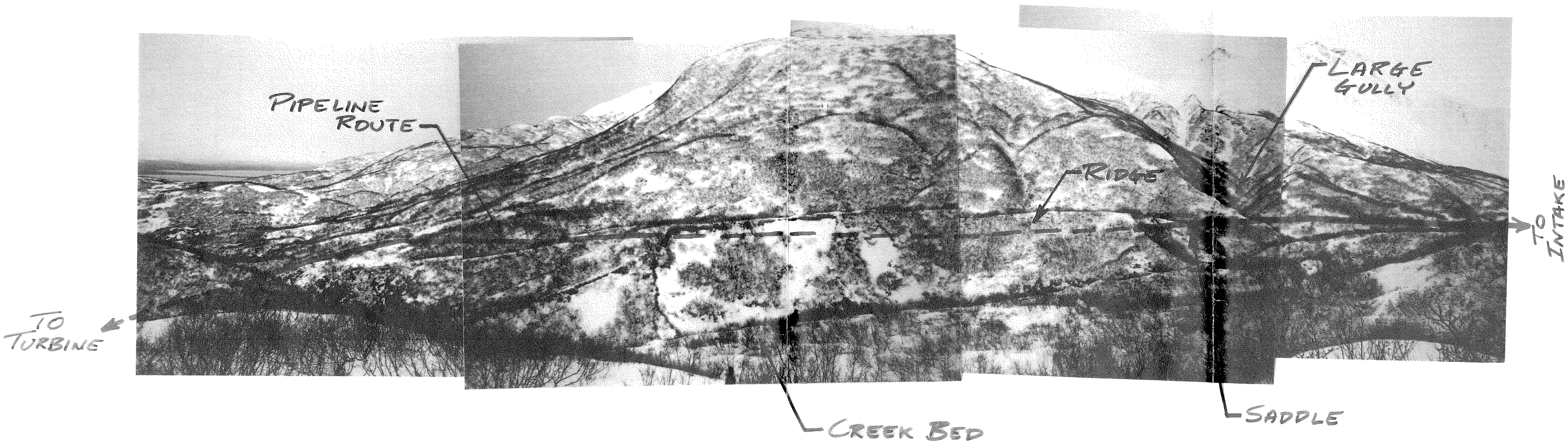
APPENDIX E - PHOTOS SHOWING PIPING LAYOUT AND INTAKE LOCATION

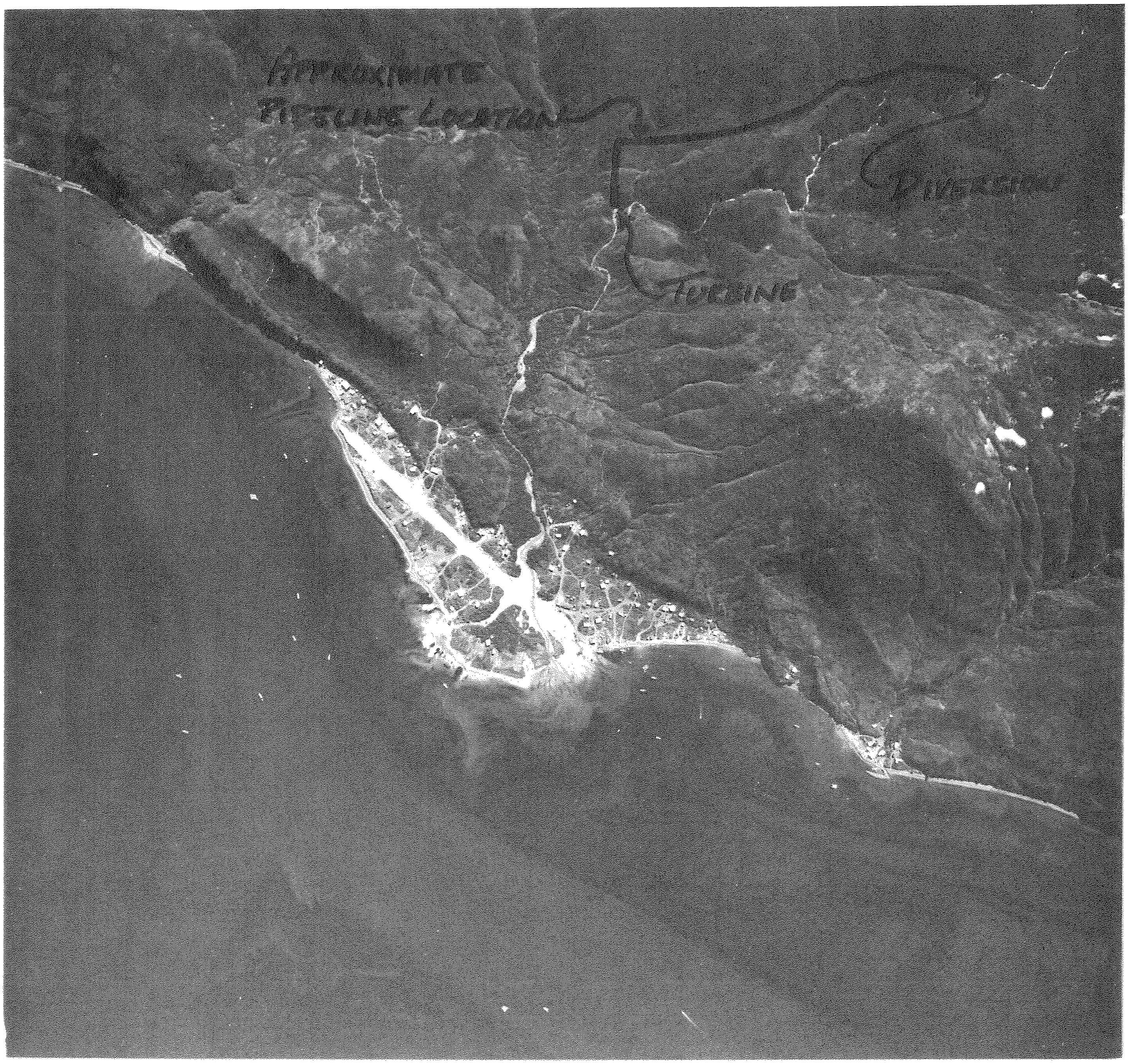

POTENTIAL INTAKE
STREAM GAUGE
FLOW

FLOW

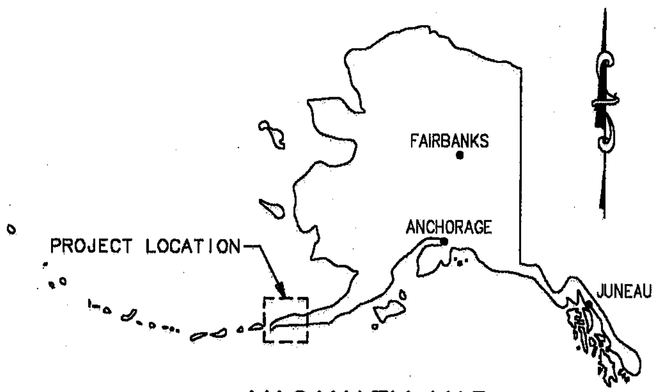
STREAM GAUGE
INSTALLATION

FLOW


PIPELINE ROUTE
LARGE GULLY
RIDGE
TO INTAKE
TO TURBINE
CREEK BED
SADDLE

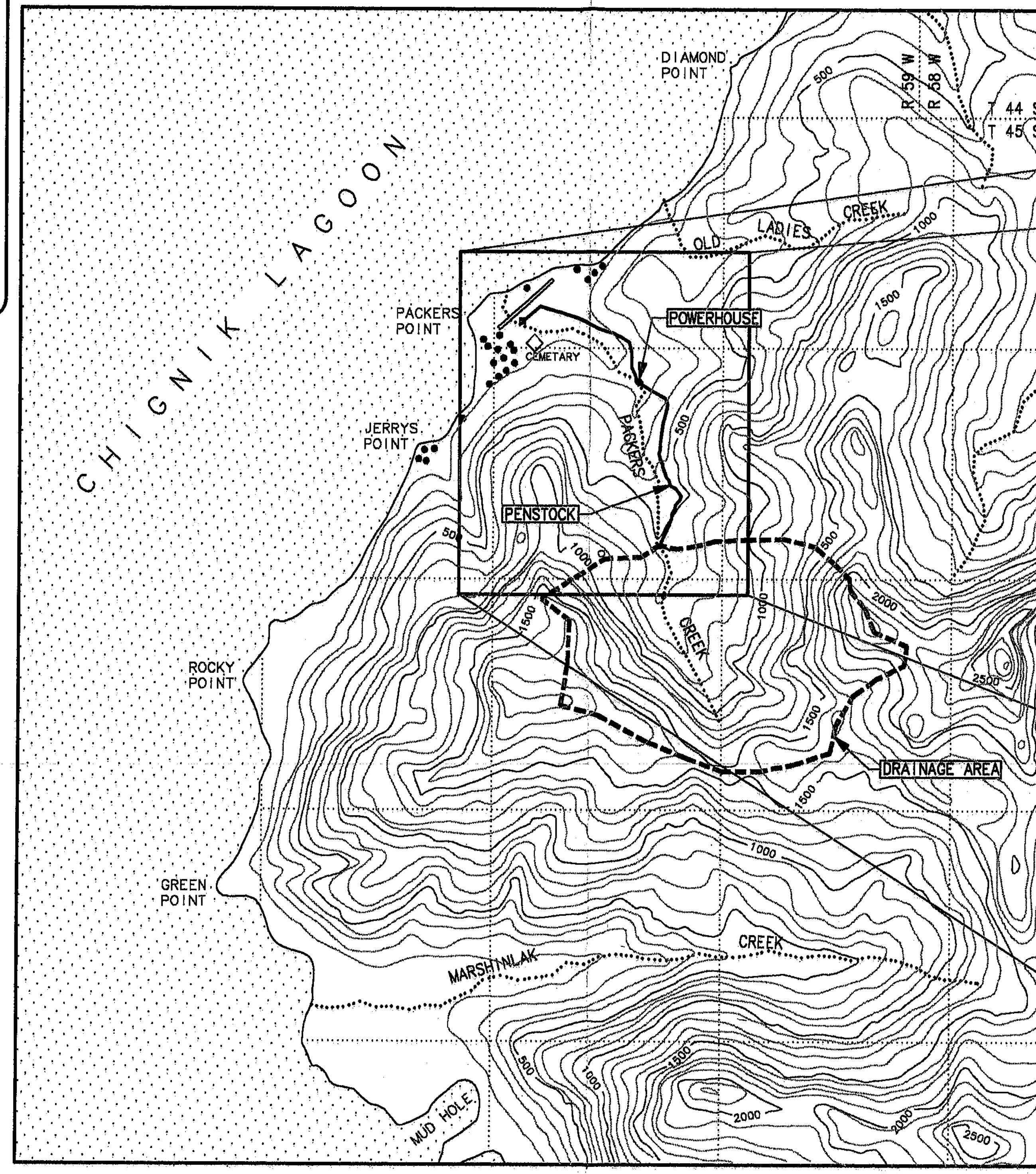

APPROXIMATE
PIPELINE LOCATION
DIVERSION
TURBINE

APPENDIX F - DRAWINGS

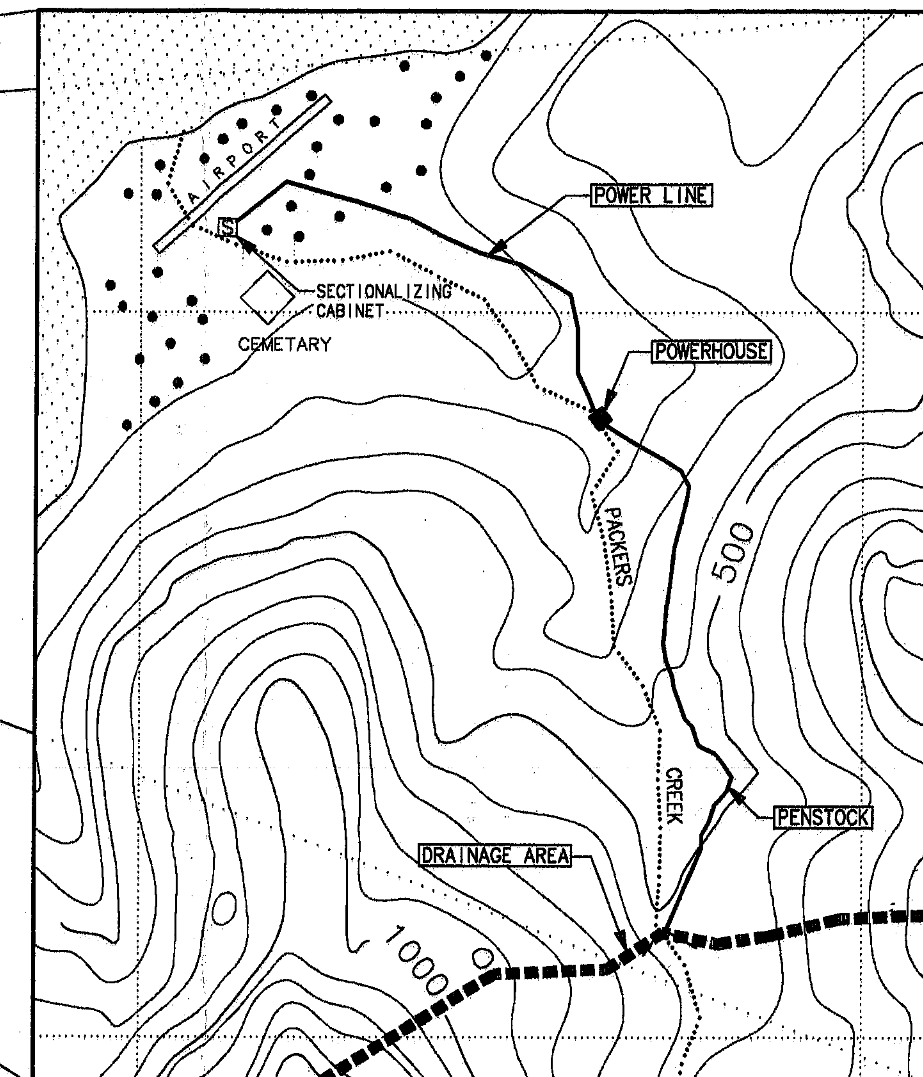


VICINITY MAP

0 500 2500 5000
SCALE IN FEET



PROJECT MAP



PROJECT DETAIL

DATE:	4/5/95
DESIGNED:	DJH
DRAWN:	DJR
CHECKED:	EA
SCALE:	1"=3500'
FILE:	CHLH1

NO.	DATE	REVISIONS

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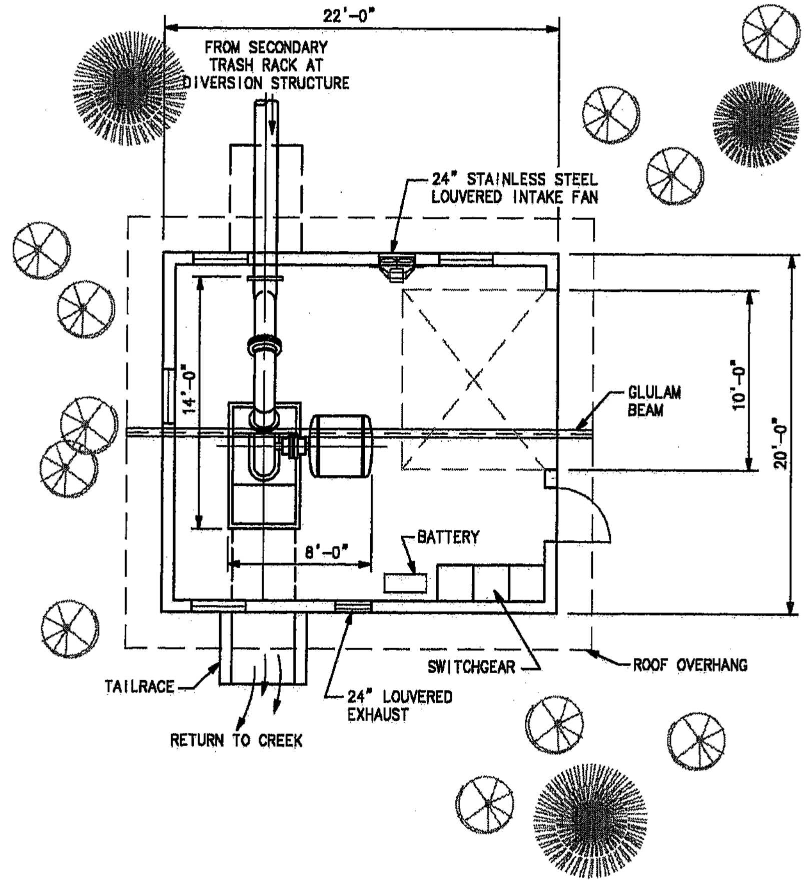
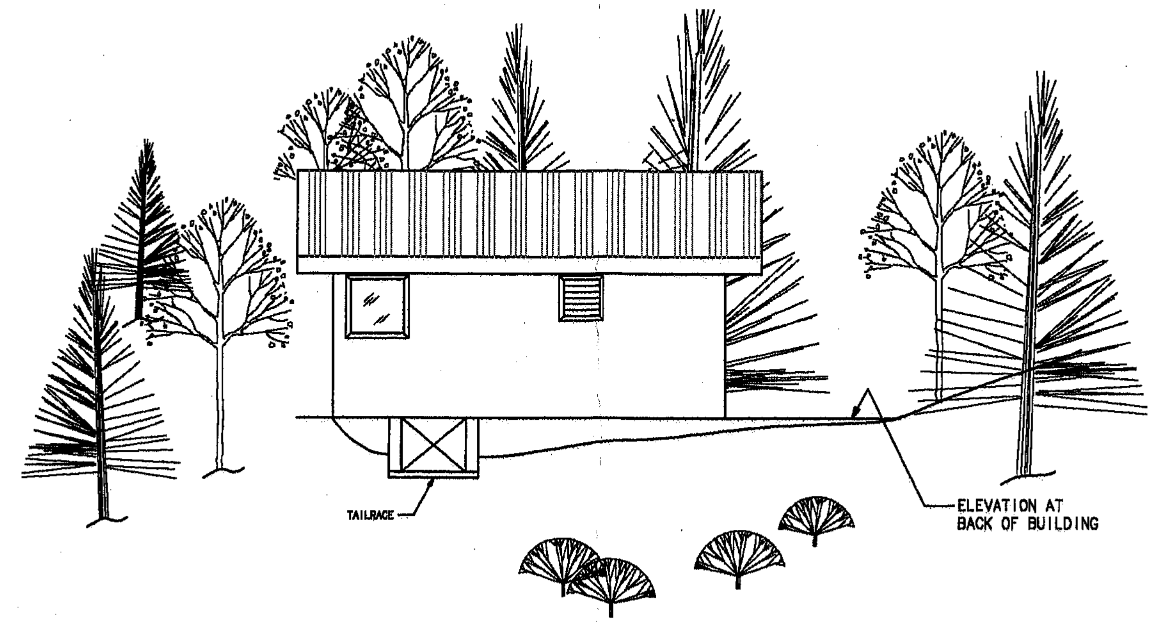
DRAWING
PROJECT VICINITY AND SITE PLAN

PROJECT
CHIGNIK LAGOON HYDROPOWER PROJECT
Chignik Lagoon, Alaska

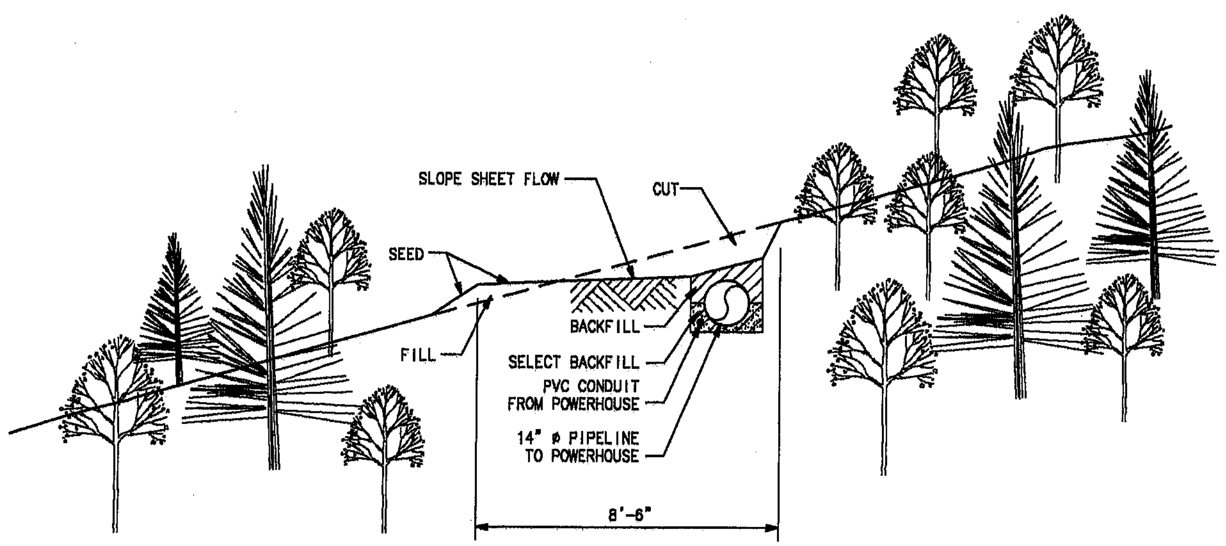
FIGURE
1
OF 4



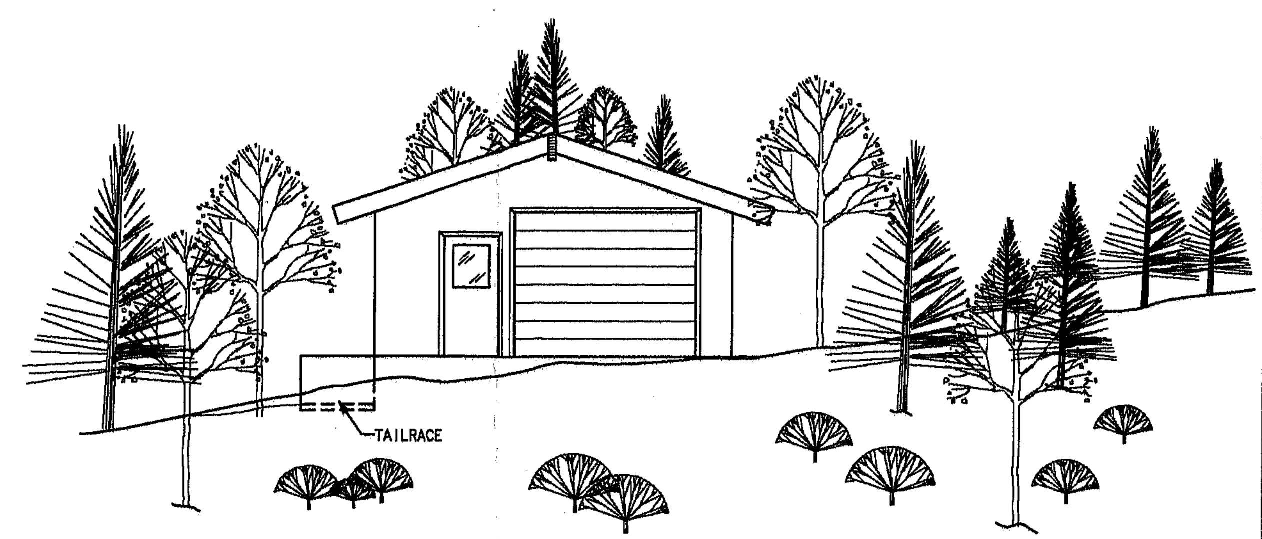
POWERPLANT PLAN
SCALE: 1/4"=1'-0"



POWERPLANT ELEVATION
SCALE: 1/4"=1'-0"



TYPICAL PIPELINE SECTION AT SLOPE
SCALE: 1/4"=1'-0"



POWERPLANT ELEVATION
SCALE: 1/4"=1'-0"

DATE:	4/5/95
DESIGNED:	DJH
DRAWN:	DJR
CHECKED:	EA
SCALE:	3/32"=1'-0"
FILE:	CHLH2

NO.	DATE	REVISIONS

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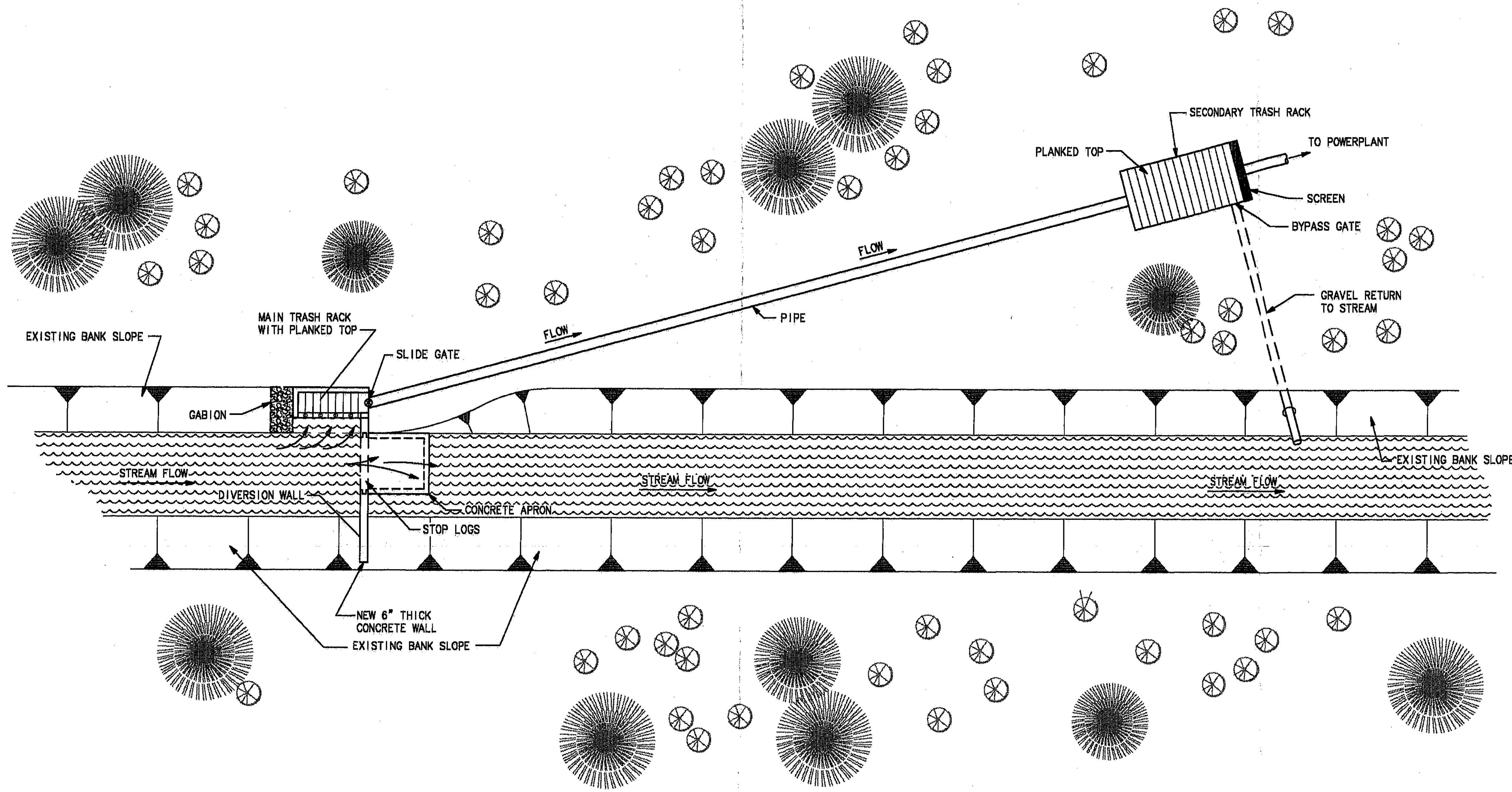
DRAWING
POWERHOUSE PLAN AND ELEVATIONS

PROJECT
CHIGNIK LAGOON HYDROPOWER PROJECT
Chignik Lagoon, Alaska

FIGURE
2
OF 4



DATE:	4/5/95
DESIGNED:	DJH
DRAWN:	DJR
CHECKED:	EA
SCALE:	1/16"=1'-0"
FILE:	CHLH3

NO.	DATE	REVISIONS

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ANCHORAGE, ALASKA 99503

PHONE (907) 258-2420
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DRAWING

DIVERSION STRUCTURE PLAN

PROJECT

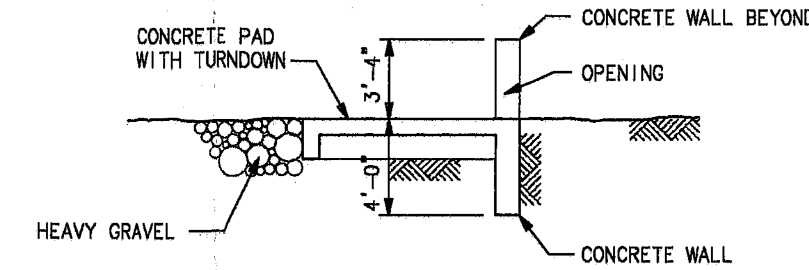
CHIGNIK LAGOON HYDORPOWER PROJECT

Chignik Lagoon, Alaska

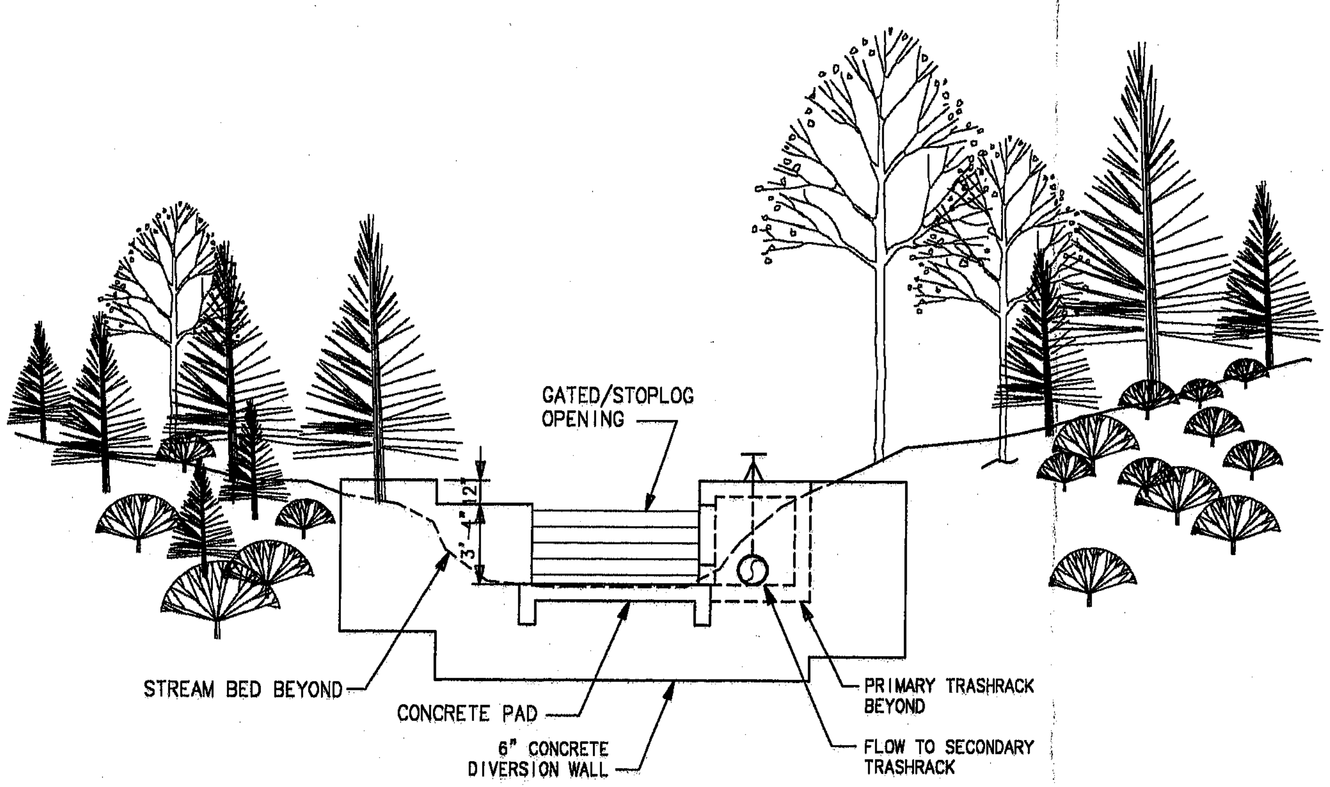
FIGURE

3

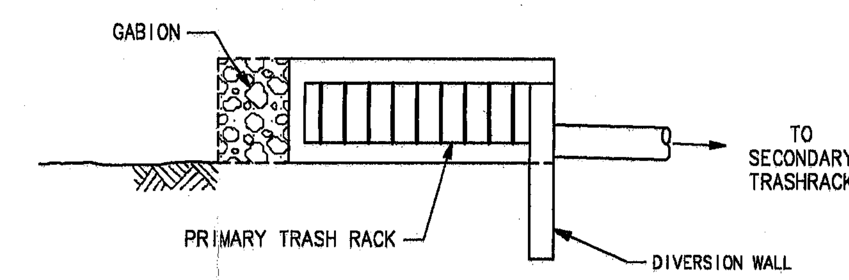
OF 4



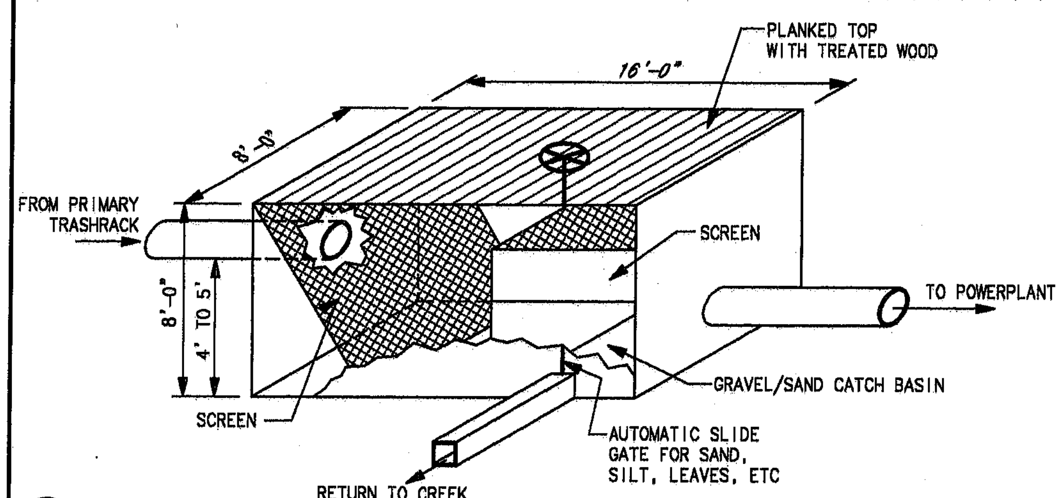
1 SECTION AT OPENING IN DIVERSION STRUCTURE
SCALE: 1/8"=1'-0"



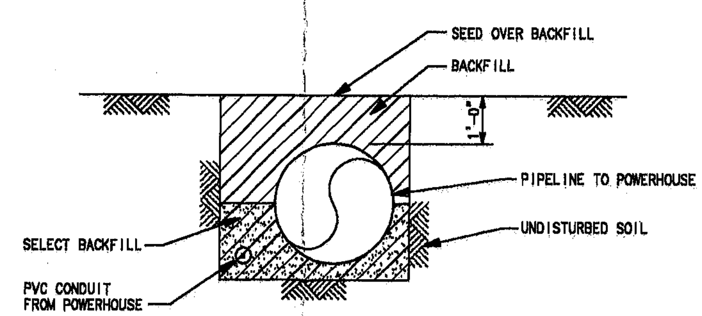
2 ELEVATION AT DIVERSION STRUCTURE
SCALE: 1/8"=1'-0"



3 ELEVATION AT INTAKE STRUCTURE (PRIMARY TRASHRACK)
SCALE: 1/8"=1'-0"



4 SECONDARY TRASHRACK
SCALE: 1/8"=1'-0"



5 TYPICAL PIPE SECTION TO POWERHOUSE
SCALE: 1/2"=1'-0"

DATE:	4/5/95
DESIGNED:	DJH
DRAWN:	DJR
CHECKED:	EA
SCALE:	1/8"=1'-0"
FILE:	CHLH4

NO.	DATE	REVISIONS

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DRAWING
DETAILS

PROJECT
CHIGNIK LAGOON
HYDROPOWER PROJECT
Chignik Lagoon, Alaska

FIGURE
4
OF 4

APPENDIX G - FIELD TRIP TWO, STREAM GAUGE AND RAINFALL DATA

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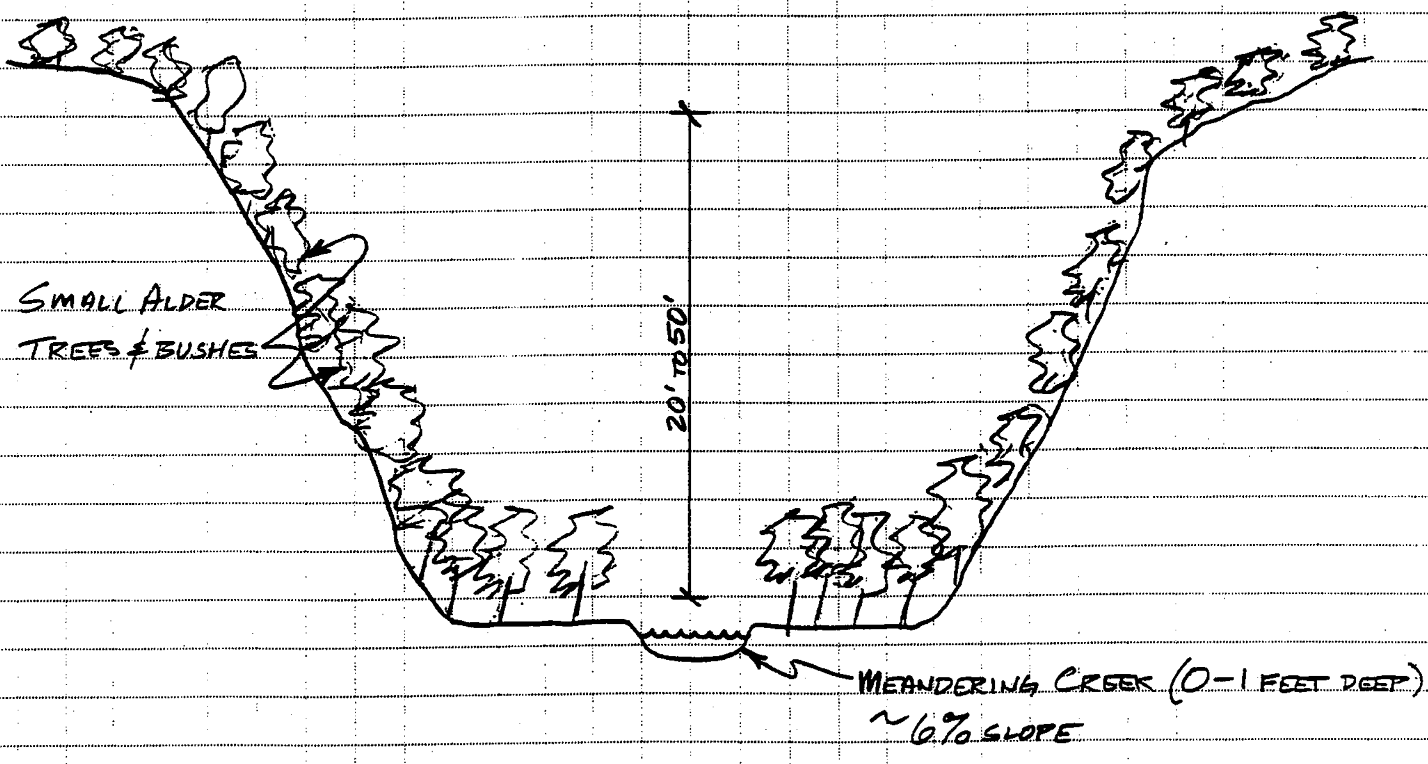
JOB CHIGNIK LAGOON HYDRO
SHEET NO. OF
CALCULATED BY D. THIEMAN DATE 01/27/95
CHECKED BY DATE
SCALE

TYPICAL CROSS SECTION AT PACKER'S CREEK



SOILS: MOSTLY GLACIAL TILL WITH SOME LARGE BOULDERS

APPROXIMATE SCALE: ☐ = 5 FEET

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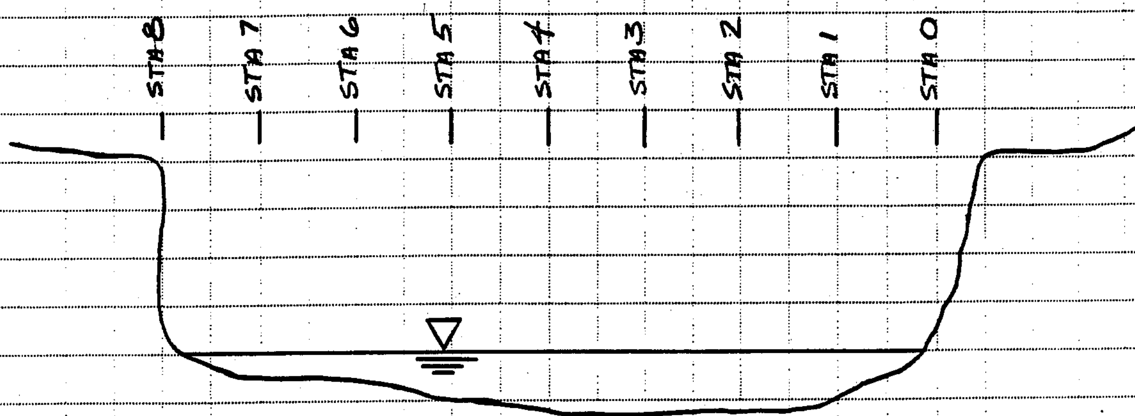
JOB CHIGNIK LAGOON HYDRO
SHEET NO. ______ OF ______
CALCULATED BY D. THIEMAN DATE 01/27/95
CHECKED BY ______ DATE ______
SCALE ______

CROSS SECTION OF PACKER'S CREEK AT STREAM GAUGE



STA	VEL.	DEPTH	WIDTH OF SECTION	INCREMENTAL FLOW = (VELOCITY)(DEPTH)(WIDTH)
0	0	0	.5	0
1	.3	.5	1	0.15
2	.7	.6	1	0.42
3	1.5	.7	1	1.05
4	1.0	.6	1	0.6
5	.7	.6	1	0.42
6	.3	.3	1	0.09
7	.3	.3	1	0.09
8	0	0	.5	0

Σ = FLOW OF CREEK = 2.82 CFS

Chignik Lagoon Survey Data

Shot	Distance		Vert. Angle				Vert. Dist.	HI	Elev.	Description
	ft.	deg	min	sec	deg	rad		ft.	ft.	
FS	394.46	91	51	0	91.9	1.603085	-12.7343	4.8	0.0	To Sea Level (approx. mean high tide)
BS	434.28	90	53	42	91.0	1.58825	-7.57923		7.9	To Tribal Office
FS	1496.42	95	44	42	95.9	1.672898	-152.522		0.4	To Tribal Office
FS	509.54	86	32	30	86.6	1.511746	30.07101		152.9	To Top of Town
BS	60.61	94	19	18	94.4	1.647009	-4.61478		122.8	To Incinerator
FS	1394.05	91	58	0	92.0	1.605121	-47.8411		118.2	To Incinerator
BS	14.22	85	33	48	85.7	1.495456	1.070322		166.0	To Knoll
FS	1447	98	6	24	98.2	1.713332	-205.551		167.1	To Knoll
BS	1015.91	83	29	18	83.5	1.457932	114.417		372.7	To Ridge
FS	540.41	88	14	24	88.3	1.541126	16.03193		487.1	To Ridge
BS	68.08	124	24	8	124.4	2.171577	-38.4847	4.8	471.0	To Stream Gage
PT	198.326	105	16	36	105.4	1.838995	-52.5554	4.8	108.7	To Stream bed near knoll, most likely powerho
PT	719.62	94	48	6	94.8	1.654863	-60.4248	4.8	87.7	To Stream bed near incinerator

Chignik Lagoon Stream Gauge Data

Date 1/19/95

STA	Vel ft/sec	Depth ft	Width ft	Flow cfs
0	0	0	0.5	0.0
1	0.3	0.5	1	0.2
2	0.7	0.6	1	0.4
3	1.5	0.7	1	1.1
4	1	0.6	1	0.6
5	0.7	0.6	1	0.4
6	0.3	0.3	1	0.1
7	0.3	0.3	1	0.1
8	0	0	0.5	0.0
Total Flow				2.82

Date 6/8/95

STA	Vel ft/sec	Depth ft	Width ft	Flow cfs
0	0	0	0.5	0.0
1	0.9	0.6	1	0.5
2	3.5	1.4	1	4.9
3	4.5	1.4	1	6.3
4	5.7	1	1	5.7
5	7	1.8	1	12.6
6	2.9	1.2	1	3.5
7	2.8	1.2	1	3.4
8	1.8	1	1	1.8
9	1.6	0.8	1	1.3
10	1.6	0.5	1	0.8
11	1.1	0.6	1	0.7
12	0.8	0.5	1	0.4
13	0.6	0.4	0.5	0.1
Total Flow				41.94

Date	Q (cfs)
1/20/95	2.79
1/21/95	2.91
1/22/95	2.85
1/23/95	2.91
1/24/95	2.89
1/25/95	3.51
1/26/95	3.24
1/27/95	2.76
1/28/95	2.65
1/29/95	2.51
1/30/95	2.49
1/31/95	2.46
2/1/95	4.77
2/2/95	7.65
2/3/95	4.30
2/4/95	5.72
2/5/95	14.35
2/6/95	7.62
2/7/95	5.42
2/8/95	4.51
2/9/95	3.97
2/10/95	3.68
2/11/95	3.80
2/12/95	4.25
2/13/95	3.91
2/14/95	3.65
2/15/95	3.43
2/16/95	3.25
2/17/95	3.13
2/18/95	3.12
2/19/95	3.10
2/20/95	2.89
2/21/95	2.80
2/22/95	2.74
2/23/95	2.58
2/24/95	2.44
2/25/95	2.50
2/26/95	2.46
2/27/95	2.47
2/28/95	3.66
3/1/95	4.01
3/2/95	3.22
3/3/95	3.11
3/4/95	3.02
3/5/95	2.87
3/6/95	2.72
3/7/95	2.65
3/8/95	2.58
3/9/95	2.52
3/10/95	2.43
3/11/95	2.38
3/12/95	2.36
3/13/95	2.41

Date	Q (cfs)
3/14/95	2.47
3/15/95	2.52
3/16/95	2.56
3/17/95	2.25
3/18/95	2.08
3/19/95	1.95
3/20/95	1.91
3/21/95	1.92
3/22/95	1.88
3/23/95	1.80
3/24/95	1.79
3/25/95	1.79
3/26/95	1.74
3/27/95	1.73
3/28/95	1.68
3/29/95	1.70
3/30/95	1.66
3/31/95	1.65
4/1/95	1.67
4/2/95	1.67
4/3/95	1.65
4/4/95	1.62
4/5/95	1.60
4/6/95	1.61
4/7/95	1.60
4/8/95	1.59
4/9/95	1.56
4/10/95	1.58
4/11/95	1.59
4/12/95	1.60
4/13/95	1.61
4/14/95	1.69
4/15/95	2.32
4/16/95	2.46
4/17/95	2.06
4/18/95	1.91
4/19/95	2.00
4/20/95	2.01
4/21/95	1.90
4/22/95	1.87
4/23/95	2.23
4/24/95	4.40
4/25/95	12.71
4/26/95	10.55
4/27/95	7.76
4/28/95	6.59
4/29/95	6.33
4/30/95	6.34
5/1/95	6.04
5/2/95	5.86
5/3/95	6.03
5/4/95	6.34
5/5/95	9.64

Date	Q (cfs)
5/6/95	15.29
5/7/95	15.33
5/8/95	11.80
5/9/95	22.81
5/10/95	46.54
5/11/95	37.31
5/12/95	29.94
5/13/95	25.74
5/14/95	22.32
5/15/95	22.06
5/16/95	17.92
5/17/95	15.18
5/18/95	17.28
5/19/95	31.89
5/20/95	36.15
5/21/95	49.91
5/22/95	33.31
5/23/95	68.32
5/24/95	38.48
5/25/95	32.62
5/26/95	33.83
5/27/95	33.10
5/28/95	30.24
5/29/95	26.96
5/30/95	24.29
5/31/95	22.45
6/1/95	22.35
6/2/95	22.97
6/3/95	22.90
6/4/95	25.33
6/5/95	28.92
6/6/95	35.57
6/7/95	54.62
6/8/95	40.97

CHIGNIK, ALASKA

DRAFT SMALL HYDROPOWER FEASIBILITY REPORT AND ENVIRONMENTAL IMPACT STATEMENT

JULY 1984

US Army Corps of Engineers
Alaska District

TABLE A-1 CLIMATOLOGICAL DATA SUMMARY

STATION: Chignik LATITUDE: 56° 18' LONGITUDE: 158° 24' ELEVATION: 30

MONTH	POR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE (°F)														
Means														
Daily Max.	12	32.4	31.2	33.1	38.9	45.9	54.2	59.6	60.6	50.3	45.1	39.1	34.4	43.7
Daily Min.	12	22.0	19.6	20.5	26.6	33.8	40.4	44.9	45.8	41.0	34.1	27.1	23.7	29.7
Monthly	12	26.9	25.1	26.8	32.6	39.4	44.3	52.3	52.8	44.4	39.4	33.5	29.0	37.2
Extremes														
Rec. High	13	48	47	50	51	69	72	76	72	75	63	57	55	76
Year		1968	1971+	1974	1930	1968	1974+	1971	1969	1930	1967	1970	1970	1971
Rec. Low	13	-12	-9	-10	5	15	30	33	33	27	14	4	2	-12
Year		1971	1974	1975	1971+	1973	1930	1930	1928	1976+	1976+	1930	1975+	1971
PRECIPITATION (in inches)														
Mean	12	10.52	11.21	6.36	4.50	11.44	8.44	4.86	5.98	12.75	10.99	12.03	8.87	107.9
Greatest/d	11	7.15	5.80	3.49	2.90	7.33	3.60	3.68	7.15	7.12	6.52	4.82	4.40	57.33
Year		1930	1927	1928	1970	1930	1969	1929	1927	1927	1930	1928	1927	1930
Greatest/mo	11	29.89	22.49	16.26	7.48	35.71	27.25	11.61	18.09	34.34	20.13	27.99	18.81	34.34
Year		1930	1928	1974	1968	1930	1969	1971	1927	1929	1930	1929	1928	1929
Snow, Ice Pellets														
Mean	11	8.9	16.0	8.3	6.0	1.1	0	0	0	0	3.8	4.6	9.1	57.8
Greatest/mo	11	27.2	31.0	18.0	18.2	5.3	0	0	0	T	12.0	12.0	25.5	31.0
Year		1931	1969	1969	1972	1971	-	-	-	1972	1927	1930	1930	1969
Greatest/d	10	9.1	12.0	8.0	8.0	5.3	0	0	0	T	10.0	14.1	9.0	14.1
Year		1975	1929	1969	1928	1971	-	-	-	1972	1927	1975	1930	1975
High Depth	11	23	34	47	57	59	0	0	0	0	10	7	16	59
Year		1972+	1973	1972	1973	1973	-	-	-	-	1927	1972-	1928	1973
WIND														
Ave. speed (mph)		*	*	*	*	*	NOT AVAILABLE		*	*	*	*	*	*
Direction	5	SE	NW	NW	NW	SE	SE	SW	SW	W	NW	NW	W	NW
MEAN NUMBER OF DAY														
Precipitation .10 inches or more	7	6	9	8	6	7	5	4	5	9	11	10	9	89
Temperature														
Maximum														
70°+	12	0	0	0	0	0	*	1	1	*	0	0	0	2
32°-	12	10	10	11	3	*	0	0	0	0	1	5	12	52
Minimum														
32°-	12	24	23	25	22	10	1	0	0	2	12	21	24	164
0°-	12	2	2	2	0	0	0	0	*	*	0	*	0	6

POR Period of Record
+ Also on earlier dates, months, or years

* Less than one half
T Trace, an amount too small to measure