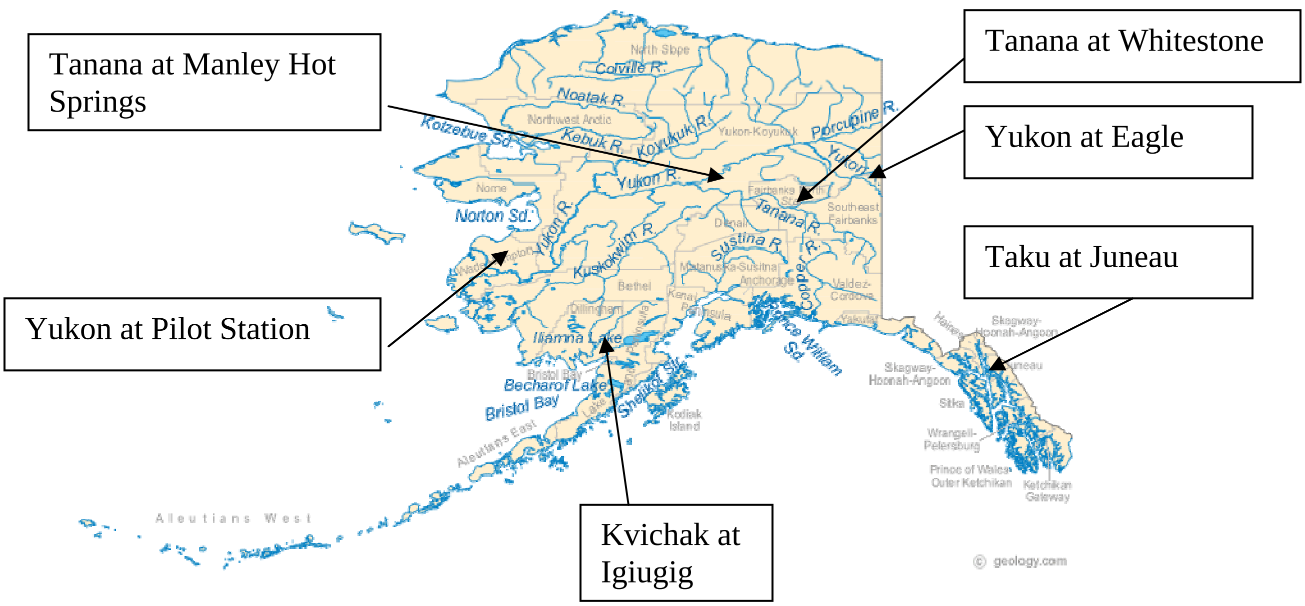
ELECTRIC POWER RESEARCH INSTITUTE

River In-Stream Energy Conversion (RISEC) Characterization of Alaska Sites



Project: Alaska RISEC Feasibility Study
Phase: Site Assessment
Report: EPRI - RP- 003-Alaska
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Date: February 29, 2008

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Organization(s) that prepared this document:

Electric Power Research Institute

re vision consulting LLC

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1. Introduction and Summary

The EPRI North American River In-Stream Energy Conversion (RISEC) Power Program is investigating the feasibility of river current power to provide efficient, reliable, environmentally friendly and cost-effective electrical energy. This project is being conducted by the Electric Power Research Institute (EPRI) under the sponsorship of the Alaska Energy Authority, Chugach Electric and Anchorage Municipal and Light.

This document describes the results of the River In-Stream Energy Conversion (RISEC) site characterization for Alaska. This study's primary focus is on understanding the velocity profiles at various locations, as they have the most significant impact on energy extraction and resulting cost of electricity. In order to accomplish this, EPRI worked very closely with USGS and local contacts through the Alaska Energy Authority (AEA). A substantial amount of local knowledge of site attributes was provided by local contacts.

EPRI was able to obtain information on six sites. The six sites characterized are located near USGS stations as shown below. The locations of the six sites are illustrated in Figure 1.

1. Taku River near Juneau and near Canadian border (USGS Station ID 15041200)
2. Tanana River at Manley Hot Springs (USGS Station ID 15515500, 60 miles upstream)
3. Tanana River at Whitestone Community (USGS Station ID 15478000)
4. Yukon River at Eagle ((USGS Station ID 15356000)
5. Yukon River at Pilot Station (USGS Station ID 15565447)
6. Kvichak River at Igiugig (USGS Station ID 15300500)

The primary criterion for an in-stream river energy site is the strength of the current. While other characterization criteria may prove a site to be unsuitable for RISEC, a site without currents has no development potential. In order to establish a frequency distribution of velocities at the site suitable for subsequent evaluation of RISEC device performance, first a relationship between discharge rate and velocity was established using USGS discharge calibration data. That relationship function was then applied to the full data of historical daily discharge rates. It is important to understand that the velocity profiles and associated power densities are only valid for the transect used by the USGS to calibrate the flow data and used in this study to calibrate the velocity data.

From the strength and distribution of current velocities, it is possible to determine the kinetic power density (kW/m^2) for a site. The cost of energy (COE) for a site is closely correlated to power density, with sites of higher power density showing a lower COE.

The total in-stream resource is given by multiplying the kinetic power density (kW/m^2) in a channel by its cross-sectional area (m^2). This procedure is described in Reference 2.

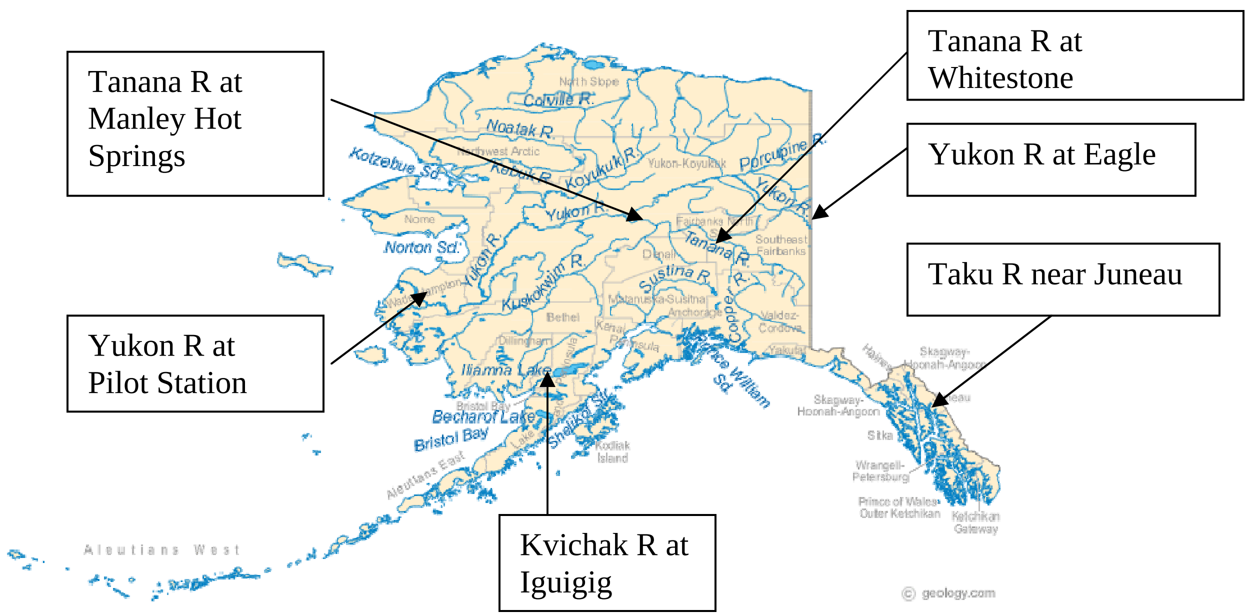


Figure 1 - Location of selected sites

All six locations are in close proximity to small villages that typically have power needs of a few hundred kW. The following table provides an overview of the generic 'suitability' site attributes for each of the six sites, as well as a velocity data summary. All sites except Manley Hot Springs has a USGS close to the site; for Manley Springs, the closest USGS station is 60 miles upstream at Nenana.

Table 1: Site data summaries

	Yukon @ Pilot	Yukon @ Eagle	Tanana @ Nenana (1)	Tanana @ Whitestone	Taku @ Juneau	Kvichak @ Iguigig
USGS discharge data (years)	1975 to Present	1950 to Present	1962 to Present	1949 to 1952	1987 to Present	1967 to 1987
Ice Freeze Over	October	October	Does not Freeze	Does not Freeze	January	Does not Freeze
Ice Breakup	April/May	April/May	April/May	April/May	March	None
Distance to electrical interconnection	1.5 Miles	< 1Mile	< 1Mile	< 1 Mile	24 Miles	< 1 Mile

1) Tanana is the closest USGS station 60 miles upstream of Manley Hot Springs

The six sites under investigation cover a wide spectrum of potential deployment sites in terms of size, power density, and physical dimensions. The following table summarizes key resource-attributes of the six sites under investigation. Detailed background on each of these sites can be found in subsequent chapters.

Table 2: Site Resource Overview

		Unit	Yukon @ Pilot	Yukon @ Eagle	Tanana @ Nenana (1	Tanana @ Big Delta	Taku @ Juneau	Kvichak @ Iguigig
Velocities								
	Average Velocity	m/s	0.49	1.18	0.92	0.98	0.92	1.41
	Average Mid-Channel Velocity	m/s	0.64	1.54	1.19	1.28	1.20	1.84
Power								
	X-Section Average Power Density	kW/m^2	0.15	1.45	0.80	0.67	0.53	1.48
	Mid-Stream Average Power Density	kW/m^2	0.32	3.20	1.75	1.48	1.16	3.24
	Average Total Kinetic Power	kW	1,675	4,601	694	762	482	719
Dimensions (During Typical Discharge Conditions)								
	Discharge Rate for Referenced Dimensions	m^3/s	6,201	5,182	1,724	1,167	1,809	487
	Cross-Section	m^2	11,393	3,162	870	1,132	911	365
	Width	m	808	465	256	169	207	152
	Average Depth	m	14.10	6.80	3.40	6.70	4.40	2.40
	Deepest Point	m	18.60	9.70	4.20	11.90	5.60	3.70
Discharge								
	Average	m^3/s	3,989	2,363	691	421	388	507
	Maximum	m^3/s	33,414	15,433	5,182	1,767	3,200	1,277
	Minimum	m^3/s	204	204	113	105	20	181

1) Tanana is the closest USGS station 60 miles upstream of Manley Hot Springs

A key question that remains to be answered is what fraction of the kinetic power or energy of this resource may be extracted by in-stream turbines. There are a number of issues which limit in-stream extraction: (1) changes to river fluid flow, (2) interconnection limits, and (3) the density of turbines which can be physically placed within a constricted channel. As a result, the extractable in-stream resource is as much a function of site-specific issues as the kinetic power present in a flow.

This report contains units in both English and SI units. The conversion factors are:

English to SI units	SI to English units
Area	
1 ft^2 = 0.0929 m^2	1 m^2 = 10.76 ft^2
Length	
1 ft = 0.3048 m 1 mile = km	1 m = 3.281 ft 1 km = mile
Velocity	
1 ft/sec = 0.3048 m/sec	1 m/sec = 3.281 ft/sec
Mass and Density	
1 lb = 0.4536 kg 1 lb/ft^3 = 0.06234 kg/m^3	1 kg = 2.2046 lb 1 kg/m^3 = 16.02 lb/ft^3
Discharge Rate	
1 ft^3 /sec = 0.02832 m^3 /sec	1 m^3 /sec = 35.31 ft^3 /sec

2. Taku River at Juneau

2.1. Site Description

The Taku River runs from British Columbia, Canada, to the northwestern coast of North America, at Juneau, Alaska. The Taku River starts in British Columbia, Canada, and flows generally southwest, emptying into Stephens Passage near Juneau, Alaska. The river on the U.S. side of the border is approximately 36 miles long. There is a USGS gauging station located at Canyon Island, approximately 3 miles from the U.S./Canadian border (see figure 2).

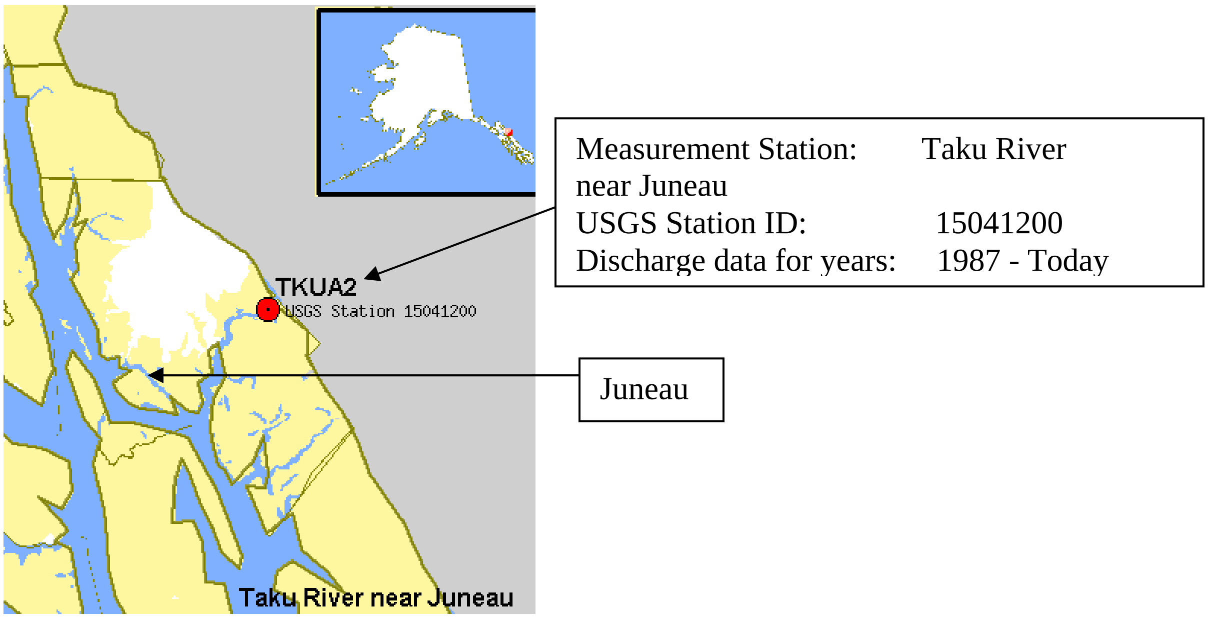


Figure 2: Location Overview Map

For the purposes of this report, we are interested in the portion of the river extending from the border to Canyon Island (about 3 miles), where the river is relatively narrow and deep: 150 to 300 yards wide and 15 to 20 feet deep. The ovals in Figure 3 indicate the area of interest. The channel is well-defined in this reach.

The Canyon Island area is the best site on the Taku River for a RISEC system. It has the best velocity regime and river bed. Unfortunately, it is 24 miles to the nearest interconnection point to the electrical system. The low flows in the winter and debris-loading during flood events also make this site more problematic.

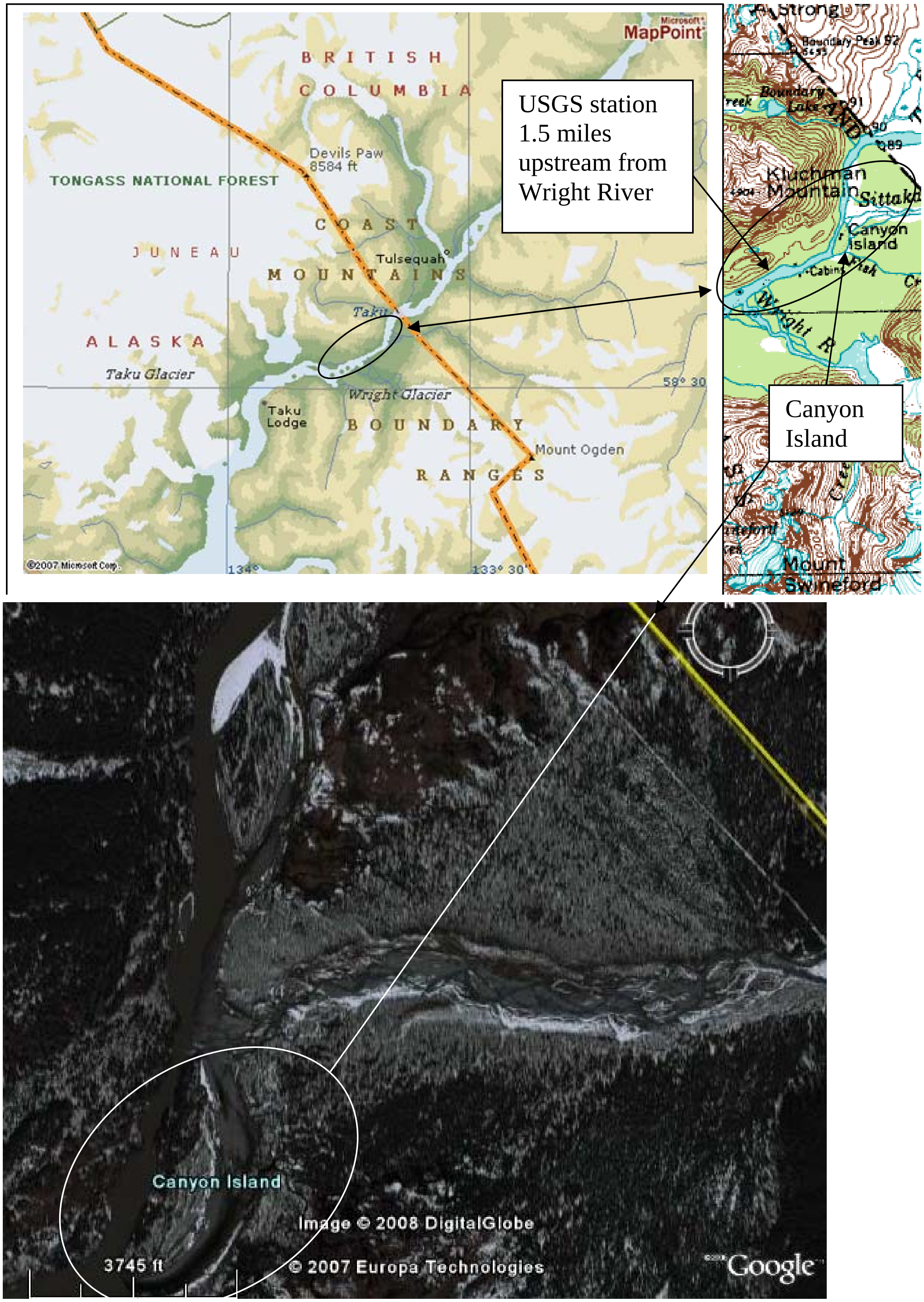


Figure 3: Location Map

2.2. Electrical Interconnection

Juneau is an isolated electrical system. All electric power generation, transmission and distribution is provided by the local utility, Alaska Electric Light and Power (AEL&P). AEL&P has about 84 MW of installed hydro capacity and another 84 MW of diesel-fired backup generation. As AEL&P's base load generation is entirely hydro, there is some energy storage in the reservoirs.

AEL&P operates six power plants, four on the road system and two remote plants. One of the remote plants, the Annex Creek hydro plant, is located on the Taku River, approximately 28 miles from the border. Transmission voltage for the Annex Creek system is 23 kV. The system peak in the winter is 70 MW. Summer peaks are under 60 MW.

2.3. Other Considerations

Population and Census Data

Juneau has a population of around 32,000 people. Summer population is probably slightly higher due to temporary jobs in the tourist industry. The primary employer is state government. Tourist activity is high, with over a million tourists visiting Juneau from May through September, mostly on cruise ships.

Local Infrastructure

Juneau possesses all the necessary infrastructures to support a RISEC system. There is no overland access to Juneau. Everything arrives by boat or by plane.

River Bed

Based on discussions with local residents, the river bed near Canyon Island is gravelly. It becomes sandy for a few miles downstream, and is silty for the remainder of the river.

Ice

The river typically freezes over in January down to Taku Point. Ice thickness is usually around 2 feet. There is not a well defined breakup, as in rivers further north, but the ice gets slushy and eventually melts sometime in March. Residents report that at times, the slush extends through the water column to the bottom of the river. Peak runoff is typically in early June. The Taku River does experience jokulhlaups, or glacial outburst floods, twice a year. During these events water from glacially impounded lakes break out from the Tulsquah Glacier and produce a large flood on the river. (See photo 2) These floods last from three to five days. The first often occurs in June or July, and the second in August or September. During these events there is a sharp rise in water level and a great deal of debris in the water.

Water Clarity/Suspended Sediments

Several glaciers feed into the Taku River. Consequently there is significant silt in the river. Residents report that during the spring runoff there is also a significant amount of debris, brush and logs, in the river; so much, in fact, that it was assumed that an in-stream machine would have to be removed from the river during the spring flood. It was also reported that a significant amount of debris washes down the river during the glacial outburst floods each season.

Competing Uses of River-space

Boating in the river is primarily recreational, with some landing craft (three foot draft) traffic. There are numerous cabins along the river. There are a few fish net sites and fish wheels at Canyon Island. Development of a gold mine is being considered on the Canadian side of the border. If this is developed there may be barge traffic up and down the river.

Environmental Considerations

All five species of Pacific salmon run up the Taku River; these runs are important both commercially and environmentally. The river is also the natural habitat of bald eagles. In addition, subsistence and personal use fishing must be taken into consideration prior to development in and near the river

Unique Opportunities

The hydro based electrical system could provide storage of energy during high river flows. Juneau's infrastructure is well-developed and could easily support such an installation.

2.4. Photographs

The following photographs were taken in June 2007.

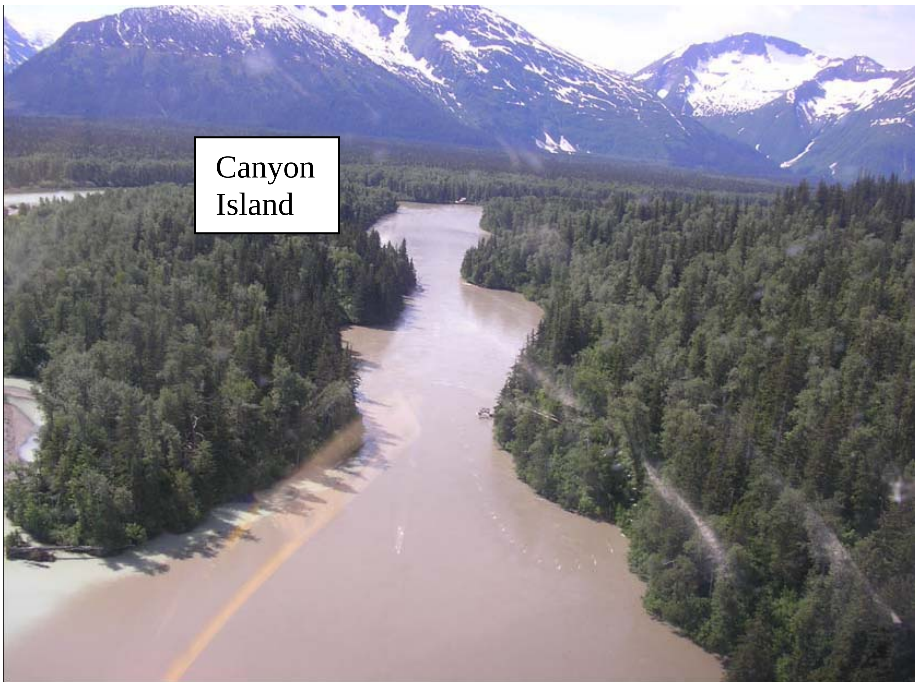


Figure 4: Reach A. Looking downstream at Canyon Island

Figure 5:Tulsequah Glacier in Canada, source of Taku River jokulhlaups

2.5. Site Energy Data

The USGS maintains a stream gauging station on the Taku River near Canyon Island (Station# 15041200 Taku R nr Juneau AK), with 19 years of daily discharge records (1987-2006). That data was used to establish a data set suitable for evaluating RISEC technology. First a relationship between discharge rate and velocity was established; that relationship function was then applied to the full data set to determine the statistical parameters shown below. It is important to understand that the velocity profiles and associated power densities are only valid for the transect the USGS used to calibrate the flow data and which we used to calibrate the velocity data.

Table 3: USGS station summary

Station ID: 15041200
City & Borough Of Juneau, Alaska
Hydrologic Unit Code 19010301
Latitude 58°32'19", Longitude 133°42'00"
Drainage area 6,600 square miles
Gage datum 50 feet above sea level

Table 4: Site Resource Summary

Velocities		Unit	
	Average Velocity	m/s	0.92
	Average Mid-Channel Velocity	m/s	1.20
Power			
	X-Section Average Power Density	kW/m^2	0.53
	Mid-Stream Average Power Density	kW/m^2	1.16
	Average Total Kinetic Power	kW	482
Dimensions (During Typical Discharge Conditions)			
	Discharge Rate for Referenced Dimensions	m^3/s	1,809
	Cross-Section	m^2	911
	Width	m	207
	Average Depth	m	4.4
	Deepest Point	m	5.6
Discharge			
	Average	m^3/s	388
	Maximum	m^3/s	3,200
	Minimum	m^3/s	20
Maximum Stage Differential		m	4.4

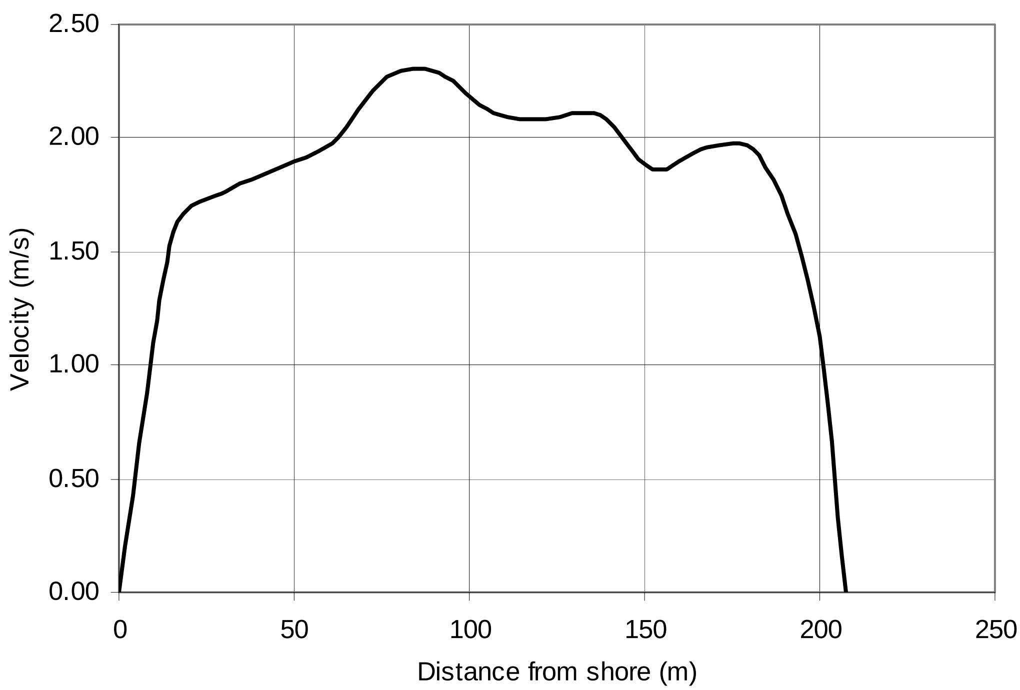


Figure 6: USGS Measurement Cross Section, velocity at a discharge rate of 63,900 ft^3/s

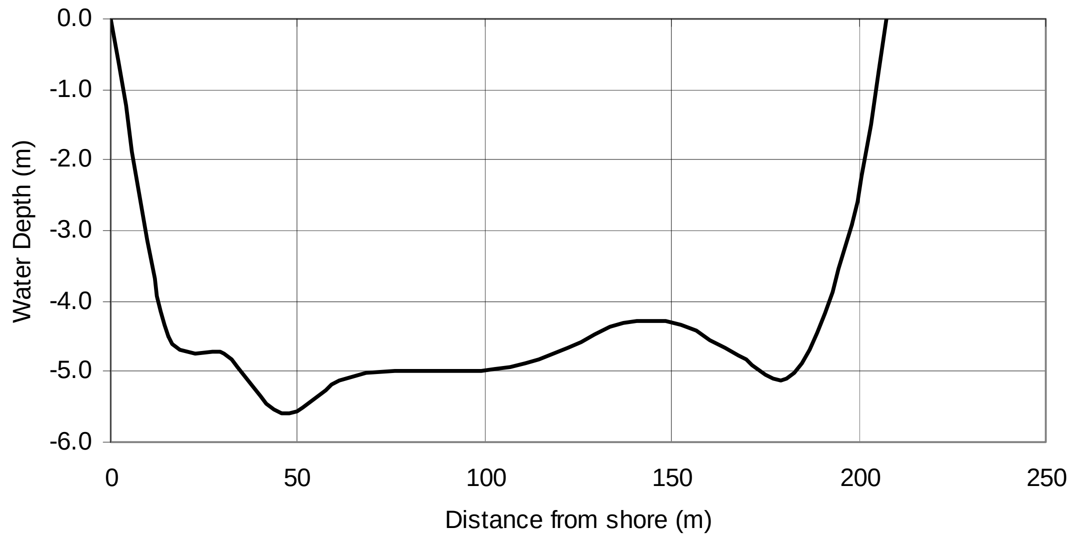


Figure 7: USGS Measurement Cross Section, showing water depth at a discharge rate of 63,900 ft^3/s

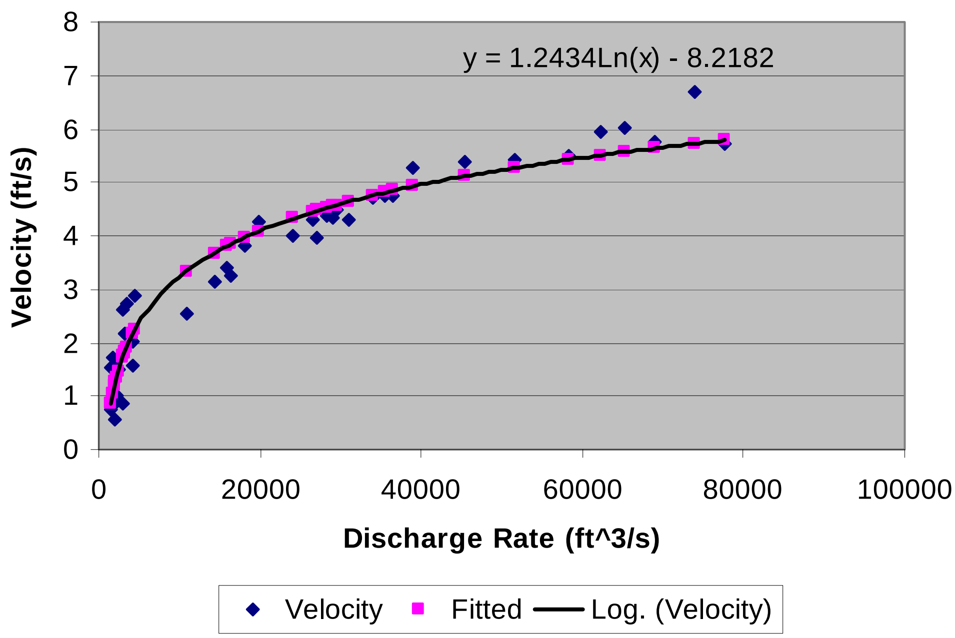


Figure 8: Relationship between velocity and Discharge Rate

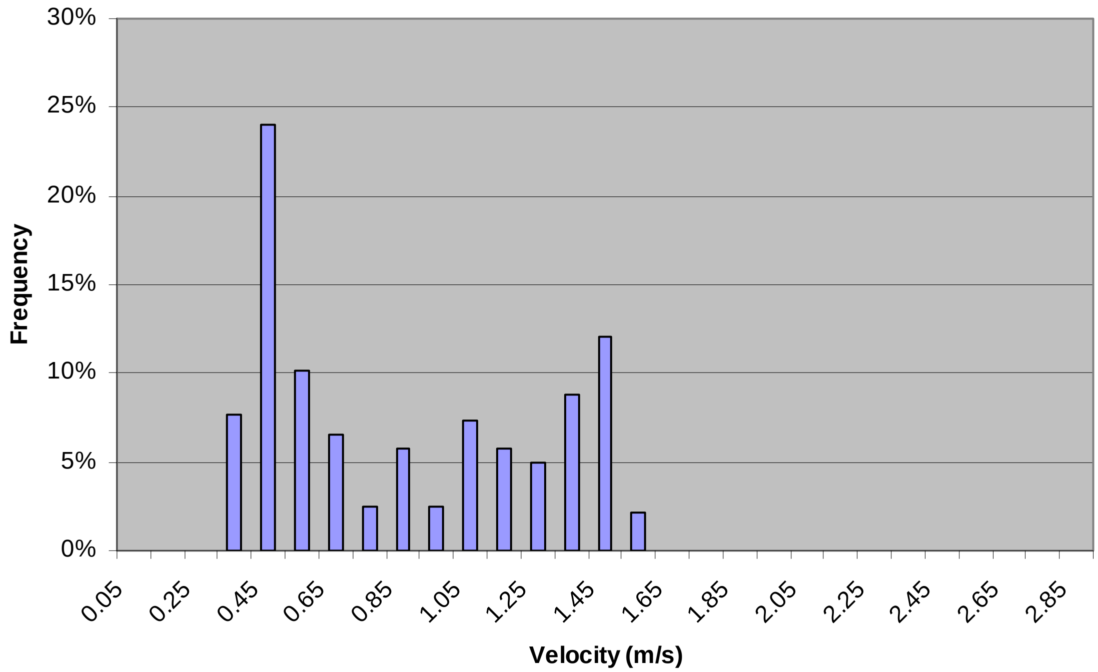


Figure 9: Velocity Distribution at Site

Table 5: Velocity Distribution Table at Site

Speed Bin					
Low (m/s)	Up (m/s)	Mid (m/s)	Dist. %	Power (kW/m^2)	Dist x Power
0.0	0.1	0.1	0%	0.000	0.000
0.1	0.2	0.2	0%	0.002	0.000
0.2	0.3	0.3	0%	0.008	0.000
0.3	0.4	0.4	8%	0.021	0.002
0.4	0.5	0.5	24%	0.046	0.011
0.5	0.6	0.6	10%	0.083	0.008
0.6	0.7	0.7	7%	0.137	0.009
0.7	0.8	0.8	2%	0.211	0.005
0.8	0.9	0.9	6%	0.307	0.018
0.9	1.0	1.0	2%	0.429	0.011
1.0	1.1	1.1	7%	0.579	0.043
1.1	1.2	1.2	6%	0.760	0.044
1.2	1.3	1.3	5%	0.977	0.048
1.3	1.4	1.4	9%	1.230	0.108
1.4	1.5	1.5	12%	1.524	0.183
1.5	1.6	1.6	2%	1.862	0.041
1.6	1.7	1.7	0%	2.246	0.000
1.7	1.8	1.8	0%	2.680	0.000
1.8	1.9	1.9	0%	3.166	0.000
1.9	2.0	2.0	0%	3.707	0.000
2.0	2.1	2.1	0%	4.308	0.000
2.1	2.2	2.2	0%	4.969	0.000
2.2	2.3	2.3	0%	5.695	0.000
2.3	2.4	2.4	0%	6.489	0.000
2.4	2.5	2.5	0%	7.353	0.000
2.5	2.6	2.6	0%	8.291	0.000
2.6	2.7	2.7	0%	9.305	0.000
2.7	2.8	2.8	0%	10.398	0.000
2.8	2.9	2.9	0%	11.575	0.000
Average Power Density (kW/m^2)					**0.529**

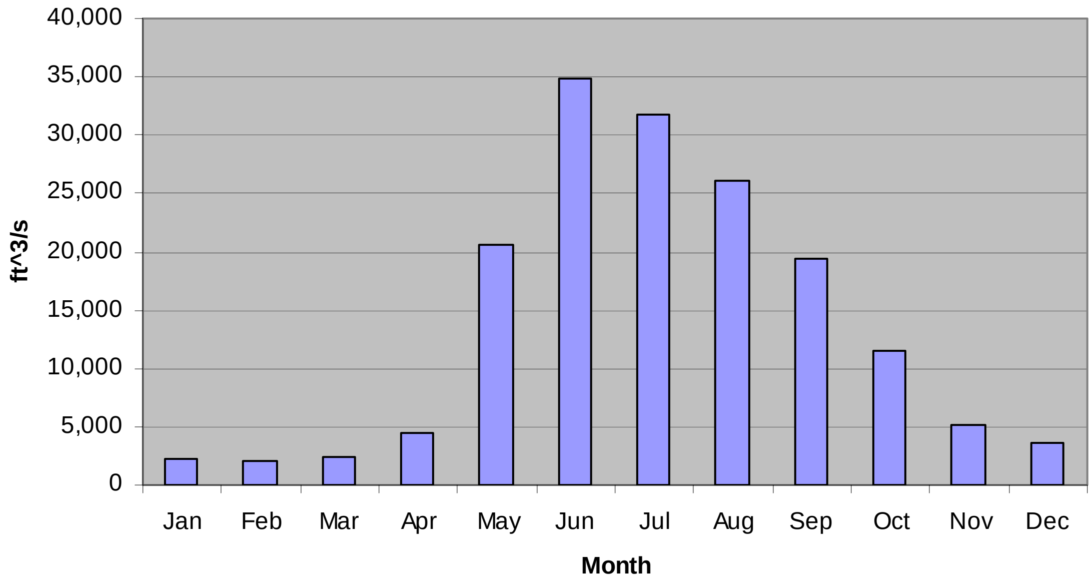


Figure 10: Monthly Average Discharge Rates

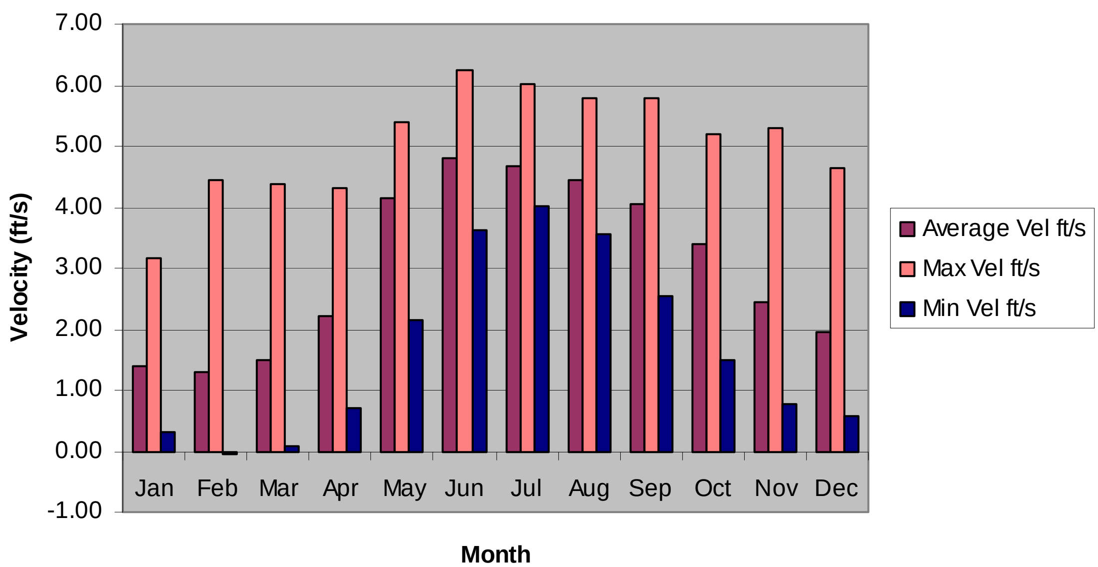


Figure 11: Monthly Velocities at Site

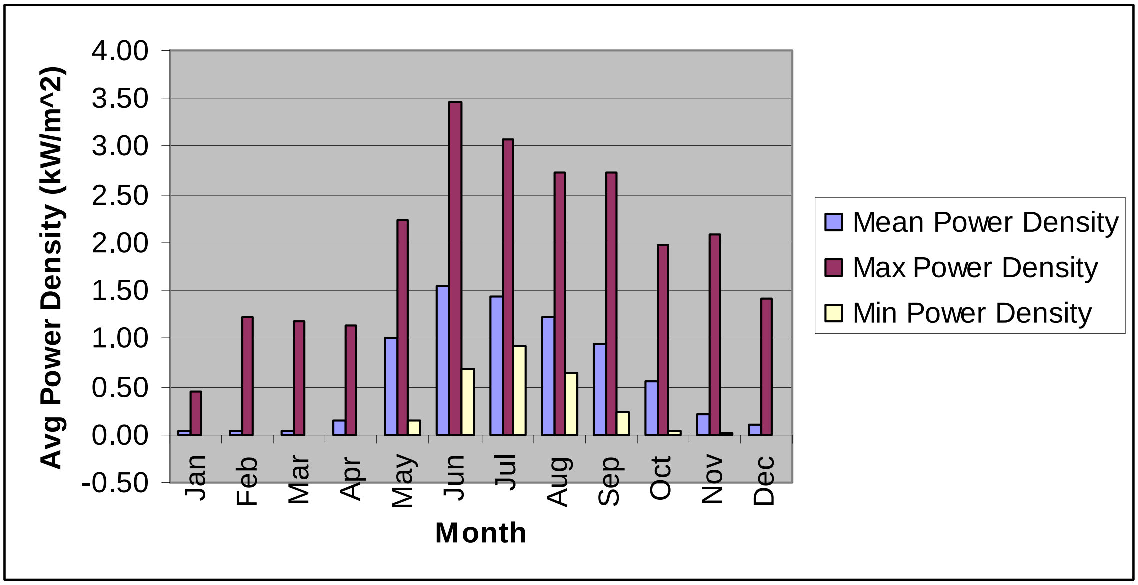


Figure 12: Monthly Power Densities at Site

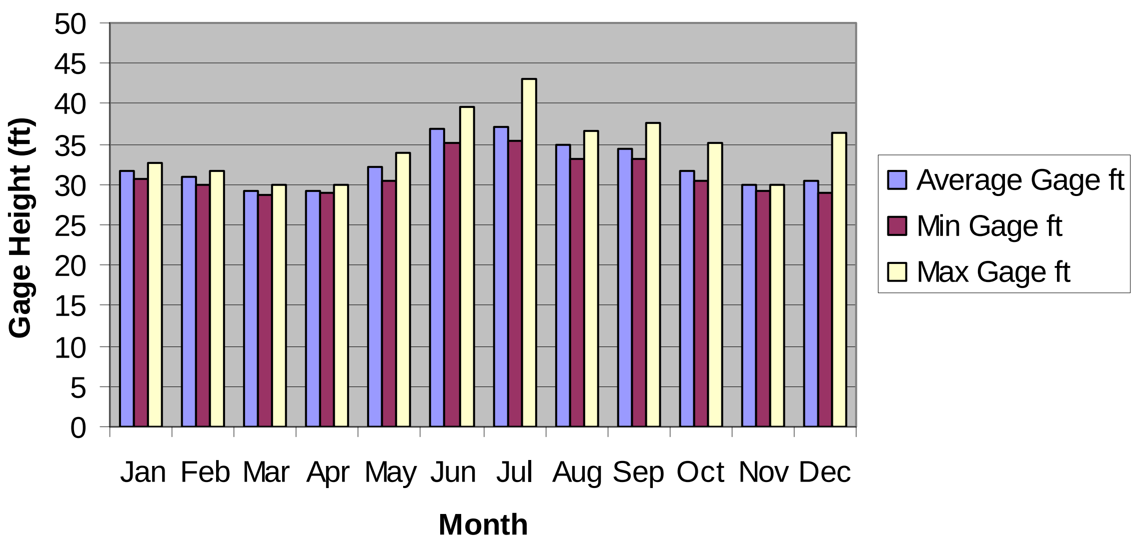


Figure 13: Monthly Gage Height

3. Tanana River at Manley Hot Springs

3.1. *Site Description*

The Tanana River flows to the north of the Wrangell Mountains and the Alaska Range. Fairbanks is the largest community in the Tanana River Valley. The river levels are influenced by the glacial melt in the nearby mountains. The river is about 650 miles long and is the largest tributary of the Yukon River. This is a remote river with only a handful of communities on its waters.

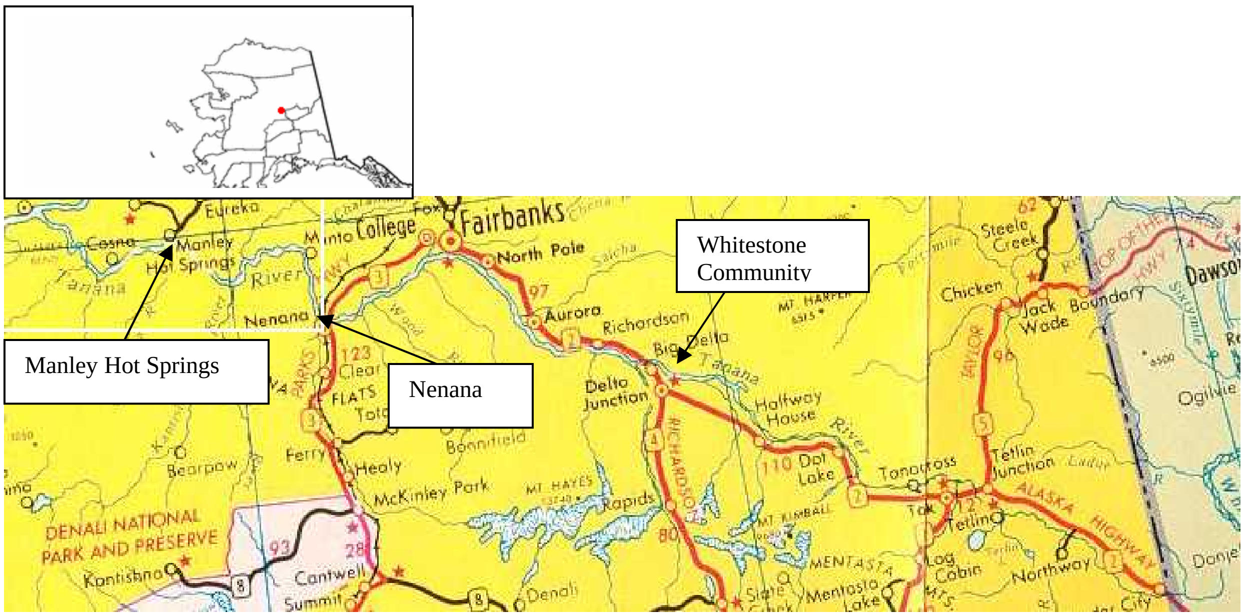


Figure 14: Location overview map

Tanana's headwaters are located on the north slope of the Wrangell Mountains in southeast Alaska. The river flows in a northeast direction, then turns to the northwest near the border with the Yukon Territory, and flows laterally along the northern slope of the Alaska Range, roughly paralleled by the Alaska Highway. In central Alaska, it emerges into a lowland marsh region known as the Tanana Valley and passes to the south of the city of Fairbanks and past the village of Ester. In the marsh regions it is joined by several large tributaries, including the Nenana (near the city of Nenana) and the Kantishna. The river empties into the Yukon approximately 70 miles (110 km) downriver from the village of Manley Hot Springs.

Manley Hot Springs is located about 8 km (5 miles) north of the Tanana River on Hot Springs Slough, at the end of the Elliott Highway, 260 km (162 miles) west of Fairbanks. About 100 people live in

Manley, along with a handful of dog teams. The village has one hotel, a Laundromat with showers, a gas station, school (UAF rural adult education classes available), post office, museum, well house, landfill, and grocery store. There are several public campgrounds (one with boat ramp, covered picnic shelter and playground) near the bridge over Manley Slough, maintained by the Manley Hot Springs Park Association. There is also a maintained airstrip and hangar (a 45 minute flight from Fairbanks).

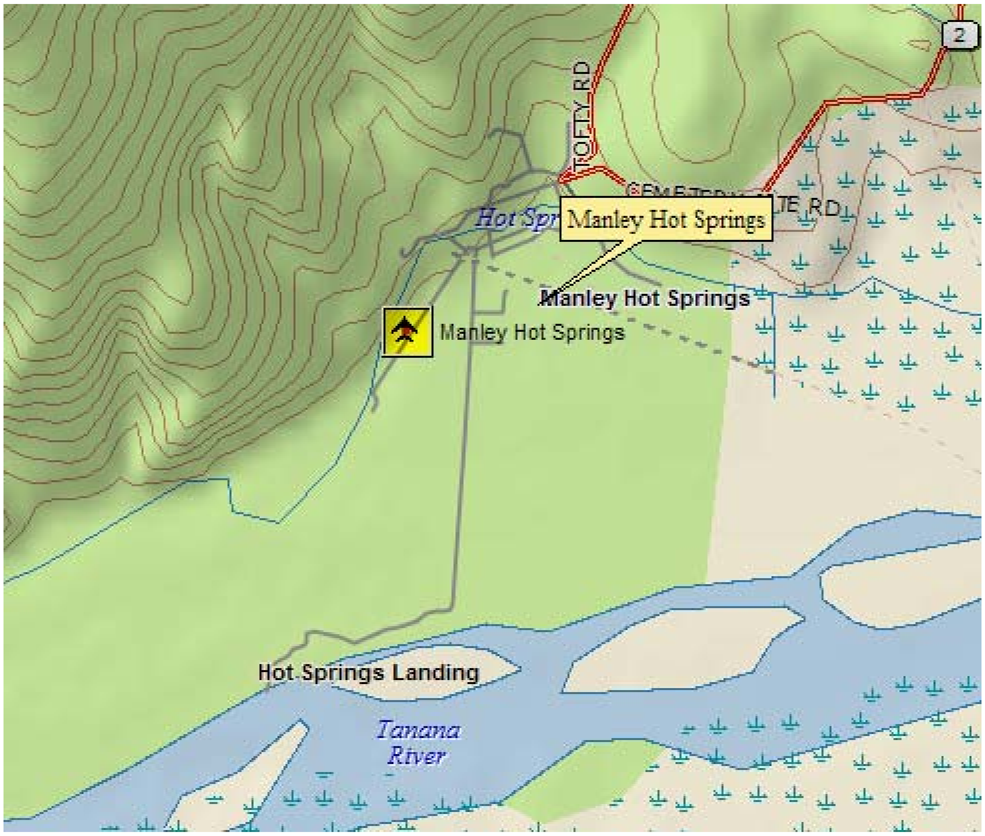


Figure 15: Site Overview Map

3.2. Electrical Interconnection

The Manley Hot Springs grid is an isolated grid with a total generator capacity of 250kW. The generator/storage area is located along the airstrip next to the general store. The distribution voltage in the village is 4.16kV and 2.4kV three phase. The nearest distribution line is located about one mile from the river. Three-phase 4.16kV power is available about 2 miles from the river. The average load is 67kW in summer and 110kW in winter. The utilities contact info follows below.

Manley Electric Utility, 5450 "A" Street

Anchorage, AK 99518-1278

Phone 907-561-1674

Fax 907-273-5322

3.3. Other Considerations

The total population at Manley Hot Springs is estimated at 78 (2006 estimate). A federally recognized tribe, Manley Village Council, is located in the community Twenty-three percent of the population is Alaska Native or part Native. Government employment accounts for about one quarter of the total adult population. Nine residents hold commercial fishing permits.

Manley Hot Springs has a cold, continental climate. The average daily high is in the upper 50s (Fahrenheit) in summer, and minimum winter temperatures range from minus 6 to minus 21. Temperature extremes have been measured from 93 to minus 70. The average annual precipitation is 15 inches, with snowfall of 59.3 inches.

Economy

The local economy is based on a wide variety of small businesses, with many residents relying on three or four means of income. The Tribe operates the clinic and the Manley Roadhouse is open during summer months. A barter system thrives between residents. Government employment accounts for about one quarter of the total adult employment population. Nine residents hold commercial fishing permits. Gardening, hunting and fishing provide food sources, with salmon and moose as the primary meat sources.

Transportation

The Elliott Highway is the primary means of accessing Manley Hot Springs. Goods and fuel are typically delivered by truck. The Highway runs through Manley to the Tanana River Landing, 3 miles southwest. The Tanana River Landing is used to launch boats for fishing or transportation. Barge services are sometimes provided during summer months, but there is no docking facility due to severe erosion. The State-owned 2,875' long by 30' wide gravel runway is available year-round.

Environment

Rivers fed only by glaciers cease to flow during winter and are not viable winter fish habitat. Large glacial rivers with substantial base flows of groundwater (e.g., Tanana River) are essential fish habitat and play a critical role for fish in winter. The amount of Oxygen decreases in winter downstream of open water patches, sometimes reaching minimums that threaten fish survival in March and April just before breakup. The "sealed" nature of some glacial river and stream reaches in winter also gives rise for concerns about the ecological effects of waste discharge in these rivers (Reynolds 1997).

3.4. Photographs

Figure 16: Fishwheel at the frozen Tanana River near Manley Hot Springs

3.5. River Energy Resource

There is no USGS Calibration station located near Manley Hot Springs, making it impossible to estimate flow velocities and associated river in-stream power densities. A calibration station for Nenana that is located about 60 miles upstream could be viewed as a proxy for discharge rates for Manley Hot Springs. Table 1 and 2 in Section 1 of this report provides velocity, cross sectional area and power density data for Nenana at the USGS station. However, local Manley Hot Springs velocity measurements would need to be carried out to establish a local velocity-to-discharge relationship.

4. Tanana River at Whitestone

4.1. Site Description

The Whitestone community is located northwest of Delta Junction on the western side of the Delta River. The community has over 200 residents and is represented by the Whitestone Community Association (WCA) in its work with State agencies and other organizations. The Department Commerce and Community Development certified the Whitestone Community Association as an unincorporated community for purposes of revenue sharing for FY04. The community's permanent residents reside in close geographical proximity to one another. The community is connected by a series of public and private roads. Neither public access nor the right to reside in the community is restricted. The community is not dependent upon an adjacent community for its existence.

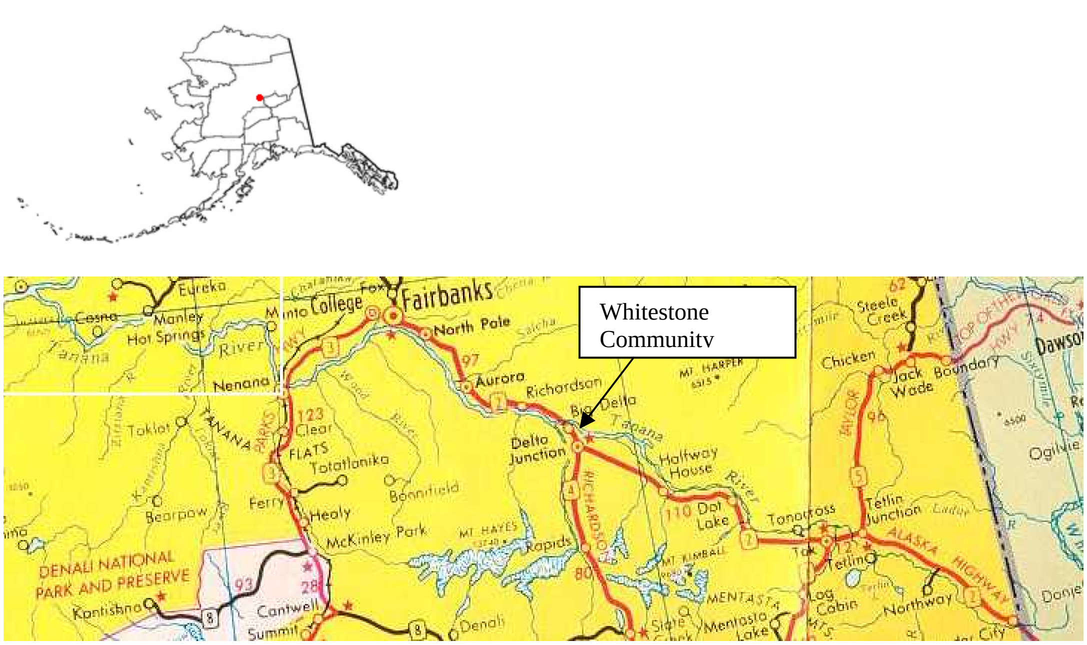
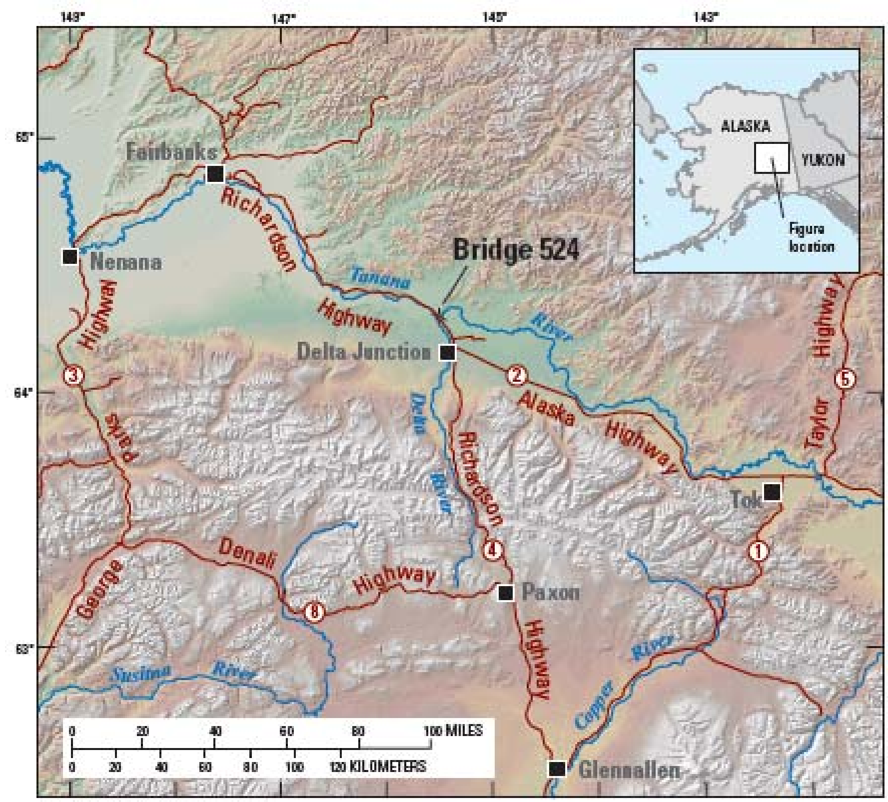


Figure 17: Whitestone Community on the Tanana River



Base from U.S. Geological Survey digital data, 1:63,360

Figure 18: Road Network near Big Delta

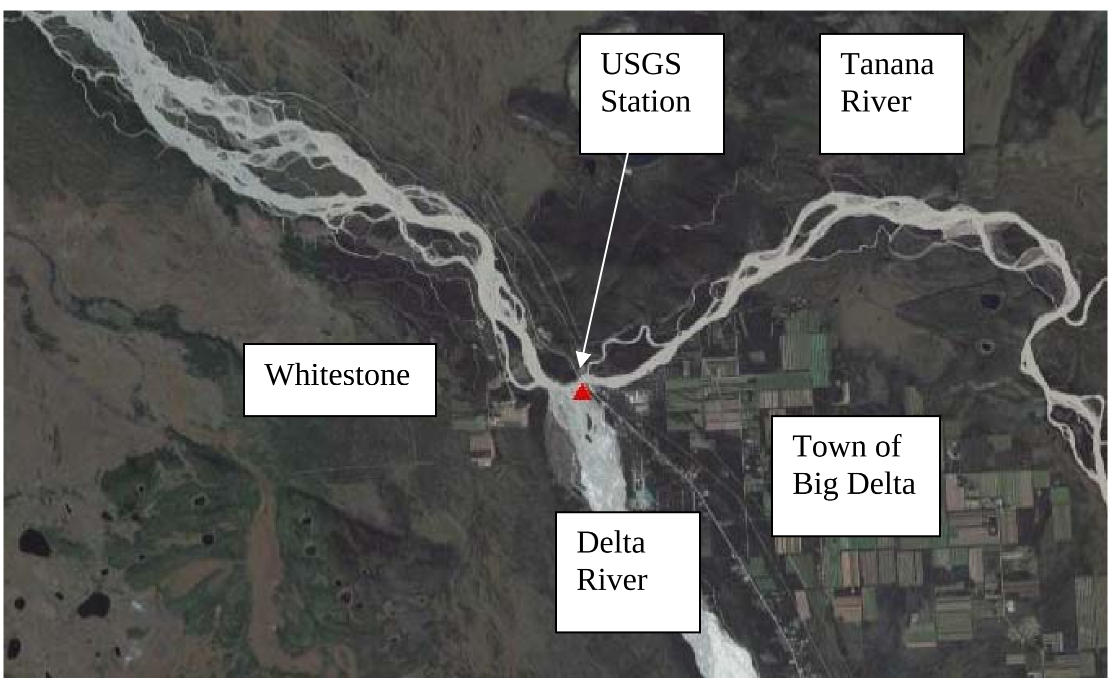


Figure 19: Big Delta Overview Map

Figure 20: Site Overview

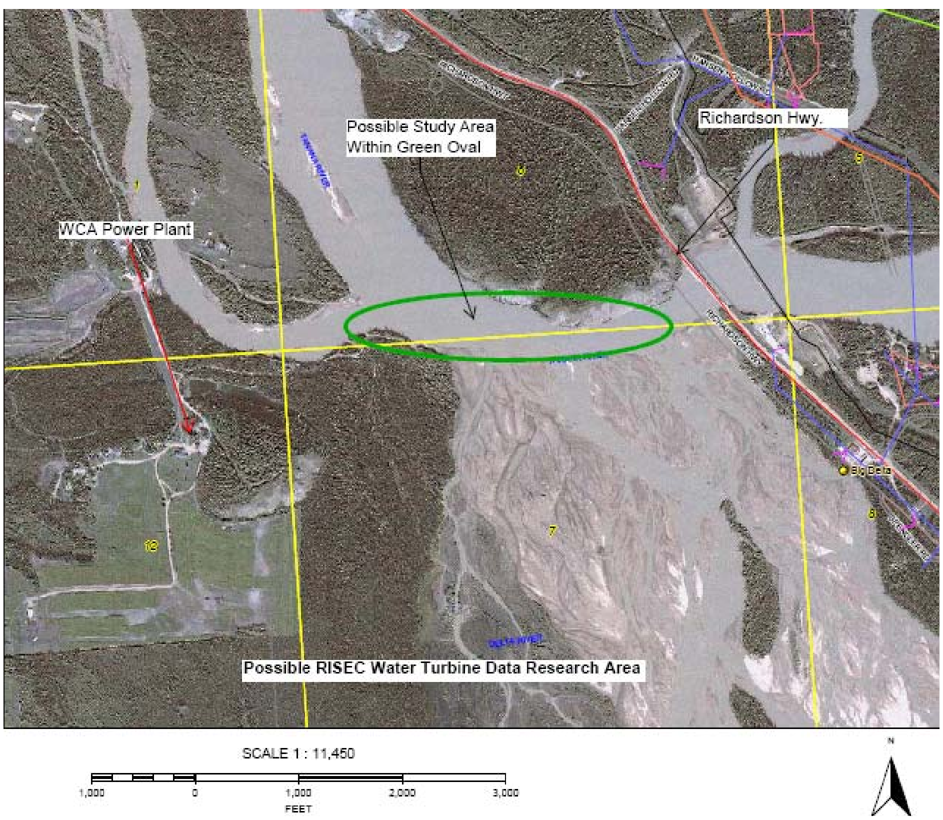


Figure 21: Deployment Site of Interest

4.2. Electrical Interconnections

There are two main grid interconnection options. The first option is interconnecting directly to the isolated grid of the Whitestone community; the second is to connect to the Golden Valley Electric Association (GVEA) grid. The isolated grid at the Whitestone community has a generator capacity of 390kW. A RISEC farm could be connected to the grid at 480V and 12.47kV. The remote portion of the GVEA Intertie, operating at 12.47kV, will likely provide for more substantial feed-in capacity, and could be connected to at Mile 275 Richardson Highway. The following table shows the average and peak loads on the Whitestone isolated grid.

Table 6: Whitestone Community Monthly Load Patterns

Month	Average Load(kW)	Peak Load (kW)
January	115	160
February	120	160
March	120	150
April	120	150
May	110	130
June	90	120
July	90	120
August	90	120
September	110	130
October	115	130
November	115	140
December	120	150

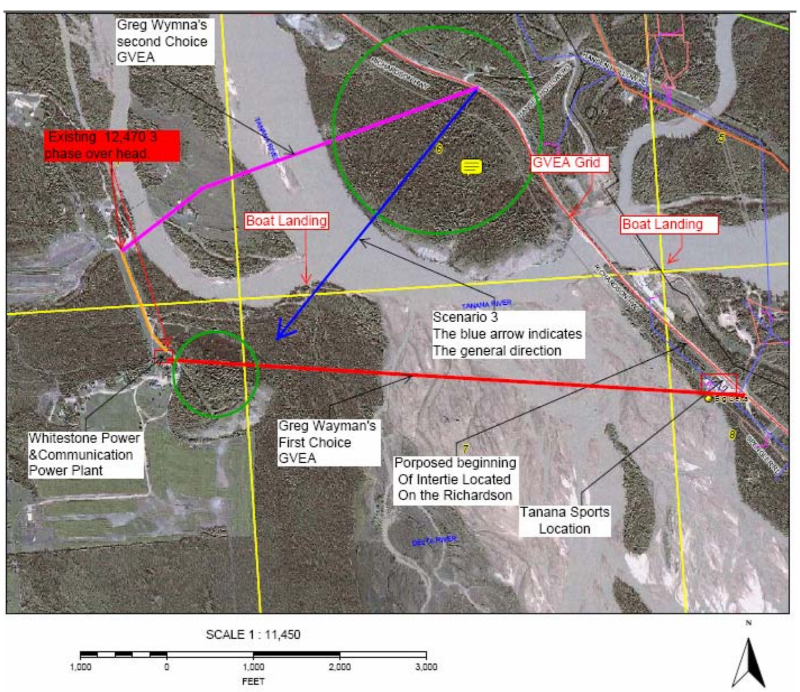


Figure 22: Grid Interconnection Locations

4.3. Other Considerations

Existing Infrastructure

There is one boat ramp located at Mile 275 Richardson Highway between the Tanana River Bridge and the Alyeska Pipeline Bridge. The ramp is wide enough and strong enough to accept any type of heavy equipment and can be used to launch small boats (up to 30 ft). The only bridge near the site is located upstream from the proposed research site at Mile 275 Richardson Highway and is called the Tanana River Bridge. It is a two-lane bridge supported on piers.

There is one mechanic shop located within the boundaries of the WCA. However, the community is only accessible by boat during the summer months. There are three workboats which could be mobilized: two 18-ft. boats and one 25-ft. boat with an 1800 lb. capacity. All are equipped with Honda, 4-stroke, outboard motors. The largest boats operating within this river reach have a draft of 3ft.

During the summer the only available and reliable transportation option is small boats. If the water is at acceptable levels, the Delta River can be crossed using all-terrain track vehicles. The WCA has access to one of these vehicles. In the winter, there is an ice bridge across the Delta River and no limitation of vehicular access.

Ice & Debris

The rivers at Big Delta do not freeze over. Ice breakup, however, affects the area in late April and lasts for about 48 hours. The river is saturated with silt from May through September and is clear for the rest of the year. A significant amount of wood debris is present during the warm months.

Existing Scientific Report

Hydraulic Survey and Scour Assessment of Bridge 524, Tanana River at Big Delta, Alaska By Thomas A. Heinrichs, Dustin E. Langley, Robert L. Burrows, and Jeffrey S. Conaway Prepared in cooperation with the Alaska Department of Transportation and Public Facilities Scientific Investigations Report 2006–5282

4.4. Photographs

Figure 23: TransAlaska Pipeline crossing the Tanana River at BigDelta Junction

Figure 24: Richardson Highway crossing the Tanana River

Figure 25: View onto the Tanana River

4.5. Flow Velocity

The USGS maintains a stream gauging station on the Tanana River near Big Delta (Station# 15478000 Tanana R at Big Delta) with 10 years of daily discharge records (1947-1957). This data was used to establish a data set suitable for evaluating RISEC technology. First a relationship between discharge rate and velocity was established; that relationship function was then applied to the full data set to determine the statistical parameters shown below. It is important to understand that the velocity profiles and associated power densities are only valid for the transect the USGS used to calibrate the flow data and which we used to calibrate the velocity data. Also, since the data was collected (1957), the river bathymetry has probably shifted, and therefore further local calibration may be required to gain more insight into the local flow velocity distributions. Also, no gage height data and very few calibration points were available for that site.

Table 7: USGS station Summary

Name: Tanana River at Big Delta, AK
Station ID: 15478000
Southeast Fairbanks Division, Alaska
Hydrologic Unit Code 19040503
Latitude 64°09'20", Longitude 145°51'00"
Drainage area 13,500 square miles
Gage datum 962.95 feet above sea level

Table 8: Resource Data Overview

Velocities		Unit	
	Average Velocity	m/s	0.98
	Average Mid-Channel Velocity	m/s	1.28
Power			
	X-Section Average Power Density	kW/m^2	0.67
	Mid-Stream Average Power Density	kW/m^2	1.48
	Average Total Kinetic Power	kW	762
Dimensions (During Typical Discharge Conditions)			
	Discharge Rate for Referenced Dimensions	m^3/s	1,167
	Cross-Section	m^2	1,132
	Width	m	169
	Average Depth	m	6.7
	Deepest Point	m	11.9
Discharge			
	Average	m^3/s	421
	Maximum	m^3/s	1,767
	Minimum	m^3/s	105
Maximum Stage Differential		m	NA

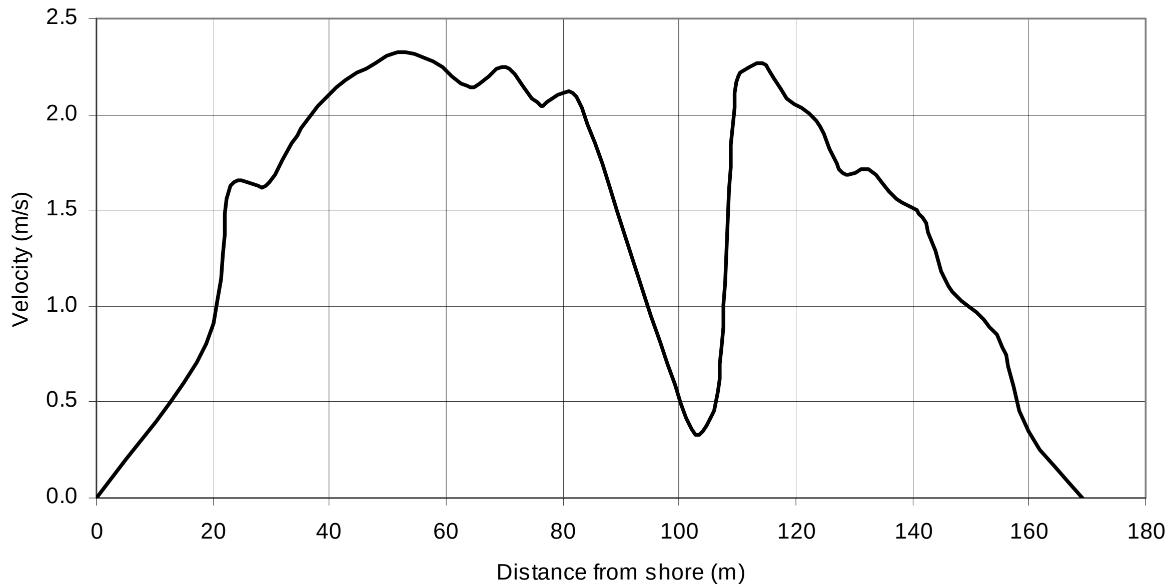


Figure 26: USGS cross-section showing velocity at a discharge rate of 41,200ft^3/s

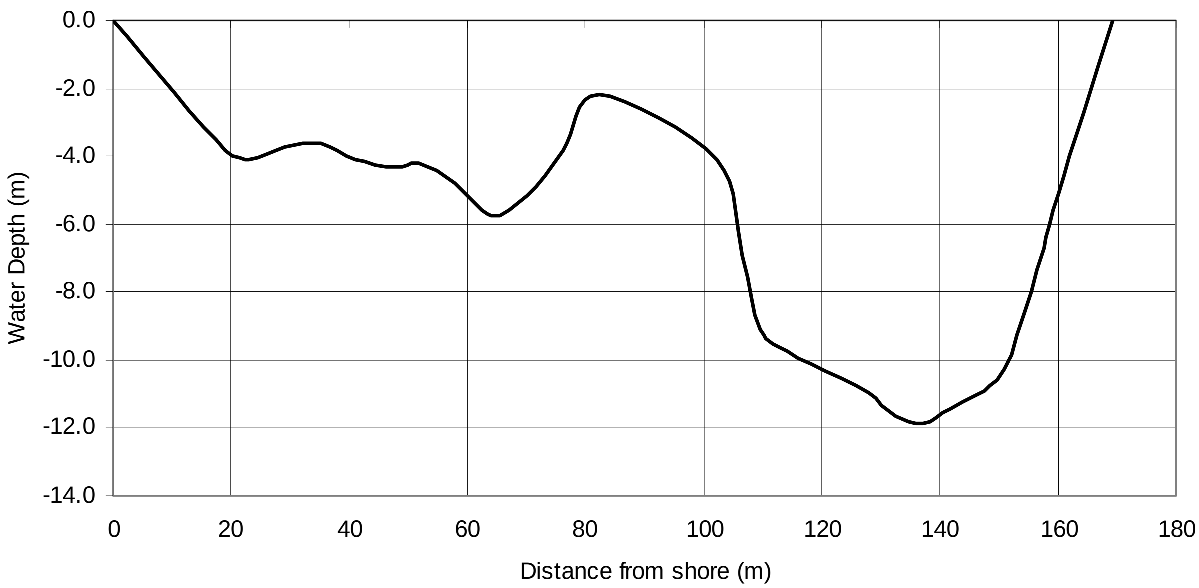


Figure 27: USGS cross-section showing water depth at a discharge rate of 41,200ft^3/s

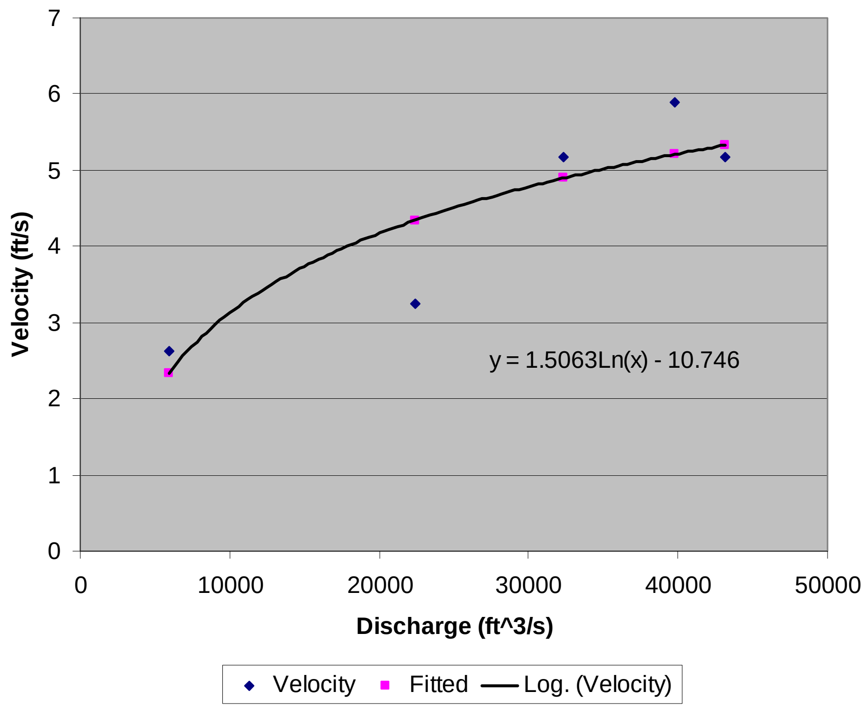


Figure 28: Relationship between Velocity and Discharge Rate

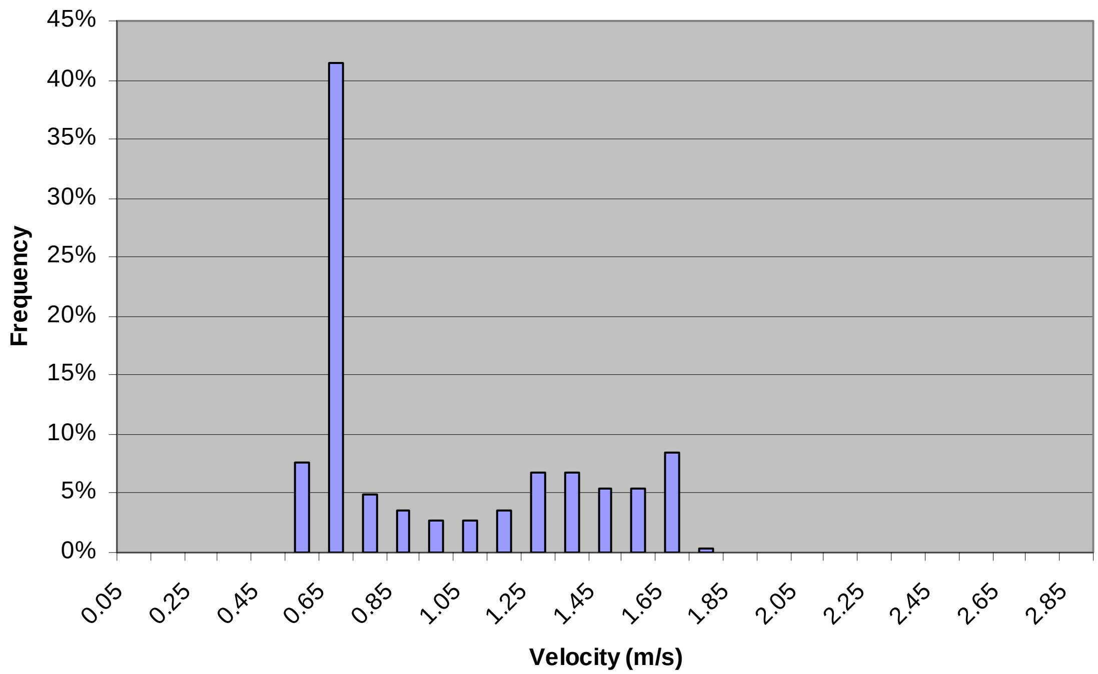


Figure 29: Velocity Distribution at Site

Table 9: Velocity Distribution Table at Site

Speed Bin					
Low (m/s)	Up (m/s)	Mid (m/s)	Dist. %	Power (kW/m^2)	Dist x Power
0.0	0.1	0.1	0%	0.000	0.000
0.1	0.2	0.2	0%	0.002	0.000
0.2	0.3	0.3	0%	0.008	0.000
0.3	0.4	0.4	0%	0.021	0.000
0.4	0.5	0.5	0%	0.046	0.000
0.5	0.6	0.6	8%	0.083	0.006
0.6	0.7	0.7	42%	0.137	0.057
0.7	0.8	0.8	5%	0.211	0.010
0.8	0.9	0.9	4%	0.307	0.011
0.9	1.0	1.0	3%	0.429	0.012
1.0	1.1	1.1	3%	0.579	0.016
1.1	1.2	1.2	4%	0.760	0.027
1.2	1.3	1.3	7%	0.977	0.067
1.3	1.4	1.4	7%	1.230	0.084
1.4	1.5	1.5	5%	1.524	0.083
1.5	1.6	1.6	5%	1.862	0.102
1.6	1.7	1.7	8%	2.246	0.190
1.7	1.8	1.8	0%	2.680	0.007
1.8	1.9	1.9	0%	3.166	0.000
1.9	2.0	2.0	0%	3.707	0.000
2.0	2.1	2.1	0%	4.308	0.000
2.1	2.2	2.2	0%	4.969	0.000
2.2	2.3	2.3	0%	5.695	0.000
2.3	2.4	2.4	0%	6.489	0.000
2.4	2.5	2.5	0%	7.353	0.000
2.5	2.6	2.6	0%	8.291	0.000
2.6	2.7	2.7	0%	9.305	0.000
2.7	2.8	2.8	0%	10.398	0.000
2.8	2.9	2.9	0%	11.575	0.000
Average Power Density (kW/m^2)					**0.673**

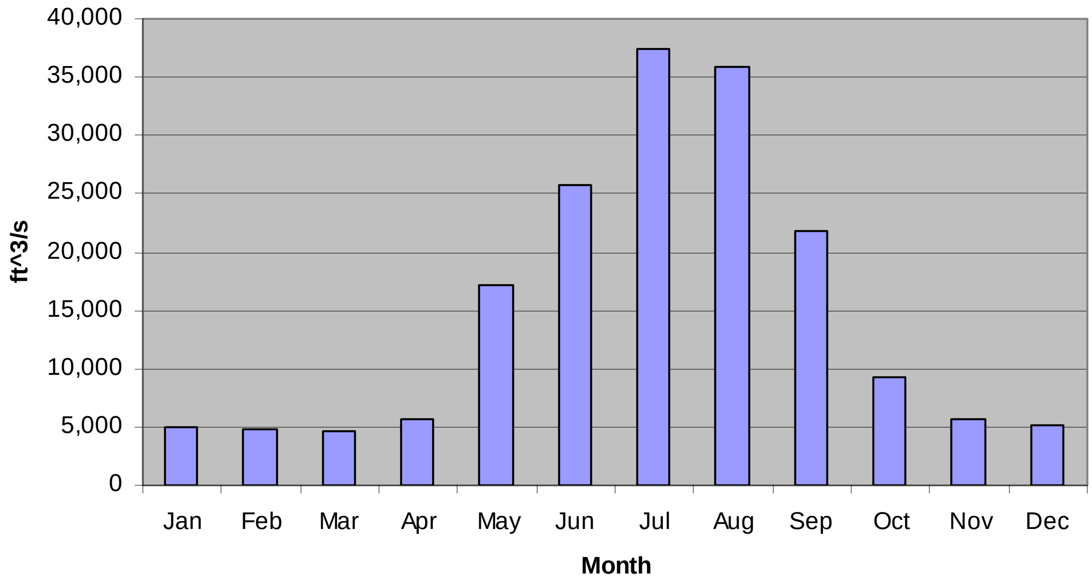


Figure 30: Monthly Average Discharge Rates

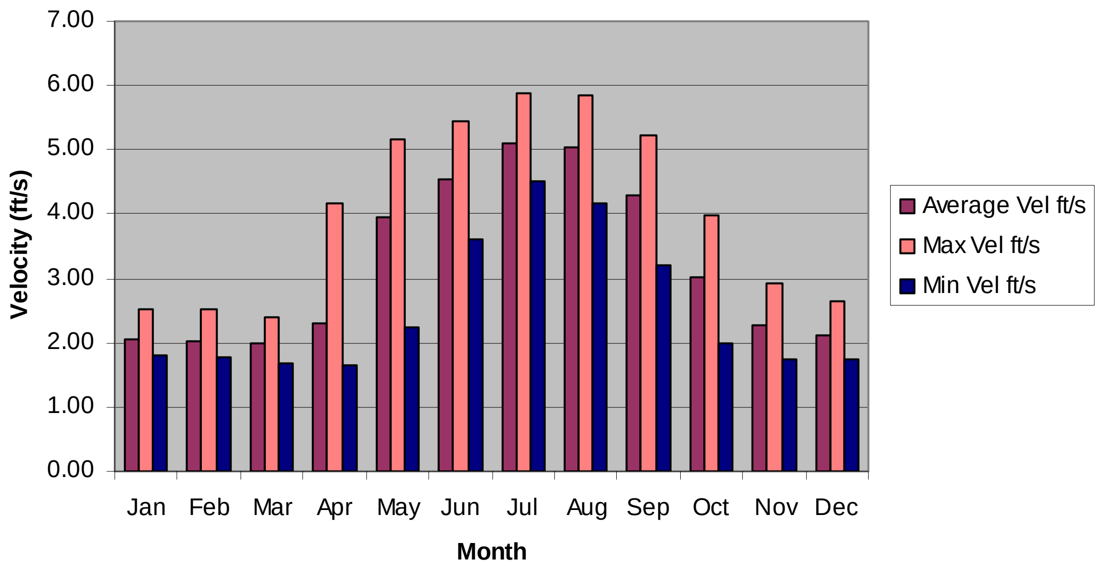


Figure 31: Monthly Velocities at Site

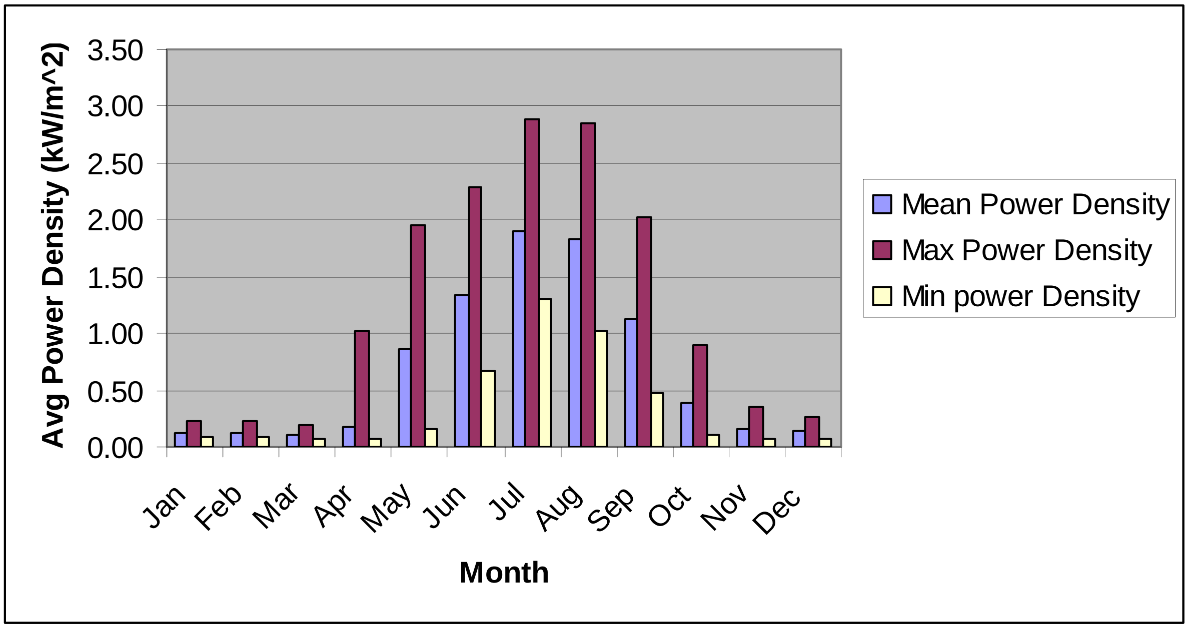


Figure 32: Monthly Power Densities at Site

5. Yukon River at Eagle

5.1 Site Description

Eagle is located on the west bank of the Yukon River, on the north terminus of the Taylor Highway and about 6 miles west of the Alaska-Canada border. Eagle Village, at about 850 feet above sea level, .is located approximately 3 miles upriver from the City of Eagle

Figure 33: Overview map

The Yukon River is located in the middle region of Alaska. The 2,300 mile-long Yukon River is the mother river to the Tanana River and Chena Rivers. The river starts in the Yukon, Canada, and flows through Alaska, emptying into the Bering Sea. The Yukon is one of the largest rivers in North America. The river is very remote with only a few dozen sizeable communities along its entire length. The river was a highway for prospectors during gold rush days (1890's) and continues to be an important river highway. The waters of the Yukon are silty (from glacial melt) most of the year.

Eagle has a state-owned airstrip with commercial flights from Fairbanks, which provides access to this remote community all year long. In summer the small community is also accessible by river boat and via the Taylor Highway.

Figure 34: Google earth view onto airstrip and village

Figure 35: View onto village and Deer island

5.2 Electrical Interconnect

AP&T serves about 190 customers in the two communities (Eagle Village and City of Eagle), providing electricity and communication services. The isolated grid has average loads of 70kW in summer and 150kW in winter. Diesel generators are used to generate electricity and produce an annual fuel consumption of 57,000 gallons.

5.3 Other Considerations

Eagle has a population of about 140, while Eagle Village is home to about 80. Subsistence activities are part of the lifestyle. The local economy includes retail businesses, a school, utilities and mining. Tourism is seasonal, and there is a river boat trip from Eagle to Dawson. Eagle has lodging and restaurants.

The river normally begins to freeze in October, freezing to solid ice with a thickness of 4-8 feet. There is also a frazil ice-layer below the solid ice. Ice breakup normally occurs in April and clears by May. This breakup is potentially destructive, with large pieces of ice scouring the river bottom and edges.

5.4 Photographs

Figure 36: View onto Yukon River at Eagle

Figure 37: Ice jamb during spring breakup. View upstream from Eagle

Figure 38: Ice jamb during spring breakup. View downstream from Eagle

5.5 Flow Velocity

The USGS maintains a stream gauging station on the Yukon River at Eagle, (Station# 15356000 Yukon River at Eagle) with 57 years of daily discharge records (1949-2006). That data was used to establish a data set suitable for evaluating RISEC technology. First a relationship between discharge rate and velocity was established; that relationship function was then applied to the full data set to determine the statistical parameters shown below. It is important to understand that the velocity profiles and associated power densities are only valid for the transect the USGS used to calibrate the flow data and which we used to calibrate the velocity data.

Table 10: USGS station summary

Station Name: Yukon River at Eagle AK
Station ID: 15356000
Southeast Fairbanks Division, Alaska
Hydrologic Unit Code 19040401
Latitude 64°47'22", Longitude 141°11'52"
Drainage area 113,500 square miles
Gage datum 850.00 feet above sea level

Table 11: Resource Data Overview

Velocities		Unit	
	Average Velocity	m/s	1.18
	Average Mid-Channel Velocity	m/s	1.54
Power			
	X-Section Average Power Density	kW/m^2	1.45
	Mid-Stream Average Power Density	kW/m^2	3.20
	Average Total Kinetic Power	kW	4,601
Dimensions (During Typical Discharge Conditions)			
	Discharge Rate for Referenced Dimensions	m^3/s	5,182
	Cross-Section	m^2	3,162
	Width	m	465
	Average Depth	m	6.8
	Deepest Point	m	9.7
Discharge			
	Average	m^3/s	2,363
	Maximum	m^3/s	15,433
	Minimum	m^3/s	204
Maximum Stage Differential		m	14.8

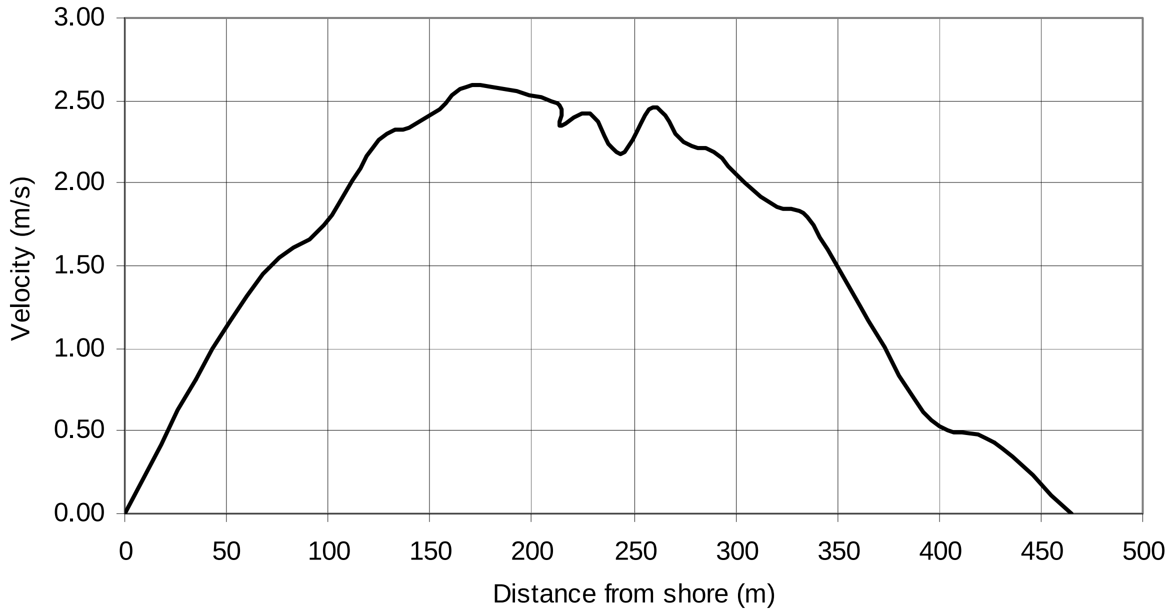


Figure 39: USGS cross-section showing velocity at a discharge rate of 183,000ft^3/s

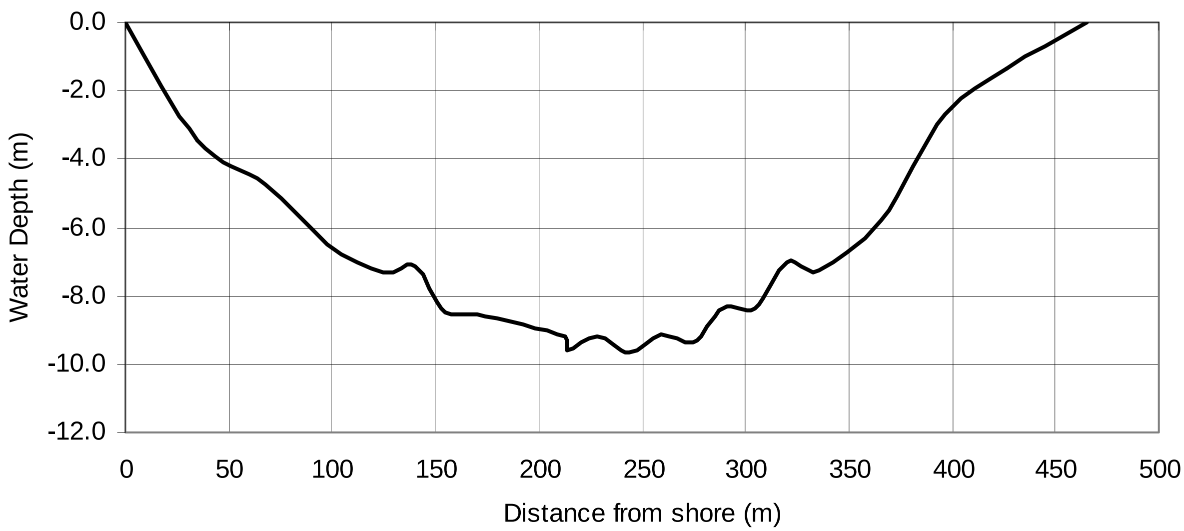


Figure 40: USGS cross-section showing water depth at a discharge rate of 183,000ft^3/s

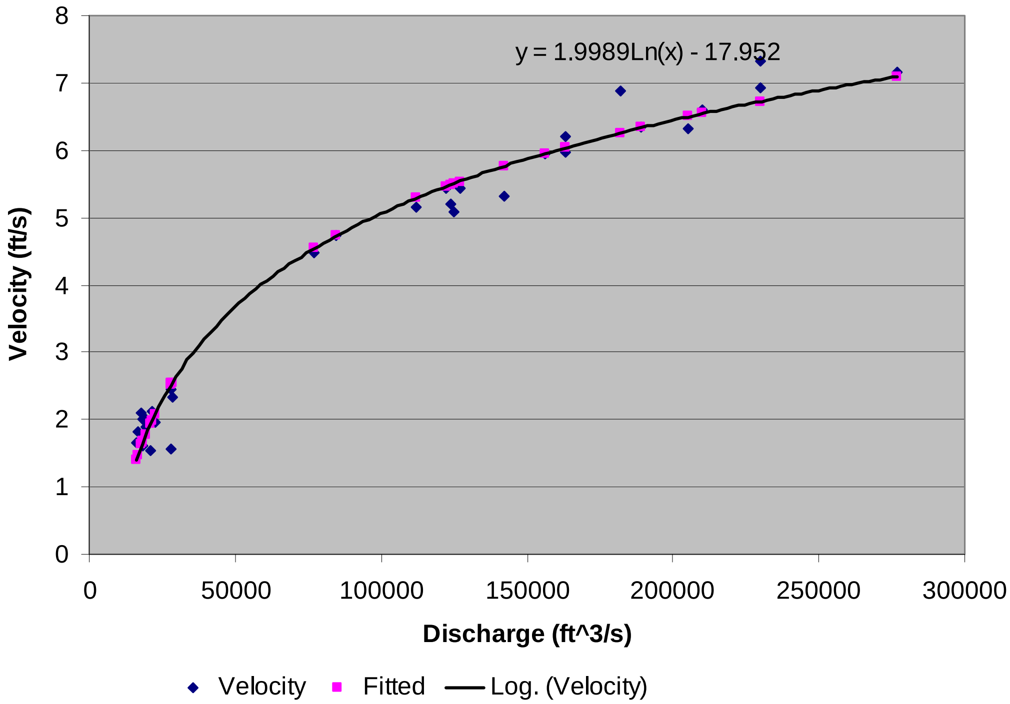


Figure 41: Relationship between Velocity and Discharge Rate

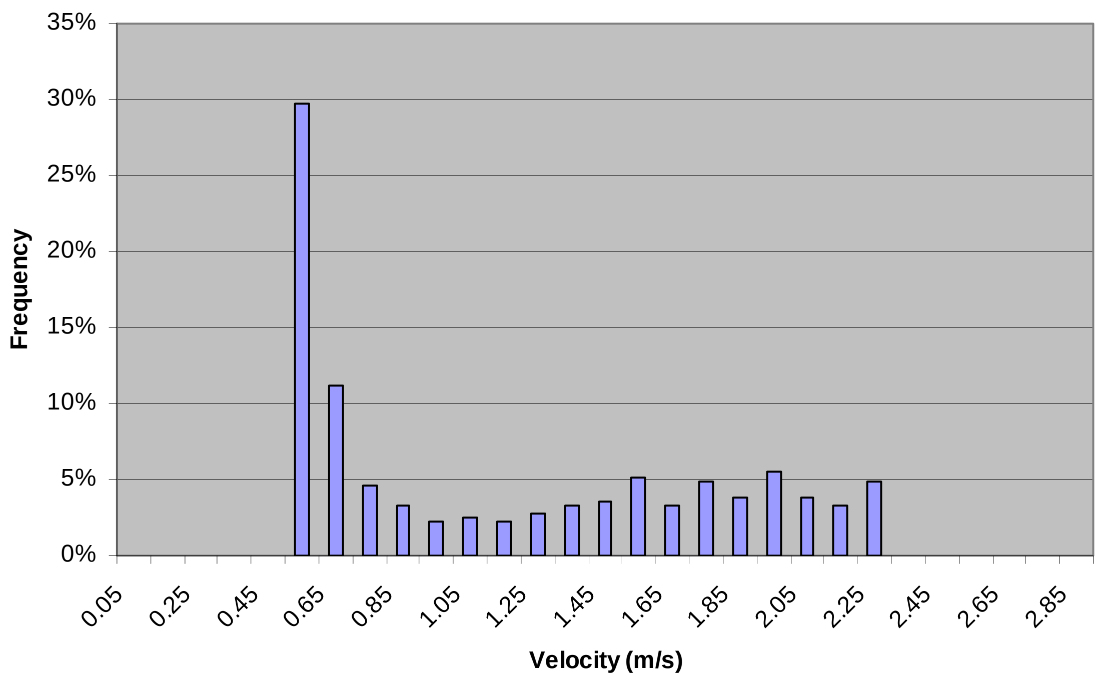


Figure 42: Velocity Distribution at Site

Table 12: Velocity Distribution Table at Site

Speed Bin					
Low (m/s)	Up (m/s)	Mid (m/s)	Dist. %	Power (kW/m^2)	Dist x Power
0.0	0.1	0.1	0%	0.000	0.000
0.1	0.2	0.2	0%	0.002	0.000
0.2	0.3	0.3	0%	0.008	0.000
0.3	0.4	0.4	0%	0.021	0.000
0.4	0.5	0.5	0%	0.046	0.000
0.5	0.6	0.6	30%	0.083	0.025
0.6	0.7	0.7	11%	0.137	0.015
0.7	0.8	0.8	5%	0.211	0.010
0.8	0.9	0.9	3%	0.307	0.010
0.9	1.0	1.0	2%	0.429	0.009
1.0	1.1	1.1	2%	0.579	0.014
1.1	1.2	1.2	2%	0.760	0.017
1.2	1.3	1.3	3%	0.977	0.027
1.3	1.4	1.4	3%	1.230	0.040
1.4	1.5	1.5	4%	1.524	0.054
1.5	1.6	1.6	5%	1.862	0.097
1.6	1.7	1.7	3%	2.246	0.074
1.7	1.8	1.8	5%	2.680	0.132
1.8	1.9	1.9	4%	3.166	0.121
1.9	2.0	2.0	5%	3.707	0.203
2.0	2.1	2.1	4%	4.308	0.165
2.1	2.2	2.2	3%	4.969	0.163
2.2	2.3	2.3	5%	5.695	0.280
2.3	2.4	2.4	0%	6.489	0.000
2.4	2.5	2.5	0%	7.353	0.000
2.5	2.6	2.6	0%	8.291	0.000
2.6	2.7	2.7	0%	9.305	0.000
2.7	2.8	2.8	0%	10.398	0.000
2.8	2.9	2.9	0%	11.575	0.000
Average Power Density (kW/m^2)					**1.455**

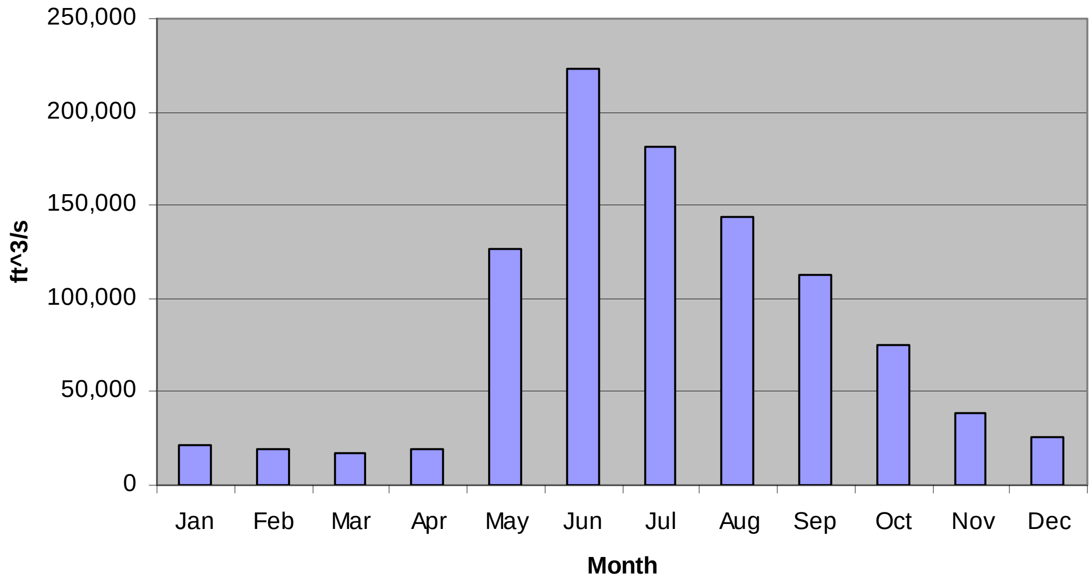


Figure 43: Monthly Average Discharge Rates

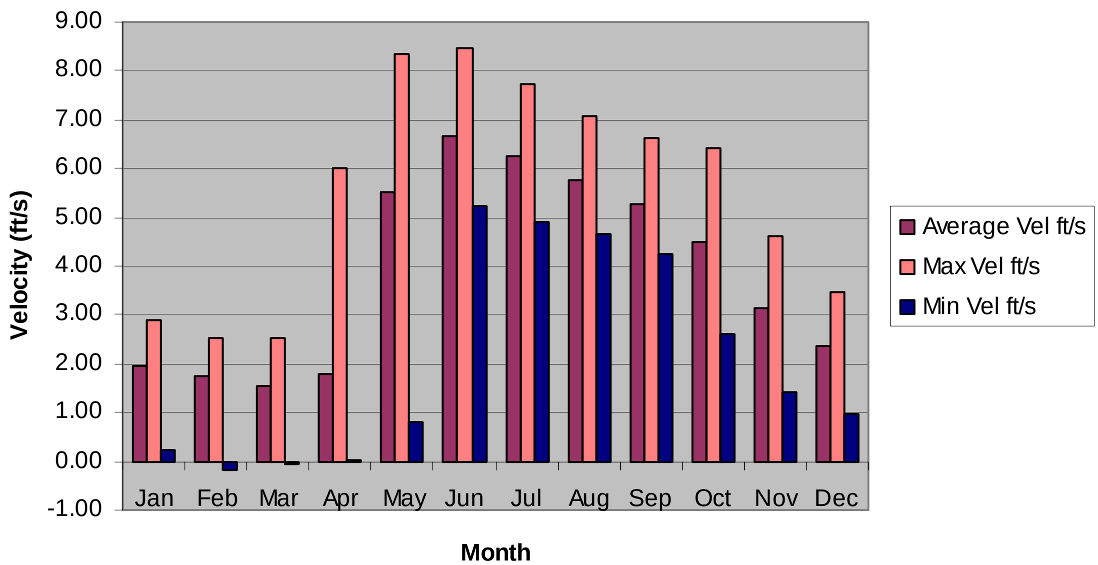


Figure 44: Monthly Velocities at Site

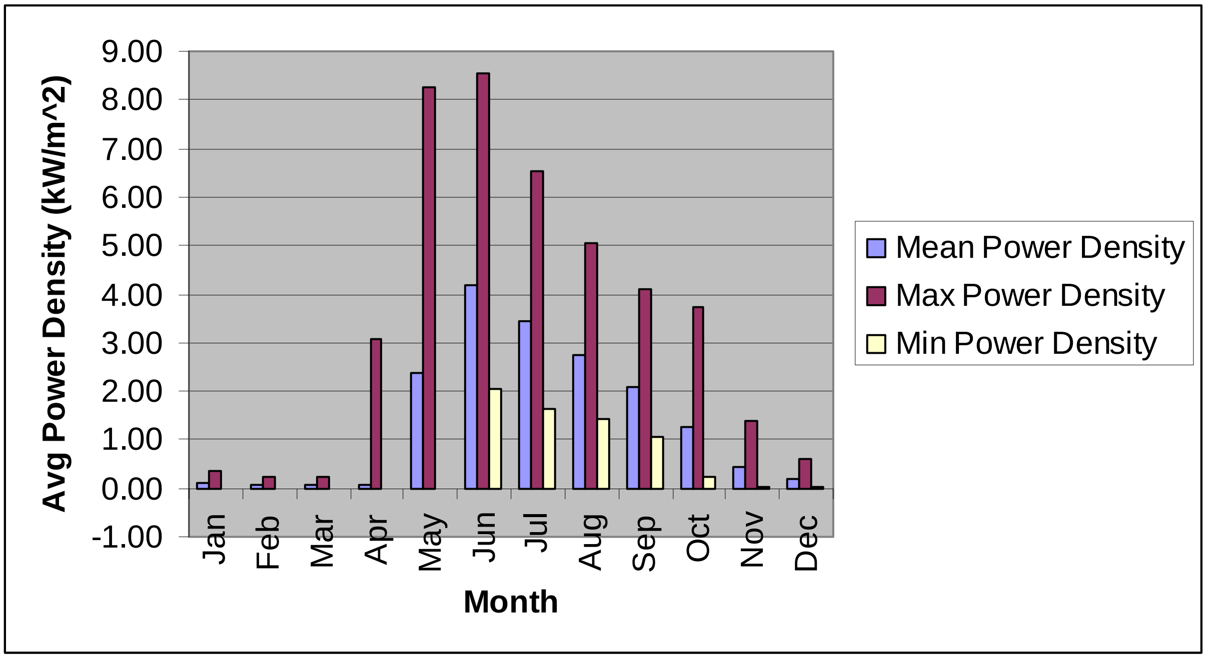


Figure 45: Monthly Average Power Densities at Site

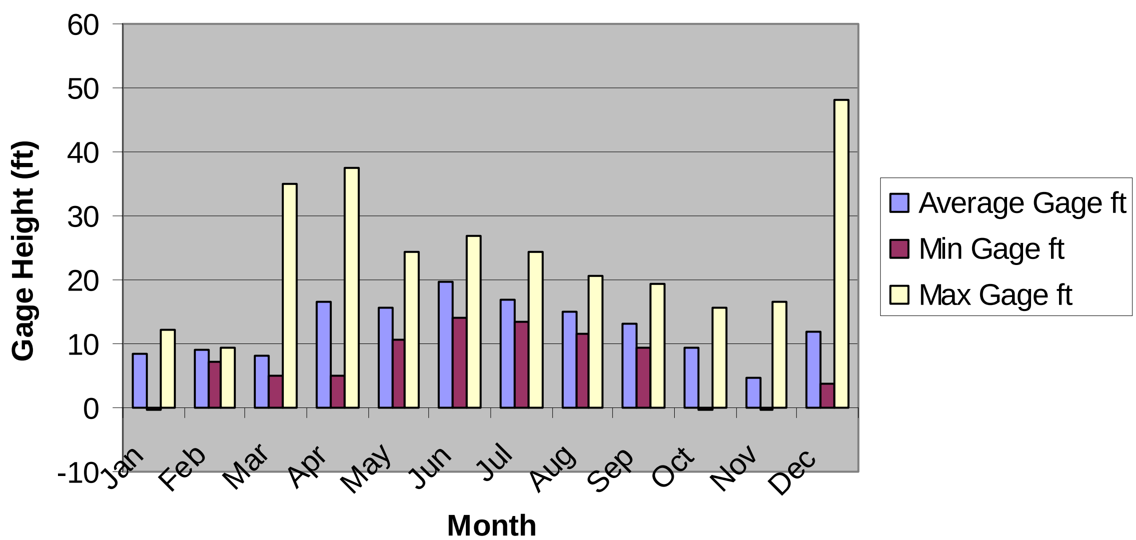


Figure 46: Monthly Gage Height

6. Yukon River at Pilot Station

6.1. Site Description

The Yukon River is located in the middle region of Alaska. The 2,300 mile-long river starts in the Yukon, Canada, and flows through Alaska, emptying in the Bering Sea. The Yukon is one of the largest rivers in North America. The river is very remote, with only a few dozen sizeable communities on its entire length. The river was a highway for prospectors during gold rush days (1890's) and continues to be an important river highway. The waters of the Yukon are silty (from glacial melt) most of the year.

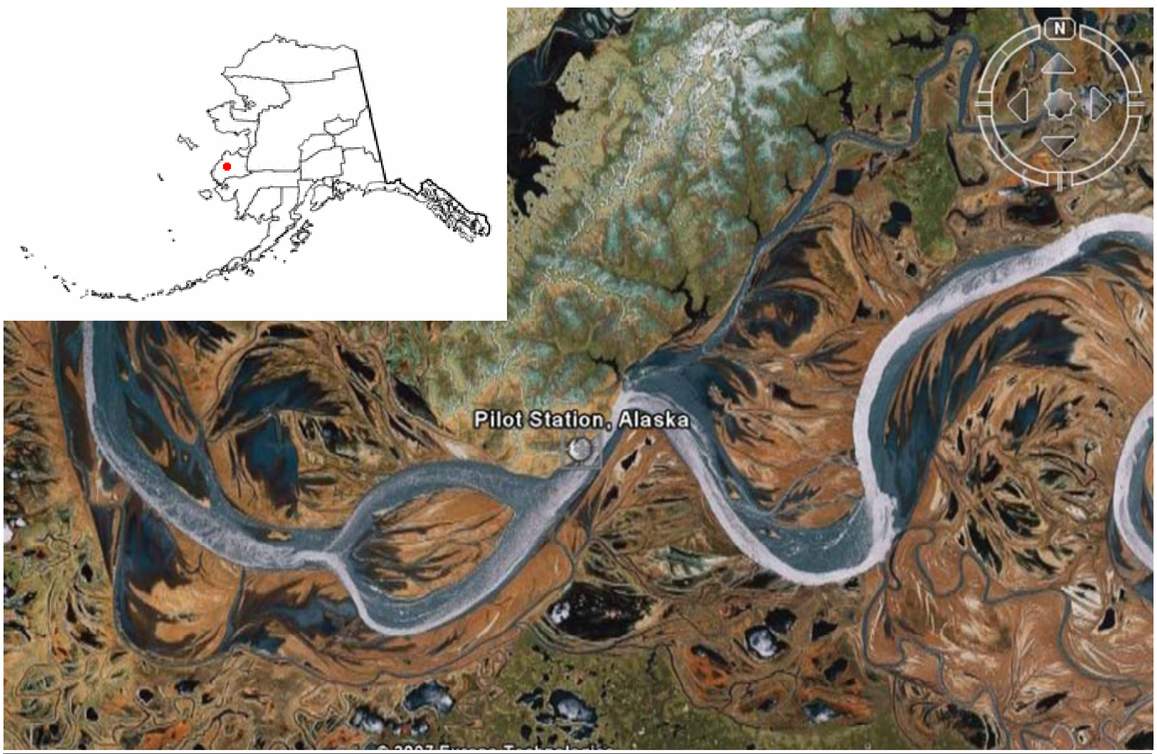


Figure 47: Pilot Station on the Yukon River

6.3. Electrical Interconnection

The Pilot Station power plant is currently equipped with one peak load generator set capable of individually meeting the current peak load requirements. The highest capacity unit is a high-efficiency 1800 RPM Cummins QSX15. Based upon the peak load projections, the power plant will have adequate single engine generation capacity beyond the next four years. The installation of a higher-capacity generator set inside the power plant or inside a future fireproof engine-generator module is currently being deferred beyond the two-year period of this work plan. The Pilot Station power plant is equipped with two remote radiators which provide redundant cooling capacity. There is a heat exchanger and a hydronic heating system for transfer of heat to plant storage facilities. The existing Pilot Station power plant site is subject to flooding. The relocation of the power plant and tank farm to a site above maximum flood level, along with installation of an impermeable liner beneath the tank farm, installation of a fence around the new power plant site, and extension of the fuel fill line, is being deferred. The Pilot Station tank farm has marginal excess useable fuel storage capacity to meet the annual requirements of the next two-year period. The major system improvements completed for the Pilot Station generation and distribution system during the past two-year construction work plan periods include installation of a second remote radiator, connection of all three generator sets to the remote radiator cooling system, installation of a heat exchanger and hydronic heating system, conversion of the generating voltage from 240 volt single-phase to 480 volt three-phase, installation of a new control panel, and installation of a storage van and a ground grid. These improvements have all been completed. Pilot station is currently on an isolated grid. However, AP&T has plans to connect the Pilot station electrical grid with the nearby villages of St. Mary's and Mt. Village. This could provide an opportunity for the development of a RISEC system at a larger scale. The following table provides an overview of the loads in the villages.

Table 13: Load Summary

	Peak Load	Average Load	Minimum Load (estimated)
Pilot Station	385 kW	195 kW	98 kW
St. Mary's	603 kW	339 kW	169 kW
Mt. Village	544 kW	307 kW	153 kW
Total	1,532 kW	841 kW	420 kW

Distribution lines are available in all villages, but a dedicated feeder all the way back to the diesel plant may be good practice. For estimating purposes, one should expect to build 1.5 miles of new distribution lines from a shore-side cable landing to the local grid interconnection point. The grid interconnection voltage is 7.2kV and 12.47kV.

6.4. Other Considerations

Population and Census data

The stated population is in respect to local town and nearby villages that are served by the same distribution grid. AVEC is investigating the possibility of interconnecting the mid-Yukon villages of Pilot Station, St. Mary's and Mt. Village. St. Mary's is currently interconnected to Andreasky and Pitka's Point. This interconnection would consolidate loads that are presently served by three separate diesel generating plants.

Table 14: Population Summary

Village	**Population**
Pilot Station	574
St. Mary's	551
Andreafsky	140
Pitka's Point	109
Mt. Village	796
Total	**2,170**

Local Infrastructure

Motorboats are available locally to carry out installation and operational activities. In some cases, workboats may be available only seasonally. Pilot Station has an airport suitable for small planes that is maintained for year-round VFR operation. The village is served by tugs and barges from the period immediately after ice breakup until fall of each year. As with the rest of rural Alaska, this estimate is subject to change depending on factors such as spring runoff or winter storms.

River bed

The riverbank on the North (village) side of the river may have some instances of cobbles and rocks, based on the surrounding geology, but this requires confirmation. For the most part, the entire riverbed could be described as silt-laden sands. A potential site for an in-stream turbine at Pilto Station is located about one mile upstream from the village at a bend and constriction in the Yukon River. At Mt. Village, the best site for an in-stream turbine may be at the toe of Azachorok Hill, about one mile downstream form the beach barge landing at Mt. Village.

Ice / Sedimentation

Ice breakup begins in May and lasts for two to three weeks, from the time ice begins to move until the main stem is ice-free to the river mouth. The river freezes over again in October. The following table lists the historical dates at which ice started moving. Water clarity in the Yukon is generally poor due to silt. There are instances in which large trees and root wads can be moved downstream during spring runoff or along with ice movement during breakup.

Table 15: Historical ice breakup dates

BREAKUP YEAR	DATE ICE MOVED
1990	05-14
1995	05-09
2001	05-29
2002	05-18
2003	05-15
2004	05-03
2006	05-25

Competing uses of River-space

The deepest commercial vessels that serve the central Yukon do not normally exceed 6-8 feet draft. Deeper draft vessels may navigate the river on occasion, but they are the exception and are attempted only during high water periods in the spring. Vessels hold to the deepest channel in the river to avoid grounding. Awareness of channels is acquired through local knowledge and trial and error, and is subject to change. There are no aids to navigation marking the channel that are similar to what is used on navigable waterways of the continental U.S. At each of the villages served by tug and barge operations, an area in front of the village is required for maneuvering, and the most serviceable beach is used as a landing to offload dry freight and fuel. There may be multiple landing areas in the same village to accommodate different fuel customers (school, electric utility, village, store, etc.).

Environmental Considerations

The Yukon supports runs of King, Coho, Pink, and Chum salmon. It is known that the King Salmon commercial fishery in the lower Yukon River is substantially regulated to prevent over-harvesting of stocks.

Unique Opportunities

AVEC is investigating the possibility of interconnecting the mid-Yukon villages of Pilot Station, St. Mary's and Mt. Village. St. Mary's is currently interconnected to Andreafsky and Pitka's Point. This interconnection would consolidate loads that are presently served by three separate diesel generating plants and may enhance the feasibility of an in-stream turbine project. Peak electrical loads in the area typically occur in the winter months of January and February, with lowest loads in the summer months of June or July. The possible peak load of the communities would be about 1532 KW, and the combined average load is 841 KW. We do not record the lowest demand, but for planning purposes one could use 0.5 of the average demand, or about 420 KW for the combined villages. It is likely that the peak load would occur during the low flow period on the Yukon River, and the low load would occur during the peak flow period on the Yukon. Therefore, the water availability and load needs are mismatched; the question, then, is what portion of the load could be met during low flow periods. If all of the output could be absorbed by the local grid, then the need for storage or power conditioning would be simplified.

6.5. Photographs

Figure 48: Yukon River

6.5. Flow Velocity

The USGS maintains a stream gauging station on the Yukon River at Pilot Station, (Station# 15565447 Yukon River at Pilot Station) with 31 years of daily discharge records (1975-2006). This data was used to establish a data set suitable for evaluating RISEC technology. First a relationship between discharge rate and velocity was established; that relationship function was then applied to the full data set to determine the statistical parameters shown below. It is important to understand that the velocity profiles and associated power densities are only valid for the transect the USGS used to calibrate the flow data and which we used to calibrate the velocity data.

Table 16: USGS station summary

Station Name: Yukon River at Pilot Station, AK
Station ID: 15565447
Wade Hampton Division, Alaska
Hydrologic Unit Code 19040805
Latitude 61°56'04", Longitude 162°52'50" NAD27
Drainage area 321,000 square miles
Gage datum 20.00 feet above sea level

Table 17: Resource Data Overview

Velocities		Unit	
	Average Velocity	m/s	0.49
	Average Mid-Channel Velocity	m/s	0.64
Power			
	X-Section Average Power Density	kW/m^2	0.15
	Mid-Stream Average Power Density	kW/m^2	0.32
	Average Total Kinetic Power	kW	1675
Dimensions (During Typical Discharge Conditions)			
	Discharge Rate for Referenced Dimensions	m^3/s	6,201
	Cross-Section	m^2	11,393
	Width	m	808
	Average Depth	m	14.1
	Deepest Point	m	18.6
Discharge			
	Average	m^3/s	3,989
	Maximum	m^3/s	33,414
	Minimum	m^3/s	204
Maximum Stage Differential		m	29.2

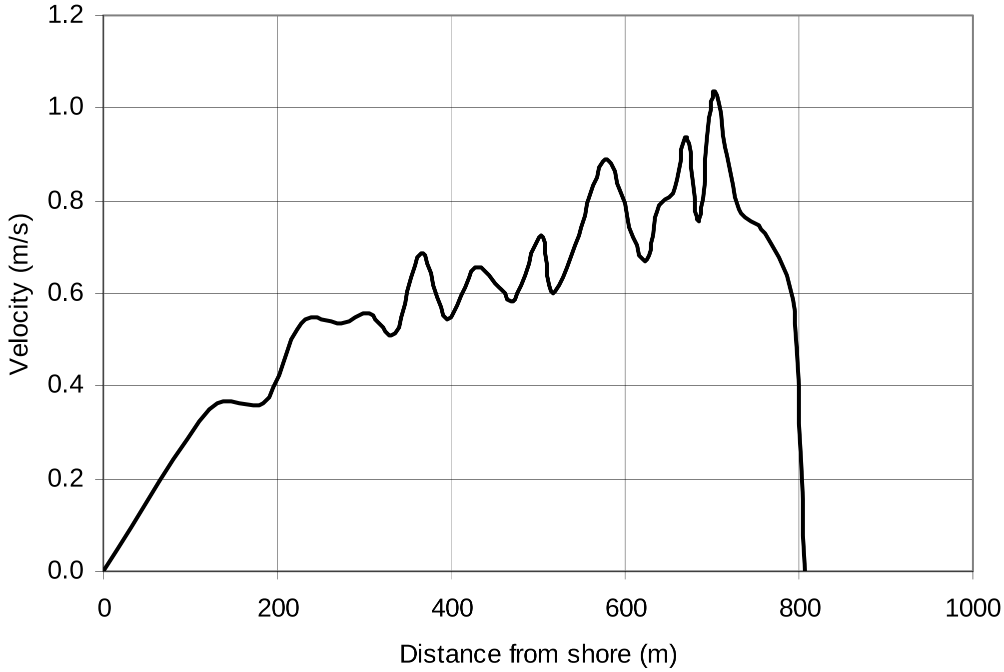


Figure 49: USGS cross-section showing velocity at a discharge rate of 219,000ft^3/s

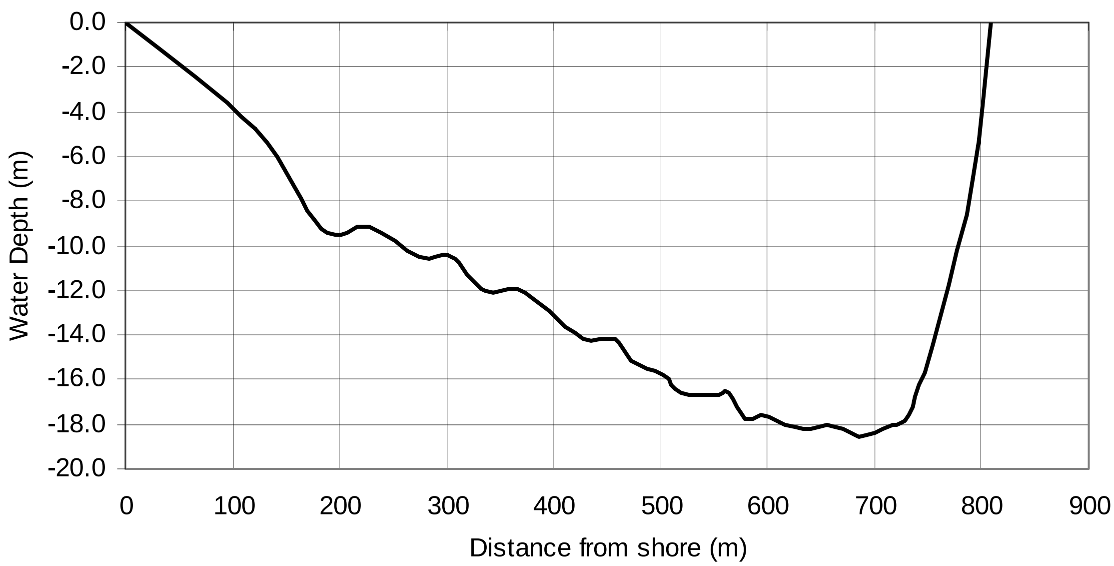


Figure 50: USGS cross-section showing water at a discharge rate of 219,000ft^3/s

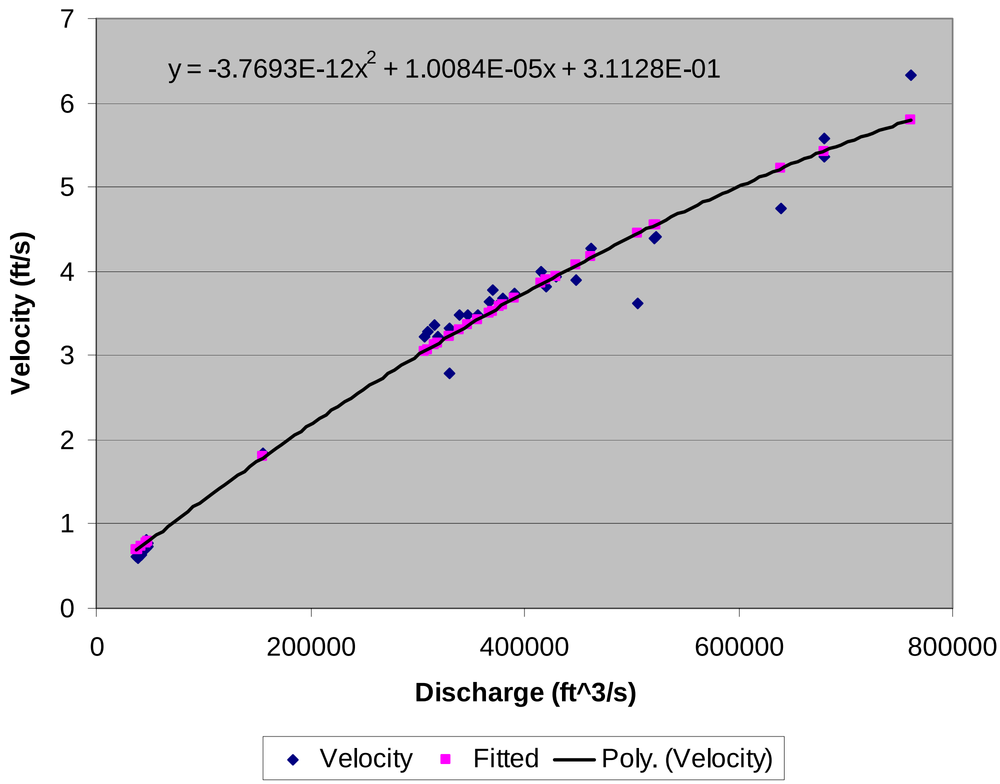


Figure 51: Relationship between Velocity and Discharge Rate

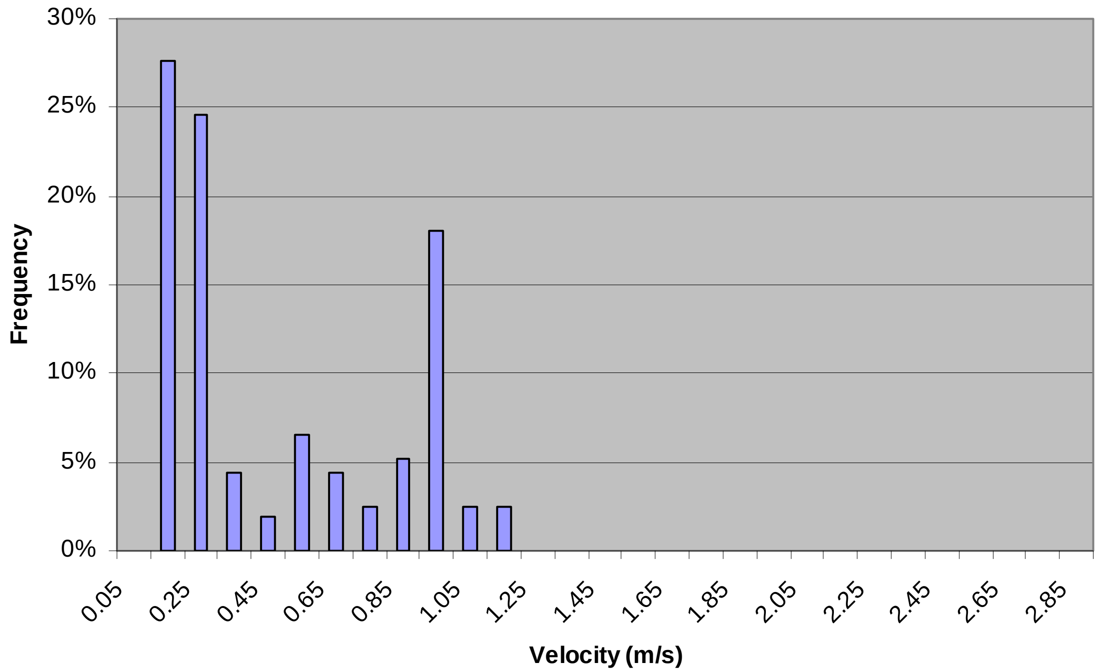


Figure 52: Velocity Distribution at Site

Table 18: Velocity Distribution Table at Site

Speed Bin					
Low (m/s)	Up (m/s)	Mid (m/s)	Dist. %	Power (kW/m^2)	Dist x Power
0.0	0.1	0.1	0%	0.000	0.000
0.1	0.2	0.2	28%	0.002	0.000
0.2	0.3	0.3	25%	0.008	0.002
0.3	0.4	0.4	4%	0.021	0.001
0.4	0.5	0.5	2%	0.046	0.001
0.5	0.6	0.6	7%	0.083	0.005
0.6	0.7	0.7	4%	0.137	0.006
0.7	0.8	0.8	2%	0.211	0.005
0.8	0.9	0.9	5%	0.307	0.016
0.9	1.0	1.0	18%	0.429	0.077
1.0	1.1	1.1	2%	0.579	0.014
1.1	1.2	1.2	2%	0.760	0.019
1.2	1.3	1.3	0%	0.977	0.000
1.3	1.4	1.4	0%	1.230	0.000
1.4	1.5	1.5	0%	1.524	0.000
1.5	1.6	1.6	0%	1.862	0.000
1.6	1.7	1.7	0%	2.246	0.000
1.7	1.8	1.8	0%	2.680	0.000
1.8	1.9	1.9	0%	3.166	0.000
1.9	2.0	2.0	0%	3.707	0.000
2.0	2.1	2.1	0%	4.308	0.000
2.1	2.2	2.2	0%	4.969	0.000
2.2	2.3	2.3	0%	5.695	0.000
2.3	2.4	2.4	0%	6.489	0.000
2.4	2.5	2.5	0%	7.353	0.000
2.5	2.6	2.6	0%	8.291	0.000
2.6	2.7	2.7	0%	9.305	0.000
2.7	2.8	2.8	0%	10.398	0.000
2.8	2.9	2.9	0%	11.575	0.000
Average Power Density (kW/m^2)					**0.147**

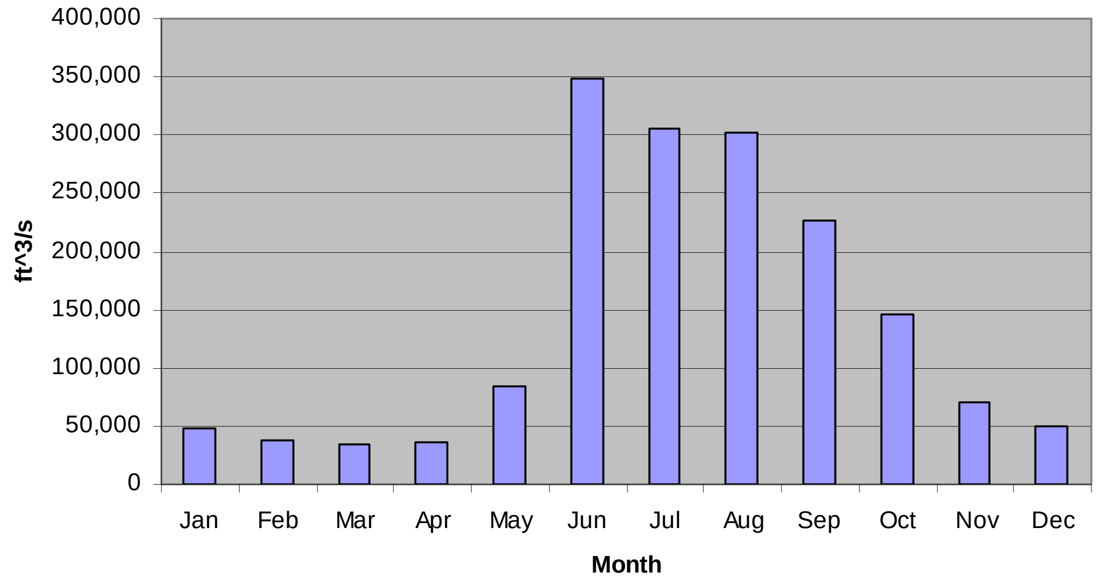


Figure 53: Monthly Average Discharge Rates

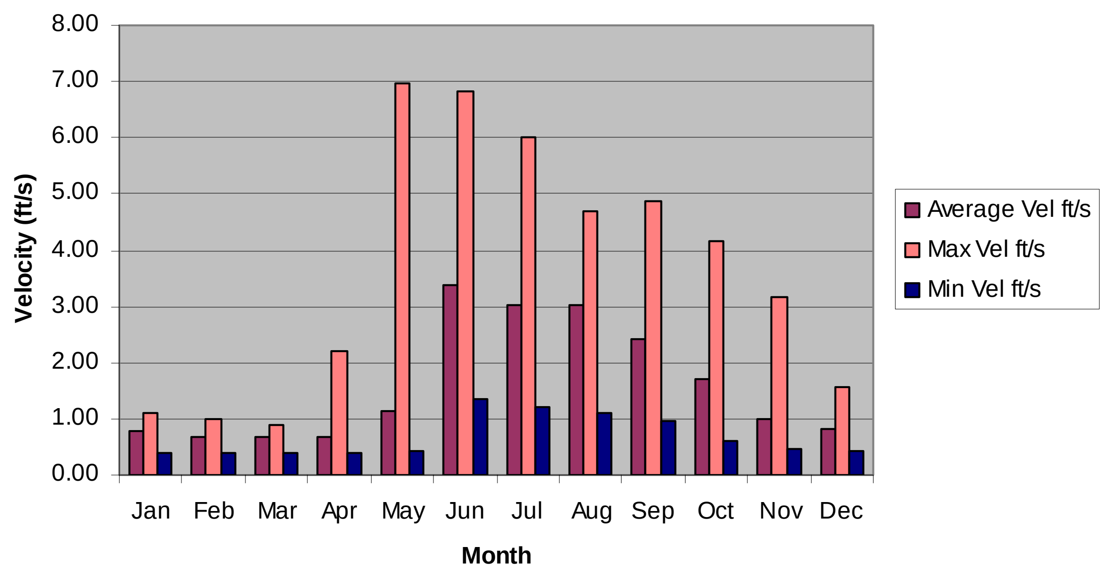


Figure 54: Monthly Velocities

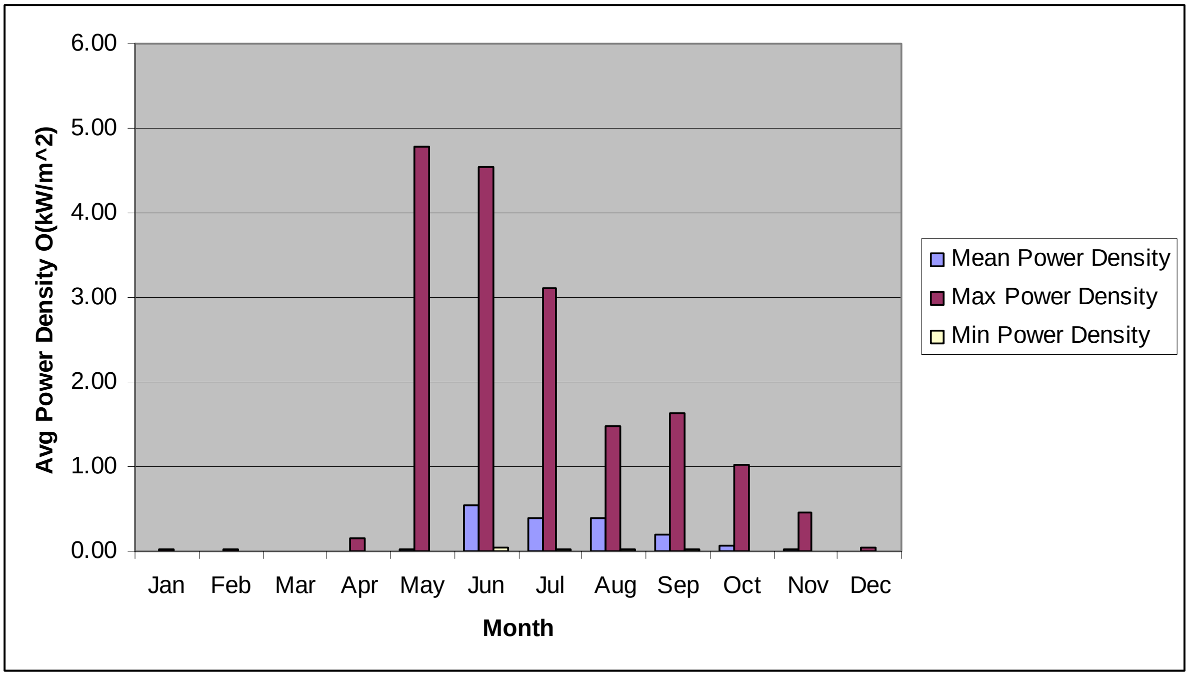


Figure 55: Monthly Power Densities at Site

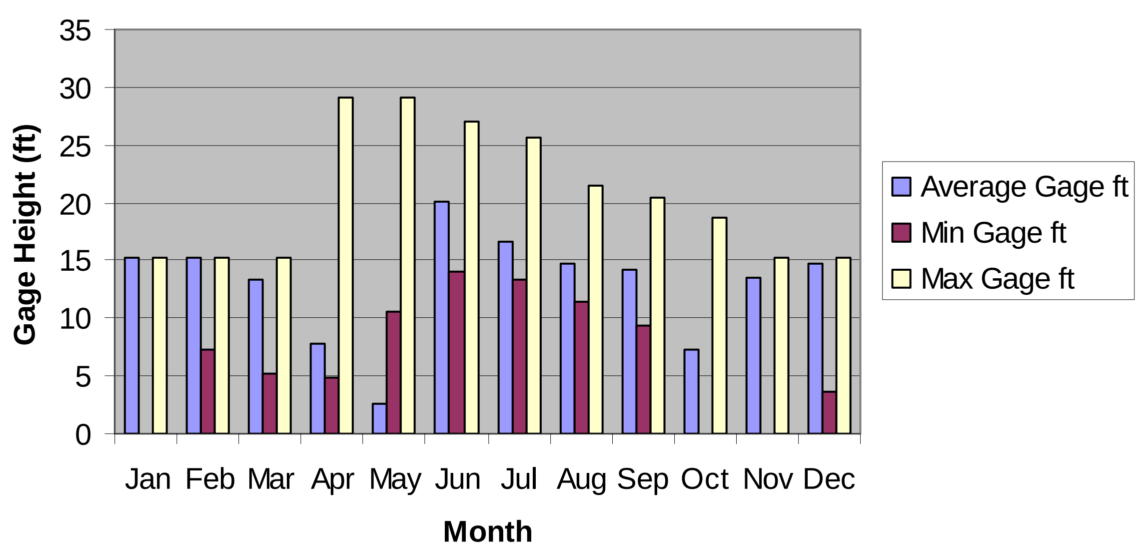


Figure 56: Monthly Gage Height

7. Kvichak River at Igiugig

7.1. Site Description

Igiugig is located on the south shore of the Kvichak River, which flows from Iliamna Lake, on the Alaska Peninsula. It is 50 air miles northeast of King Salmon and 48 miles southwest of Iliamna. Igiugig lies at approximately 59.327780° North Latitude and -155.894720° West Longitude. (Sec. 08, T010S, R039W, Seward Meridian.) It is located in the Iliamna Recording District. The area encompasses 19.8 sq. miles of land and 1.3 sq. miles of water. Igiugig lies within the transitional climatic zone. Average summer temperatures range from 42 to 62; winter temperatures average 6 to 30. The record high is 91, and the record low is -47. Precipitation averages 26 inches annually, including 64 inches of snow.

Igiugig is accessible primarily by water and air. Charter flights are available from Iliamna and King Salmon. The State owns and maintains a 3,000' long by 75' wide gravel runway. A small public dock is available. Barges deliver goods from Naknek or Dillingham in the fall, and Igiugig Corp. operates a barge system on Lake Iliamna.

As is typical for the region, salmon fishing is the mainstay of Igiugig's economy. Five residents hold commercial fishing permits. Many travel to Naknek each summer to fish or work in the canneries. Subsistence is an important part of the residents' lifestyle. Salmon, trout, whitefish, moose, caribou and rabbit are utilized, with some trapping activity. Lake Iliamna is the second largest lake in the U.S., and trophy rainbow trout attract sport fishermen. There are seven commercial lodges in Igiugig that serve sports fishermen and hunters seasonally.

The community of Igiugig is located at 59°19’47”N, 155°54’29”W at the mouth of the Kvichak River as it drains out of Lake Iliamna. Igiugig is a small village (population 56) located in southwestern Alaska, on the south bank of the mouth of the Kvichak River and Lake Iliamna. The village is 48 miles southwest of Iliamna, Alaska, and 56 miles northeast of King Salmon, Alaska. The Village's population consists mainly of Yupik Eskimos, Aleuts, and Athabascan Indians.

Figure 57: Location overview map

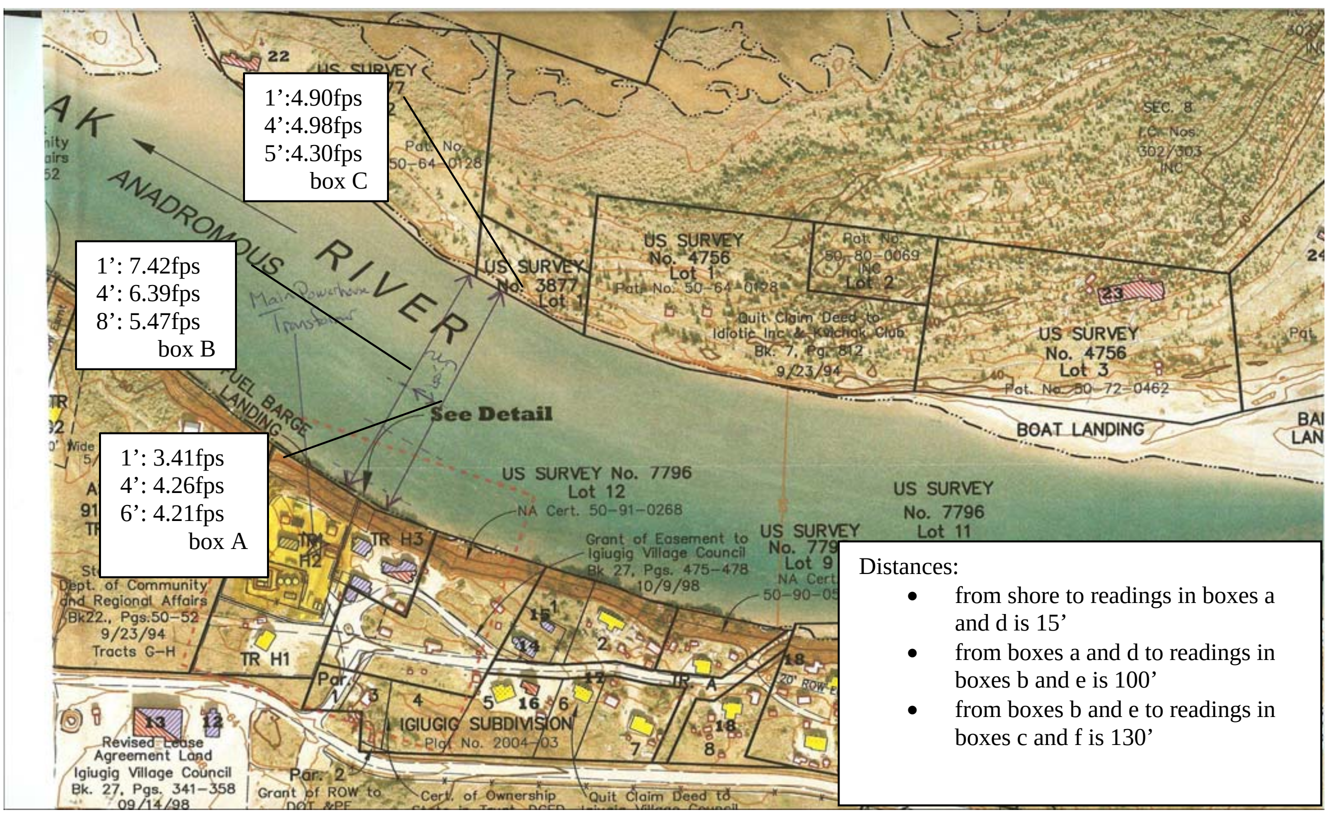


Figure 58: Water velocity readings at proposed site: June 20th 2007

7.2. Electrical Interconnection

The Alaska Energy Authority is preparing a conceptual design report for a powerhouse upgrade at Igiugig. The upgrade is expected to include new Tier II marine gensets and auto synchronized switch gear that interprets loads and integrates proper generator set capacity and operation per load requirement. Design engineers are evaluating alternative energy upgrades in the powerhouse design to ensure cost-efficient implementation, if successful with a hydro potential project.

IEC has three generators ranging from 60 to 100kW that work independently per load, as necessary to energize the community's 7200 volt three-phase distribution system installed in two phases, 1998 and 2002.

Tract H1 (attached community profile map) contains the community powerhouse/bulk fuel facility and illustrates the optimal location of the powerhouse to the river/hydro source for generation and distribution (all within 200' of the rivers edge). Historical load patterns range from 40kW to 95kW with the coldest months of December, January, and February requiring the greatest peak load demands. These demands typically spike morning through afternoon when the local K-12 school is in session. Currently load recorders are gathering data for AEA, and a copy of as-builts of Igiugig Community's distribution system is on file with AEA.

7.3. Other Considerations

Population and Census Data

Currently Igiugig has 56 year-round residents with a summer population of 75, and provides goods and services to six area tourism lodges and their respective clientele and workforce of 90 additional persons per week. Igiugig is a distribution hub for bulk fuel, propane, barging services, a DEC Class III landfill, public water/wastewater distribution system, washeteria, health clinic, and airport expediting covering an area exceeding 25 square miles.

Local Infrastructure

Igiugig Village Council has an extensive infrastructure. The community has a 3300-foot airport runway with AWOS and GPS approach. Barge service via Bristol Bay is available August through September most years. The community is barge accessible for Anchorage/Kenai/Homer May through

October via the Pile Bay/Williamsport Road, and across Lake Iliamna all years. The IVC owns a 30' x 80' FlexiFloat flat deck barge capable of carrying 225,000 pounds and distributes 90% of non fuel-related goods for all the communities and businesses of the Lake Iliamna region. Local residents have multiple 32'x13' aluminum 450HP plus diesel-powered fishing boats that pull or push the FlexiFloat when needed. Many power skiffs ranging from 18' to 24' and 80 to 150HP are available as well to assist in any potential installation and/or operational activities.

IVC is an owner of a tribally owned heavy construction firm, Iliamna Lake Contractors LLC, and has access to a large inventory of heavy equipment that is fully operational, modern and well maintained, including:

- Cat 330 and 320 excavator
- Cat 966 and 950 loaders, buckets and forks
- 10 yard cement truck and fill hopper
- Cat 163 grader and JD 572 grader
- Numerous 10/12 yard end dumps, 20 yard Cat D300E articulating dump
- Plasma cutter/welders, aluminum, steel, etc.
- Cat D7, Cat D6, Cat D4, 2 JD 450 dozer/backhoes
- 40' Boom Truck, 15,000 lb. crane
- Numerous light and heavy power tools, winches, etc.

All of the above can operate off of FlexiFloat barge.

River Bed

The Kvichak River bed consists of a fine silt base and an overburden of cobbles, rocks and gravel, depending on current and location of river width. Directly adjacent to the powerhouse the river expends its greatest velocity and/or gradient as it leaves Lake Iliamna and winds down the "cut-bank." The riverbed here is characterized by rocks approximately 6"- 12" in diameter interlaced with stones, sand, and gravel for a protective barrier to the underlying silts. River width at this location is approximately 437 feet.

Ice

Ice formation may occur from November through February, and is periodic as the high current and large volume of moving water typically precludes its retention. Total river freeze-over is rare at this location and usually requires a freeze/thaw/wind event to push ice out of the lake and fill the river. Twenty-five years of local experience estimates that this portion of the river is frozen over completely less than two weeks of the year. Some years no ice has formed or discharged down the Kvichak. Spring breakup usually occurs March through May, with ice passage lasting approximately two to three weeks. Thickness of passing ice ranges from 3” to 4’.

River depth raises approximately 4 to 6 feet in depth May through October with temporary wind-driven increases of an additional 6” to 2’. Greatest depths occur in late fall (September/October) and lowest depth after ice cover loss on Lake Iliamna in April/May. Please note attachment 2 obtained from ADF&G Smolt Sonar Coordinator Fred West. The higher averages f/sec was obtained at a camp located 3.6km to the outlet of Lake Iliamna. Our site is approximately .2km below the outlet of Lake Iliamna.

Water Clarity/Suspended Sediments

Water clarity is extremely clear during periods of calm wind with visual bottom observation possible at 10 feet or more. Prevailing east winds may increase turbidity with organics and silt, but these readily settle depending on direction and change of wind speed. The Kvichak River has little to no large debris, as sparse vegetation and its close proximity to the outlet doesn’t allow these obstructions to accumulate. The west end of Lake Iliamna is virtually free of large debris.

Competing Uses of River-space

The Kvichak River is a navigable waterway that allows a range of marine traffic from a skiff to a LCM barge that may draw up to 8’. Directly adjacent to the powerhouse, traffic is minimal due to the heavy current and lack of infrastructure requiring access.

Environmental Considerations

The Kvichak River supports populations of all five species of Alaska Salmon, as well as an abundant stock of Rainbow Trout, Grayling, Dolly Varden, Whitefish, Pike, Ling Cod, etc. Annual smolt outmigration generally occurs in May/June for approximately three weeks, with peak passage occurring in the cover of nightfall. Mitigation efforts to deflect fish passage, removal or shutdown of equipment may be required to manage potential conflicts.

Unique Opportunities

IEC, a sustainable operation for over 25 years, will ensure success if considered for a hydroelectric study in new technologies. Management, accounting, and maintenance staff have a combined 65 years experience with this utilities operation and distribution. IEC Manager Dan Salmon has worked 14+ summers as an ADF&G fisheries technician during salmon smolt outmigration and adult spawning return on this section of the river and will be directly involved with mitigation efforts and timely deployment of proposed technology. Locally available heavy equipment, suitable barge and numerous boats will provide safe and cost-effective deployment and maintenance. The local utilities powerhouse and distribution proximity to the proposed site is optimal and cost-efficient for this study to occur. The Kvichak River’s clarity, debris-free, lack of ice coverage and discharge are all characteristics conducive to minimal disturbance and effective operation of proposed technology. Lastly, IEC’s stage of powerhouse upgrade engineering, its recent distribution network of 7200V 3-phase underground upgrade, and a guaranteed $50,000.00 cash match from the community will provide a vested interest and guarantee the success of this proposed project.

7.4. Photographs

Figure 59: Landing strip at Igiugig

7.5. Flow Velocity

The USGS maintains a stream gauging station on the Kvichak River at Igiugig (Station# 15300500 Kvichak River at Igiugig), with 21 years of daily discharge records over the period between 1966 and 1987. That data was used to establish a data set suitable for evaluating RISEC technology. First a relationship between discharge rate and velocity was established; that relationship function was then applied to the full data set to determine the statistical parameters shown below. It is important to understand that the velocity profiles and associated power densities are only valid for the transect the USGS used to calibrate the flow data and which we used to calibrate the velocity data.

Table 19: USGS Station Summary

Station Name: Kvichak River at Igiugig, AK
Station ID: 15300500
Lake And Peninsula Borough, Alaska
Hydrologic Unit Code 19030206
Latitude 59°19'44", Longitude 155°53'57"
Drainage area 6,500.00 square miles
Gage datum 45.00 feet above sea level

Table 20: Resource Data Overview

		Unit	
Velocities		Unit	
	Average Velocity	m/s	1.41
	Average Mid-Channel Velocity	m/s	1.84
Power			
	X-Section Average Power Density	kW/m^2	1.48
	Mid-Stream Average Power Density	kW/m^2	3.24
	Average Total Kinetic Power	kW	719
Dimensions (During Typical Discharge Conditions)			
	Discharge Rate for Referenced Dimensions	m^3/s	487
	Cross-Section	m^2	365
	Width	m	152
	Average Depth	m	2.4
	Deepest Point	m	3.7
Discharge			
	Average	m^3/s	507
	Maximum	m^3/s	1,277
	Minimum	m^3/s	181
Maximum Stage Differential		m	NA

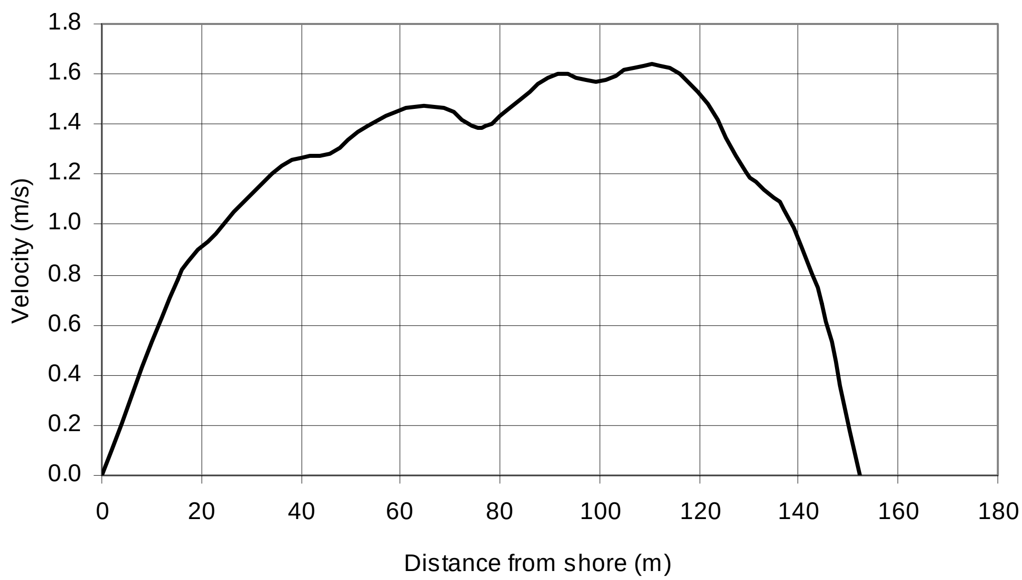


Figure 60: USGS cross-section showing velocity at a discharge rate of 17,200ft^3/s

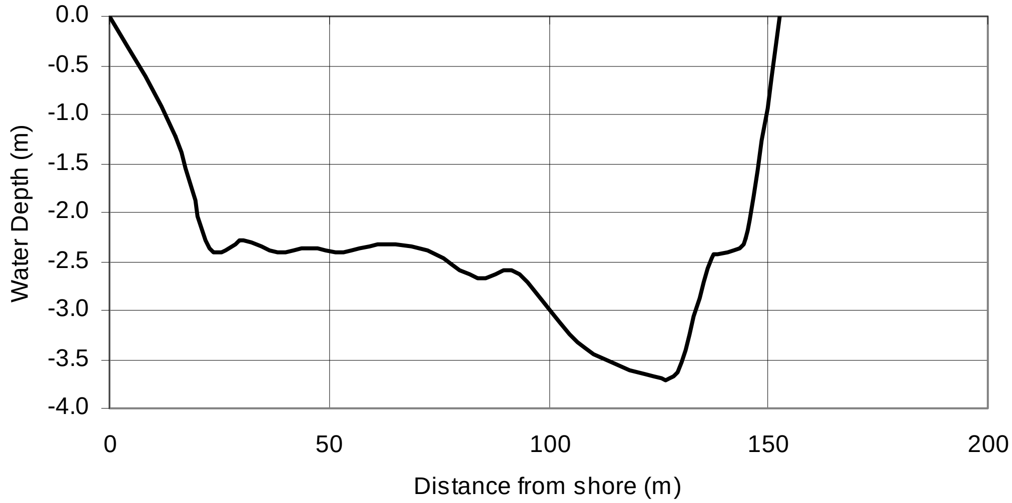


Figure 61: USGS cross-section showing water depth at a discharge rate of 17,200ft^3/s

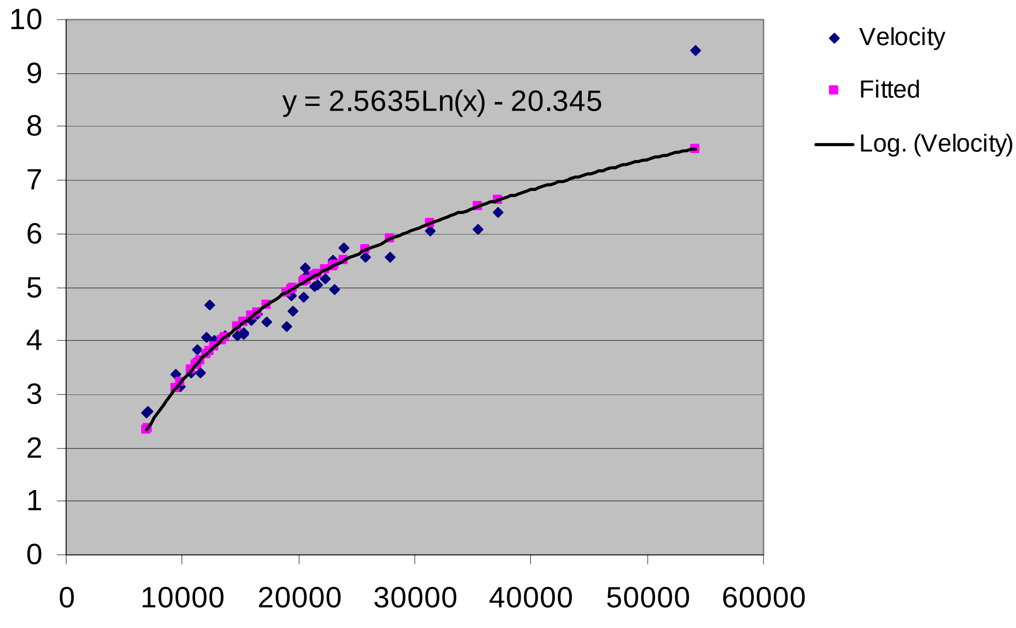


Figure 62: Relationship between Velocity and Discharge Rate

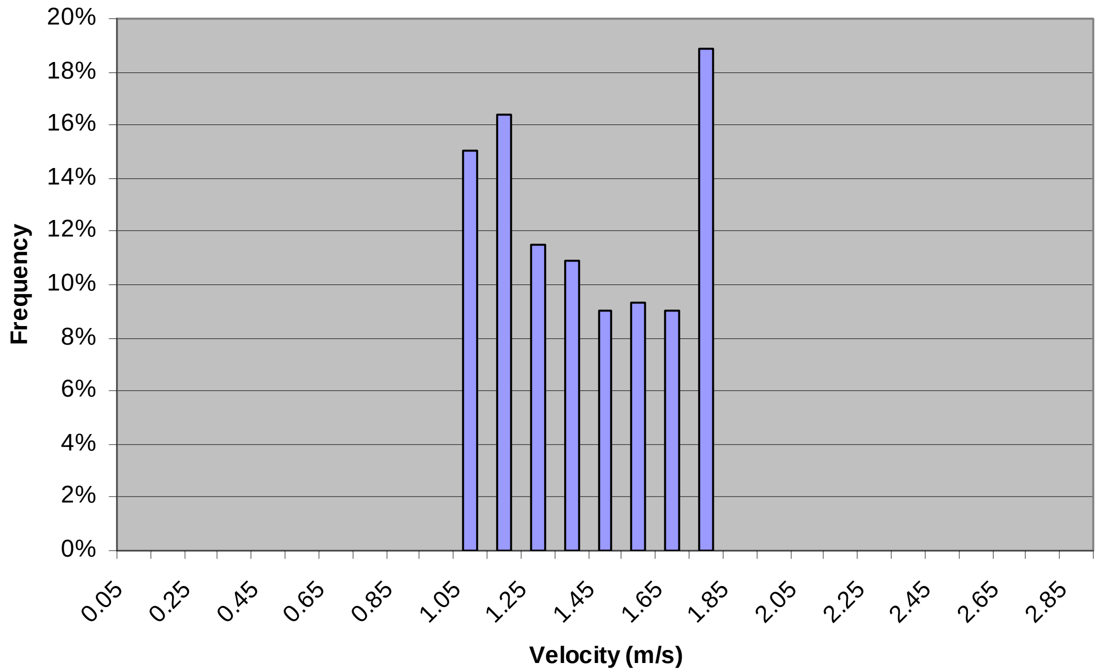


Figure 63: Velocity Distribution at Site

Table 21: Velocity Distribution Table at Site

Speed Bin					
Low (m/s)	Up (m/s)	Mid (m/s)	Dist. %	Power (kW/m^2)	Dist x Power
0.0	0.1	0.1	0%	0.000	0.000
0.1	0.2	0.2	0%	0.002	0.000
0.2	0.3	0.3	0%	0.008	0.000
0.3	0.4	0.4	0%	0.021	0.000
0.4	0.5	0.5	0%	0.046	0.000
0.5	0.6	0.6	0%	0.083	0.000
0.6	0.7	0.7	0%	0.137	0.000
0.7	0.8	0.8	0%	0.211	0.000
0.8	0.9	0.9	0%	0.307	0.000
0.9	1.0	1.0	0%	0.429	0.000
1.0	1.1	1.1	15%	0.579	0.087
1.1	1.2	1.2	16%	0.760	0.125
1.2	1.3	1.3	11%	0.977	0.112
1.3	1.4	1.4	11%	1.230	0.134
1.4	1.5	1.5	9%	1.524	0.137
1.5	1.6	1.6	9%	1.862	0.173
1.6	1.7	1.7	9%	2.246	0.203
1.7	1.8	1.8	19%	2.680	0.505
1.8	1.9	1.9	0%	3.166	0.000
1.9	2.0	2.0	0%	3.707	0.000
2.0	2.1	2.1	0%	4.308	0.000
2.1	2.2	2.2	0%	4.969	0.000
2.2	2.3	2.3	0%	5.695	0.000
2.3	2.4	2.4	0%	6.489	0.000
2.4	2.5	2.5	0%	7.353	0.000
2.5	2.6	2.6	0%	8.291	0.000
2.6	2.7	2.7	0%	9.305	0.000
2.7	2.8	2.8	0%	10.398	0.000
2.8	2.9	2.9	0%	11.575	0.000
Average Power Density (kW/m^2)					**1.476**

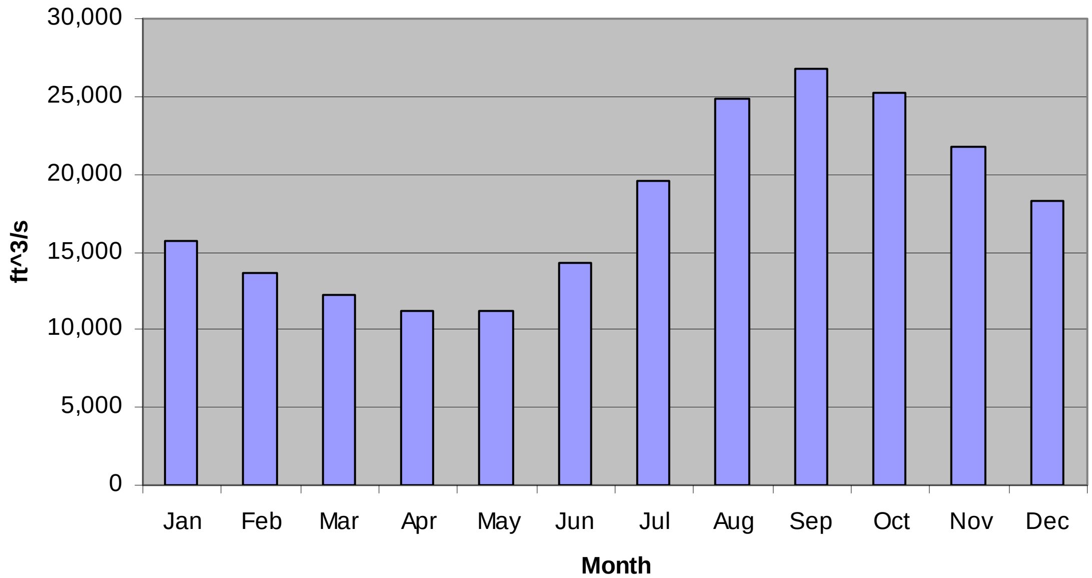


Figure 64: Monthly Average Discharge Rates

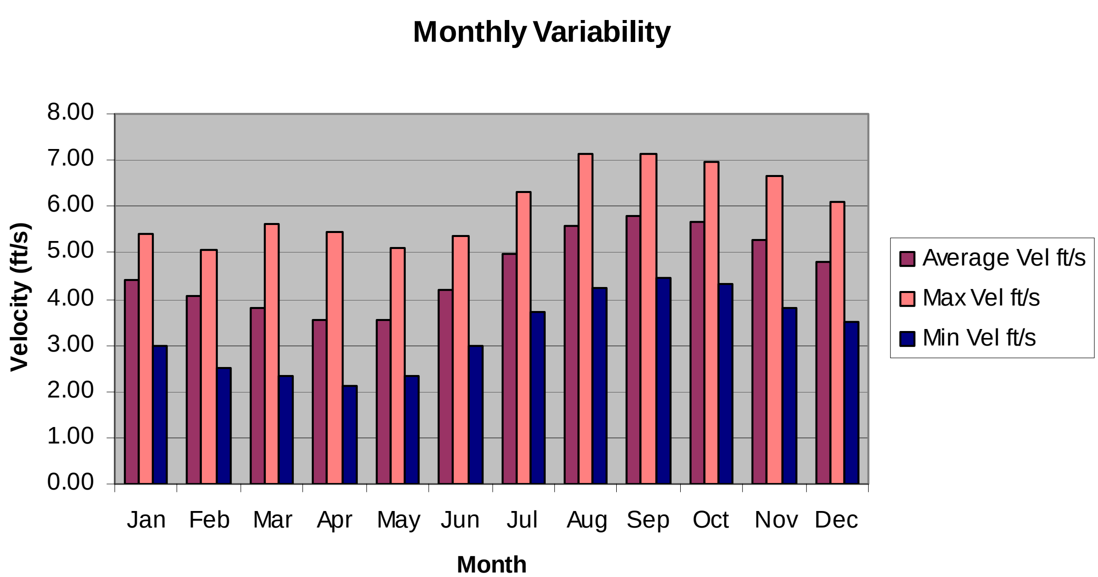


Figure 65: Monthly Velocities at Site

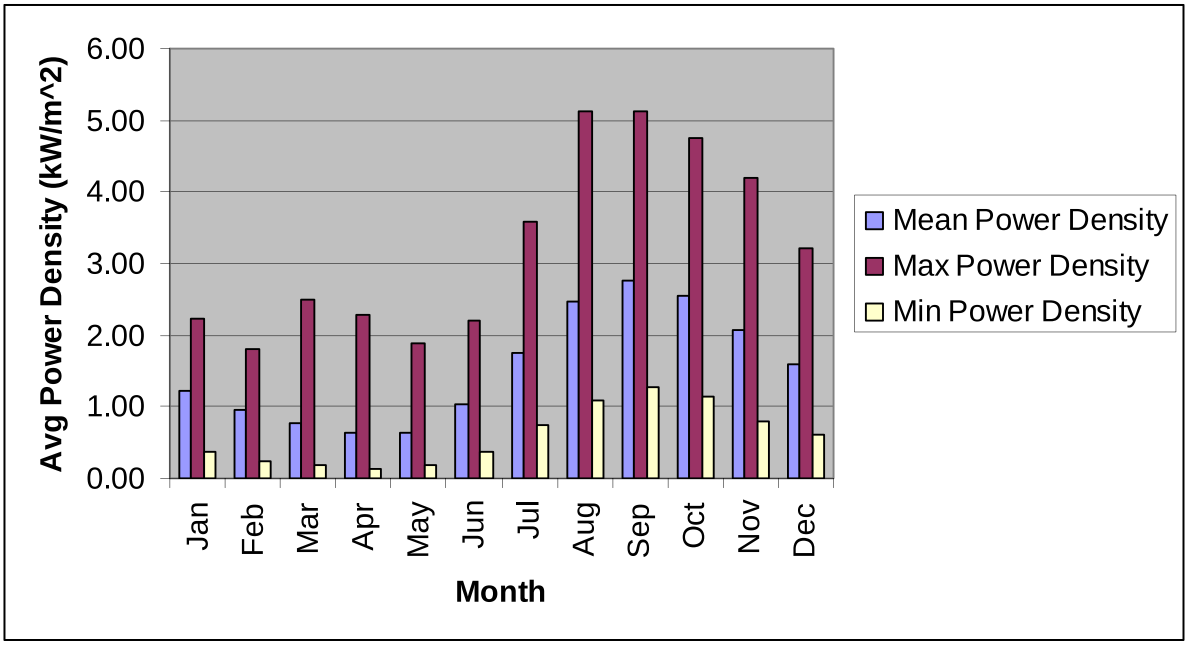


Figure 66: Monthly Power Densities at Site

8. References

1) K.Schulze, M.Hunger, P.Doll, "Simulating river flow velocity on global scale."
2) G. Hagerman, B.Polagye, "EPRI TP-001 Methodology for Estimating Tidal Current Energy Resources and Power Production by Tidal In-Stream Energy Conversion (TISEC) Devices." Available under the title page at www.epri.com/oceanenergy/
3) Personal communication with David Lockard
4) Personal communication with Steve Selvaggio – Big Delta / Whitestone Community
5) Personal communication with Alex Leavens – Manley Hot Springs
6) Personal communication with Scott Willis – Juneau
7) Personal communication with Bob Grimm – Eagle
8) Personal communication with Brent Petrie – Mountain Village