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FINAL PROJECT REPORT

Hoopa Valley Small Scale Hydroelectric Feasibility Project

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Table of contents

List of Tables

List of Figures

Introduction

This study considered assessing the feasibility of developing small scale hydro-electric power from seven major tributaries within the Hoopa Valley Indian Reservation of Northern California (http://www.hoopa-nsn.gov/). The purpose of the assessment was to identify opportunities for the Tribe to develop hydro-power from it's tributaries that could be used to 1). Meet some level of local energy demands for the valley community 2). Maintain a source of power when the mainline supply over the mountains is cut-off and 3). Sell excess energy to the local power utility for profit.

Environmental Setting

The Reservation is bisected by the Trinity River into East side streams and West side streams. The East side streams drain from high up in the Trinity Alps wilderness at about 5900 ft and collect snow melt well into July. The west side streams drain from elevation between 1300-3800 feet and rarely receive enough snow melt to last past April. In short, the east side streams flow into bigger watersheds than the west side streams and run more water longer into the summer months.

All seven tributaries identified for assessment flow through the Reservation and drain into the Trinity River. The Trinity River is a major producer of Chinook and Coho Salmon and Steelhead Trout which are the center of Hupa culture and continue to be subsistence for the Hupa people to this day. Furthermore, the Hoopa Valley Tribe is one of the 8 members of the Trinity Management Council dedicated to restoring fish and wildlife populations in the Trinity River Basin. Therefore, protection of anadramous fisheries in the Reservation tributaries is of primary concern in planning hydro-power systems.

Current Power Demand and Distribution

The current electric power demand for Willow Creek power grid including the Hoopa Valley Community is 3.5-4.0 MWatts throughout the year. This grid is owned and operated by Pacific Gas and Electric Company. The easiest plan for providing power for the Hoopa community from hydropower projects is to utilize this existing grid. This would require a developing a wholesale power purchase agreement between the Tribe and PG&E. Negotiating a premium rate of return to achieve the highest revenue benefit for project investment is imperative to planning cost effective projects that realize a net profit within 7-10 year investment period. The reason for this is so that the Tribe does not inherit ownership of a system that is worn out and requires substantial costs for upgrades and repair.

Tribal Water Authority

The following is a timeline of progress in the development of Tribal water quality control authority for the all waters within the Reservation.

- In 1991, The Tribe received CWA 106 grant funds to implement programmatic water quality control program through the office of the Tribal EPA.
- In 1996, The Tribe received Treatment as State for CWA 401 and 303(d) Authority.
- In 1998 The Tribe received CAA 103 grant funds to administer CAA programs.
- In 2001 The Tribe received EPA Certified WQ Standards to control water quality and water quantity form all waters that flow through the Reservation

Assessment Approach

This study pursued the assessment of seven major tributaries of the Reservation that flow into the Trinity River (Figure 1). It considered a two phase approach. using the Evaluation Criteria given below. The **Phase I** analysis took into account the amount of head, duration of adequate stream flow, pipe size and the amount of investment required for development. The goal was to separate out streams that were more cost effective for development from those that would require excessive costs and environmental impacts in order to realize a profit beyond a 7 year investment period. The **Phase II** analysis focused on quantifying available stream flows for hydropower above those that are essential to maintain critical habitat for anadramous salmoniods and therefore, have a realistic potential for development.

The seven watersheds assessed for hydropower development are given below.

Name	Size
Pine Creek	31,413 acres
Mill Creek	30,810 acres
Tish Tang Creek	19,131 acres
Supply Creek	10,254 acres
Hostler Creek	5,976 acres
Soctish Creek	5,924 acres
Campbell Creek	4,355 acres

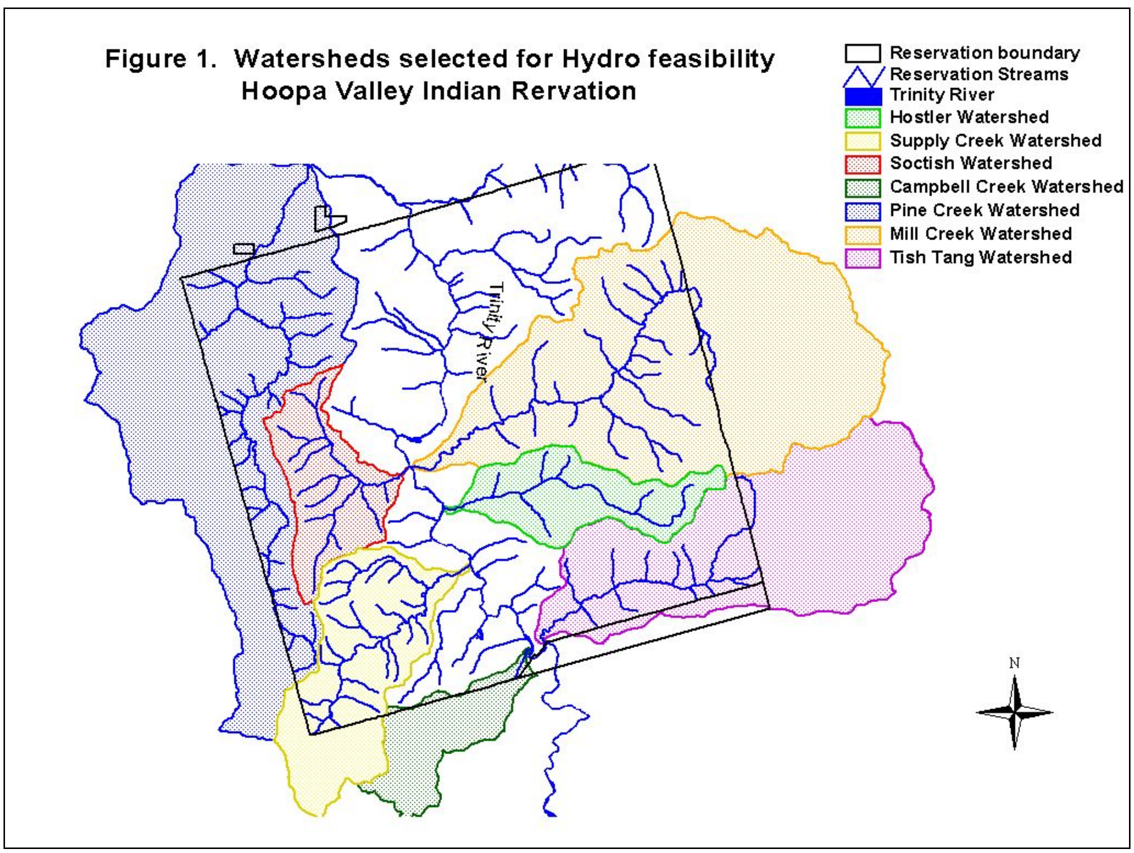


Figure 1. Watersheds selected for Hydro feasibility
Hoopa Valley Indian Rervation

Evaluation Criteria
In order to focus the assessment effort, an objective approach to evaluating the potential of streams for hydropower was pursued using the following criteria

1. Road access
   a. Intake sites, pipeline construction and turbine sites

2. Distance to Valley
   a. Produce enough power to get down to the valley and still have plenty for the community to use or for sale to PG&E

3. Proximity to power lines – connectivity to PG&E

4. Location for turbine
   a. Relatively flat, close to power lines

5. Adequate head and majority of stream flows at intake site

6. Fish friendly intake – does not suck fingerlings into turbine, allows passage of upstream migrants

The following (Tables 1 – 5) provide results of the Phase I analysis that identify the potential for hydropower from the streams that meet the evaluation criteria (Steve Coley UPP Inc.). The results represent a "first cut" analysis which considered various alternatives based on pipe size and turbine type. Profit or loss was valued on meeting the investment costs at 6% interest over a 7 year period. The subsequent discussion explains why some streams were separated out from further Phase II analysis. It also includes recommendations for additional analysis to be considered for some streams that still have alternative opportunities.

Campbell Creek
Campbell Creek watershed is approximately 90% owned by the U.S Forest Service and privately owned interests. Only 10% of the watershed is owned by the Tribe, which theoretically receives 100% of the water. The lowest 0.75 miles of Campbell Creek flow into the Hoopa Valley Indian Reservation and is where hydro power would have to be developed.

Since the winter of 2002, the Hoopa Tribal Environmental Protection Agency (TEPA), has observed and measured increasing turbidity and suspended sediment loads discharged from Campbell Creek (Figure 2). An evaluation of the water quality data on Campbell Creek shows that turbidity and suspended sediment loads are greater than 40 times than is allowed in the Hoopa Tribes water quality standards of 50 NTU's (HVT WQTP 3.5.1 specific uses (A) vi Turbidity.) In 2006 it was found that there are two large landslides, one on the south slope and one on the north slope of the creek, each located 3 miles upstream from the Trinity River.

TEPA staff have studied the landslide via helicopter, aerial photos, GIS data and on the ground surveys to the slide area. It is a 28 acre deep rotational slide that is currently active with no signs of recovery. It is located on U.S. Forest Service Lands and is outside of the Tribes jurisdiction to implement effective restoration projects. Therefore, for the time being Campbell Creek is not considered feasible for hydropower development.

Table 1. Soctish Creek

Turbine/Generator	Power output KW	Pipe Sizes inches	Design Flow CFS	Min Flow CFS	Est. Annual KWH	Annual Revenues	Development Costs	Profit / Loss
Canyon Crossflow	125	24"	20.0	2.0	991,532	$86,659	$688,860	-$3,909
Canyon Francis	1300	48"	145.0	43.5	4,827,014	$421,881	$1,962,460	$163,862
Ossberger Crossflow	1258	66"	173.0	17.3	3,798,808	$332,015	$1,596,060	$122,170
Leffel Francis	1300	48"	145.0	43.5	4,827,014	$421,881	$1,818,460	$182,795

Table 2. Supply Creek

Turbine/Generator	Power output KW	Pipe Sizes inches	Design Flow CFS	Min Flow CFS	Est. Annual KWH	Annual Revenues	Development Costs	Profit / Loss
Canyon Crossflow	175	20"	14.0	1.4	839,817	$73,400	$804,825	-$32,415
Canyon Crossflow	750	36"	60.0	6.0	2,732,097	$238,785	$972,825	$110,881
Ossberger Crossflow	850	60"	140.0	14.0	3,568,355	$311,874	$1,448,825	$121,387
Leffel Francis	1100	36"	60.0	18.0	3,081,850	$269,353	$1,598,825	$59,145

Table 3. Pine Creek

Turbine/Generator	Power output KW	Pipe Sizes inches	Design Flow CFS	Min Flow CFS	Est. Annual KWH	Annual Revenues	Development Costs	Profit / Loss
Canyon Crossflow	35	24"	11.0	1.1	191,754	$16,759	$866,000	-$97,099
Canyon Crossflow	220	48"	60.0	6.0	625,964	$54,709	$1,090,000	-$88,600
Ossberger Crossflow	195	42"	62.0	6.25	678,752	$59,322	$1,112,400	-$86,932
Leffel Francis	300	48"	60.0	18.0	730,144	$63,814	$1,600,800	-$146,653

Table 4. Hostler Creek

Turbine/Generator	Power output KW	Pipe Sizes inches	Design Flow CFS	Min Flow CFS	Est. Annual KWH	Annual Revenues	Development Costs	Profit / Loss
Canyon Crossflow	10	12"	6.0	.60	91,590	$8,004.97	$244,050	-$24,081
Canyon Crossflow	110	30"	56.0	5.6	435,707	$38,080.79	$445,650	-$20,511
Ossberger Crossflow	130	48"	62.0	6.0	431,346	$37,699.64	$445,650	-$20,893
Leffel Francis	160	30"	56.0	5.6	564,187	$49,309.94	$552,450	-$23,324

Table 5. Mill Creek

Turbine/Generator	Power output KW	Pipe Sizes inches	Design Flow CFS	Min Flow CFS	Est. Annual KWH	Annual Revenues	Development Costs	Profit / Loss
Canyon Crossflow	175	42"	48.0	4.8	782,181	$68,362	$1,831,470	-$172,433
Canyon Crossflow	670	72"	170.0	17.0	1,820,681	$159,127	$2,117,070	-$119,218
Ossberger Crossflow	735	72"	225.0	22.5	1,466,885	$128,205	$2,437,470	-$192,265
Leffel Francis	1000	72"	170.0	51.0	2,075,877	$181,431	$3,295,470	-$251,834

Figure 2. Sediment discharge from a landslide of Campbell creek into the Trinity River, Hoopa Valley Indian Reservation 2007.

Tish Tang Creek

Tish Tang Creek is an east side watershed that crosses the Reservation boarder into the U.S. Forest Service lands. It is a 19,131 acre watershed that includes 7,640 acres within the Reservation. Typical stream flows range from about 5cfs to 800cfs on average but can exceed estimates of 1200 CFS during very high flows when conditions prohibit the ability to take measurements. It is a high gradient stream in the upper 3/4 of the watershed but gradually slopes down to a low gradient stream of about 3-5% in the lower 2 mile stretch to the valley. Tish Tang has good potential for generating hydropower. However, due to the orientation of the stream course relative to the valley, development of the lower end for hydropower poses several problems. For one, the stream course itself takes a sharp turn to the south away from the valley. This is due to an elongate steep ridge which rises up and curves toward to south (Figure 3). The lower portion of Tish Tang creek where development was considered for *this* study, consists of stream bed deposits of loose unconsolidated gravel surrounded by unstable rocky slopes making development risky and subject to constant maintenance at potentially high costs.

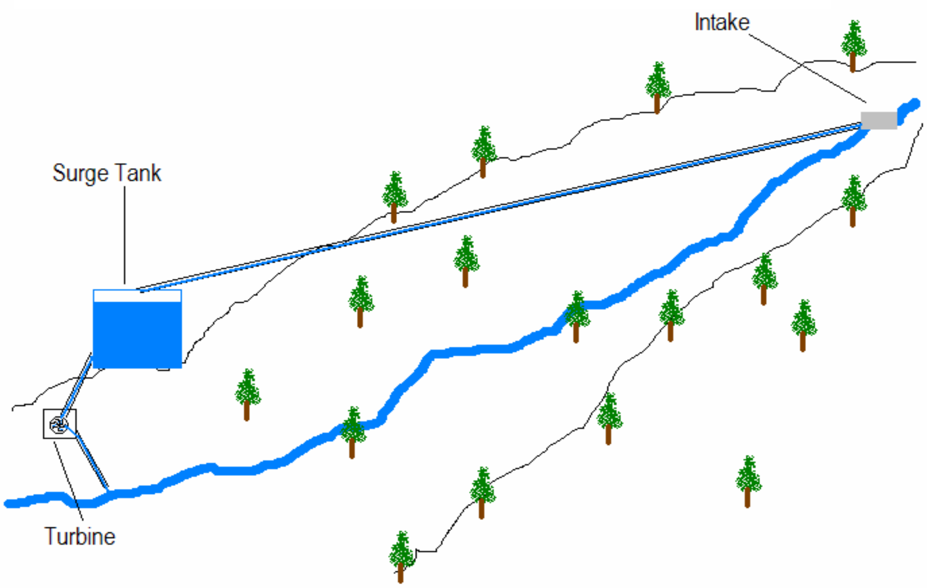
Figure 3. Lower end of Tish Tang creek showing curvature of the stream, loose gravel and unstable slopes

Secondly, there are traditional fishing and recreation sites that could be compromised from the placement of a pipeline and turbine house where stability is most secure. Even if the Tribe were to tunnel through the ridge to maintain a straight approach to the valley, the most logical place for a turbine house is located on a traditional and historic village site maintained by the Tribe.

Therefore, development of lower Tish Tang would require a much more detailed assessment as well as substantial decisions by the Tribal Council on the level of development the community is willing to accept.

However there is an alternative option for developing hydropower upstream at a more favorable location where water can be piped down hill toward the valley to fill tanks could be used a ballast to control flow directly down slope through a turbine and then back to the stream (Figure 4). This alternative would require a more extensive assessment of site location, stream flow and technology options that is beyond the scope of this study. Therefore, Tish Tang Creek was not considered for Phase II at this time.

Figure 4. Basic schematic of alternative concept for hydropower development in Upper Mill creek and Tish Tang creek



Mill Creek

Mill Creek is the biggest east side watershed on the Reservation extending from 6,200 feet in the Trinity Alps wilderness to 320 feet down in the Hoopa Valley. Approximately 14,040 acres occur within Forest Service lands at higher elevations and the remaining 16,780 acres on the Reservation. Stream flows range from 15 CFS in the late summer to as much as 1100cfs in high winter flows. When applying the "evaluation criteria" to determine the potential for Mill Creek hydro power, difficulties arise when trying to achieve #5 - adequate head with the majority of stream flows. Mill Creek is a large watershed with a high gradient in the upper 2/3 of the watershed but gradually slopes down to a low gradient stream of about 2-3% in the lower 4 mile stretch to the valley where it is practical to use the power (Figure 5). Therefore the feasibility of hydropower would be more dependant on the quantity of water rather than the level of head generating velocity.

Figure 5
Lower Mill Creek showing shallow sloping grade

In other words based on the selected locations for the intake and turbine, power would have to be generated based on lots of water with low flow. Considering this model, the initial analysis of penstock size and turbine type conducted by the Phase I Consultant determined that most options suited for lower Mill creek would require a pipe size of 6 feet in diameter in order to reduce the effects of friction loss in the pipeline. This system would transfer water to a Leffel Francise type turbine (Figure 6).

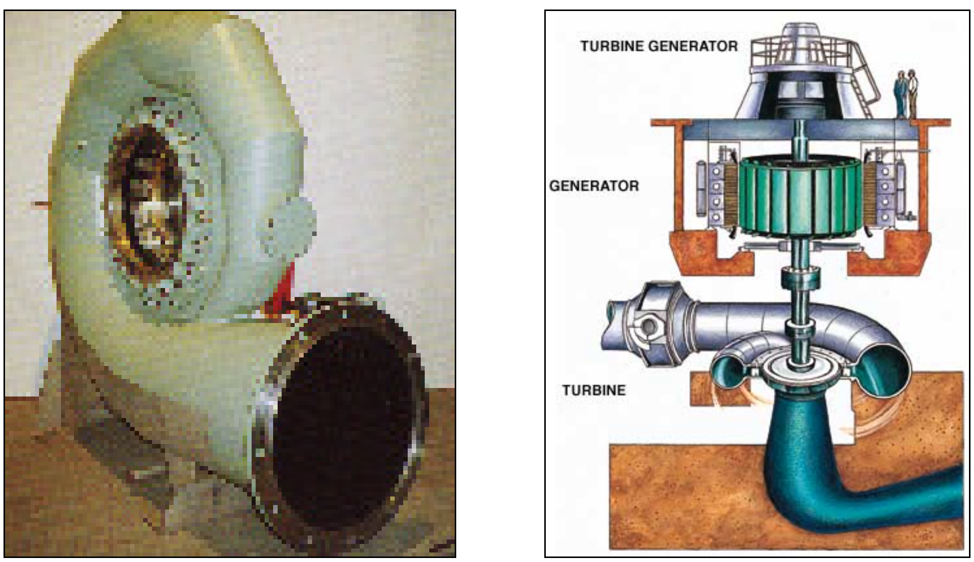


Figure 6. True photo and schematic of the Francis “snail-shell” turbine

This would require an estimated 1.02 miles of pipeline and 820 feet of power line that would have to cross multiple property jurisdictions of Tribal, trust, fee and private ownerships (Figure 7). Crossing these properties would require financial compensation of about 1.5 acres total to allow access and construction of the pipeline. This is an added cost to the project ranging from $25,000 to $100,000 depending on the current real estate market.

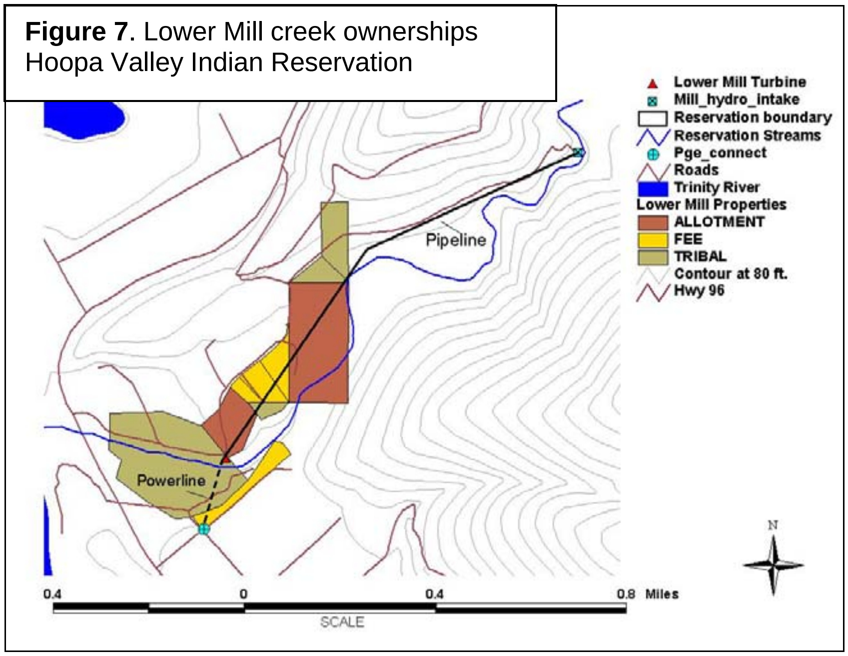


Figure 7. Lower Mill creek ownerships
Hoopa Valley Indian Reservation

In summary, based on the results of Phase I assessment (Table 5), development of hydropower in Lower Mill Creek would not be cost effective and is complicated with land ownership issues. This will also have development issues due to public concerns over having such a large pipeline constructed in the stream. Therefore, Mill Creek was not considered for the Phase II assessment.

Pine Creek

Pine creek is the largest watershed associated with the Hoopa Reservation. In boarders the entire west side of the boundary and is about 40% on the Reservation. About 14 miles of the mainstem runs through the Reservation and 3 miles runs off the Reservation and flows into the Klamath River. Perennial stream flow is dependant primarily on rain fall with very little snow pack. Using the evaluation criteria, the most appropriate hydropower project sites were selected that were accessible from roads within the Tribes jurisdiction and could capitalize off the most water flow (Figure 8).

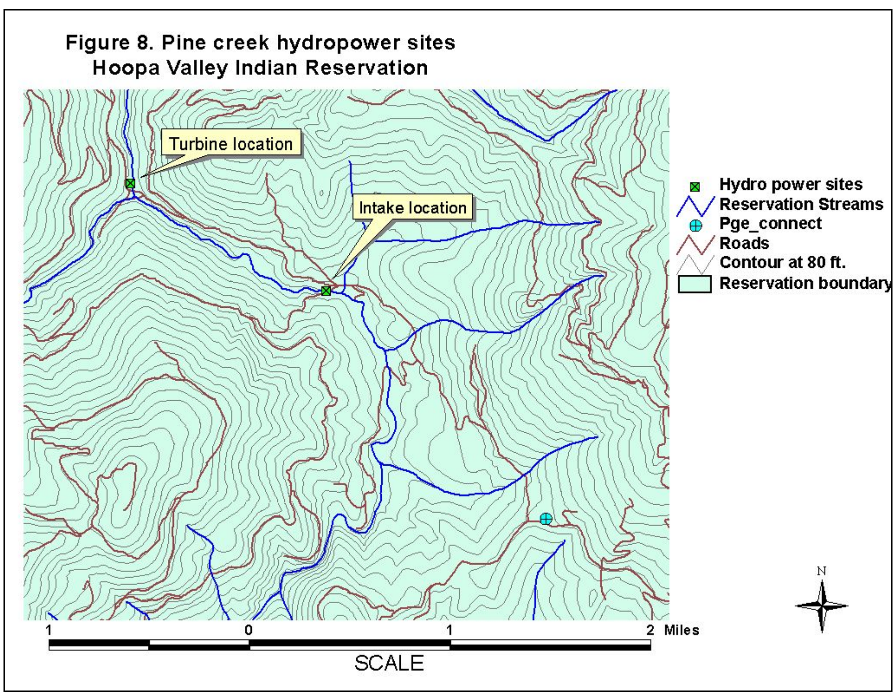


Figure 8. Pine creek hydropower sites
Hoopa Valley Indian Reservation

Unfortunately, the data given in (Table 3) shows a net loss of revenue at the end of the 7 year period. Three restraints exist in relation to the sites selected. First, there is limited head with a stream gradient of only 5.3% (Figure 9). Second, this project would require about 5900 feet of pipeline which is a substantial cost. Finally, there is a long span between the proposed turbine site and connectivity to the PG&E grid that would require about 2.8 miles of electrical power line to be constructed in order to sell the power to PG&E. The actual cost of this has been difficult to assess but one can assume it would be substantial. Therefore, Pine creek was not considered further in the Phase II analysis.

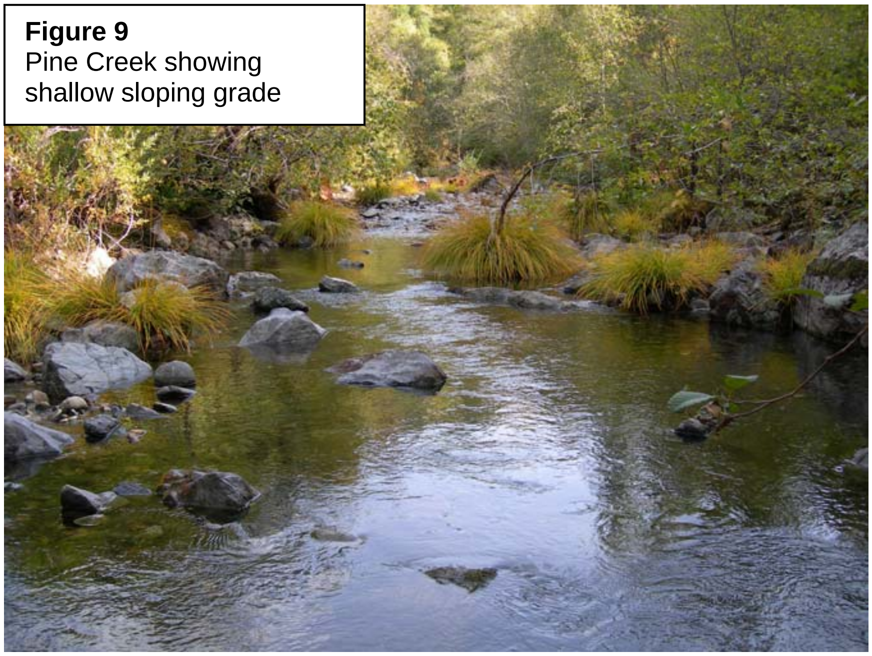


Figure 9
Pine Creek showing shallow sloping grade

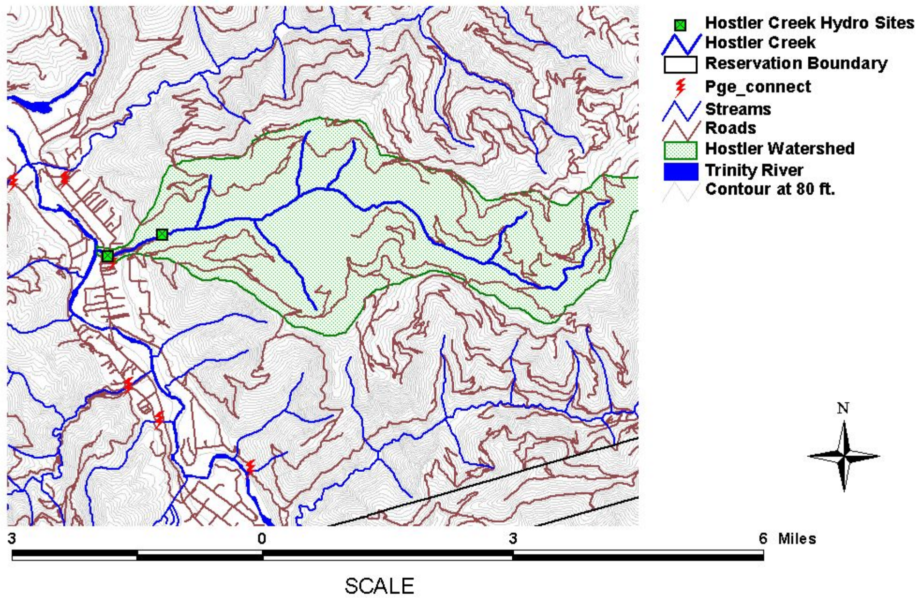
Hostler Creek
Hostler creek is a relatively smaller watershed of 5,976 acres situated entirely on the Reservation (Figure 10). It flows from about 4700 feet in elevation down to 300ft in the valley. Stream flows range from as low as 3cfs to about 300cfs on average. With this relatively low amount of flow available, a site location for the intake and turbine were chosen as close to the valley as possible in order to meet the "evaluation criteria" concepts #1 - #5.

The results of the evaluation for Hostler creek are given:

- Gross head, 39 feet
- Length of pipe, 375 feet
- Flow range, 10 cfs
- Flow duration 317 days
- Recommended pipe diameter, 16
- Calculated net head - 35 feet
- Expected power, 19KW

Assuming an average return rate from PG&E of 10 cents/per KW Hour for premium power, this system would generate an estimated $14,555 per year. However it would cost about $250,000 to develop and the cost benefit would not be realized for 17 – 18 years.
With the small amount of electricity being generated this would not be a viable project for wholesale development. Therefore, Hostler creek was not considered for Phase II.

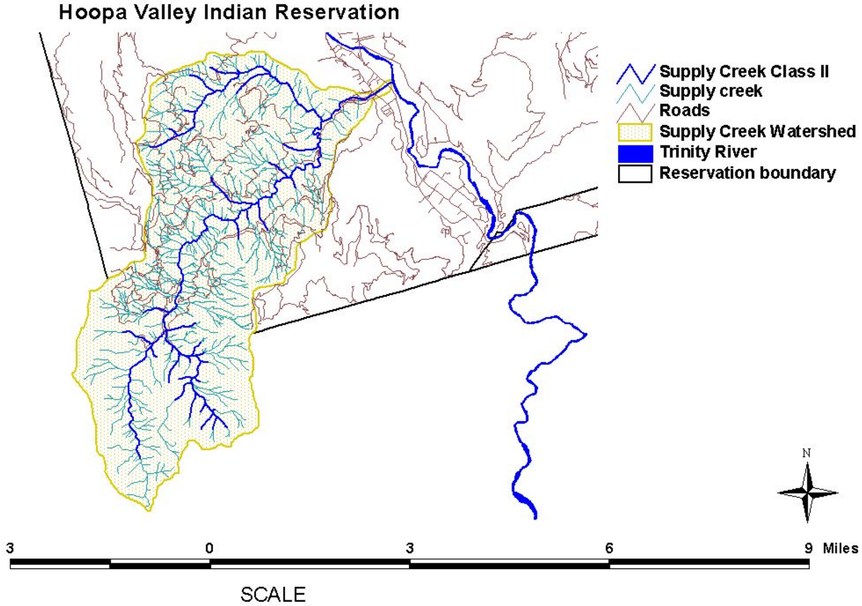
Figure 10. Hostler Creek watershed
Hoopa Valley Indian Reservation



Supply Creek

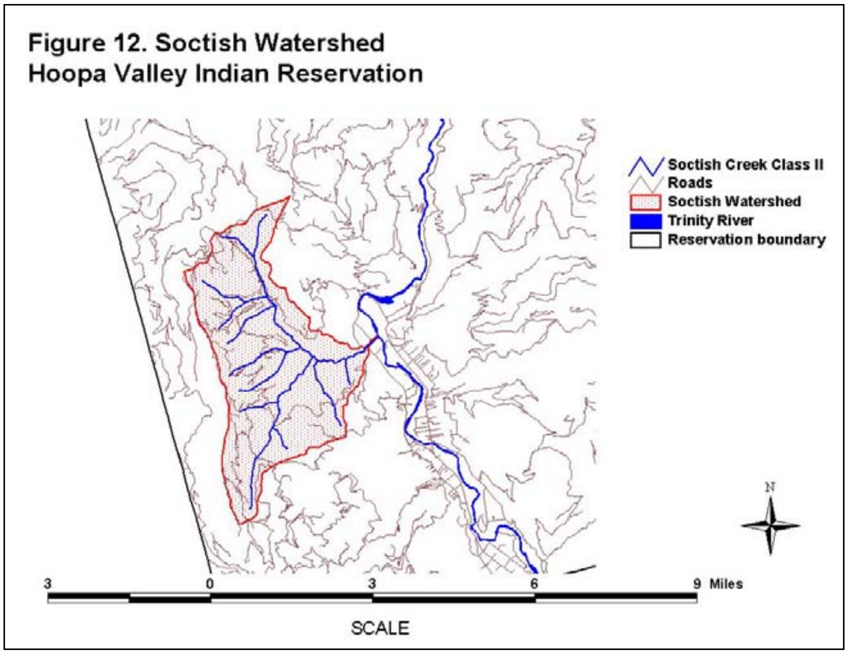
Supply Creek is one of two streams that were determined to have the potential for real development. It is a10,253 acre watershed with 70% existing within the boundaries of the Reservation (Figure 11). Stream flows range from about 7cfs to 700cfs and are very dynamic in nature. Stream gradient is between the intake and turbine location 17% and provides useable head for the transfer of high velocity water. The results of the Phase I assessment yielded 3 systems using a range of pipe sizes and turbines that potentially would generate about $59,000 – $121,000 at the end of the 7 year period. Supply creek also meets all 5 of the evaluation criteria and therefore, was analyzed further in the Phase II analysis.

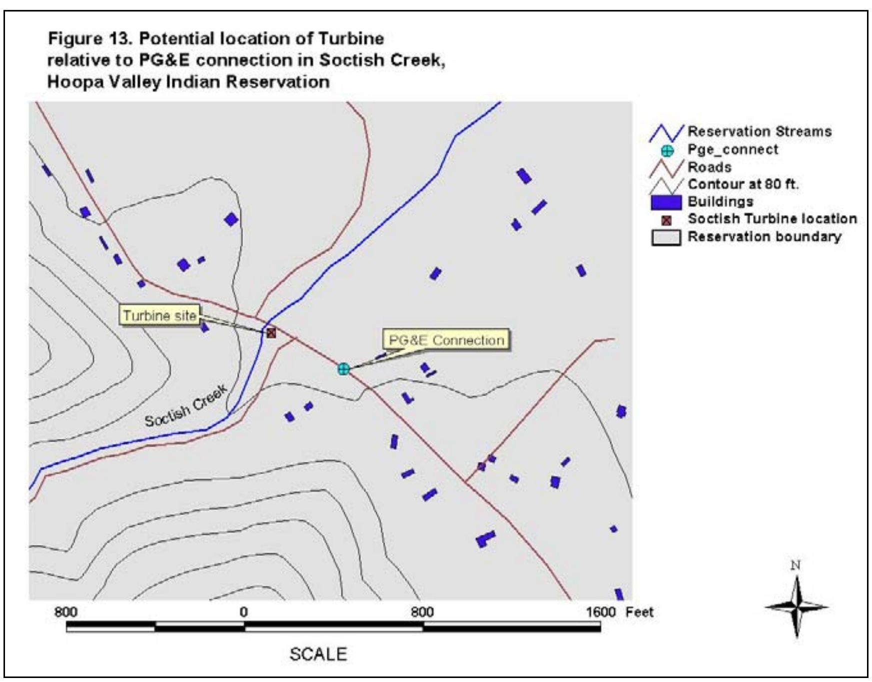
Figure 11. Supply Creek Watershed
Hoopa Valley Indian Reservation



Soctish Creek

Soctish Creek is the other of the two streams that was determined to have the potential for real development. It is a 5,924 acre watershed that is 100% within the boundaries of the Reservation (Figure 12). Stream flows range from about 1.5cfs to over 700cfs and are very dynamic in nature. Generated solely by rainfall, stream flows can very from 325cfs to 60cfs within a 24 hour period. Stream gradient between the proposed intake and turbine locations is 12% and provides useable head for the transfer of high velocity water. Soctish meets all 5 of the evaluation criteria including a PG&E connection that is proximal to the location for the Turbine (Figure 13). Data presented in (Table 1) shows cost effective systems that could produce marketable energy from two different turbine types and a range of pipe sizes. However, a more detailed analysis was required to focus the results to one type system that is profitable realistic. Therefore, Soctish creek was analyzed in Phase II.





Results of Phase II Analysis
As mentioned, the goal of Phase I was to separate out streams that could meet the evaluation criteria and realize a substantial profit after a 7 year investment period. The goal of Phase II was to conduct a more detailed civil engineering analysis of hydropower potential and project development. For this purpose, Winzler & Kelly Consulting Engineers was contracted to conduct the Phase II assessment.

The following objectives were pursued under Phase II in order to quantify the size, capacity and costs of the system.

1. Available stream flow that can be utilized for hydropower
2. Intake structures type and size
3. Optimal pipe size(s) and material
4. Head loss from friction
5. Pipeline alignment and total length
6. Turbine type and generator
7. Power generation, how much for how long
8. Project development costs including equipment and construction
9. Estimated revenue and simple payback period.

Out of the seven streams analyzed in this study, only Supply Creek and Soctish Creek qualified for further assessment in Phase II.

Rainfall Data
Because stream flow is dependant on rain fall, determination of available flow utilized water year 2005 data collected by the Hoopa Tribal EPA (TEPA). As compared to other water years and historic rainfall data, 2005 was considered an average rain year.

Considerations for Fish
Fish are the center of life for the Hupa people. Therefore, a determination of base flows to maintain fish passage and spawning was critical for quantifying the flows available for hydropower. In 2006 and 2007, TEPA conducted surveys of Supply Creek and Soctish Creek to investigate critical water levels relative to fish use. These observations were compared to habitat availability to determine water levels correlated with stream flows. A minimum water level of 1.6 feet is to be maintained as possible for fish habitat.
This yielded the following base flows for fish.

- Supply creek base flow 32cfs
- Soctish Creek base flow 65cfs

With all criteria taken into consideration, the following (Table 6) summarizes the results of the Phase II analysis highlighting the specifications for a hydropower system for both creeks.

Due to the dynamic nature of flows the Ossberger Crossflow Turbine was selected as the most appropriate equipment to use for both Supply Creek and Soctish Creek (Figure 14).
Because these two creeks are so dependent on rainfall, power generation is limited to the wet months of the year. At best these systems could be generating power 5-6 months out of the year with peaks occurring in relation to storm events. The full executive summary including diagrams of system configuration, intake structures and pipeline alignment is provided in **Appendix A**.

Figure 14. Exploded view and scale view of Ossberger Crossflow Turbine

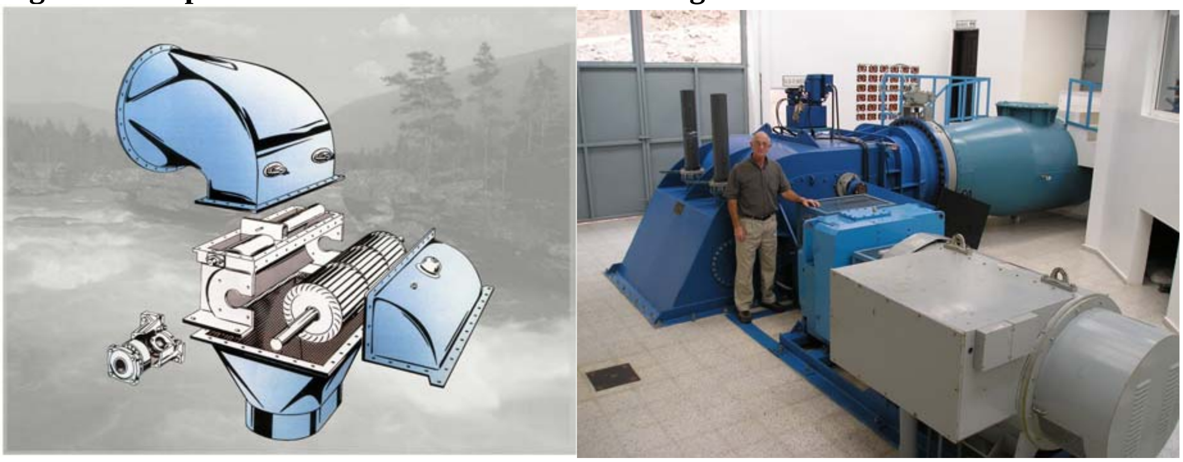


Table 6. Summary of results of the Phase II analysis

Characteristics of Hydropower Systems for Supply and Soctish Creeks.		
Characteristic	**Supply Creek**	**Soctish Creek**
Design Flow (cfs)	50	32
Base Flow Required for Fish Passage (cfs)	32	65
Forebay Inlet Width (ft)	15	10
Fish Screen Area (ft^2)	149	95
Static Head (ft)	165	80
Net Head (ft)	146	57
Nominal Penstock Diameter (in)	30	24
Penstock Length	3400	2350
Penstock Material	ELS	ELS
Turbine Size (kW)	508	120
Generator Size (kW expected)	475	110
Annual Energy Production (kWh expected)	1,826,000	662,500
Estimated Annual Revenue	$164,400	$61,000
Estimated Project Cost	$2,347,000	$1,514,000
Simple Payback Period Years	14.3	24.8

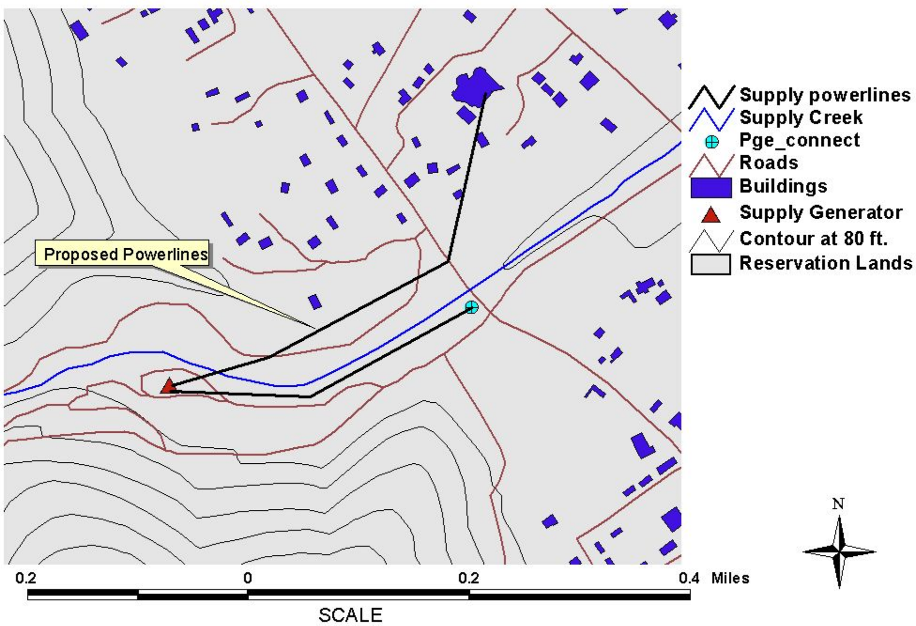
Notes:
1) Fish screen area based on vertical flat panel screen
2) ELS stands for Epoxy Lined Steel Pipe
3) Annual revenue based on $0.09/kWh. Actual rate that Pacific Gas & Electric will pay for the electricity produced may be more or less depending on a variety of factors.

As indicated by values given in (Table 6) neither project would realize a cost effective payback within a 7year investment period. However, capital costs for development could be substantially reduced through a combination of federal grants, renewable energy tax credits for investors and the sale of "green tags" as carbon offsets to industries that emit green house gases. Furthermore, hydropower is a renewable energy and would qualify as a credit to PG&E to help them meet the goal of 20% of their energy coming from renewables. Therefore, the Tribe as a Sovereign entity has an elevated position to negotiate a higher rate of return for the KW hours that could increase the payout and decrease the payback period further. For example if the Tribe were to receive 10 cents per KWhour instead of 9 cents, this alone would reduce the payback period for Supply creek from 14 years to 12 years and from 24 years to 22 years for Soctish Creek. In addition, power generation in "wet" years when rainfall exceeds the normal average will be higher than estimated and can also help realize the cost benefit earlier.

Utilization of Electricity
As discussed in this report, the plan to utilize the electricity generated by these two systems is to sell the power to PG&E through a whole sale agreement. However for Supply Creek there is a concept to also divert some of the power directly to the Tribal office to reduce the annual utility costs. This set up would also allow the Tribal office to have back-up power during power outages that regularly occur in the Willow Creek grid. A switch gear would allow the electricity to be diverted through a direct line from the generator to the Tribal office (Figure 15).

The annual utility costs for the Tribal office is $47,848 with peak use occurring during the months of (June – October) due to use of air conditioning to cool the office. However, because hydropower is generated by rainfall, electricity generated to support the Tribal office will occur primarily during the months of (November – April) and could save the Tribe $17,000 a year on average.

Figure 15. Plan layout for the diversion of electricity from the Supply Creek generator to the Tribal office Hoopa Valley Indian Reservation



Environmental Impacts
Hydropower development in Hoopa has the potential to impact anadramous fisheries in all 7 tributaries assessed in this study. The Southern Oregon/Northern California Coasts (SONCC) Coho salmon (*Oncorhynchus kisutch*), is a species listed as threatened under the Endangered Species Act (ESA). Considerations of direct and indirect impacts on fish focus on reduction in water quantity due to intake drafting and alteration of water quality from the outfall of the Turbine. The Ossberger crossflow turbine is made of stainless steel and has an immeasurable affect on water quality in terms of conductivity, or temperature. The only real effect is addition of oxygen from aeration through the turbine. However, the outfall water would be held in the spillway for about 5 seconds before discharge back into the creek. This allows the oxygen to dissipate rapidly and in no way creates an anoxic condition for fish.

One of the most important issues related to the effects of hydropower on fish is the reduction in habitat from reduction in water quantity. In Supply and Soctish Creeks a real attempt was made to identify minimum water levels needed to maintain adequate habitat for spawning and migration. The other important factor is flow control and screening of the intake so as not to suck in small fish. This has been accomplished by designing an intake structure that is compliant with the following National Marine Fisheries Service (NMFS) criteria for hydropower systems as described in (NOAA 1997).

- Off-channel fish screen structure
- Structures placed as close to the instream diversion as possible
- Provide for bypass pipe to return fish to the creek
- Maximum inflow velocity of 0.33 ft/sec to allow Salmon fry to swim away from the intake screen

Construction impacts

By far the most conceivable impacts to fisheries habitat from hydropower development are activities that need to occur during construction. In Soctish Creek most of the construction can be accomplished from working along the stream bank out of the stream channel. The only instream activities that need to occur are during the installation of the fish screened intake (Appendix A).

However, in Supply creek, considerable construction will need to take place within the stream channel and along the banks. This would include building an access road proximal to the stream channel and erecting concrete pylons *in* the stream channel to support the pipeline.

These activities have to occur in order to implement a hydropower project in Supply Creek.
Therefore a combination of mitigations would have to be implemented during the construction phase in order to reduce the environmental impacts of construction on fisheries. The most important of these is project timing and duration. The project will have to be implemented during the dry season and during the late summer flow period, subsequent to downstream out-migration of juvenile Coho salmon and prior to upstream migration of adult Coho salmon. Based on recommendations from Hoopa Tribal Fisheries, the best time of year for this activity is from (August 4 to August 15) when virtually no anadromous fish are in the River or emigrating from Reservation tributaries.

Conclusion

The feasibility of hydropower on the Hoopa Valley Indian Reservation has real potential for development and many alternative options for project locations, designs, operations and financing. In order to realize this opportunity further will require at least 2-3 years of intense data collection focusing on stream flow measurements at multiple locations in order to quantify real power potential. This also includes on the ground stream gradient surveys, road access planning and grid connectivity to PG&E for sale of electricity. Imperative to this effort is the need for negotiations between the Hoopa Tribal Council and PG&E to take place in order to finalize the power rate the Tribe will receive through any wholesale agreement that utilizes the alternative energy generated on the Reservation.

Appendix A.

EXECUTIVE SUMMARY

In FY2006 the Hoopa Valley Tribe (Tribe) obtained funding from the US Department of Energy to study the feasibility of small scale hydro-electric development on Tribal Lands. As part of the project, the Tribe contracted with Winzler & Kelly to analyze potential hydroelectric systems for Supply Creek and Soctish Creek. The purpose of this report is to present the results of that analysis. The following tasks were completed during the course of the analysis:

- Conducted two site visits
- Analyzed hydrologic data
- Conducted a hydraulic analysis
- Assisted Tribal staff with selection of apparent best penstock size
- Developed conceptual designs and opinions of probable costs for hydropower systems for Supply and Soctish Creeks

The site visits were conducted to observe site conditions and record GIS/GPS data for both creeks, intake locations, penstock alignments, powerhouse and spillway locations.

The hydrologic analysis involved analyzing stream flow and stage date that was provided by the Tribe for both creeks. The Tribe also indicated that for Supply Creek, the base flow to be left in the creek for fish passage was 32 cubic feet per second (cfs). For Soctish Creek the base flow provided by the Tribe was 65 cfs. The hydrologic analysis provided information about how much water would be available for hydropower for a typical hydrologic year without adversely impacting fish migration patterns.

The hydraulic analysis involved analyzing the pressurized pipe hydraulics for penstock diameters ranging in six inch increments from 18 inches to 48 inches. The maximum velocity of water in the penstock was limited to 10 feet per second (ft/sec) to prevent damage to the penstock that could occur in the event of a plant trip. The apparent best penstock diameters for Soctish and Supply Creeks were 24 inch and 30 inch respectively and were determined with Tribal Staff based on constructability, economics, and other factors.

Conceptual designs were then developed for small hydropower systems for both creeks. The conceptual designs included information about the following major system components:

- Intake Structure
- Penstock
- Turbine
- Power House
- Spillway

A surface water intake with an off-channel screening structure was determined to be the most appropriate diversion system for both Supply and Soctish Creeks. The following three types of fish screening systems that meet NOAA Fisheries fish screen and fish passage criteria were considered:

- A Rotary Drum Screen
- Cylindrical Tee Screen with Air Sparging
- Vertical Flat Panel Screen with Brush Cleaner

The results of the analysis indicate that a Vertical Flat Panel is the apparent best screen system for use at both sites.

Penstock

Both Epoxy Lined Steel (ELS) pipe and High Density Polyethylene (HDPE) pipe were analyzed as potential penstock material. HDPE pipe was ruled out for use on the Supply Creek System because of geologic conditions. Cost estimates were developed for ELS pipe for both creeks and HDPE for Soctish Creek only. HDPE pipe was ultimately ruled out for use on the Soctish Creek system for economic reasons. Therefore, the apparent best penstock material for both systems is ELS pipe.

The Tribe specifically requested that Ossberger Crossflow Turbines be used in the conceptual designs. The results of the hydraulic analyses indicated that, for the penstock type and diameters indicated, the apparent best turbine sizes for Supply and Soctish Creeks are 508 kW and 120 kW respectively. Hydropower Turbine Systems Inc. (HTS), the North American distributor for Ossberger Turbines verified the turbine sizing calculations and provided a detailed cost proposal for hydroelectric generating equipment for both systems.

Approximate equipment footprint and required clearances for the power houses were also provided by HTS. The building footprint for the power houses for Supply and Soctish Creeks were then determined to be approximately 530 and 400 square feet respectively. The ceiling height of the powerhouses should be 10 feet and each building should have a roll up door for maintenance and two H beams cast into the floor for equipment mounting.

The spillway concepts are based on a trapezoidal concrete ditch constructed between the turbine tailrace and the creek channel with a six foot leaping barrier placed at a natural grade break near the stream channel to prevent fish from entering the ditch. The spillway ditches would be sized to accommodate the design flow for each system with 6 inches of freeboard.

The Table below lists the characteristics of the apparent best hydropower systems for Supply and Soctish Creeks.

Characteristics of Hydropower Systems for Supply and Soctish Creeks.

Characteristic	Supply Creek	Soctish Creek
Design Flow (cfs)	50	32
Base Flow Required for Fish Passage (cfs)	32	65
Forebay Inlet Width (ft)	15	10
Fish Screen Area (ft^2)	149	95
Static Head (ft)	165	80
Net Head (ft)	146	57
Nominal Penstock Diameter (in)	30	24
Penstock Length	3400	2350
Penstock Material	ELS	ELS
Turbine Size (kW)	508	120
Generator Size (kW expected)	475	110
Annual Energy Production (kWh expected)	1,826,000	662,500
Estimated Annual Revenue	$164,400	$61,000
Estimated Project Cost	$2,347,000	$1,514,000
Simple Payback Period Years	14.3	24.8

Notes:

4) Fish screen area based on vertical flat panel screen
5) ELS stands for Epoxy Lined Steel Pipe
6) Annual revenue based on $0.09/kWh. Actual rate that Pacific Gas & Electric will pay for the electricity produced may be more or less depending on a variety of factors.

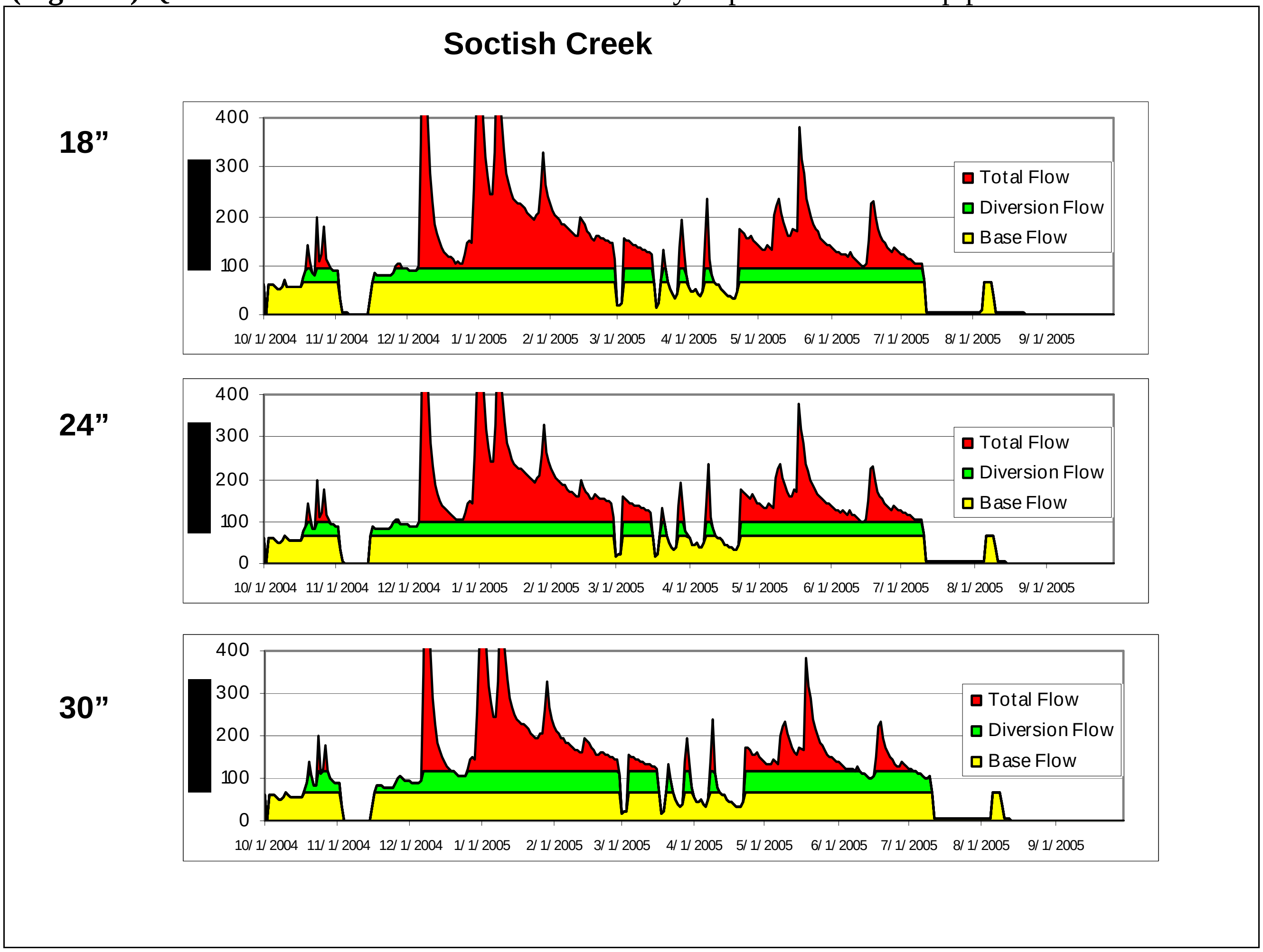
Note that the estimate of simple payback period shown in the table above is sensitive to the rate that PG&E will pay for electricity. For example, if PG&E will pay $0.07/kWh instead of $0.09/kWh, the estimates of simple payback periods shown would change to 18.4 years and 32.6 years for Supply and Soctish Creeks respectively.

Based on the results of the analysis, a hydropower system for Soctish Creek does not appear to be economically feasible. A hydropower system for Supply Creek could be economically feasible if a favorable power purchase agreement with PG&E can be arranged. Our analysis indicated that, if all other economic considerations remained the same, the Tribe would need to receive $0.18/kWh for the renewable electricity produced from the project to realize a 7 year payback period for the Supply Creek system.

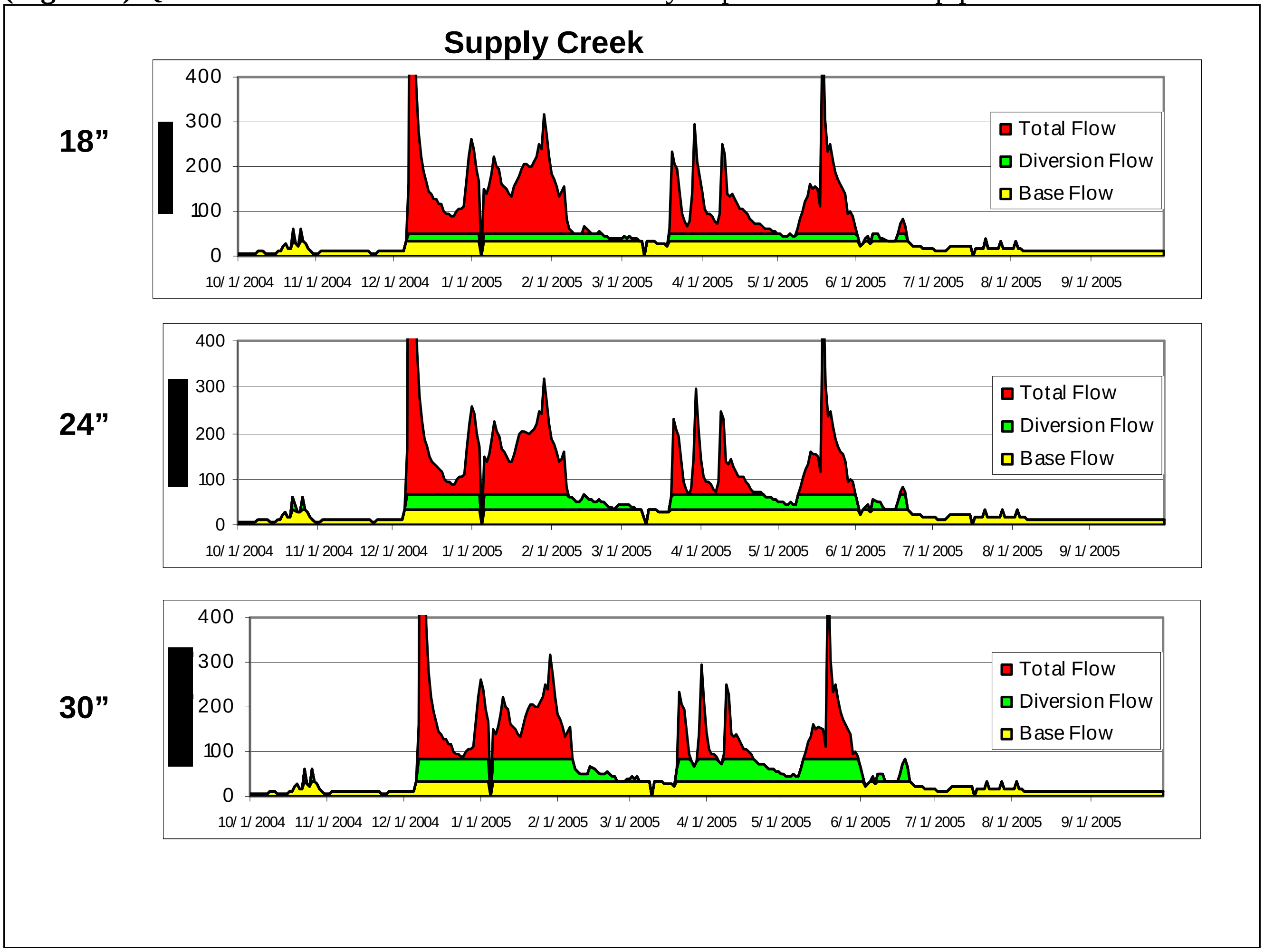
The analysis did not account for potential cost sharing by the Tribe in the project, which could enhance the economic feasibility of the project. Potential cost sharing opportunities include but are not limited to:

- Use of Tribally owned heavy equipment for construction
- Use of Tribal labor crews for construction
- Use of Tribal staff and equipment for topographic surveying

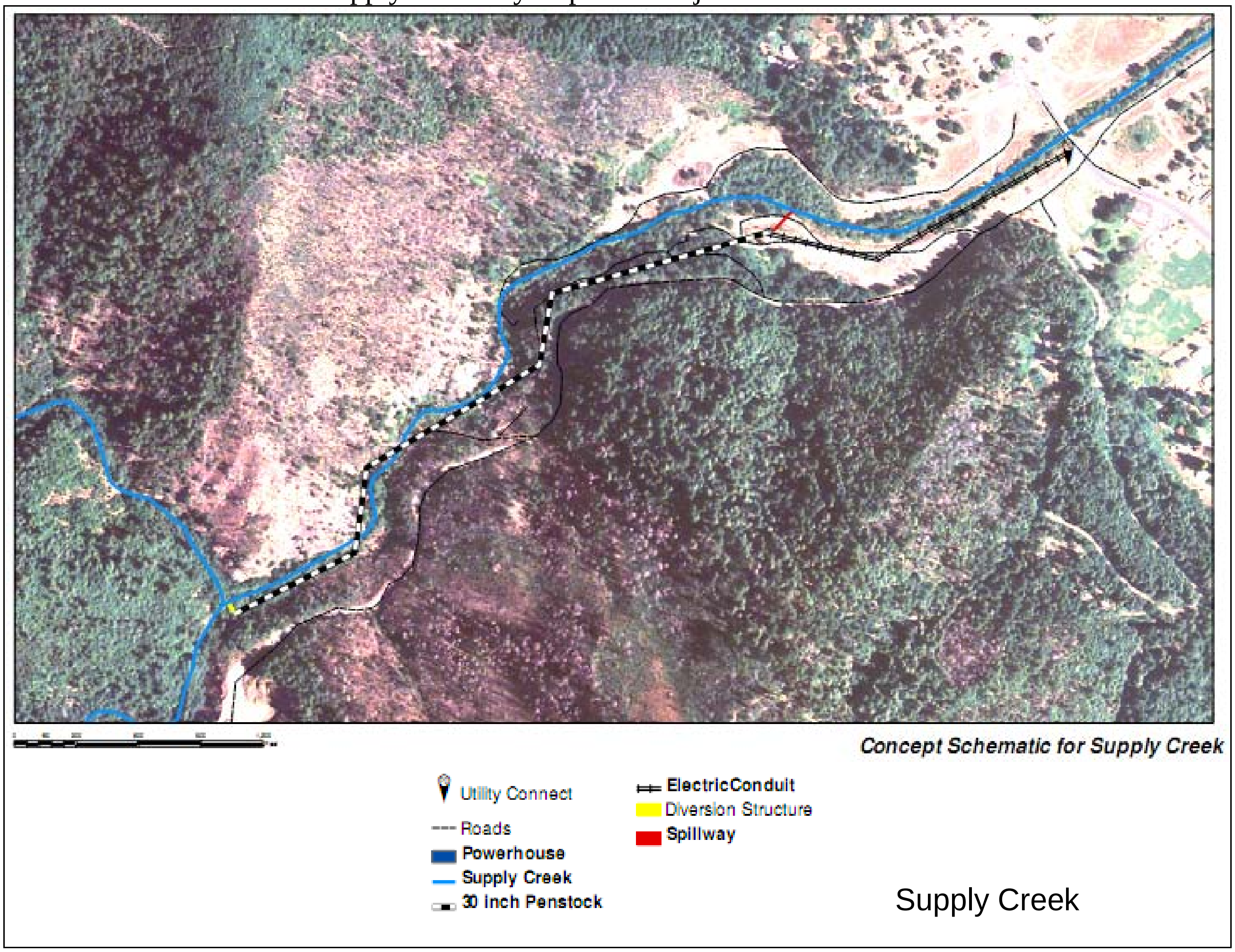
(Figure 1) Quantities of diversion flow available for hydropower relative to pipe diameter



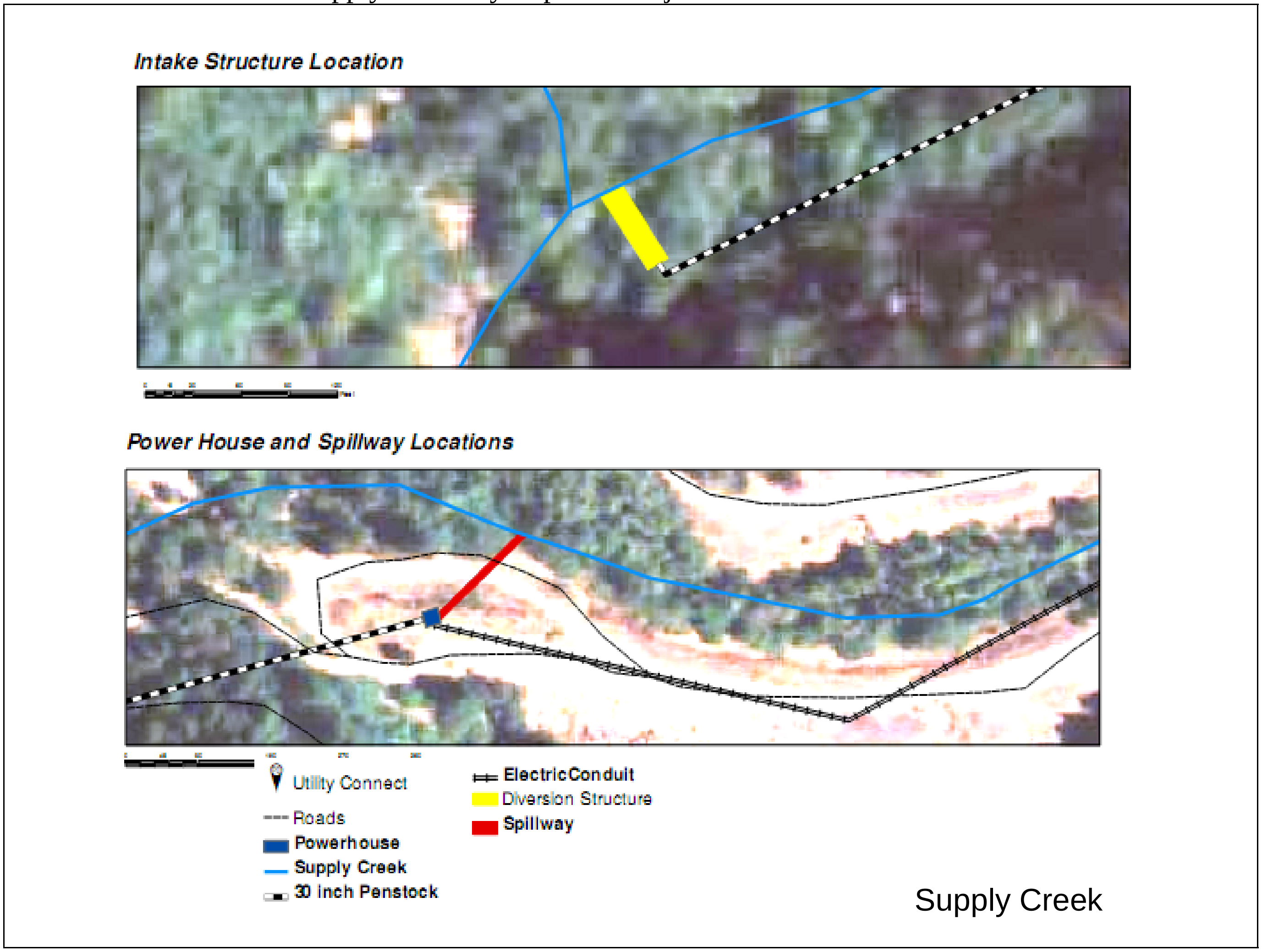
(Figure 2) Quantities of diversion flow available for hydropower relative to pipe diameter



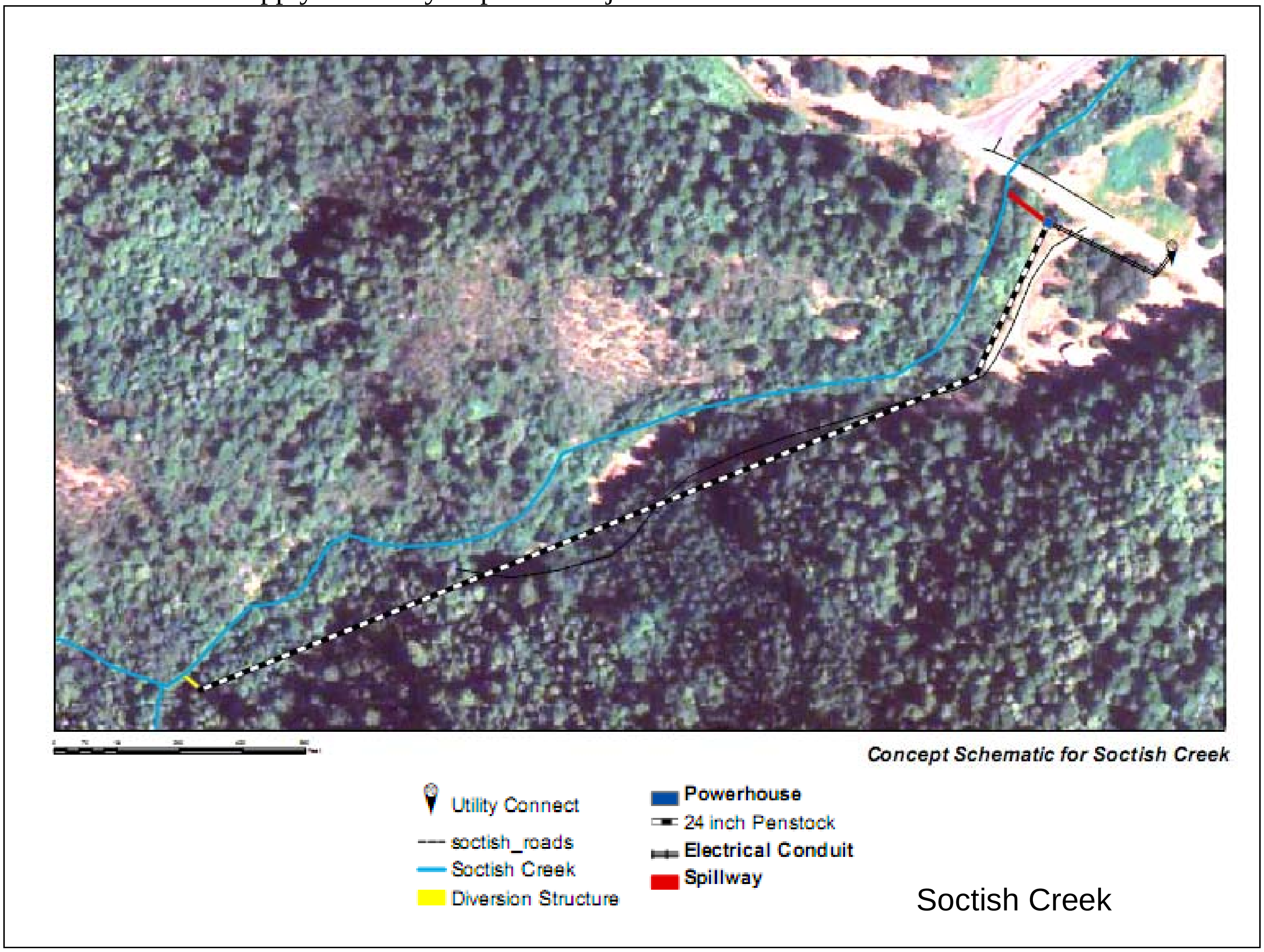
(Figure 3) Plan layout of intake location, pipeline and spillway for the Supply Creek Hydropower Project



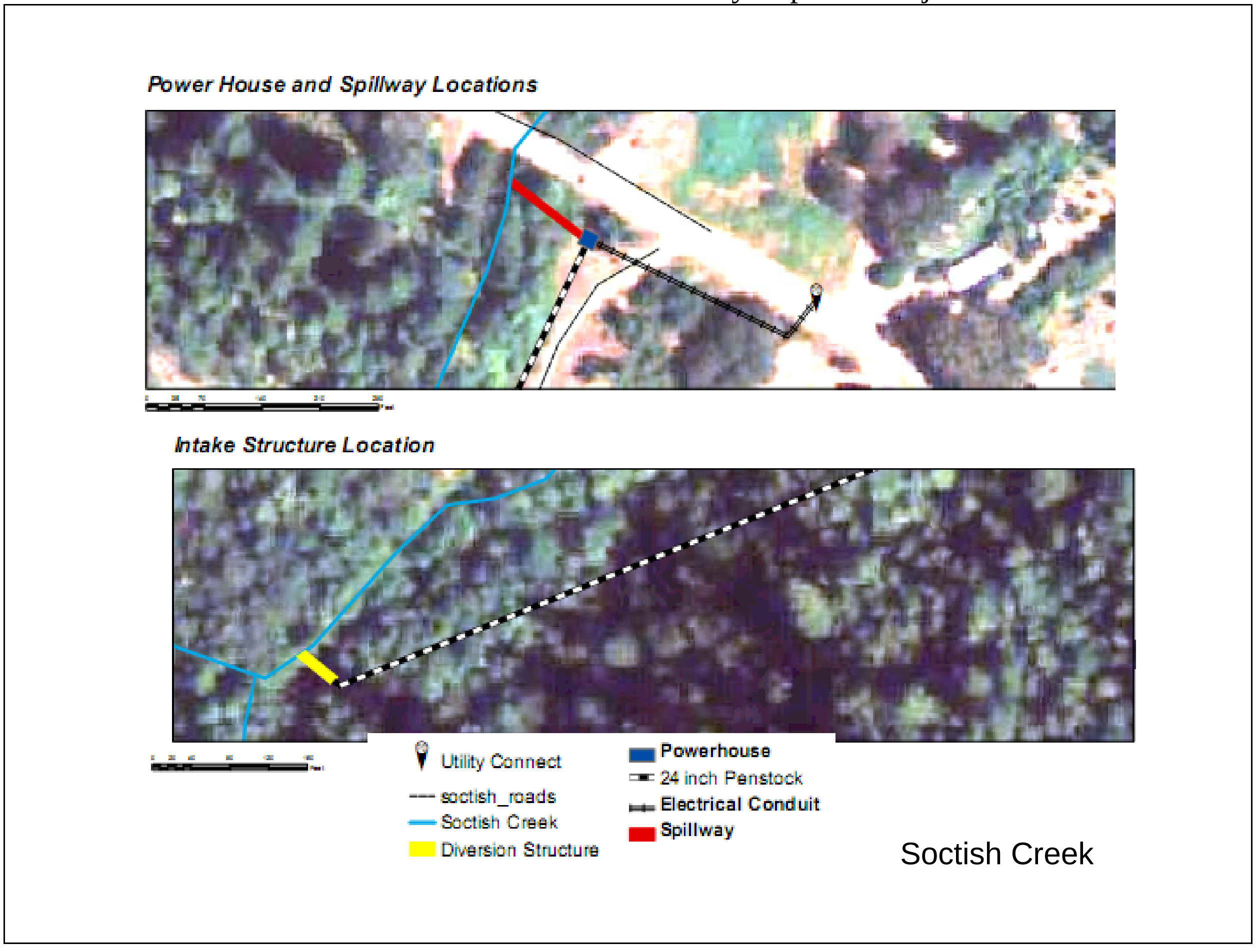
(Figure 4) Isolated view of intake structure, power house and spillway location for the Supply Creek Hydropower Project



(Figure 3) Plan layout of intake location, pipeline and spillway for the Supply Creek Hydropower Project



(Figure 6) Isolated view of intake structure, power house, spillway location and PG&E connection for the Soctish Creek Hydropower Project



(Figure 7) Conceptual layout of screened diversion types