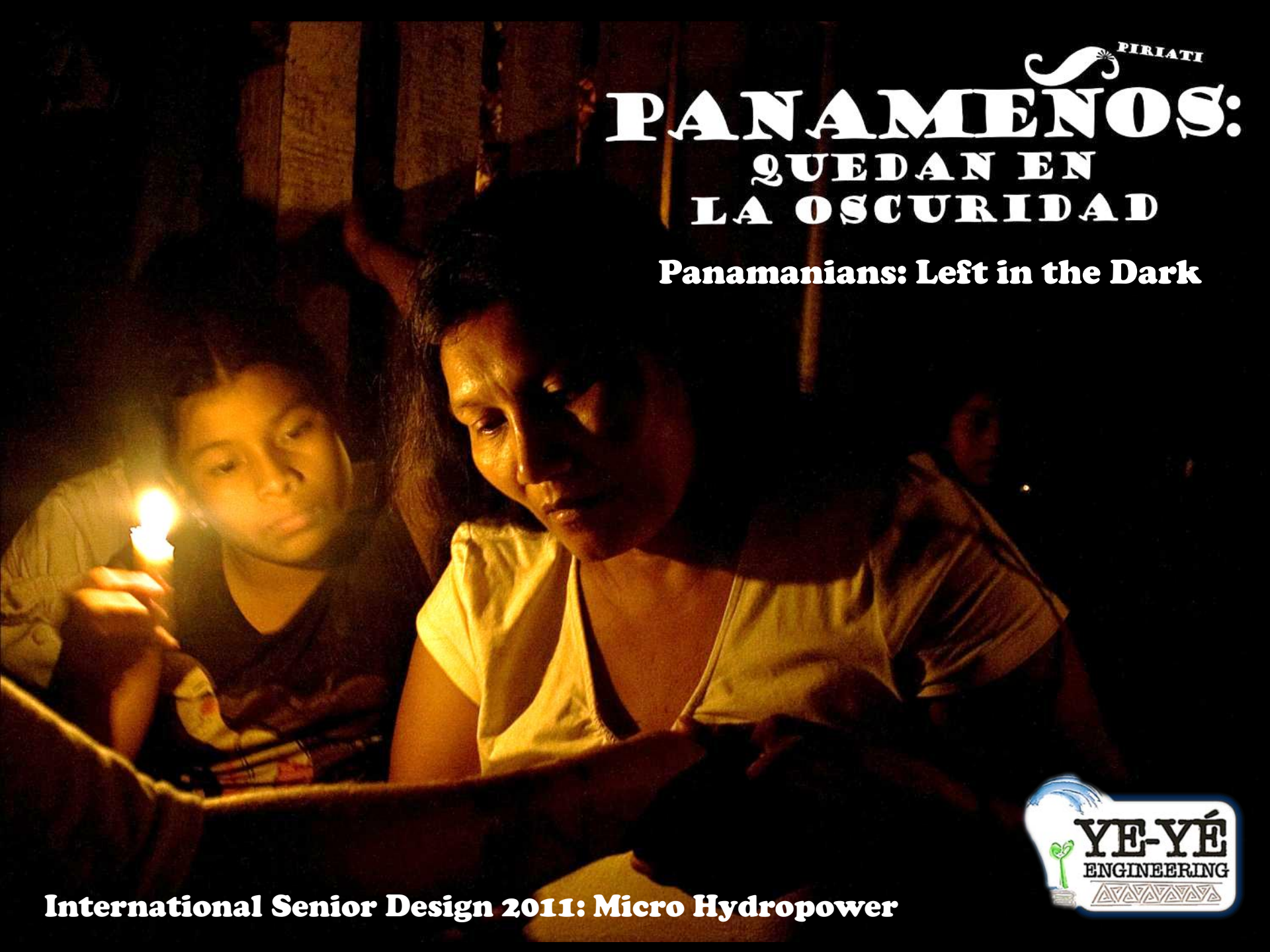
PIRIATI
PANAMEÑOS:
QUEDAN EN
LA OSCURIDAD
Panamanians: Left in the Dark
YE-YÉ
ENGINEERING
International Senior Design 2011: Micro Hydropower

Presented By: Yé-Yé Engineering

Mechanical Engineering

Josh Wiljanen

Electrical Engineering

Becca Prich
Alex Baril

Civil Engineering

Tyler Fincher
Kate Engels

Overview

- Site Location
- Community Information
- Assessment Trip
- Potential Sites
- Recommended Design
- Project Cost
- Construction Schedule
- Disclaimer & Conclusion

Map


North Atlantic Ocean
Panama
© 2011 Europa Technologies
US Dept of State Geographer
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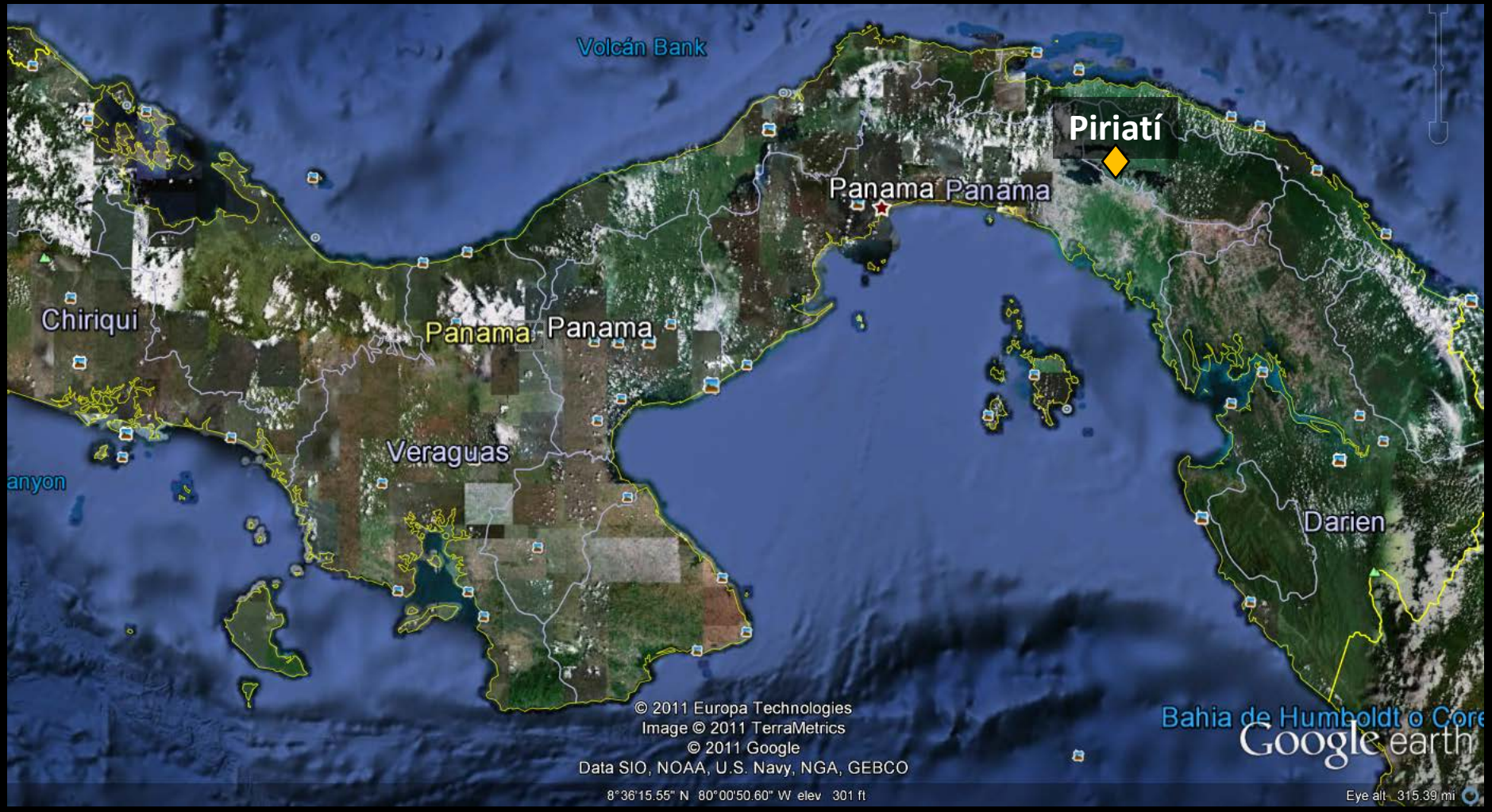
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google

Map


Volcán Bank
Piriatí
Panama Panama
Chiriqui
Panama Panama
Veraguas
Darien
© 2011 Europa Technologies
Image © 2011 TerraMetrics
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Data SIO, NOAA, U.S. Navy, NGA, GEBCO
8°36'15.55" N 80°00'50.60" W elev 301 ft
Eye alt 315.39 mi
Google earth

The Community

The Emberá

- Farmers, Artisans, and Service Providers
  - Subsistence farmers
  - Variable income with season
  - Multiple jobs for extra income
- Average Income: $150/ month
- 120 Homes with ~500 people

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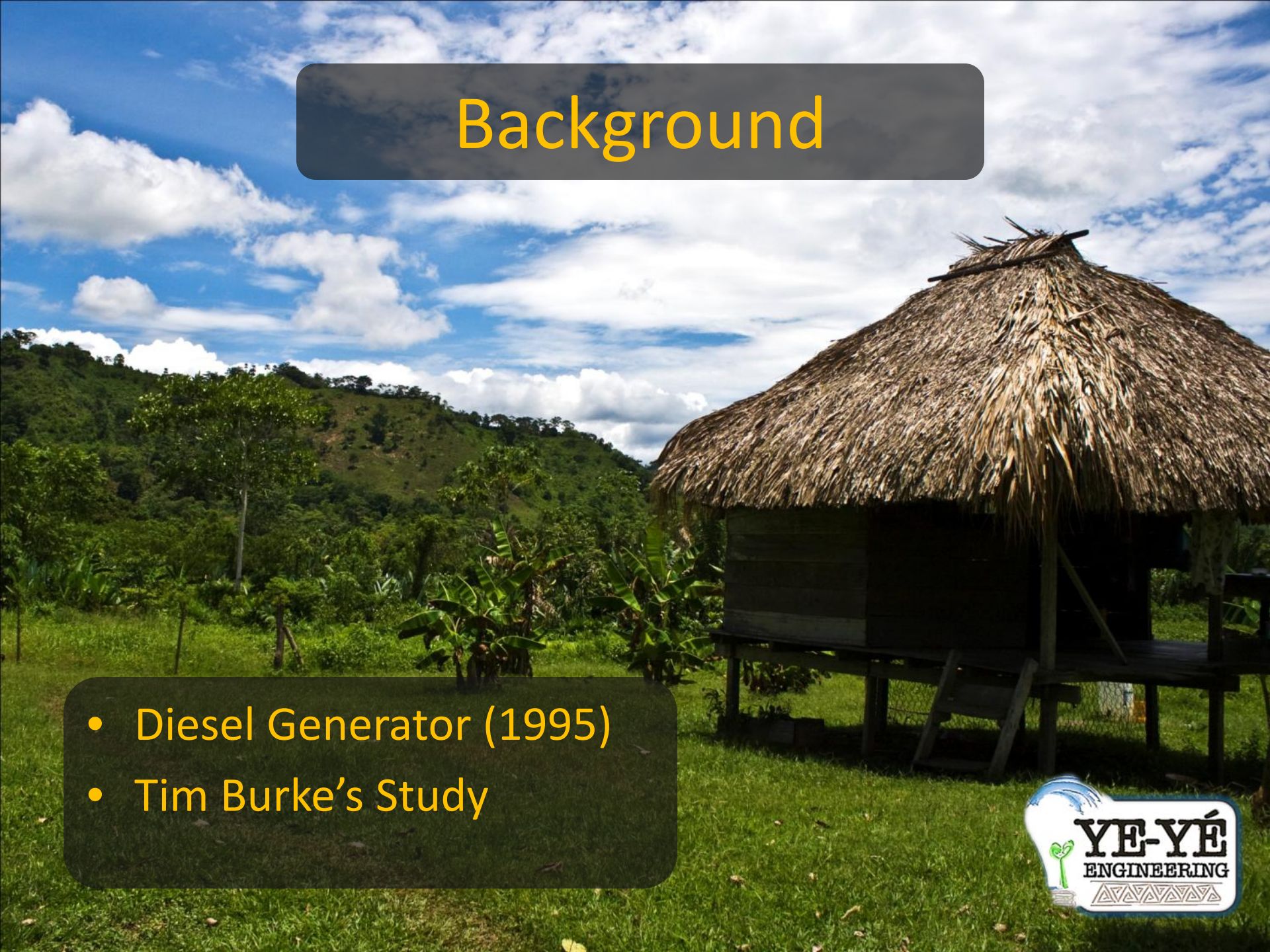
Background

- Diesel Generator (1995)
- Tim Burke's Study



Assessment Trip

- Met Community Leaders
- Survey
  - Land
  - Community
- Water Data Collection
- Land Exploration

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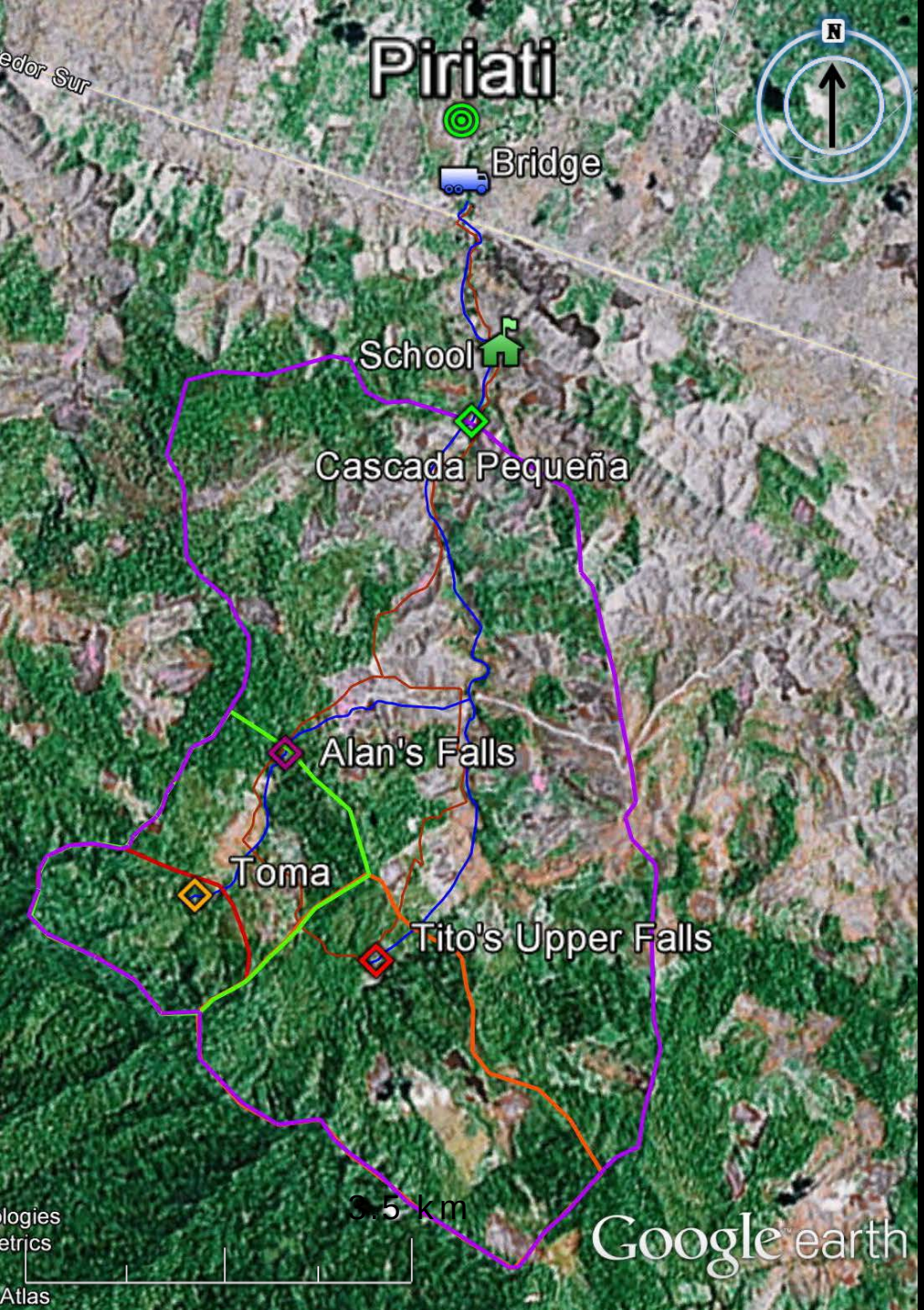
Potential Sites

- Cascada Pequeña
  - Power Canal
- Alan's Falls
- Tito's Upper Falls
- Tito's Lower Falls
- The Toma

Site Comparison

Waterfall Site	Transmission Distance (Km)	Potential Power (kW)	Power/Distance
Cascada Pequeña	2.6	4.2	1.62
Cascada Pequeña w/ Power Canal	**1.1**	**7.4**	**6.76**
Alan's Falls	**5.5**	**9.9**	**1.80**
Tito's Upper Falls	7.2	13.8	1.92
Tito's Lower Falls	7.0	14.7	2.10
The Toma	7.1	9.3	1.31



Watershed Map

- Land Overview
- Waterfall Locations
- Watershed Delineation
- Flow Rate Calculations

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Flow Rate Estimations

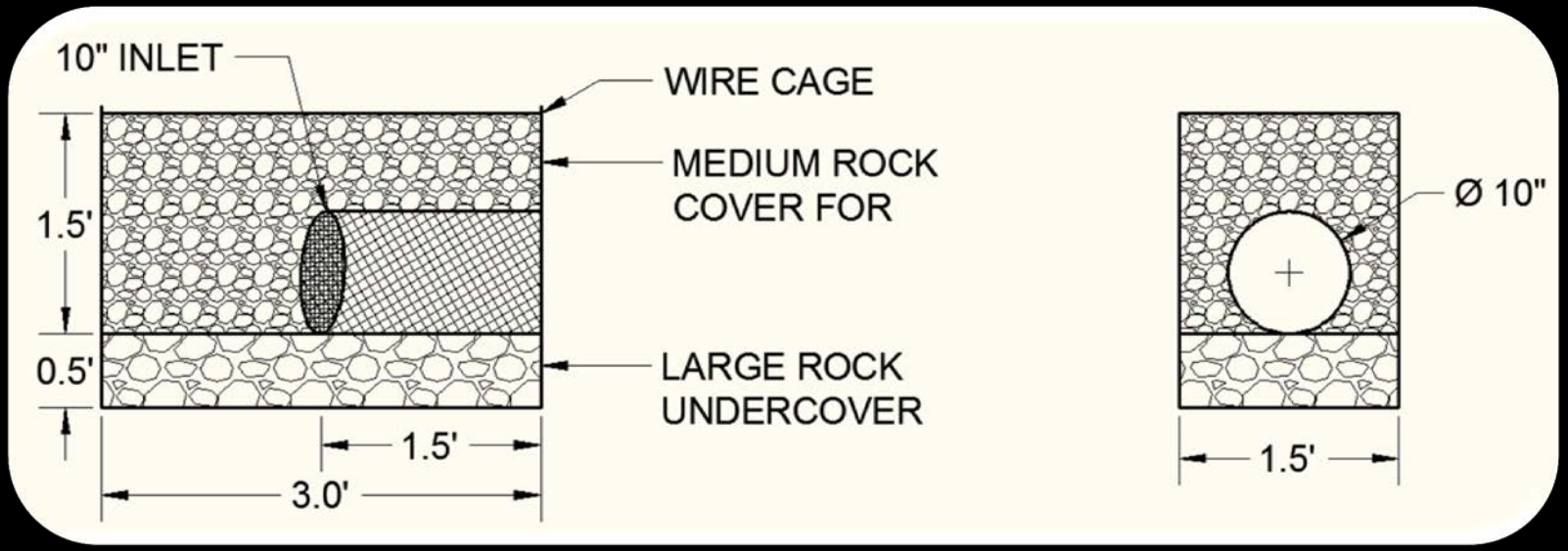
Waterfall Site	Area (km^2)	Percent of Total Area	Flow Rate (lps)
Cascada Pequeña	23.7	100.00%	969
Alan's Falls	3.7	15.39%	149
Tito's Upper Falls	4.9	20.85%	202
Tito's Lower Falls	4.9	20.85%	202
The Toma	1.5	6.44%	62

Primary Site: Alan's Falls

- Set of 5 Falls
- 3.4 Miles From Village
- Total Head
  - 22.9 meters
- Flow Rate
  - 149 lps
- Power Potential
  - 9.9 kW

Inlet Location

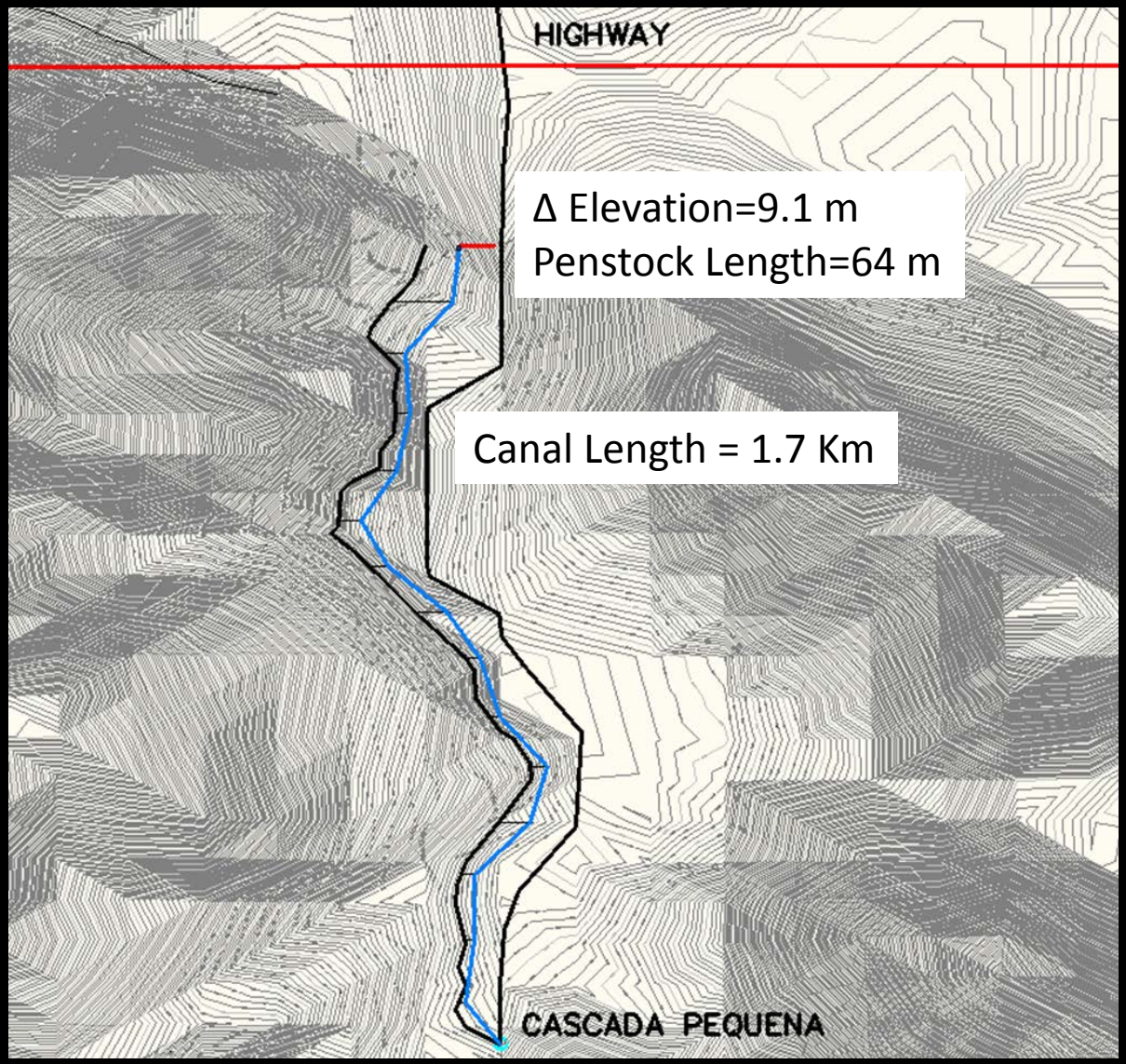
- Hydraulic Structure
- Inlet Details
- Penstock Design



Secondary Site: Cascada Pequeña with Power Canal

- Total Head
  - 9.1 meters
- Flow Rate
  - 309 lps
- Power Potential
  - 7.4 kW

Cascada Pequeña: Power Canal



- Water Fall Location
- Trench Length
- Pressure Head
- Penstock Length

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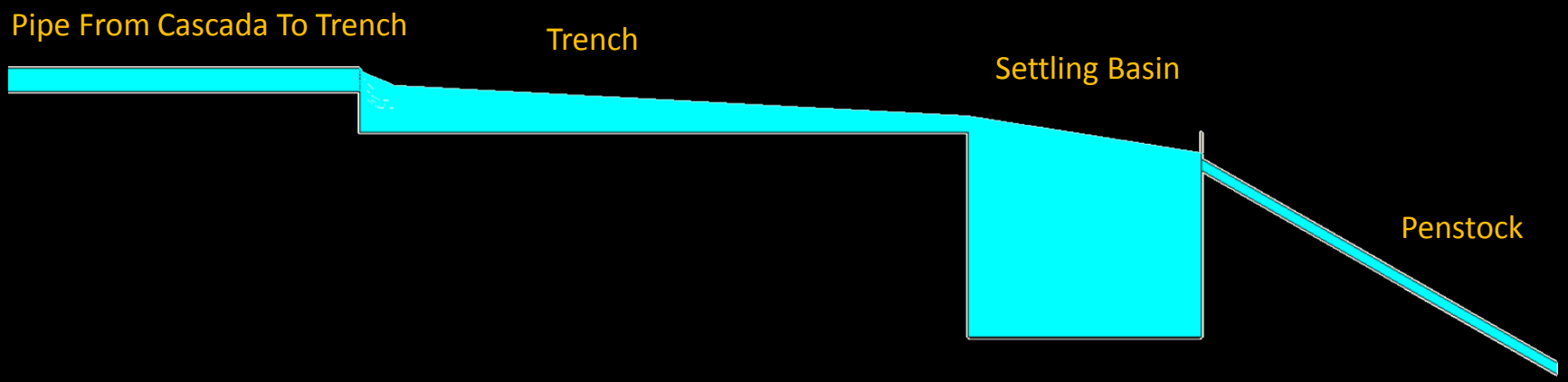
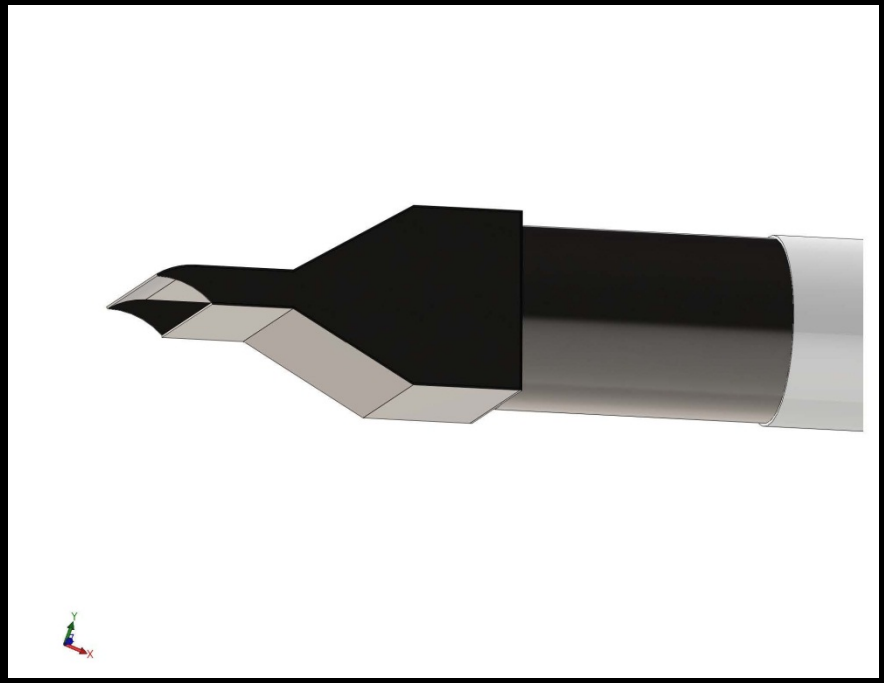
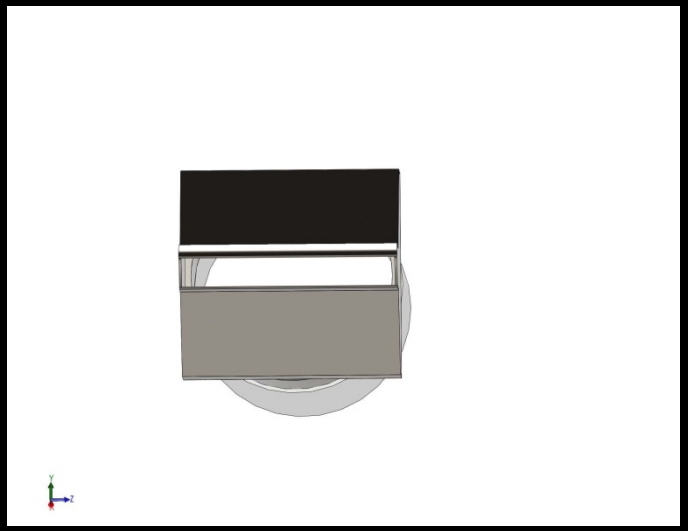
Profile View of Power Canal



Nozzle

- Rectangular Cross-Section
- Mostly Flat Steel Plate





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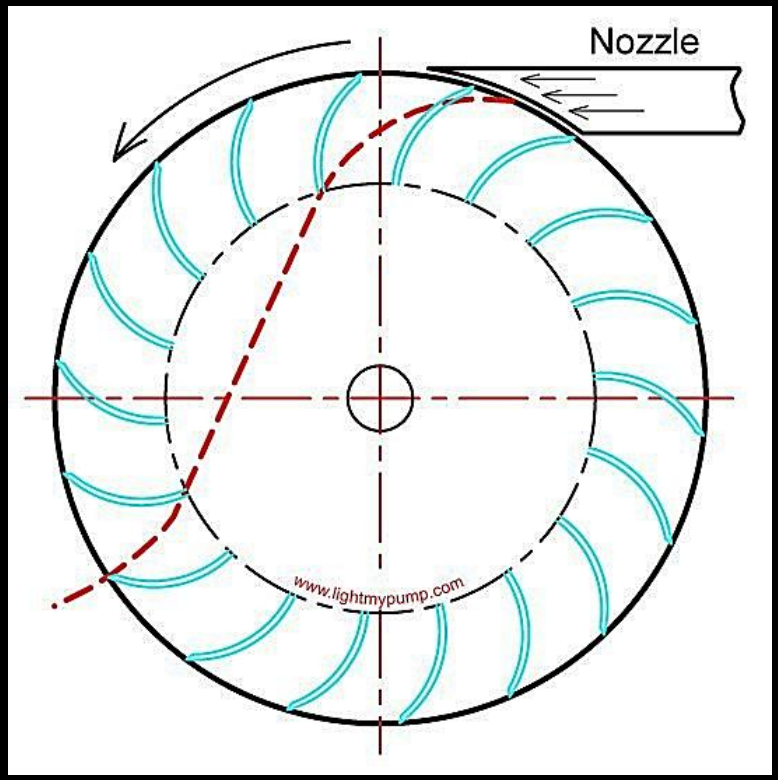
Cross-Flow Turbine

- Impulse Type
- Efficient for our Head and Flow
- Simple Construction
- Double Impact



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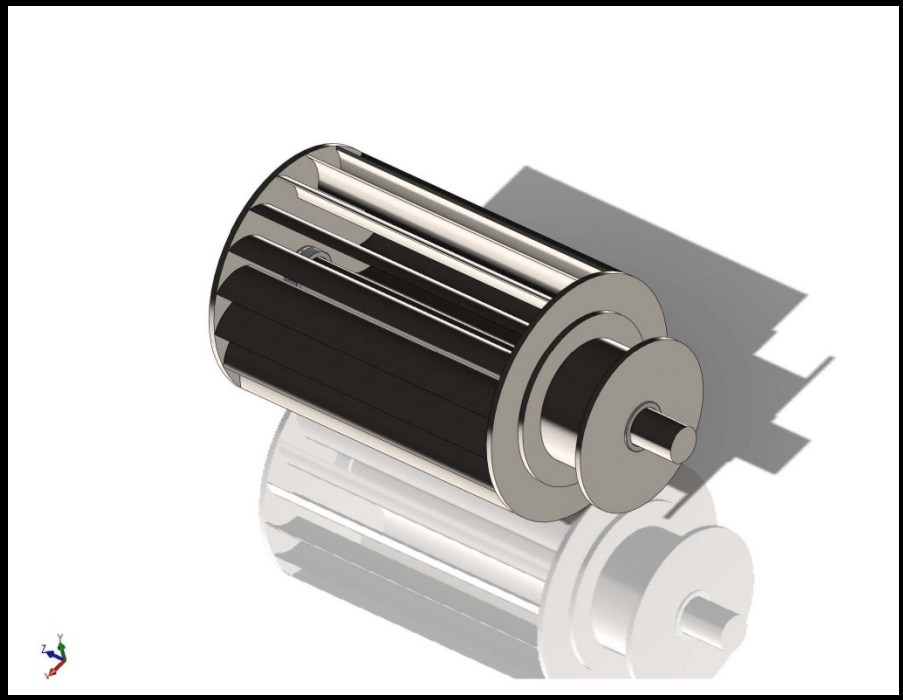
Turbine 3-D Model and Specifications

- Diameter: 200mm
- Width: 275mm
- Radius of Blade: 32.6mm
- Number of Blades: 18



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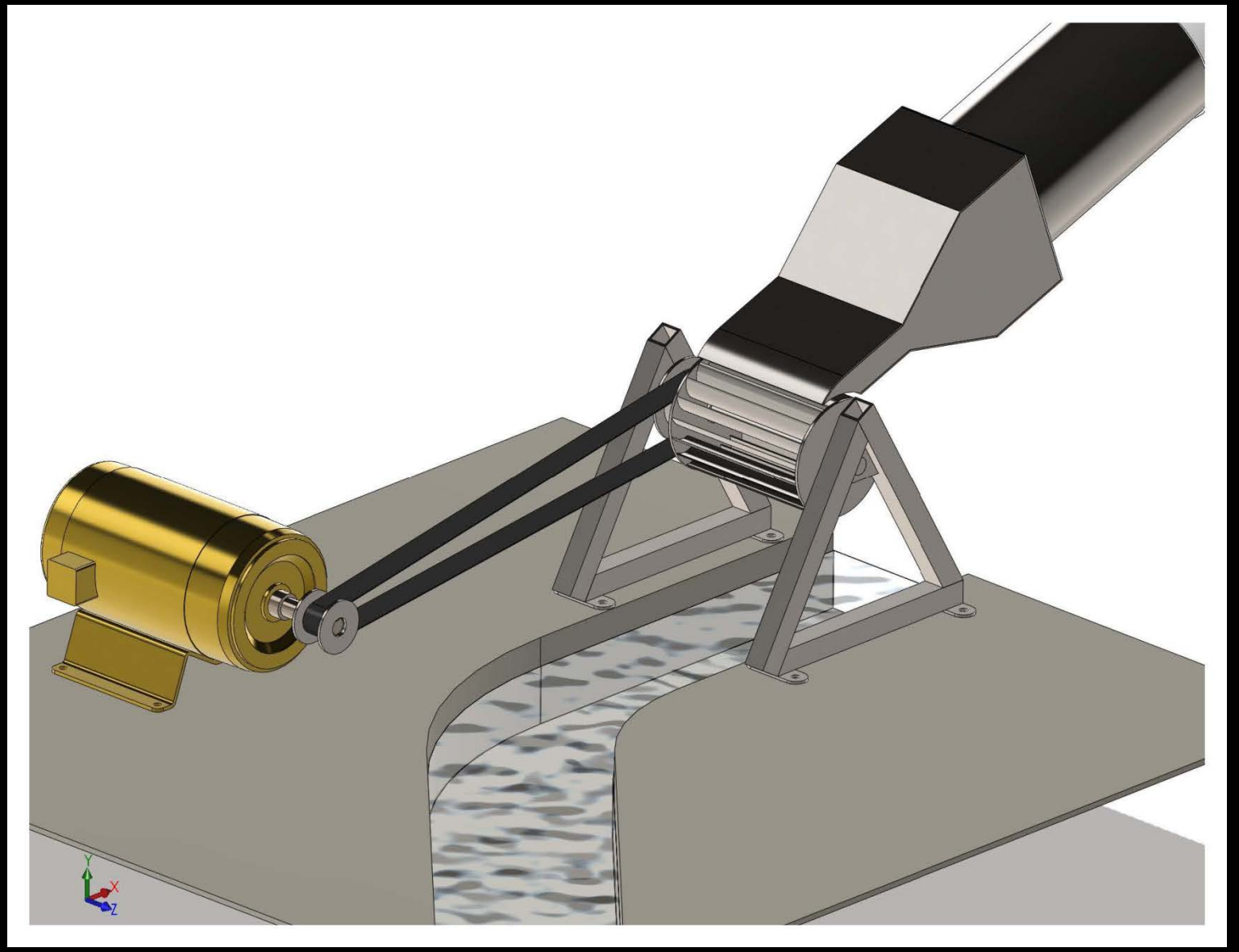
Full 3-D Assembly



Generator Specifications

- Induction Motor
- 15 HP
- 3-Phase
- Single Phase Reconfiguration
- Power Usage

Courtesy of www.baldor.com

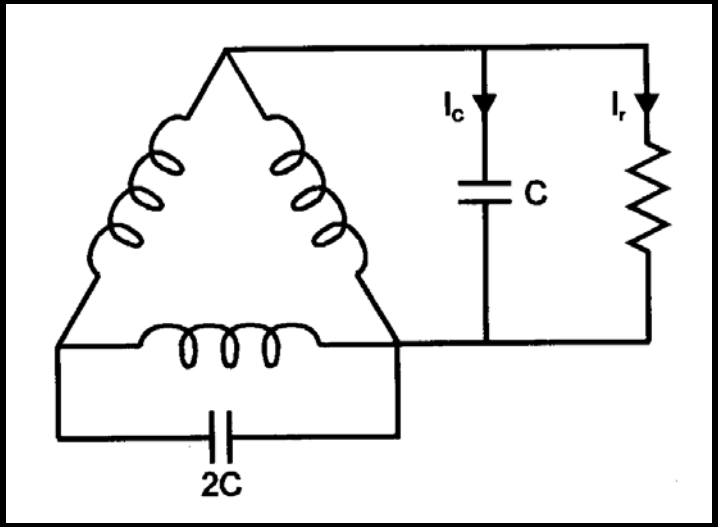


Diagram Courtesy of Nigel Smith, *Motors as Generators*

Control Elements

- Induction Generator Controller
- Ground Fault Circuit Interrupter
- Main Disconnect Switch

Photo Courtesy of ludens.cl

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Transmission System

- 10 kVA 460V/600V Step-Up Transformer
- Tie-Wire Fastening
- 600V - Single Phase
- Approx. 6.5 km Transmission Length (13 km of cable)

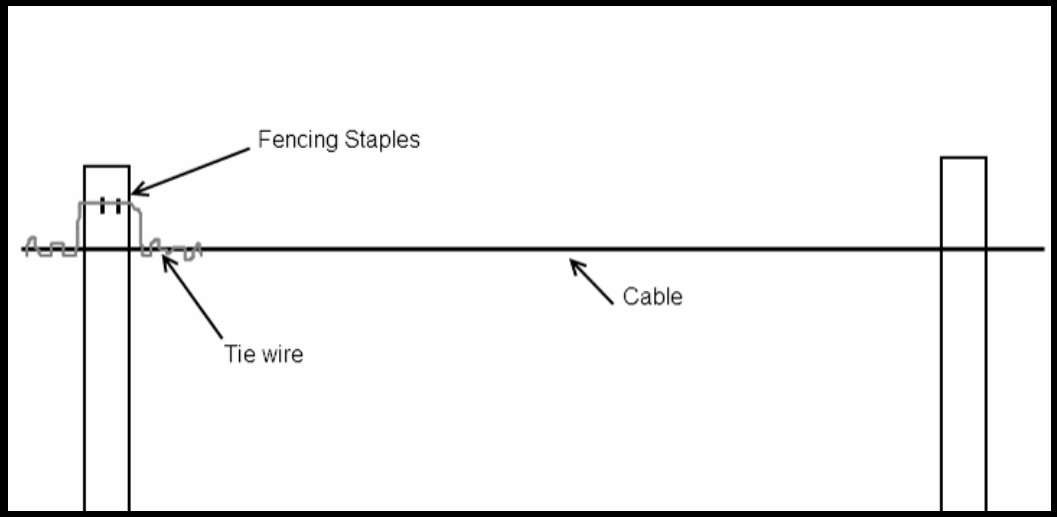

Diagram Courtesy of Tim Burke, *As-Built Documentation*

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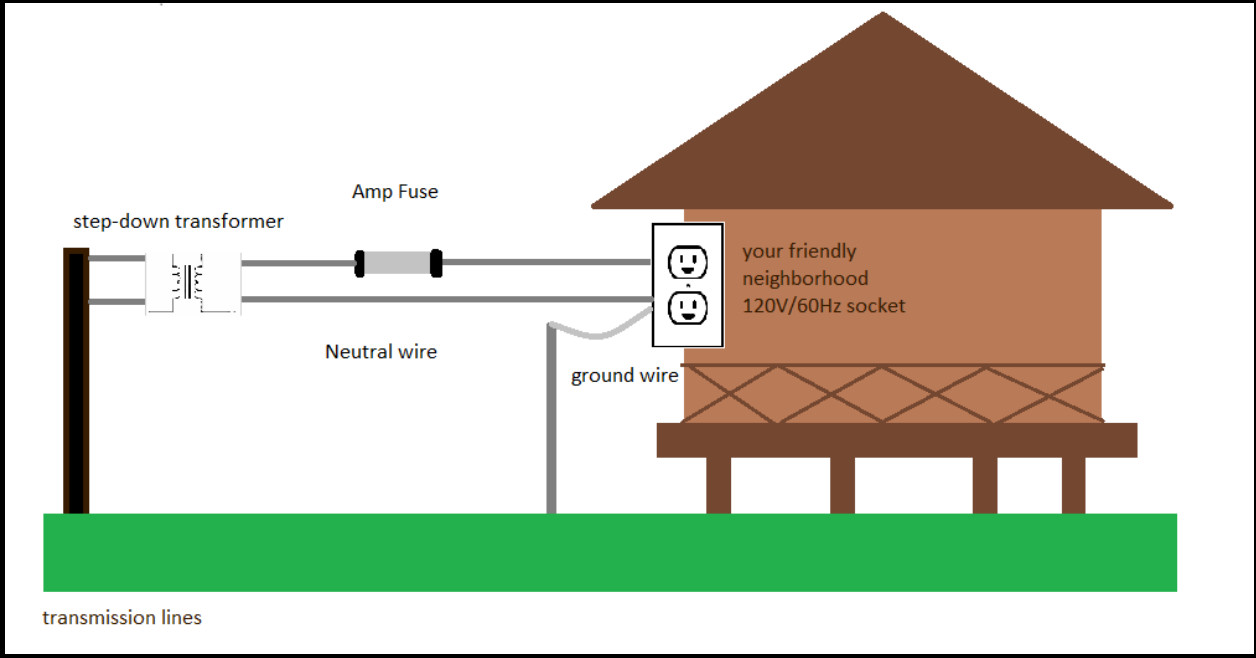
Distribution System

- 600V/120V Step-Down Transformers at Each Home
- Graduated Slow-Blow Fuse System
- 120V, 60 Hz Output from Wall Outlet



Cost Estimate

High-Cost Elements:

Penstock Piping

Quantity	Unit	Item/Material	Base Cost	Extension Cost
42	20’ section	10” PVC	$80	$3,360.00

Transformers and Transmission Cable

Quantity	Unit	Item	Base Cost	Extension Cost
100	Pc.	Transformer – 600V/120V .5kVA	$146.00	$14,600
13	Km	#1/0 Shielded Aluminum Cable	$1,505	$19,565

Projected Cost

Cost Breakdown by Category	
Concrete	$245.15
Penstock	$3,590.00
Turbine	$336.75
Transmission Material	$124.00
Technical Expertise	$1,600.00
Electrical Equipment	$46,292.20
Total Cost	**$56,484.00**

Construction Schedule

General Construction				
Commence Construction	3 days	Wed 8/1/12	Fri 8/3/12	
Acquire High Demand Supplies	14 days	Mon 8/6/12	Thu 8/23/12	3
Acquire Medium Demand Supplies	14 days	Mon 8/6/12	Thu 8/23/12	3
Acquire Low Demand Supplies	14 days	Mon 8/6/12	Thu 8/23/12	3
Final Inspection	3 days	Tue 12/25/12	Fri 12/28/12	62,56,48
Civil Construction				
Carry In Penstock Supplies	6 days	Fri 8/24/12	Fri 8/31/12	4
Mark Penstock Route	1 day	Mon 9/3/12	Mon 9/3/12	10
Construct Hydraulic Barrier	1 day	Mon 8/6/12	Mon 8/6/12	3
Construct Inlet	2 days	Mon 9/3/12	Tue 9/4/12	12,10
Layout Penstock	1 day	Mon 9/3/12	Mon 9/3/12	10
Construct Supports	1 day	Tue 9/4/12	Tue 9/4/12	14
Construct Penstock	1 day	Tue 9/4/12	Tue 9/4/12	14
Review Constructed Penstock	1 day	Wed 9/5/12	Wed 9/5/12	16
Foundation				
Bring in Aggregate and Cement for Foundation	6 days	Fri 8/24/12	Fri 8/31/12	4
Prepare Base for Generator house	1 day	Wed 9/5/12	Wed 9/5/12	19,16
Haul in Wood for Forms	1 day	Mon 9/3/12	Mon 9/3/12	4,19
Build wooden forms	1 day	Tue 9/4/12	Tue 9/4/12	21
Pour concrete for generator house	2 days	Thu 9/6/12	Fri 9/7/12	22,20
Foundation Curing Time	7 days	Fri 9/7/12	Mon 9/10/12	23
Build Generator house	2 days	Mon 9/10/12	Tue 9/11/12	24

Construction Schedule

Mechanical Construction				
Cut 30'x1" Dia. Steel Bars	2 days	Fri 8/24/12	Mon 8/27/12	4
Construct Wheel	7 days	Tue 8/28/12	Wed 9/5/12	28
Construct Base	4 days	Fri 8/31/12	Wed 9/5/12	29FF
Move Constructed Turbine to Alan's Falls	1 day	Thu 9/6/12	Thu 9/6/12	30
Install Turbine on Concrete Slab	1 day	Mon 9/10/12	Mon 9/10/12	24,31
Adjust Penstock Nozzles to Turbine	1 day	Tue 9/11/12	Tue 9/11/12	17,32
Connect Turbine to Generator	1 day	Tue 9/11/12	Tue 9/11/12	32
Electrical Construction				
Generation				
Purchase Motor to be Used as Generator	7 days	Fri 8/24/12	Mon 9/3/12	5
Send Motor Out to be Modified	4 days	Tue 9/4/12	Fri 9/7/12	38
Generator Winding Fix and Capacitor Bank Addition	35 days	Mon 9/10/12	Fri 10/26/12	39
Haul Generator to Site	1 day	Mon 10/29/12	Mon 10/29/12	39,40
Mount Generator to Foundation	1 day	Tue 10/30/12	Tue 10/30/12	41,24
Fit Turbine to Generator With Appropriate Gear	2 days	Wed 10/31/12	Thu 11/1/12	42,34
Haul in Transformer and Power Electronics	1 day	Fri 11/2/12	Fri 11/2/12	6,43
Wire Generator to Ballast Loads and IGC	3 days	Mon 11/5/12	Wed 11/7/12	44
Tie in the Ground Fault Breaker	2 days	Thu 11/8/12	Fri 11/9/12	45
Install Main Breaker	1 day	Mon 11/12/12	Mon 11/12/12	46
Install Step Up Transformer	1 day	Tue 11/13/12	Tue 11/13/12	47

Construction Schedule

Transmission				
Layout Path of Transmition Line	5 days	Mon 8/6/12	Fri 8/10/12	3
Clear Right-of-Way	30 days	Mon 8/13/12	Fri 9/21/12	50
Dig Holes for Transmission Poles	40 days	Mon 8/27/12	Fri 10/19/12	51SS+10 d
Haul Poles to Specific Locations	24 days	Tue 9/18/12	Fri 10/19/12	6,52FF
Install Poles	30 days	Thu 9/20/12	Wed 10/31/12	6,53SS+2 d
Roll Out Transmission Lines to Specific Locations	25 days	Tue 10/2/12	Mon 11/5/12	54FF+3 da
Run Lines	21 days	Mon 10/8/12	Mon 11/5/12	55FF
Distribution				
Distribute Copper Lines, Electrical Boxes, Fuses and Outl	18 days	Sat 10/20/12	Tue 11/13/12	6
Install Step Down Transformer for Village Distribution	2 days	Tue 11/13/12	Thu 11/15/12	58
Run Transmission Lines for In-village Distribution	14 days	Thu 11/15/12	Wed 12/5/12	59
Install Step Down Transformers	14 days	Thu 11/15/12	Wed 12/5/12	60SS
Wire Each Home	28 days	Thu 11/15/12	Tue 12/25/12	61SS

Disclaimer

- Feasibility Analysis
- Recommended Design
- Advise Further Study
- Alternative Answers

Conclusion

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Questions?

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