Appendix I-12 Construction Cost for Lomo Largo Power Station

I. Summary of Construction Cost for Lomo Largo Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**4,485**	
(1) Access Road	0	
(2) Facilities for Construction Office	1,687	Cost of Civil Works x 0.05
(3) Transportation cost	2,798	279.01ton x $10.03/ton
2. Cost for Environmental Mesures	**337**	Cost of Civil Works x 0.01
3. Civil Works	**33,757**	
(1) Weir	1,282	
(2) Intake	2,011	
(3) Settling Basin	1,397	
(4) Headrace	2,077	
(5) Head Tank	3,847	
(6) Penstock & Spillway Channel	18,002	
(7) Power House	4,326	
(8) Outlet	815	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**26,900**	
(1) Gate & Screen	1,182	
(2) Penstock	0	
(3) PVC (φ300)	14,903	
(4) PVC (φ150)	6,381	
(5) Others	4,434	
5. Electrical Equipment	**17,500**	
6. Direct Cost	**82,979**	1.+2.+3.+4.+5.
7. Engineering Cost	**8,298**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**7,723**	6. x 0.093
9. IGV	**18,810**	19.00%
10. Total Cost	**117,810**	

II. Detailed Statement of Transportation Cost for Lomo Largo Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**9.48**	
a. Cements		1.98	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		7.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.14	
(2) Intake	ton	**19.18**	
a. Gate		0.09	
b. Screen		0.04	
c. Cements		3.98	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		14.74	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.32	
(3) Settling Basin	ton	**8.63**	
a. Cements		1.71	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		6.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.57	
(4) Headrace	ton	**4.48**	
a. PVC (φ300)		4.48	Weight: 870m x 30.918kg/6m
(5) Head Tank	ton	**21.13**	
a. Cements		4.32	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		16.00	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.82	
(6) Penstock & Spillway Channel	ton	**188.04**	
a. Penstock Steel (φ150)		0.00	
b. Penstock PVC (φ150)		1.12	Weight: 210m x 32.000kg/6m
c. Cements		39.74	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		147.18	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.00	
(7) Power House	ton	**25.92**	
a. Cements		5.29	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		19.59	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.05	
(8) Outlet	ton	**2.15**	
a. Cements		0.38	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		1.42	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.34	
(9) Subtotal		**279.01**	
(10) Transportation Cost		**2,799**	(9) x $10.03/ton

III. Detailed Statement of Civil Works Cost for Lomo Largo Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**1,282**	
a. Excavation	m^3	5.53	42.2	233	
b. Concrete	m^3	93.05	7.3	683	
c. Reinforcement Bars	ton	1,070.00	0.1	153	
d. Others	-			213	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**2,011**	
a. Excavation	m^3	5.53	6.6	36	
b. Concrete	m^3	93.05	14.7	1,371	
c. Reinforcement Bars	ton	1,070.00	0.3	342	
d. Others	-			262	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**1,397**	
a. Excavation	m^3	5.53	12.1	66	
b. Concrete	m^3	93.05	6.3	590	
c. Reinforcement Bars	ton	1,070.00	0.6	614	
d. Others	-			127	(a+b+c) x 0.10 (including other works)
(4) Headrace				**2,077**	
a. Excavation	m^3	5.53	313.2	1,731	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			346	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**3,847**	
a. Excavation	m^3	5.53	70.1	387	
b. Concrete	m^3	93.05	16.0	1,488	
c. Reinforcement Bars	ton	1,070.00	0.8	873	
d. Others	-			1,099	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**18,002**	
a. Excavation	m^3	5.53	483.2	2,671	
b. Concrete	m^3	93.05	147.2	13,695	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,636	(a+b+c) x 0.10 (including filling works)
(7) Power House				**4,326**	
a. Excavation	m^3	5.53	70.3	388	
b. Concrete	m^3	93.05	19.6	1,822	
c. Reinforcement Bars	ton	1,070.00	1.0	1,118	
d. Others	-			998	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**815**	
a. Excavation	m^3	5.53	37.9	209	
b. Concrete	m^3	93.05	1.4	132	
c. Reinforcement Bars	ton	1,070.00	0.3	368	
d. Others	-			106	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**33,757**	

IV. Detailed Statement of Hydraulic Equipment Cost for Lomo Largo Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,182**	
a. Gate	ton	8,811.04	0.09	824	
b. Screen	ton	8,811.04	0.04	358	
(3) Penstock Steel (φ150）	ton	3,100.00	0.00	**0**	
(4) PVC (φ300）for headrace	m	17.13	870	**14,903**	
(5) Penstock PVC (φ150) C-10	m	30.39	210	**6,381**	
(6) Subtotal				**22,466**	
(7) Others				**4,434**	19.74%
(8) Total				**26,900**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**42.21**	(m^3)
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**7.35**	(m^3)
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.14**	(ton)
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton) (unconsidered)

Where,

H_d:	Height of Dam =	**0.20**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**6.57**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**14.74**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.32**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.09**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.04**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.030**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**12.09**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**6.35**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.57**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.11**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.06**	(ton)

Where,

Q: Maximum Discharge = 0.030 (m^3/s)

(4) Headrace

In the case of PVCφ300:

Excavation:	$V_e = B \times H \times L$	=	**313.20**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.030	(m^3/s)	
L:	Length of Channel =	**870.00**	(m)	
B:	Width of Channel =	**0.60**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.60**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**70.14**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**16.00**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**0.82**	(ton)

Where,

Q: Maximum Discharge = 0.030 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ150:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**97.40**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ150:

Excavation:	$V_e = B \times H \times L$	=	124.51	(m^3)

Where,

Q:	Maximum Discharge =	0.030	(m^3/s)	
L:	Length of Channel =	**210.00**	(m)	
B:	Width of Channel =	**0.77**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.77**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.29	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	358.65	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	147.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.030	(m^3/s)
L:	Length of Channel =	**210.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**483.16**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**147.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**70.31**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**19.59**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**1.05**	(ton)

Where,

Q:	Maximum Discharge =	0.030	(m^3/s)
He:	Effective Head =	97.40	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	37.91	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	1.42	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.34	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.030	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

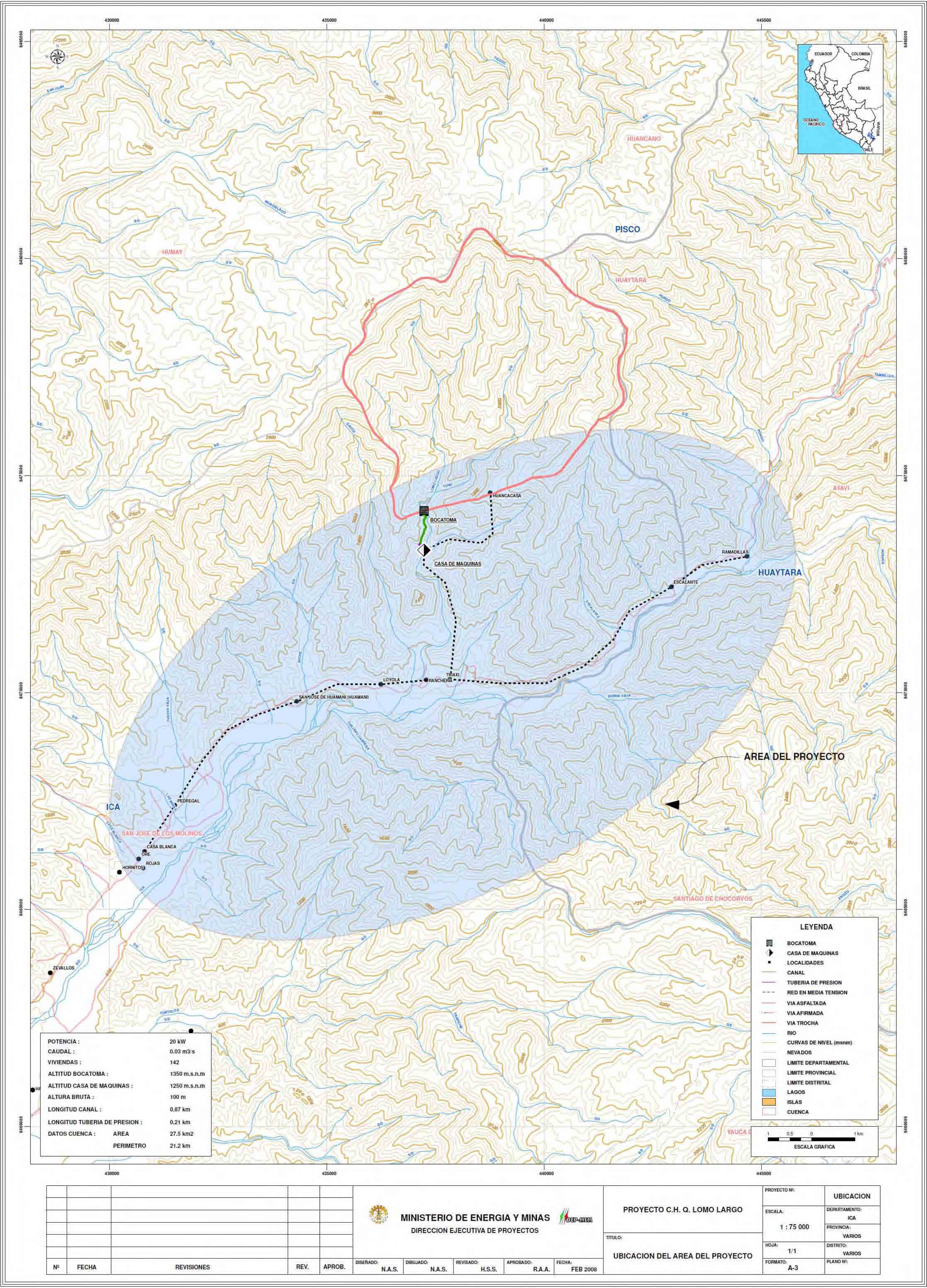
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ300)		**17.13**	(US$/m)	RIB LOC for Headrace
PVC (φ150)	:	**30.39**	(US$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.7 = 30.39

(3) Others				
Access Road	:	**-**	(US$/m)	-

(4) Transportation Cost				
Ica to the site	:	**10.03**	(US$/ton)	24km (minimum rate for 46 km)

Lomo Largo Map



Appendix I-13 Construction Cost for Poyeni Power Station

I. Summary of Construction Cost for Poyeni Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**82,875**	
(1) Access Road	9,169	
(2) Facilities for Construction Office	3,564	Cost of Civil Works x 0.05
(3) Transportation cost	70,142	567.26ton x $123.65/ton
2. Cost for Environmental Mesures	**712**	Cost of Civil Works x 0.01
3. Civil Works	**71,289**	
(1) Weir	2,221	
(2) Intake	3,042	
(3) Settling Basin	2,939	
(4) Headrace	5,732	
(5) Head Tank	7,043	
(6) Penstock & Spillway Channel	40,389	
(7) Power House	8,687	
(8) Outlet	1,236	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**63,500**	
(1) Gate & Screen	1,881	
(2) Penstock	1,007	
(3) PVC (φ400)	35,545	
(4) PVC (φ200)	14,556	
(5) Others	10,511	
5. Electrical Equipment	**35,000**	
6. Direct Cost	**253,376**	1.+2.+3.+4.+5.
7. Engineering Cost	**25,338**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**25,286**	6. x 0.100
9. IGV	**57,760**	19.00%
10. Total Cost	**361,760**	

II. Detailed Statement of Transportation Cost for Poyeni Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.23	
(2) Intake	ton	**28.60**	
a. Gate		0.15	
b. Screen		0.07	
c. Cements		5.93	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		21.96	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.51	
(3) Settling Basin	ton	**18.94**	
a. Cements		3.79	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		14.02	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.12	
(4) Headrace	ton	**9.27**	
a. PVC (φ400)		9.27	Weight: 1,350m x 41.214kg/6m
(5) Head Tank	ton	**38.77**	
a. Cements		7.92	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		29.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.50	
(6) Penstock & Spillway Channel	ton	**399.08**	
a. Penstock Steel (φ200)		0.33	
b. Penstock PVC (φ200)		3.49	Weight: 419m x 50.000kg/6m
c. Cements		84.02	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		311.19	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.05	
(7) Power House	ton	**51.84**	
a. Cements		10.56	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		39.12	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.16	
(8) Outlet	ton	**3.71**	
a. Cements		0.69	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.54	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.49	
(9) Subtotal		**567.26**	
(10) Transportation Cost		**70,142**	(9) x $123.65/ton

III. Detailed Statement of Civil Works Cost for Poyeni Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**3,042**	
a. Excavation	m^3	5.53	11.6	63	
b. Concrete	m^3	93.05	22.0	2,042	
c. Reinforcement Bars	ton	1,070.00	0.5	541	
d. Others	-			396	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,939**	
a. Excavation	m^3	5.53	29.9	165	
b. Concrete	m^3	93.05	14.0	1,305	
c. Reinforcement Bars	ton	1,070.00	1.1	1,202	
d. Others	-			267	(a+b+c) x 0.10 (including other works)
(4) Headrace				**5,732**	
a. Excavation	m^3	5.53	864.0	4,777	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			955	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**7,043**	
a. Excavation	m^3	5.53	126.6	700	
b. Concrete	m^3	93.05	29.3	2,730	
c. Reinforcement Bars	ton	1,070.00	1.5	1,601	
d. Others	-			2,012	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**40,389**	
a. Excavation	m^3	5.53	1393.5	7,705	
b. Concrete	m^3	93.05	311.2	28,956	
c. Reinforcement Bars	ton	1,070.00	0.1	57	
d. Others	-			3,671	(a+b+c) x 0.10 (including filling works)
(7) Power House				**8,687**	
a. Excavation	m^3	5.53	132.4	731	
b. Concrete	m^3	93.05	39.1	3,640	
c. Reinforcement Bars	ton	1,070.00	2.2	2,312	
d. Others	-			2,004	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,236**	
a. Excavation	m^3	5.53	56.9	314	
b. Concrete	m^3	93.05	2.5	236	
c. Reinforcement Bars	ton	1,070.00	0.5	525	
d. Others	-			161	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**71,289**	

IV. Detailed Statement of Hydraulic Equipment Cost for Poyeni Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,881**	
a. Gate	ton	8,811.04	0.15	1,295	
b. Screen	ton	8,811.04	0.07	586	
(3) Penstock Steel (φ200)	ton	3,100.00	0.33	**1,007**	
(4) PVC (φ400) for headrace	m	26.33	1,350	**35,545**	
(5) Penstock PVC (φ200) C-10	m	34.74	419	**14,556**	
(6) Subtotal				**52,989**	
(7) Others				**10,511**	19.84%
(8) Total				**63,500**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**11.56**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**21.96**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.51**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.15**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.07**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.070**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**29.93**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**14.02**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.12**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.18**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.11**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**864.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**1,350.00**	(m)	
B:	Width of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	**-**	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**126.60**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**29.35**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.50**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	26.92	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	3.01	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.05	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**21.00**	(m)

Weight of Penstock	W_{p1} =	$7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.33	(ton)
Thickness of Penstock:	t_m =	$0.0362 \times H \times D_m + 2$	=	2.73	(mm)

Where,

W_{p1}:	Weight of Penstock	0.33	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.73	(mm)	
D_m:	Avg. Diameter of Penstock =	0.20	(m)	
H:	Design Head =	**100.80**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	21.00	(m)	

Penstock (PVC)φ200:

Excavation:	V_e =	$B \times H \times L$	=	317.14	(m^3)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**419.00**	(m)	
B:	Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	(B x H)^0.5 =	$1.09 \times Q^{0.379}$	=	0.40	
Excavation:	V_e =	$6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	1,049.42	(m^3)
Concrete:	V_c =	$H \times t \times 2 + (B + 2t) \times L$	=	308.18	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
L:	Length of Channel =	**440.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**1,393.48**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**311.19**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.05**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.33**	(ton)

(7) Power House

Excavation:	V_e =	$97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**132.35**	(m^3)
Concrete:	V_c =	$28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**39.12**	(m^3)
Reinforcement Bars	W_r =	$0.046 \times V_c^{1.05}$	=	**2.16**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
He:	Effective Head =	100.80	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	56.89	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.54	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.49	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.070	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

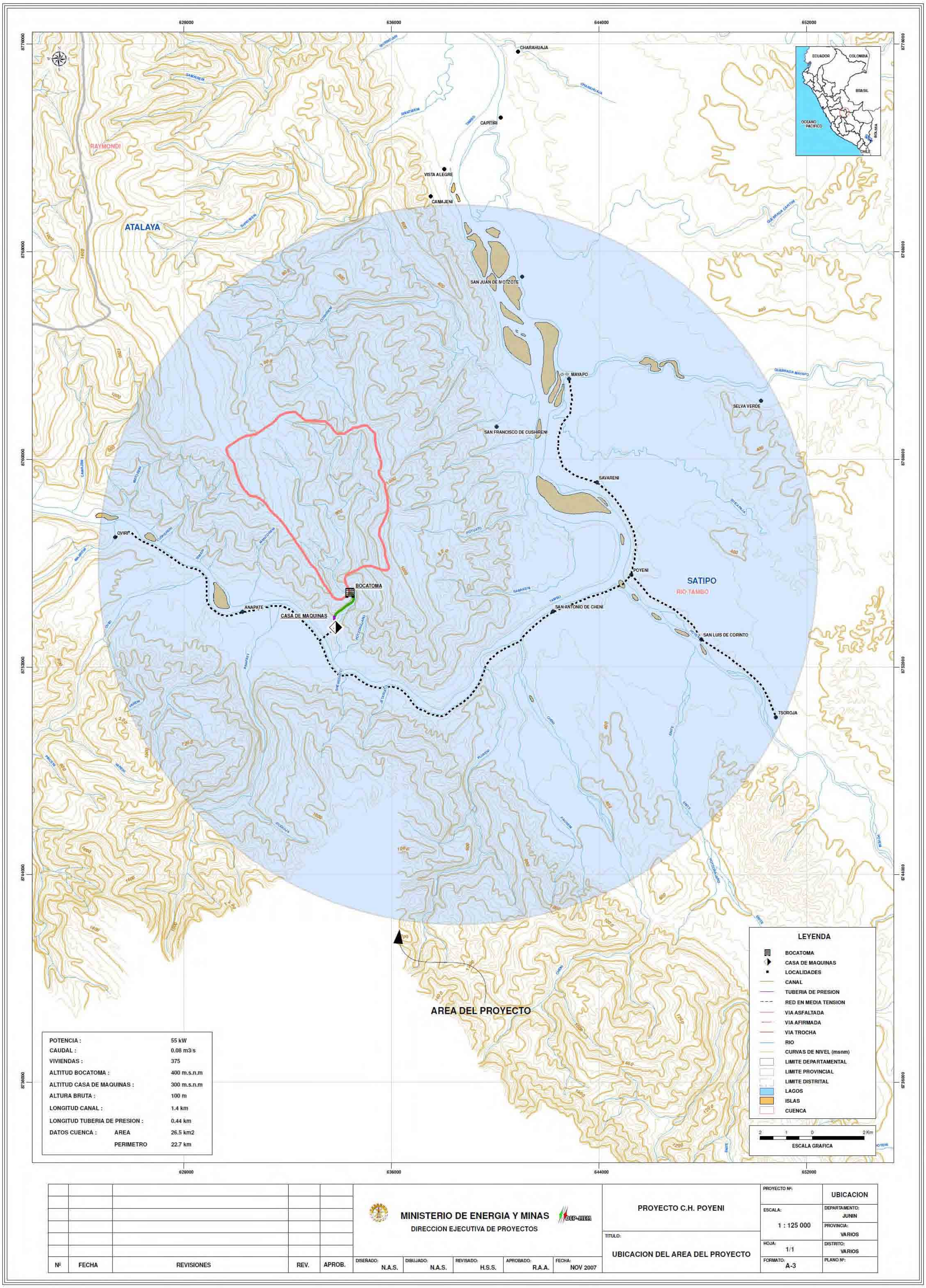
(1) Civil Works				
Excavation				
Open	:	**5.53**	(US$/m³)	* (8.70+2.35) x 0.5 = $5.53/m³, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m³)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment				
Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ400）		**26.33**	(US$/m)	RIB LOC for Headrace
PVC (φ200)	:	**34.74**	(US$/m)	80% of TUBOPLAST(φ 315） for Penstock (C-10) = 43.42 x 0.8 = 34.74

(3) Others				
Access Road	:	**5,877.89**	(US$/m)	Constrruction of Unpaved Road (3.0m Width)

(4) Transportation Cost				
Huancayo to the site	:	**123.65**	(US$/ton)	479 km (road) + 100km (river) = 24.98 + 98.67 = 123.65 US$/ton

Poyeni Map



RAYMONDI
ATALAYA
SATIPO
RIO TAMBO
CHARAHUAJA
CAPITIRI
VISTA ALEGRE
CAMAJENI
SAN JUAN DE INOTZOTE
MAYAPO
SELVA VERDE
SAN FRANCISCO DE CUSHIRENI
SAVARENI
OVIRI
BOCATOMA
ANAPATE
CASA DE MAQUINAS
POYENI
SAN ANTONIO DE CHENI
SAN LUIS DE CORINTO
TSOROJA
AREA DEL PROYECTO
ECUADOR
COLOMBIA
BRASIL
OCEANO PACIFICO
BOLIVIA
CHILE
LEYENDA
BOCATOMA
CASA DE MAQUINAS
LOCALIDADES
CANAL
TUBERIA DE PRESION
RED EN MEDIA TENSION
VIA ASFALTADA
VIA AFIRMADA
VIA TROCHA
RIO
CURVAS DE NIVEL (msnm)
LIMITE DEPARTAMENTAL
LIMITE PROVINCIAL
LIMITE DISTRITAL
LAGOS
ISLAS
CUENCA
ESCALA GRAFICA
POTENCIA : 55 kW
CAUDAL : 0.08 m3/s
VIVIENDAS : 375
ALTITUD BOCATOMA : 400 m.s.n.m
ALTITUD CASA DE MAQUINAS : 300 m.s.n.m
ALTURA BRUTA : 100 m
LONGITUD CANAL : 1.4 km
LONGITUD TUBERIA DE PRESION : 0.44 km
DATOS CUENCA : AREA 26.5 km2
PERIMETRO 22.7 km
Nº
FECHA
REVISIONES
REV.
APROB.
MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS
DEP-MEM
DISEÑADO: N.A.S.
DIBUJADO: N.A.S.
REVISADO: H.S.S.
APROBADO: R.A.A.
FECHA: NOV 2007
PROYECTO C.H. POYENI
TITULO:
UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:
ESCALA: 1 : 125 000
HOJA: 1/1
FORMATO: A-3
UBICACION
DEPARTAMENTO: JUNIN
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Appendix I-14 Construction Cost for Saureni Power Station

I. Summary of Construction Cost for Saureni Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**65,030**	
(1) Access Road	0	
(2) Facilities for Construction Office	3,342	Cost of Civil Works x 0.05
(3) Transportation cost	61,688	498.89ton x $123.65/ton
2. Cost for Environmental Mesures	**668**	Cost of Civil Works x 0.01
3. Civil Works	**66,852**	
(1) Weir	2,221	
(2) Intake	3,443	
(3) Settling Basin	3,667	
(4) Headrace	5,905	
(5) Head Tank	8,428	
(6) Penstock & Spillway Channel	31,389	
(7) Power House	10,400	
(8) Outlet	1,399	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**61,200**	
(1) Gate & Screen	2,158	
(2) Penstock	0	
(3) PVC (φ500)	37,086	
(4) PVC (φ200)	11,811	
(5) Others	10,145	
5. Electrical Equipment	**41,100**	
6. Direct Cost	**234,850**	1.+2.+3.+4.+5.
7. Engineering Cost	**23,485**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**22,665**	6. x 0.097
9. IGV	**53,390**	19.00%
10. Total Cost	**334,390**	

II. Detailed Statement of Transportation Cost for Saureni Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.23	
(2) Intake	ton	**32.20**	
a. Gate		0.17	
b. Screen		0.08	
c. Cements		6.67	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		24.71	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.58	
(3) Settling Basin	ton	**23.91**	
a. Cements		4.79	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		17.74	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.37	
(4) Headrace	ton	**7.64**	
a. PVC (φ500)		7.64	Weight: 890m x 51.522kg/6m
(5) Head Tank	ton	**46.41**	
a. Cements		9.49	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		35.13	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.79	
(6) Penstock & Spillway Channel	ton	**305.32**	
a. Penstock Steel (φ200)		0.00	
b. Penstock PVC (φ200)		2.83	Weight: 340m x 50.000kg/6m
c. Cements		64.31	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		238.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**61.99**	
a. Cements		12.62	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		46.76	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.61	
(8) Outlet	ton	**4.37**	
a. Cements		0.81	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		3.01	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.55	
(9) Subtotal		**498.89**	
(10) Transportation Cost		**61,688**	(9) x $123.65/ton

III. Detailed Statement of Civil Works Cost for Saureni Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**3,443**	
a. Excavation	m^3	5.53	13.7	75	
b. Concrete	m^3	93.05	24.7	2,299	
c. Reinforcement Bars	ton	1,070.00	0.6	620	
d. Others	-			449	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**3,667**	
a. Excavation	m^3	5.53	39.2	216	
b. Concrete	m^3	93.05	17.7	1,651	
c. Reinforcement Bars	ton	1,070.00	1.4	1,467	
d. Others	-			333	(a+b+c) x 0.10 (including other works)
(4) Headrace				**5,905**	
a. Excavation	m^3	5.53	890.0	4,921	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			984	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**8,428**	
a. Excavation	m^3	5.53	150.8	834	
b. Concrete	m^3	93.05	35.1	3,269	
c. Reinforcement Bars	ton	1,070.00	1.8	1,917	
d. Others	-			2,408	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**31,389**	
a. Excavation	m^3	5.53	1152.7	6,374	
b. Concrete	m^3	93.05	238.2	22,162	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			2,853	(a+b+c) x 0.10 (including filling works)
(7) Power House				**10,400**	
a. Excavation	m^3	5.53	155.8	861	
b. Concrete	m^3	93.05	46.8	4,350	
c. Reinforcement Bars	ton	1,070.00	2.6	2,789	
d. Others	-			2,400	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,399**	
a. Excavation	m^3	5.53	64.2	354	
b. Concrete	m^3	93.05	3.0	280	
c. Reinforcement Bars	ton	1,070.00	0.5	583	
d. Others	-			182	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**66,852**	

IV. Detailed Statement of Hydraulic Equipment Cost for Saureni Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**2,158**	
a. Gate	ton	8,811.04	0.17	1,480	
b. Screen	ton	8,811.04	0.08	678	
(3) Penstock Steel (φ200)	ton	3,100.00	0.00	**0**	
(4) PVC (φ500) for headrace	m	41.67	890	**37,086**	
(5) Penstock PVC (φ200) C-10	m	34.74	340	**11,811**	
(6) Subtotal				**51,055**	
(7) Others				**10,145**	19.87%
(8) Total				**61,200**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**13.66**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**24.71**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.58**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.17**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.08**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.090**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**39.16**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**17.74**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.37**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.21**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.13**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)

(4) Headrace

In the case of PVCφ500:

Excavation:	$V_e = B \times H \times L$	=	**890.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)	
L:	Length of Channel =	**890.00**	(m)	
B:	Width of Channel =	**1.00**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**1.00**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**150.84**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**35.13**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.79**	(ton)

Where,

Q:	Maximum Discharge =	0.090	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m: Avg. Diameter of Penstock =	**0.00**	(m)	
L: Length of Penstock =	**0.00**	(m)	

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}: Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm: Thickness of Penstock	2.00	(mm)	
D_m: Avg. Diameter of Penstock =	0.00	(m)	
H: Design Head =	**96.80**	(m)	(Intake Water Level - Tailrace Water Level)
L: Length of Penstock =	0.00	(m)	

Penstock (PVC)φ200:

Excavation:	$V_e = B \times H \times L$	=	257.35	(m^3)

Where,

Q: Maximum Discharge =	0.090	(m^3/s)	
L: Length of Channel =	**340.00**	(m)	
B: Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H: Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{0.5} = 1.09 \times Q^{0.379}$	=	0.44	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	895.36	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	238.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q: Maximum Discharge =	0.090	(m^3/s)
L: Length of Channel =	**340.00**	(m)
B: Width of Channel =	**0.40**	(m)
H: Height of Channel =	**0.60**	(m)
t: Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**1,152.70**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**238.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**155.80**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**46.76**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**2.61**	(ton)

Where,

Q: Maximum Discharge =	0.090	(m^3/s)
He: Effective Head =	96.80	(m)
n: Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	64.16	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	3.01	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.55	(ton)

Where,

D: Diameter of Waterway =	0.50	(m)	
R: Radius of Waterway =	0.25	(m)	D/2
Q: Maximum Discharge =	0.090	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/m³)	* (8.70+2.35) x 0.5 = $5.53/m³, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	**-**	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	**-**	(US$/m³)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ500)		**41.67**	(US$/m)	RIB LOC for Headrace
PVC (φ200)	:	**34.74**	(US$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.8 = 34.74

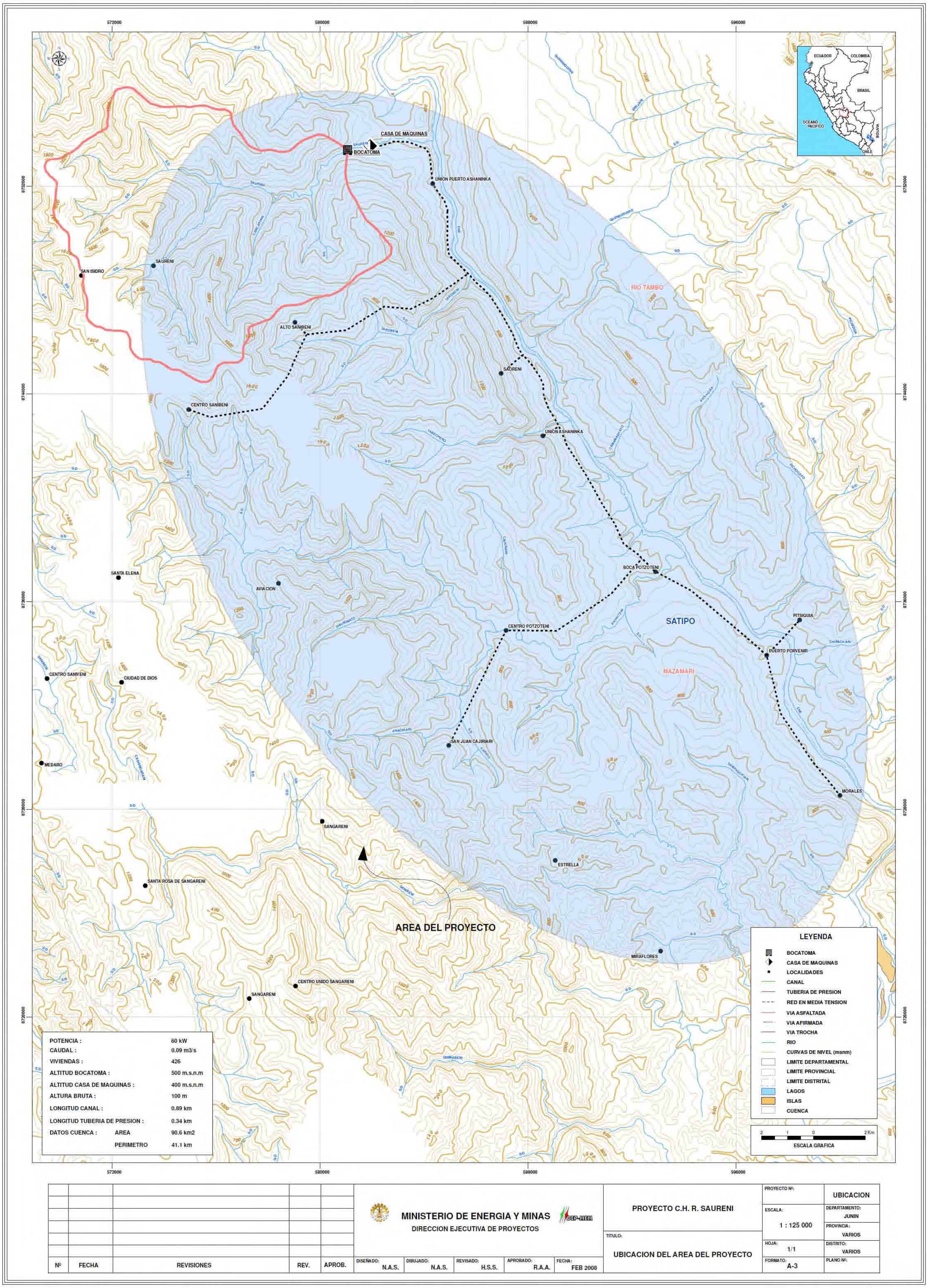
(3) Others

Access Road	:	**-**	(US$/m)	-

(4) Transportation Cost

Huancayo to the site	:	**123.65**	(US$/ton)	479 km (road) + 100km (river) = 24.98 + 98.67 = 123.65 US$/ton

Saureni Map



CASA DE MAQUINAS
BOCATOMA
UNION PUERTO ASHANINKA
SAURENI
SAN ISIDRO
ALTO SANIBENI
CENTRO SANIBENI
UNION ASHANINKA
RIO TAMBO
SATIPO
MAZAMARI
BOCA POTZOTENI
CENTRO POTZOTENI
PITSIQUIA
PUERTO PORVENIR
SAN JUAN CAJIRIARI
MORALES
SANTA ELENA
AVIACION
CENTRO SANIVENI
CIUDAD DE DIOS
MEBARO
SANGARENI
SANTA ROSA DE SANGARENI
ESTRELLA
AREA DEL PROYECTO
MIRAFLORES
CENTRO UNIDO SANGARENI
ECUADOR
COLOMBIA
BRASIL
OCEANO PACIFICO
BOLIVIA
CHILE
572000
580000
588000
596000
POTENCIA : 60 kW
CAUDAL : 0.09 m3/s
VIVIENDAS : 426
ALTITUD BOCATOMA : 500 m.s.n.m
ALTITUD CASA DE MAQUINAS : 400 m.s.n.m
ALTURA BRUTA : 100 m
LONGITUD CANAL : 0.89 km
LONGITUD TUBERIA DE PRESION : 0.34 km
DATOS CUENCA : AREA 90.6 km2
PERIMETRO 41.1 km
LEYENDA
BOCATOMA
CASA DE MAQUINAS
LOCALIDADES
CANAL
TUBERIA DE PRESION
RED EN MEDIA TENSION
VIA ASFALTADA
VIA AFIRMADA
VIA TROCHA
RIO
CURVAS DE NIVEL (msnm)
LIMITE DEPARTAMENTAL
LIMITE PROVINCIAL
LIMITE DISTRITAL
LAGOS
ISLAS
CUENCA
2 1 0 2 Km
ESCALA GRAFICA
Nº FECHA REVISIONES REV. APROB.
MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS
DEP-MEM
DISEÑADO: N.A.S.
DIBUJADO: N.A.S.
REVISADO: H.S.S.
APROBADO: R.A.A.
FECHA: FEB 2008
PROYECTO C.H. R. SAURENI
TITULO:
UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:
ESCALA: 1 : 125 000
HOJA: 1/1
FORMATO: A-3
UBICACION
DEPARTAMENTO: JUNIN
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Appendix I-15 Construction Cost for Shima Power Station

I. Summary of Construction Cost for Shima Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**89,276**	
(1) Access Road	7,053	
(2) Facilities for Construction Office	4,841	Cost of Civil Works x 0.05
(3) Transportation cost	77,382	625.82ton x $123.65/ton
2. Cost for Environmental Mesures	**968**	Cost of Civil Works x 0.01
3. Civil Works	**96,825**	
(1) Weir	2,221	
(2) Intake	5,793	
(3) Settling Basin	5,073	
(4) Headrace	21,117	
(5) Head Tank	10,953	
(6) Penstock & Spillway Channel	36,237	
(7) Power House	13,045	
(8) Outlet	2,386	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**182,600**	
(1) Gate & Screen	3,864	
(2) Penstock	0	
(3) PVC (φ600)	131,870	
(4) PVC (φ315)	16,499	
(5) Others	30,367	
5. Electrical Equipment	**45,800**	
6. Direct Cost	**415,469**	1.+2.+3.+4.+5.
7. Engineering Cost	**41,547**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**40,984**	6. x 0.099
9. IGV	**94,620**	19.00%
10. Total Cost	**592,620**	

II. Detailed Statement of Transportation Cost for Shima Power Station

Items	Unit	Quantity	Remarks
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.23	
(2) Intake	ton	**53.13**	
a. Gate		0.30	
b. Screen		0.14	
c. Cements		10.98	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		40.68	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		1.03	
(3) Settling Basin	ton	**33.63**	
a. Cements		6.76	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		25.03	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		1.84	
(4) Headrace	ton	**29.39**	
a. PVC (φ600)		29.39	Weight: 2,210m x 79.8kg/6m
(5) Head Tank	ton	**60.39**	
a. Cements		12.34	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		45.71	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		2.33	
(6) Penstock & Spillway Channel	ton	**345.83**	
a. Penstock Steel (φ300)		0.00	
b. Penstock PVC (φ315)		7.78	Weight: 380m x 122.833kg/6m
c. Cements		71.87	Cement: 0.27ton per concrete $1m^3$
d. Coarse aggregate		266.18	Coarse aggregate: 1ton per concrete $1m^3$
e. Reinforcement Bars		0.00	
(7) Power House	ton	**77.64**	
a. Cements		15.80	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		58.54	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		3.30	
(8) Outlet	ton	**8.76**	
a. Cements		1.68	Cement: 0.27ton per concrete $1m^3$
b. Coarse aggregate		6.23	Coarse aggregate: 1ton per concrete $1m^3$
c. Reinforcement Bars		0.85	
(9) Subtotal		**625.82**	
(10) Transportation Cost		**77,382**	(9) x $123.65/ton

III. Detailed Statement of Civil Works Cost for Shima Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			**370**	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**5,793**	
a. Excavation	m^3	5.53	27.7	153	
b. Concrete	m^3	93.05	40.7	3,785	
c. Reinforcement Bars	ton	1,070.00	1.0	1,100	
d. Others	-			755	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**5,073**	
a. Excavation	m^3	5.53	58.0	320	
b. Concrete	m^3	93.05	25.0	2,329	
c. Reinforcement Bars	ton	1,070.00	1.8	1,963	
d. Others	-			461	(a+b+c) x 0.10 (including other works)
(4) Headrace				**21,117**	
a. Excavation	m^3	5.53	3182.4	17,598	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			3,519	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**10,953**	
a. Excavation	m^3	5.53	194.9	1,077	
b. Concrete	m^3	93.05	45.7	4,253	
c. Reinforcement Bars	ton	1,070.00	2.3	2,494	
d. Others	-			3,129	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**36,237**	
a. Excavation	m^3	5.53	1478.4	8,175	
b. Concrete	m^3	93.05	266.2	24,768	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			3,294	(a+b+c) x 0.10 (including filling works)
(7) Power House				**13,045**	
a. Excavation	m^3	5.53	191.3	1,058	
b. Concrete	m^3	93.05	58.5	5,446	
c. Reinforcement Bars	ton	1,070.00	3.3	3,531	
d. Others	-			3,010	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**2,386**	
a. Excavation	m^3	5.53	106.7	589	
b. Concrete	m^3	93.05	6.2	579	
c. Reinforcement Bars	ton	1,070.00	0.8	907	
d. Others	-			311	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**96,825**	

IV. Detailed Statement of Hydraulic Equipment Cost for Shima Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**3,864**	
a. Gate	ton	8,811.04	0.30	2,606	
b. Screen	ton	8,811.04	0.14	1,258	
(3) Penstock Steel (φ315)	ton	3,100.00	0.00	**0**	
(4) PVC (φ600) for headrace	m	59.67	2,210	**131,870**	
(5) Penstock PVC (φ315) C-10	m	43.42	380	**16,499**	
(6) Subtotal				**152,233**	
(7) Others				**30,367**	19.95%
(8) Total				**182,600**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**27.69**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**40.68**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**1.03**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.30**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.14**	(ton)

Where,

D:	Diameter of Waterway =	**1.00**	(m)		
R:	Radius of Waterway =	0.50	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.130**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**58.04**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**25.03**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.84**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.26**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.18**	(ton)

Where,

Q: Maximum Discharge = 0.130 (m^3/s)

(4) Headrace

In the case of PVCφ600:

Excavation:	$V_e = B \times H \times L$	=	**3,182.40**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.130	(m^3/s)	
L:	Length of Channel =	**2,210.00**	(m)	
B:	Width of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**1.20**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**194.91**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**45.71**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**2.33**	(ton)

Where,

Q: Maximum Discharge = 0.130 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ315:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm²)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**85.20**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ315:

Excavation:	$V_e = B \times H \times L$	=	321.63	(m^3)

Where,

Q:	Maximum Discharge =	0.130	(m^3/s)	
L:	Length of Channel =	**380.00**	(m)	
B:	Width of Channel =	**0.92**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.92**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{0.5} = 1.09 \times Q^{0.379}$	=	0.50	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	1,156.78	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	266.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.130	(m^3/s)
L:	Length of Channel =	**380.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**1,478.41**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**266.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**191.34**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**58.54**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**3.30**	(ton)

Where,

Q:	Maximum Discharge =	0.130	(m^3/s)
He:	Effective Head =	85.20	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	106.66	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	6.23	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.85	(ton)

Where,

D:	Diameter of Waterway =	1.00	(m)	
R:	Radius of Waterway =	0.50	(m)	D/2
Q:	Maximum Discharge =	0.130	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/m^3)	* (8.70+2.35) x 0.5 = $5.53/m^3, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m^3)	
Concrete				
Open	:	**93.05**	(US$/m^3)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m^3)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ600)		**59.67**	(US$/m)	RIB LOC for Headrace
PVC (φ315)	:	**43.42**	(US$/m)	TUBOPLAST for Penstock (C-10), The number of joints is 215. This price include joint price. 190m/6m =30 (joint), 30 x $2.7 =81$, 81$/190m =0.43$/m, 42.99$/m (PVC) + 0.43$/m (joint) = 43.42$/m

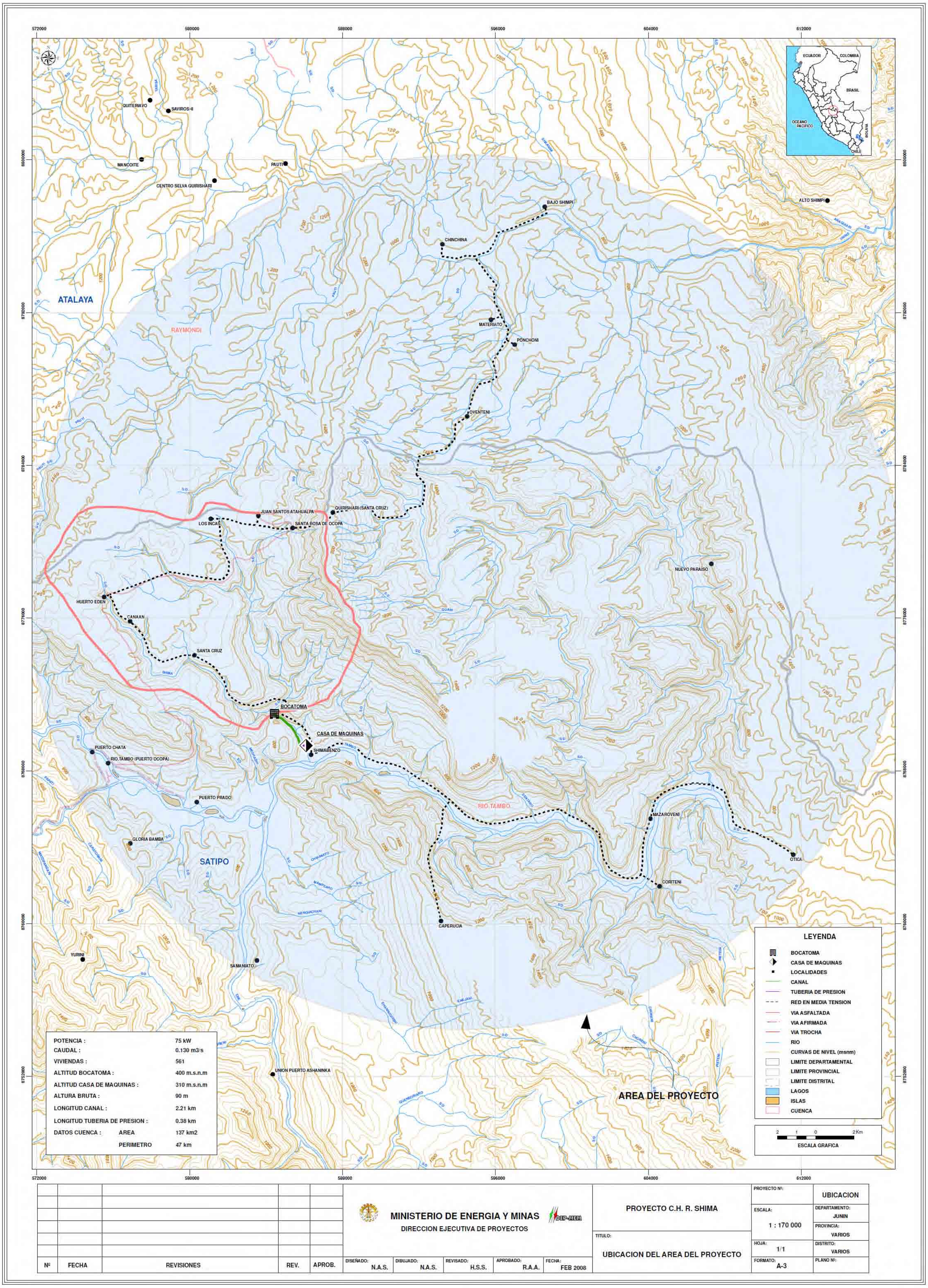
(3) Others

Access Road	:	**5,877.89**	(US$/m)	Constrruction of Unpaved Road (3.0m Width)

(4) Transportation Cost

Huanuco to the site	:	**123.65**	(US$/ton)	479 km (road) + 100km (river) = 24.98 + 98.67 = 123.65 US$/ton

Shima Map



ATALAYA
RAYMONDI
SATIPO
RIO TAMBO
AREA DEL PROYECTO
QUITERIAVO
SAVIROS-II
MANCOITE
PAUTI
CENTRO SELVA GUIRISHARI
BAJO SHIMPI
ALTO SHIMPI
CHINCHINA
MATERIATO
PONCHONI
JOVENTENI
QUIRISHARI (SANTA CRUZ)
JUAN SANTOS ATAHUALPA
LOS INCAS
SANTA ROSA DE OCOPA
NUEVO PARAISO
HUERTO EDEN
CANAAN
SANTA CRUZ
BOCATOMA
CASA DE MAQUINAS
SHIMABENZO
PUERTO CHATA
RIO TAMBO (PUERTO OCOPA)
PUERTO PRADO
GLORIA BAMBA
MAZAROVENI
OTICA
CORITENI
CAPERUCIA
YURINI
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ECUADOR
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BOLIVIA
CHILE
LEYENDA
BOCATOMA
CASA DE MAQUINAS
LOCALIDADES
CANAL
TUBERIA DE PRESION
RED EN MEDIA TENSION
VIA ASFALTADA
VIA AFIRMADA
VIA TROCHA
RIO
CURVAS DE NIVEL (msnm)
LIMITE DEPARTAMENTAL
LIMITE PROVINCIAL
LIMITE DISTRITAL
LAGOS
ISLAS
CUENCA
2 1 0 2 Km
ESCALA GRAFICA
POTENCIA : 75 kW
CAUDAL : 0.130 m3/s
VIVIENDAS : 561
ALTITUD BOCATOMA : 400 m.s.n.m
ALTITUD CASA DE MAQUINAS : 310 m.s.n.m
ALTURA BRUTA : 90 m
LONGITUD CANAL : 2.21 km
LONGITUD TUBERIA DE PRESION : 0.38 km
DATOS CUENCA : AREA 137 km2
PERIMETRO 47 km
572000
580000
588000
596000
604000
612000
Nº
FECHA
REVISIONES
REV.
APROB.
MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS
DEP-MEM
DISEÑADO: N.A.S.
DIBUJADO: N.A.S.
REVISADO: H.S.S.
APROBADO: R.A.A.
FECHA: FEB 2008
PROYECTO C.H. R. SHIMA
TITULO:
UBICACION DEL AREA DEL PROYECTO
PROYECTO Nº:
ESCALA: 1 : 170 000
HOJA: 1/1
FORMATO: A-3
UBICACION
DEPARTAMENTO: JUNIN
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Appendix I-16 Construction Cost for Huaraday Power Station

I. Summary of Construction Cost for Huaraday Power Station

Unit: US$

Work Item	*Construction Cost*	*Remarks*
1. Preliminary Works	**16,967**	
(1) Access Road	8,816	
(2) Facilities for Construction Office	2,901	Cost of Civil Works x 0.05
(3) Transportation cost	5,250	442.72ton x $11.86/ton
2. Cost for Environmental Mesures	**580**	Cost of Civil Works x 0.01
3. Civil Works	**58,025**	
(1) Weir	2,221	
(2) Intake	3,042	
(3) Settling Basin	2,939	
(4) Headrace	3,609	
(5) Head Tank	7,043	
(6) Penstock & Spillway Channel	26,736	
(7) Power House	11,199	
(8) Outlet	1,236	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**43,000**	
(1) Gate & Screen	1,881	
(2) Penstock	5,915	
(3) PVC (φ400)	22,380	
(4) PVC (φ200)	5,697	
(5) Others	7,127	
5. Electrical Equipment	**45,800**	
6. Direct Cost	**164,372**	1.+2.+3.+4.+5.
7. Engineering Cost	**16,437**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**16,191**	6. x 0.099
9. IGV	**37,430**	19.00%
10. Total Cost	**234,430**	

II. Detailed Statement of Transportation Cost for Huaraday Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**17.05**	
a. Cements		3.57	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		13.24	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.23	
(2) Intake	ton	**28.60**	
a. Gate		0.15	
b. Screen		0.07	
c. Cements		5.93	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		21.96	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.51	
(3) Settling Basin	ton	**18.94**	
a. Cements		3.79	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		14.02	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.12	
(4) Headrace	ton	**5.84**	
a. PVC (φ400)		5.84	Weight: 850m x 41.214kg/6m
(5) Head Tank	ton	**38.77**	
a. Cements		7.92	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		29.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.50	
(6) Penstock & Spillway Channel	ton	**263.09**	
a. Penstock Steel (φ200)		1.91	
b. Penstock PVC (φ200)		1.37	Weight: 164m x 50.000kg/6m =0.92ton
c. Cements		55.18	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		204.37	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.27	
(7) Power House	ton	**66.72**	
a. Cements		13.59	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		50.32	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		2.82	
(8) Outlet	ton	**3.71**	
a. Cements		0.69	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		2.54	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.49	
(9) Subtotal		**442.72**	
(10) Transportation Cost		**5,251**	(9) x $11.86/ton

III. Detailed Statement of Civil Works Cost for Huaraday Power Station

Unit: US$

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Wier				**2,221**	
a. Excavation	m^3	5.53	67.0	370	
b. Concrete	m^3	93.05	13.2	1,231	
c. Reinforcement Bars	ton	1,070.00	0.2	250	
d. Others	-			370	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**3,042**	
a. Excavation	m^3	5.53	11.6	63	
b. Concrete	m^3	93.05	22.0	2,042	
c. Reinforcement Bars	ton	1,070.00	0.5	541	
d. Others	-			396	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**2,939**	
a. Excavation	m^3	5.53	29.9	165	
b. Concrete	m^3	93.05	14.0	1,305	
c. Reinforcement Bars	ton	1,070.00	1.1	1,202	
d. Others	-			267	(a+b+c) x 0.10 (including other works)
(4) Headrace				**3,609**	
a. Excavation	m^3	5.53	544.0	3,008	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			601	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**7,043**	
a. Excavation	m^3	5.53	126.6	700	
b. Concrete	m^3	93.05	29.3	2,730	
c. Reinforcement Bars	ton	1,070.00	1.5	1,601	
d. Others	-			2,012	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**26,736**	
a. Excavation	m^3	5.53	904.0	4,998	
b. Concrete	m^3	93.05	204.4	19,016	
c. Reinforcement Bars	ton	1,070.00	0.3	292	
d. Others	-			2,430	(a+b+c) x 0.10 (including filling works)
(7) Power House				**11,199**	
a. Excavation	m^3	5.53	166.6	921	
b. Concrete	m^3	93.05	50.3	4,682	
c. Reinforcement Bars	ton	1,070.00	2.8	3,012	
d. Others	-			2,584	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**1,236**	
a. Excavation	m^3	5.53	56.9	314	
b. Concrete	m^3	93.05	2.5	236	
c. Reinforcement Bars	ton	1,070.00	0.5	525	
d. Others	-			161	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**58,025**	

IV. Detailed Statement of Hydraulic Equipment Cost for Huaraday Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,881**	
a. Gate	ton	8,811.04	0.15	1,295	
b. Screen	ton	8,811.04	0.07	586	
(3) Penstock Steel (φ200)	ton	3,100.00	1.91	**5,915**	
(4) PVC (φ400) for headrace	m	26.33	850	**22,380**	
(5) Penstock PVC (φ200) C-10	m	34.74	164	**5,697**	
(6) Subtotal				**35,873**	
(7) Others				**7,127**	19.87%
(8) Total				**43,000**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**67.01**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**13.24**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.23**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.30**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**11.56**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**21.96**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.51**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.15**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.07**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.070**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**29.93**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**14.02**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**1.12**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.18**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.11**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	$V_e = B \times H \times L$	=	**544.00**	(m^3)
Concrete:	$V_c = ((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**850.00**	(m)	
B:	Width of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**126.60**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**29.35**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.50**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ200:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	135.86	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	15.19	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.27	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.20**	(m)
L:	Length of Penstock =	**106.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	1.91	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	3.17	(mm)

Where,

W_{p1}:	Weight of Penstock	1.91	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	3.17	(mm)	
D_m:	Avg. Diameter of Penstock =	0.20	(m)	
H:	Design Head =	**162.10**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	106.00	(m)	

Penstock (PVC)φ200:

Excavation:	$V_e = B \times H \times L$	=	124.13	(m^3)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)	
L:	Length of Channel =	**164.00**	(m)	
B:	Width of Channel =	**0.87**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.87**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{0.5} = 1.09 \times Q^{0.379}$	=	0.40	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	643.96	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	189.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
L:	Length of Channel =	**270.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**903.96**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**204.37**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.27**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**1.91**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**166.62**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**50.32**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**2.82**	(ton)

Where,

Q:	Maximum Discharge =	0.070	(m^3/s)
He:	Effective Head =	162.10	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	56.89	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	2.54	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.49	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.070	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/$m^3$)	* (8.70+2.35) x 0.5 = $5.53/$m^3$, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/$m^3$)	
Concrete				
Open	:	**93.05**	(US$/$m^3$)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/$m^3$)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ400)		**26.33**	(US$/m)	RIB LOC for Headrace
PVC (φ200)	:	**34.74**	(US$/m)	80% of TUBOPLAST(φ 315) for Penstock (C-10) = 43.42 x 0.8 = 34.74

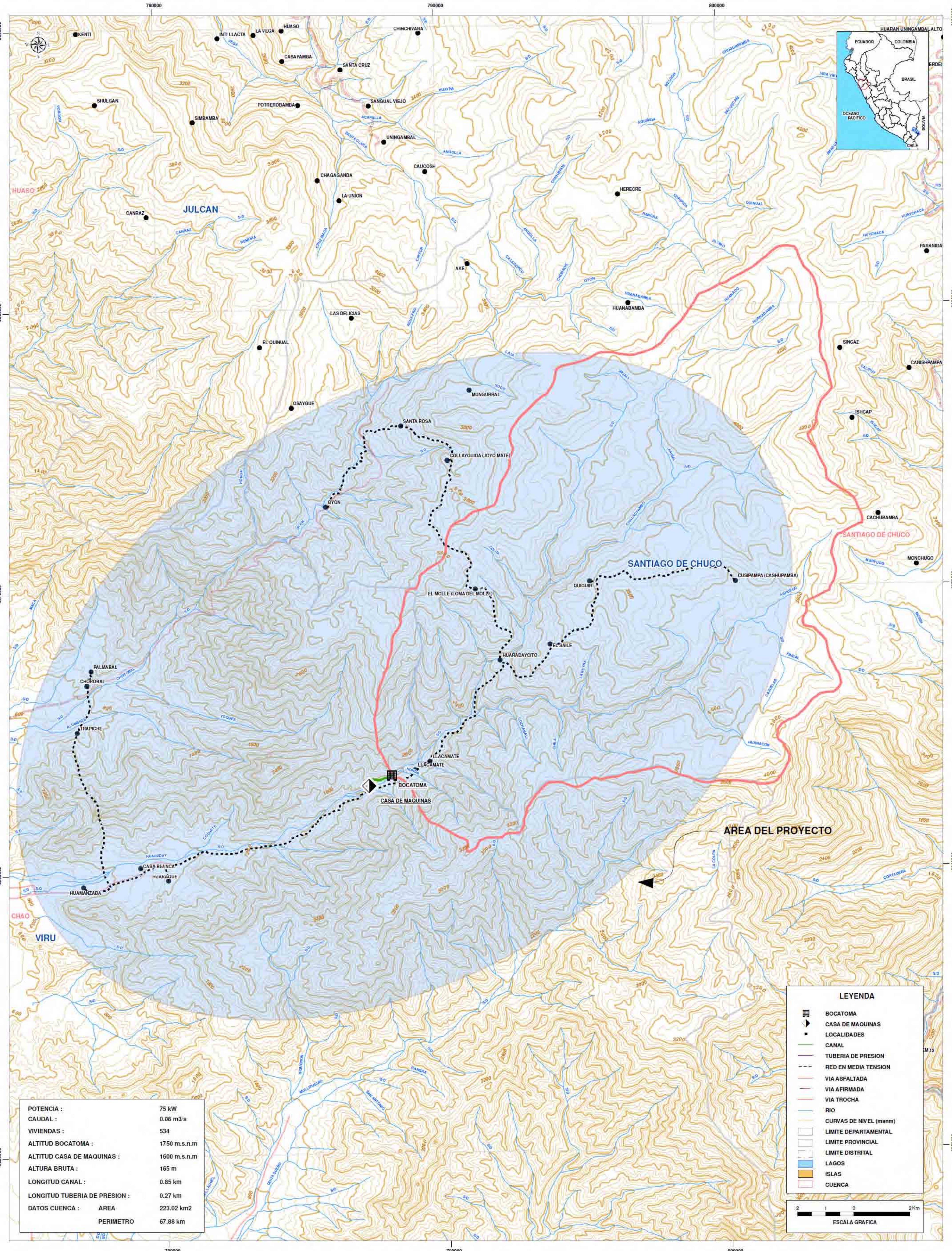
(3) Others

Access Road	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road

(4) Transportation Cost

Trujillo to the site	:	**11.86**	(US$/ton)	99 km (road)

Huaraday Map



Nº	FECHA	REVISIONES	REV.	APROB.

MINISTERIO DE ENERGIA Y MINAS
DIRECCION EJECUTIVA DE PROYECTOS
DEP-MEM

DISEÑADO: N.A.S. | DIBUJADO: N.A.S. | REVISADO: H.S.S. | APROBADO: R.A.A. | FECHA: FEB 2008

PROYECTO C.H. HUARADAY

TITULO: UBICACION DEL AREA DEL PROYECTO

PROYECTO Nº: | ESCALA: 1 : 125 000 | HOJA: 1/1 | FORMATO: A-3

UBICACION
DEPARTAMENTO: LA LIBERTAD
PROVINCIA: VARIOS
DISTRITO: VARIOS
PLANO Nº:

Appendix I-17 Construction Cost for Marachanca Power Station

I. Summary of Construction Cost for Marachanca Power Station

Unit: US$

Work Item	Construction Cost	Remarks
1. Preliminary Works	**5,658**	
(1) Access Road	2,116	
(2) Facilities for Construction Office	1,288	Cost of Civil Works x 0.05
(3) Transportation cost	2,254	192.37ton x $11.72/ton
2. Cost for Environmental Mesures	**257**	Cost of Civil Works x 0.01
3. Civil Works	**25,767**	
(1) Weir	1,282	
(2) Intake	2,451	
(3) Settling Basin	1,992	
(4) Headrace	1,018	
(5) Head Tank	5,139	
(6) Penstock & Spillway Channel	8,762	
(7) Power House	4,130	
(8) Outlet	993	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	**13,000**	
(1) Gate & Screen	1,476	
(2) Penstock	0	
(3) PVC (φ400)	6,319	
(4) PVC (φ150)	3,039	
(5) Others	2,166	
5. Electrical Equipment	**14,300**	
6. Direct Cost	**58,982**	1.+2.+3.+4.+5.
7. Engineering Cost	**5,898**	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	**5,120**	6. x 0.087
9. IGV	**13,300**	19.00%
10. Total Cost	**83,300**	

II. Detailed Statement of Transportation Cost for Marachanca Power Station

Items	*Unit*	*Quantity*	*Remarks*
(1) Wier	ton	**9.48**	
a. Cements		1.98	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		7.35	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.14	
(2) Intake	ton	**23.22**	
a. Gate		0.12	
b. Screen		0.05	
c. Cements		4.82	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		17.84	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.40	
(3) Settling Basin	ton	**12.57**	
a. Cements		2.50	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		9.27	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.79	
(4) Headrace	ton	**1.65**	
a. PVC (φ400)		1.65	Weight: 240m x 41.214kg/6m
(5) Head Tank	ton	**28.25**	
a. Cements		5.77	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		21.39	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.09	
(6) Penstock & Spillway Channel	ton	**89.66**	
a. Penstock Steel (φ150)		0.00	
b. Penstock PVC (φ150)		0.53	Weight: 100m x 32.000kg/6m
c. Cements		18.95	Cement: 0.27ton per concrete 1m^3
d. Coarse aggregate		70.18	Coarse aggregate: 1ton per concrete 1m^3
e. Reinforcement Bars		0.00	
(7) Power House	ton	**24.75**	
a. Cements		5.05	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		18.70	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		1.00	
(8) Outlet	ton	**2.79**	
a. Cements		0.51	Cement: 0.27ton per concrete 1m^3
b. Coarse aggregate		1.88	Coarse aggregate: 1ton per concrete 1m^3
c. Reinforcement Bars		0.41	
(9) Subtotal		**192.37**	
(10) Transportation Cost		**2,255**	(9) x $11.72/ton

III. Detailed Statement of Civil Works Cost for Marachanca Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Wier				**1,282**	
a. Excavation	m^3	5.53	42.2	233	
b. Concrete	m^3	93.05	7.3	683	
c. Reinforcement Bars	ton	1,070.00	0.1	153	
d. Others	-			213	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				**2,451**	
a. Excavation	m^3	5.53	8.6	47	
b. Concrete	m^3	93.05	17.8	1,659	
c. Reinforcement Bars	ton	1,070.00	0.4	426	
d. Others	-			319	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				**1,992**	
a. Excavation	m^3	5.53	18.7	103	
b. Concrete	m^3	93.05	9.3	862	
c. Reinforcement Bars	ton	1,070.00	0.8	846	
d. Others	-			181	(a+b+c) x 0.10 (including other works)
(4) Headrace				**1,018**	
a. Excavation	m^3	5.53	153.6	849	
b. Concrete	m^3	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			169	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				**5,139**	
a. Excavation	m^3	5.53	93.0	514	
b. Concrete	m^3	93.05	21.4	1,990	
c. Reinforcement Bars	ton	1,070.00	1.1	1,167	
d. Others	-			1,468	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				**8,762**	
a. Excavation	m^3	5.53	259.7	1,436	
b. Concrete	m^3	93.05	70.2	6,530	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			796	(a+b+c) x 0.10 (including filling works)
(7) Power House				**4,130**	
a. Excavation	m^3	5.53	67.4	372	
b. Concrete	m^3	93.05	18.7	1,740	
c. Reinforcement Bars	ton	1,070.00	1.0	1,065	
d. Others	-			953	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				**993**	
a. Excavation	m^3	5.53	46.0	254	
b. Concrete	m^3	93.05	1.9	174	
c. Reinforcement Bars	ton	1,070.00	0.4	436	
d. Others	-			129	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			**0**	Σ(1)-(8) x 0.05 not consider
(10) Subtotal				**25,767**	

IV. Detailed Statement of Hydraulic Equipment Cost for Marachanca Power Station

Unit: US$

Work Items	*Unit*	*Unit Price*	*Quantity*	*Cost*	*Remarks*
(1) Weir & Spillway				**0**	
a. Gate	ton	8,811.04	0.00	0	
(2) Intake				**1,476**	
a. Gate	ton	8,811.04	0.12	1,023	
b. Screen	ton	8,811.04	0.05	453	
(3) Penstock Steel (φ150）	ton	3,100.00	0.00	**0**	
(4) PVC (φ400）for headrace	m	26.33	240	**6,319**	
(5) Penstock PVC (φ150) C-10	m	30.39	100	**3,039**	
(6) Subtotal				**10,834**	
(7) Others				**2,166**	19.99%
(8) Total				**13,000**	

V. Quantity

(1) Weir

Excavation:	V_e =	$8.69 \times (H_d \times L)^{1.14}$	=	**42.21**	(m^3)	
Concrete:	V_c =	$8.64 \times (H_d^2 \times L)^{0.726}$	=	**7.35**	(m^3)	
Reinforcement Bars	W_r =	$0.0274 \times V_c^{0.830}$	=	**0.14**	(ton)	
Weight of Gate:	W_g =	$0.145 \times Q_f^{0.692}$	=	**0.00**	(ton)	(unconsidered)

Where,

H_d:	Height of Dam =	**0.20**	(m)
L:	Length of Dam =	**20.00**	(m)

(2) Intake

Excavation:	V_e =	$171 \times (R \times Q)^{0.666}$	=	**8.61**	(m^3)
Concrete:	V_c =	$147 \times (R \times Q)^{0.470}$	=	**17.84**	(m^3)
Reinforcement Bars	W_r =	$0.0145 \times V_c^{1.15}$	=	**0.40**	(ton)
Weight of Gate:	W_g =	$1.27 \times (R \times Q)^{0.533}$	=	**0.12**	(ton)
Weight of Screen:	W_s =	$0.701 \times (R \times Q)^{0.582}$	=	**0.05**	(ton)

Where,

D:	Diameter of Waterway =	**0.50**	(m)		
R:	Radius of Waterway =	0.25	(m)	D/2	Assumption; Waterway Gradient = 1/1,000
Q:	Maximum Discharge =	**0.045**	(m^3/s)		

(3) Settling Basin

Excavation:	V_e =	$515 \times Q^{1.07}$	=	**18.65**	(m^3)
Concrete:	V_c =	$169 \times Q^{0.936}$	=	**9.27**	(m^3)
Reinforcement Bars	W_r =	$0.120 \times V_c^{0.847}$	=	**0.79**	(ton)
Weight of Gate:	W_g =	$0.910 \times Q^{0.613}$	=	**0.14**	(ton)
Weight of Screen:	W_s =	$0.879 \times Q^{0.785}$	=	**0.08**	(ton)

Where,

Q: Maximum Discharge = 0.045 (m^3/s)

(4) Headrace

In the case of PVCφ400:

Excavation:	V_e =	$B \times H \times L$	=	**153.60**	(m^3)
Concrete:	V_c =	$((H \times t \times 2) + (B + 2t) \times t) \times L$	=	**-**	(m^3)
Reinforcement Bars	W_r =	$0.577 \times (V_c/L)^{0.888} \times L$	=	**-**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)	
L:	Length of Channel =	**240.00**	(m)	
B:	Width of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
H:	Height of Channel =	**0.80**	(m)	for excavation (2D from RIBLOC Brochure)
t:	Thickness of Concrete =	-	(m)	

(5) Head Tank

Excavation:	V_e =	$808 \times Q^{0.697}$	=	**93.05**	(m^3)
Concrete:	V_c =	$197 \times Q^{0.716}$	=	**21.39**	(m^3)
Reinforcement Bars	W_r =	$0.051 \times V_c$	=	**1.09**	(ton)

Where,

Q: Maximum Discharge = 0.045 (m^3/s)

(6) Penstock & Spillway Channel

Penstock (Steel)φ150:

Excavation:	V_{e1} =	$10.9 \times D_m^{1.33} \times L$	=	0.00	(m^3)
Concrete:	V_{c1} =	$2.14 \times D_m^{1.68} \times L$	=	0.00	(m^3)
Reinforcement Bars	W_{r1} =	$0.018 \times V_c$	=	0.00	(ton)

Where,

D_m:	Avg. Diameter of Penstock =	**0.00**	(m)
L:	Length of Penstock =	**0.00**	(m)

Weight of Penstock	$W_{p1} = 7.85 \times \pi \times D_m \times t_m \times 10^{-3} \times 1.15 \times L$	=	0.00	(ton)
Thickness of Penstock:	$t_m = 0.0362 \times H \times D_m + 2$	=	2.00	(mm)

Where,

W_{p1}:	Weight of Penstock	0.00	(ton)	(Tensil allowable Stress: 1,150 kgf/cm^2)
tm:	Thickness of Penstock	2.00	(mm)	
D_m:	Avg. Diameter of Penstock =	0.00	(m)	
H:	Design Head =	**48.60**	(m)	(Intake Water Level - Tailrace Water Level)
L:	Length of Penstock =	0.00	(m)	

Penstock (PVC)φ150:

Excavation:	$V_e = B \times H \times L$	=	59.29	(m^3)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)	
L:	Length of Channel =	**100.00**	(m)	
B:	Width of Channel =	**0.77**	(m)	from TUBOPLAST Brochure
H:	Height of Channel =	**0.77**	(m)	from TUBOPLAST Brochure

Spillway Channel:

	$(B \times H)^{0.5} = 1.09 \times Q^{0.379}$	=	0.34	
Excavation:	$V_e = 6.22 \times ((B \times H)^{0.5})^{1.04} \times L$	=	200.38	(m^3)
Concrete:	$V_c = H \times t \times 2 + (B + 2t) \times L$	=	70.18	(m^3)
Reinforcement Bars	$W_r = 0.577 \times (V_c/L)^{0.888} \times L$	=	0.00	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)
L:	Length of Channel =	**100.00**	(m)
B:	Width of Channel =	**0.40**	(m)
H:	Height of Channel =	**0.60**	(m)
t:	Thickness of Concrete =	**0.15**	(m)

Total Quantity of Penstock and Spillway Channel:

Excavation:	V_e =	$V_{e1} + V_{e2}$	=	**259.67**	(m^3)
Concrete:	V_c =	$V_{c1} + V_{c2}$	=	**70.18**	(m^3)
Reinforcement Bars	W_r =	$W_{r1} + W_{r2}$	=	**0.00**	(ton)
Weight of Penstock	W_p =	W_{p1}	=	**0.00**	(ton)

(7) Power House

Excavation:	$V_e = 97.8 \times (Q \times He^{2/3} \times n^{1/2})^{0.727}$	=	**67.40**	(m^3)
Concrete:	$V_c = 28.1 \times (Q \times He^{2/3} \times n^{1/2})^{0.795}$	=	**18.70**	(m^3)
Reinforcement Bars	$W_r = 0.046 \times V_c^{1.05}$	=	**1.00**	(ton)

Where,

Q:	Maximum Discharge =	0.045	(m^3/s)
He:	Effective Head =	48.60	(m)
n:	Quantity Unit of Turbine =	**1.00**	

(8) Outlet

Excavation:	V_e =	$395 \times (R \times Q)^{0.479}$	=	46.04	(m^3)
Concrete:	V_c =	$40.4 \times (R \times Q)^{0.684}$	=	1.88	(m^3)
Reinforcement Bars	W_r =	$0.278 \times V_c^{0.610}$	=	0.41	(ton)

Where,

D:	Diameter of Waterway =	0.50	(m)	
R:	Radius of Waterway =	0.25	(m)	D/2
Q:	Maximum Discharge =	0.045	(m^3/s)	

: Input Cell
: Calculation Cell
: Reference Cell

VI. Unit Price

1USD = 3.00 S/. (as of November, 2007)

(1) Civil Works

Excavation				
Open	:	**5.53**	(US$/m³)	* (8.70+2.35) x 0.5 = $5.53/m³, from CAPAECO and Fainal study on Omia <Human power and Machine excavation>
Tunnel	:	-	(US$/m³)	
Concrete				
Open	:	**93.05**	(US$/m³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US$/m³)	
Reinforcement Bar	:	**1,070.00**	(US$/ton)	*$1.07/kg, from CAPAECO

(2) Hydraulic Equipment

Gate & Screen	:	**8,811.04**	(US$/ton)	* from final study on Omia
Steel Penstock	:	**3,100.00**	(US$/ton)	including installation
PVC (φ400)		**26.33**	(US$/m)	RIB LOC for Headrace
PVC (φ150)	:	**30.39**	(US$/m)	80% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 0.7 = 30.39

(3) Others

Access Road	:	**979.65**	(US$/m)	Repair Work for Existing Unpaved Road

(4) Transportation Cost

Lima to the site	:	**11.72**	(US$/ton)	95km

Marachanca Map