Appendix I-6 Construction Cost for Quellouno Power Station

I. Summary of Construction Cost for Quellouno Power Station

Work Item	Construction Cost	Remarks
1. Preliminary Works	32,286	
(1) Access Road	24,687	
(2) Facilities for Construction Office	2,170	Cost of Civil Works x 0.05
(3) Transportation cost	5,429	392.6ton x \$13.83/ton
2. Cost for Environmental Mesures	434	Cost of Civil Works x 0.01
3. Civil Works	43,414	
(1) Weir	1,282	
(2) Intake	1,650	
(3) Settling Basin	980	
(4) Headrace	1,456	
(5) Head Tank	2,881	
(6) Penstock & Spillway Channel	29,355	
(7) Power House	5,140	
(8) Outlet	670	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	28,400	
(1) Gate & Screen	946	
(2) Penstock	8,461	
(3) PVC (\u03c6300)	10,449	
(4) PVC (φ150)	3,889	
(5) Others	4,655	
5. Electrical Equipment	24,800	
6. Direct Cost	129,334	1.+2.+3.+4.+5.
7. Engineering Cost	12,933	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	12,733	6. x 0.098
9. IGV	29,450	19.00%
10. Total Cost	184,450	

II. Detailed Statement of Transportation Cost for Quellouno Power Station

Items	Unit	Quantity	Remarks
(1) Wier		9.48	
a. Cements		1.98	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	7.35	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.14	
(2) Intake		15.84	
a. Gate		0.08	
b. Screen		0.03	
c. Cements	ton	3.29	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		12.19	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.26	
(3) Settling Basin		5.93	
a. Cements		1.17	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	4.34	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.42	
4) Headrace		3.14	
a. PVC (φ300)	ton	3.14	Weight: 610m x 30.918kg/6m
5) Head Tank		15.81	
a. Cements		3.23	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	11.97	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.61	
6) Penstock & Spillway Channel		309.97	
a. Penstock Steel (q150)		2.73	
b. Penstock PVC (φ150)		0.68	Weight: 128m x 32.000kg/6m
c. Cements	ton	65.11	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		241.14	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.31	
7) Power House		30.77	
a. Cements		6.27	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	23.24	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.25	
(8) Outlet		1.66	
a. Cements	1	0.29	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	1.08	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.29	
(9) Subtotal		392.60	
(10) Transportation Cost		5,430	(9) x \$13.83/ton

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				1,650	(,,,,,,,
a. Excavation	m ³	5.53	5.0	27	
b. Concrete	m ³	93.05	12.2	1,133	
c. Reinforcement Bars	ton	1,070.00	0.3	275	
d. Others	-			215	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				980	
a. Excavation	m ³	5.53	7.8	43	
b. Concrete	m ³	93.05	4.3	403	
c. Reinforcement Bars	ton	1,070.00	0.4	445	
d. Others	-			89	(a+b+c) x 0.10 (including other works)
(4) Headrace				1,456	(including office works)
a. Excavation	m ³	5.53	219.6	1,214	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			242	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				2,881	(mendeling mining works)
a. Excavation	m ³	5.53	52.9	292	
b. Concrete	m ³	93.05	12.0	1,113	
c. Reinforcement Bars	ton	1,070.00	0.6	653	
d. Others	-			823	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				29,355	(including gate, sereen)
a. Excavation	m ³	5.53	709.5	3,923	
b. Concrete	m ³	93.05	241.1	22,438	
c. Reinforcement Bars	ton	1,070.00	0.3	326	
d. Others	-			2,668	(a+b+c) x 0.10 (including filling works)
(7) Power House				5,140	(including mining works)
a. Excavation	m ³	5.53	82.2	454	
b. Concrete	m ³	93.05	23.2	2,162	
c. Reinforcement Bars	ton	1,070.00	1.3	1,338	
d. Others	-			1,186	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				670	(including dramage work, wooden
a. Excavation	m ³	5.53	31.2	172	
b. Concrete	m ³	93.05	1.1	100	
c. Reinforcement Bars	ton	1,070.00	0.3	311	
d. Others	-			87	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			0	(including coffer work, etc.) $\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal		1	<u> </u>	43,414	

	-		v	~	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				946	
a. Gate	ton	8,811.04	0.08	664	
b. Screen	ton	8,811.04	0.03	282	
(3) Penstock Steel (φ150)	ton	3,100.00	2.73	8,461	
(4) PVC (φ300) for headrace	m	17.13	610	10,449	
(5) Penstock PVC (φ150) C-10	m	30.39	128	3,889	
(6) Subtotal				23,745	
(7) Others				4,655	19.60%
(8) Total				28,400	

V. Quantity

Excavation:			_			
Billeurationi	$V_e =$	8.69 x (H _d x L) ^{1.14}	=	42.21	(m^3)	
Concrete:	$V_c =$	8.64 x $(H_d^2 x L)^{0.726}$	=	7.35	(m ³)	
Reinforcement Bars	$W_r =$	0.0274 x V _c ^{0.830}	=	0.14	(ton)	
Weight of Gate:	$W_g =$	0.145 x 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 x (R x Q) ^{0.666}	=	5.02	(m ³)	
Concrete:	$V_c =$	147 x (R x Q) ^{0.470}	=	12.19	(m ³)	
Reinforcement Bars	$W_r =$	0.0145 x V _c ^{1.15}	=	0.26	(ton)	
Weight of Gate:	$W_g =$	1.27 x (R x Q) ^{0.533}	=	0.08	(ton)	
Weight of Screen:	$W_s =$	$0.701 \text{ x} (\text{R x Q})^{0.582}$	=		(ton)	
Where,						
	Diameter of Waterway =	0.50 (m)				
R:	Radius of Waterway =	0.25 (m) D/2		Assumptio	on; Waterw	ay Gradient = $1/1,0$
Q:	Maximum Discharge =	0.020 (m ³ /s)				
3) Settling Basin					_	
Excavation:	$V_e =$	515 x Q ^{1.07}	=		(m ³)	
Concrete:	$V_c =$	169 x Q ^{0.936}	=	4.34	(m^3)	
Reinforcement Bars	$W_r =$	0.120 x V _c ^{0.847}	=	0.42	(ton)	
Weight of Gate:	$W_g =$	0.910 x Q ^{0.613}	=	0.08	(ton)	
Weight of Screen:	$\mathbf{W}_{\mathrm{s}} =$	0.879 x Q ^{0.785}	=	0.04	(ton)	
Where, Q:	Maximum Discharge =	3				
Q.		(0.020) (m ³ /a)				
	Maximum Discharge –	0.020 (m ³ /s)				
		0.020 (m ³ /s)				
		0.020 (m ² /s)				
In the case of PVCq3	00:			219 60	(m^3)	
In the case of PVCφ3 Excavation:	00: V _e = B	x H x L	=	219.60		
In the case of PVCφ3 Excavation: Concrete:	00: V _e = B V _c = ((1	x H x L H x t x 2) + (B + 2t) x t) x L	=	219.60	(m ³)	
In the case of PVCφ3 Excavation: Concrete: Reinforcement Bars	00: $V_e = B$ $V_c = ((I)$ $W_r = 0.3$	x H x L		219.60 - -		
In the case of PVCφ3 Excavation: Concrete: Reinforcement Bars Where,	00: $V_e = B$ $V_c = ((I W_r = 0.1))$	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_e/L)^{0.888}$ x L	=	219.60	(m ³)	
In the case of PVCφ3 Excavation: Concrete: Reinforcement Bars	00: $V_e = B$ $V_c = ((I W_r = 0.1))$ Maximum Discharge =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s)	=	219.60	(m ³)	
In the case of PVCφ3 Excavation: Concrete: Reinforcement Bars Where, Q:	00: $V_e = B$ $V_c = ((I W_r = 0.1))$	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m)	=	219.60 - - (2D from l	(m ³) (ton)	rochure)
Concrete: Reinforcement Bars Where, Q: L: B: H:	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava	= =	-	(m ³) (ton)	· · ·
In the case of PVCq3(Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava	= =	- - (2D from I	(m ³) (ton)	· · ·
In the case of PVCq3(Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava 0.60 (m) for excava	= =	- - (2D from I	(m ³) (ton)	,
In the case of PVCq3(Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 7	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava 0.60 (m) for excava	= =	- - (2D from I	(m ³) (ton)	,
In the case of PVCq3(Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 7	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava 0.60 (m) for excava - (m)	= =	- - (2D from I (2D from I	(m ³) (ton) RIBLOC E RIBLOC E	· · ·
In the case of PVC \$\vertic{93} Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank	00: $V_e = B$ $V_c = (1)$ $W_r = 0.2$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete = $V_e = 0$	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava 0.60 (m) for excava - (m) 808 x Q ^{0.697}	= = ation	- - (2D from I (2D from I 52.87	(m ³) (ton) RIBLOC E RIBLOC E	· · ·
In the case of PVCo3 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 7 (5) Head Tank Excavation:	00: $V_e = B$ $V_c = ((I W_r = 0.3))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete =	x H x L H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.020 (m ³ /s) 610.00 (m) 0.60 (m) for excava 0.60 (m) for excava - (m)	= ation ation	- (2D from I (2D from I 52.87 11.97	(m ³) (ton) RIBLOC E RIBLOC E	· · ·

Appendix

Penstock & Spillwa							
nstock (Steel)ø150:			10.0 - P ¹	.33		167.05	(3)
cavation:	V _{e1} =		$10.9 \text{ x } D_{m}^{-1}$	68 x	=	167.85	
Concrete:	V _{c1} =		$2.14 \text{ x } D_{m}^{-1}$		=	16.96	· /
Reinforcement Bars	$W_{r1} =$		0.018 x V _c	;	=	0.31	(ton)
Where,	g. Diameter of Penstock =	0.15	(m)				
$D_m: X$ L:	g. Diameter of Penstock = Length of Penstock =						
L.	Length of Tenstock =	172.00	(III)				
Weight of Penstock	W., =	7.85x π x l	D _m x t _m x 10	⁻³ x1.15 x I	_ =	2.73	(ton)
Thickness of Penstock:		0.0362 x F			_		(mm)
Where,	۲m		- · · - m · -			5.54	(IIIII)
,	Weight of Penstock	2.73	(ton)	(Tensil al	lowabl	le Stress:	1,150 kgf/cm ²)
	Thickness of Penstock		(mm)	(-,,
D _m : A	g. Diameter of Penstock =						
H:	Design Head =	247.10	(m)	(Intake W	'ater L	evel - Tai	Irace Water Level
L:	Length of Penstock =	192.00	(m)				
enstock (PVC)φ150:		Б. И. И.					. 3.
Excavation:	$V_e =$	BxHxL			=	75.89	(m ⁻)
Where,	Maniana Di t	0.000	. 3				
Q:	Maximum Discharge =		(m^3/s)				
L: B:	Length of Channel = Width of Channel =		· /	from TUI		1 ST D	hure
H:	Height of Channel =		· /	from TUE			
11.	riergin of Channel –	0.77	(iii)	1011101	, OI L/	51 0100	aure
pillway Channel:							
	$(B x H)^{0.5} =$				=	0.25	
Excavation:	$V_e =$	6.22 x ((B	$(x H)^{0.5})^{1.04}$	x L	=	465.80	
Concrete:	$V_c =$	H x t x 2 +	-(B+2t)x	L	=	224.18	(m ³)
Reinforcement Bars	$W_r =$	0.577 x (V	$(L)^{0.888} \times L$	_	=	0.00	(ton)
Where,			_				
-	Manimum Discharge -	0.020					
Q:	Maximum Discharge =	0.020	(m ³ /s)				
Q: L:	Length of Channel =		· · ·				
L: B:	Length of Channel = Width of Channel =	320.00 0.40	(m) (m)				
L: B: H:	Length of Channel = Width of Channel = Height of Channel =	320.00 0.40 0.60	(m) (m) (m)				
L: B: H:	Length of Channel = Width of Channel =	320.00 0.40 0.60	(m) (m) (m)				
L: B: H:	Length of Channel = Width of Channel = Height of Channel =	320.00 0.40 0.60	(m) (m) (m)				
L: B: H:	Length of Channel = Width of Channel = Height of Channel =	320.00 0.40 0.60	(m) (m) (m)				
L: B: H: t: 7	Length of Channel = Width of Channel = Height of Channel =	320.00 0.40 0.60 0.15	(m) (m) (m) (m)				
L: B: H: t:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete =	320.00 0.40 0.60 0.15	(m) (m) (m)		=	709.54	(m ³)
L: B: H: t: 7	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete =	320.00 0.40 0.60 0.15	(m) (m) (m) (m)		=	709.54 241.14	· /
L: B: H: t: 7 otal Quantity of Pen Excavation:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = stock and Spillway Ch V_e =	320.00 0.40 0.60 0.15	(m) (m) (m) (m) V _{e1} + V _{e2}			241.14	· /
L: B: H: t: ⁷ otal Quantity of Pen Excavation: Concrete:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = stock and Spillway Ch $V_e =$ $V_c =$	320.00 0.40 0.60 0.15	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	241.14 0.31	(m ³)
L: B: H: t: ' otal Quantity of Pen Excavation: Concrete: Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	320.00 0.40 0.60 0.15			= =	241.14 0.31	(m ³) (ton)
L: B: H: tal Quantity of Pen Excavation: Concrete: Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	320.00 0.40 0.60 0.15			= =	241.14 0.31	(m ³) (ton)
L: B: H: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	320.00 0.40 0.60 0.15			= =	241.14 0.31	(m ³) (ton)
L: B: H: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_p =	320.00 0.40 0.60 0.15	$(m) \\ (m) \\ (m) \\ (m) \\ (m) \\ V_{e1} + V_{e2} \\ V_{c1} + V_{c2} \\ W_{r1} + W_{r2} \\ W_{p1}$		= =	241.14 0.31 2.73	(m ³) (ton) (ton)
L: B: H: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_r = W_p =	320.00 0.40 0.60 0.15 mannel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21	(m ³) (ton) (ton) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_r = W_p =	320.00 0.40 0.60 0.15 mannel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_r = W_p =	320.00 0.40 0.60 0.15 mannel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³)
L: B: H: t: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where,	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_p = W_p =	320.00 0.40 0.60 0.15 mannel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_p = W_p = W_r = W_p =	320.00 0.40 0.60 0.15 annel: 297.8 x (Q 228.1 x (Q 20.046 x V _c 0.020	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _Q 0.020 247.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch V_e = V_c = W_r = W_p = W_p = W_r = W_p =	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _Q 0.020 247.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _Q 0.020 247.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _Q 0.020 247.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _Q 0.020 247.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = =	241.14 0.31 2.73 82.21 23.24	(m ³) (ton) (ton) (m ³) (m ³)
L: B: H: t: t: otal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ V_c	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 20.046 x V 0.020 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m) (m)	⁽² ,0.727 (2,0.795		241.14 0.31 2.73 82.21 23.24 1.25	(m ³) (ton) (ton) (m ³) (ton)
L: B: H: t: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x)	⁽² ,0.727 (2,0.795) (2,0.795) (2,0.795)		241.14 0.31 2.73 82.21 23.24 1.25 31.22	(m ³) (ton) (ton) (m ³) (ton) (m ³)
L: B: H: t: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete:	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x)	$(2)^{0.727}$ $(2)^{0.795}$ $(2)^{0.795}$ $(2)^{0.479}$ $(2)^{0.479}$ $(2)^{0.684}$		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x)	$(2)^{0.727}$ $(2)^{0.795}$ $(2)^{0.795}$ $(2)^{0.479}$ $(2)^{0.479}$ $(2)^{0.684}$		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where,	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q 28.1 x (Q 28.1 x (Q 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) $x He^{2/3} x n^{1}$ (m) $(m)^{3/5}$ (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c2}$	$(2)^{0.727}$ $(2)^{0.795}$ $(2)^{0.795}$ $(2)^{0.479}$ $(2)^{0.479}$ $(2)^{0.684}$		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Concrete: Reinforcement Bars Concrete: Reinforcement Bars Where, D: I	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $W_r =$ Diameter of Waterway =	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 0.046 x V _c 0.020 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_{c}))$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: contraction: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c $	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s) (m) $\overline{395 x (R x)}$ 40.4 x (R x) $0.278 x V_c$	$(2)^{0.727}$ $(2)^{0.795}$ $(2)^{0.795}$ $(2)^{0.479}$ $(2)^{0.479}$ $(2)^{0.684}$		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Concrete: Reinforcement Bars Concrete: Reinforcement Bars Where, D: I	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $W_r =$ Diameter of Waterway =	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_{c}))$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: contraction: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c $	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s) (m) $\overline{395 x (R x)}$ 40.4 x (R x) $0.278 x V_c$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: contraction: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c $	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s) (m) $\overline{395 x (R x)}$ 40.4 x (R x) $0.278 x V_c$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: contraction: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ W_r	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s) (m) $\overline{395 x (R x)}$ 40.4 x (R x) $0.278 x V_c$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)
L: B: H: t: cotal Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Length of Channel = Width of Channel = Height of Channel = Fhickness of Concrete = Stock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $W_r =$ Maximum Discharge = $V_c =$ $W_r =$ Maximum Discharge = $W_r =$ $W_r =$ $V_c =$ $W_r =$	320.00 0.40 0.60 0.15 annel: 28.1 x (Q = 28.1 x (Q = 28.1 x (Q = 247.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s) (m) $\overline{395 x (R x)}$ 40.4 x (R x) $0.278 x V_c$	² ,0.727 2,0.795 Q) ^{0.479} Q) ^{0.684} 0.610		241.14 0.31 2.73 82.21 23.24 1.25 31.22 1.08	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)

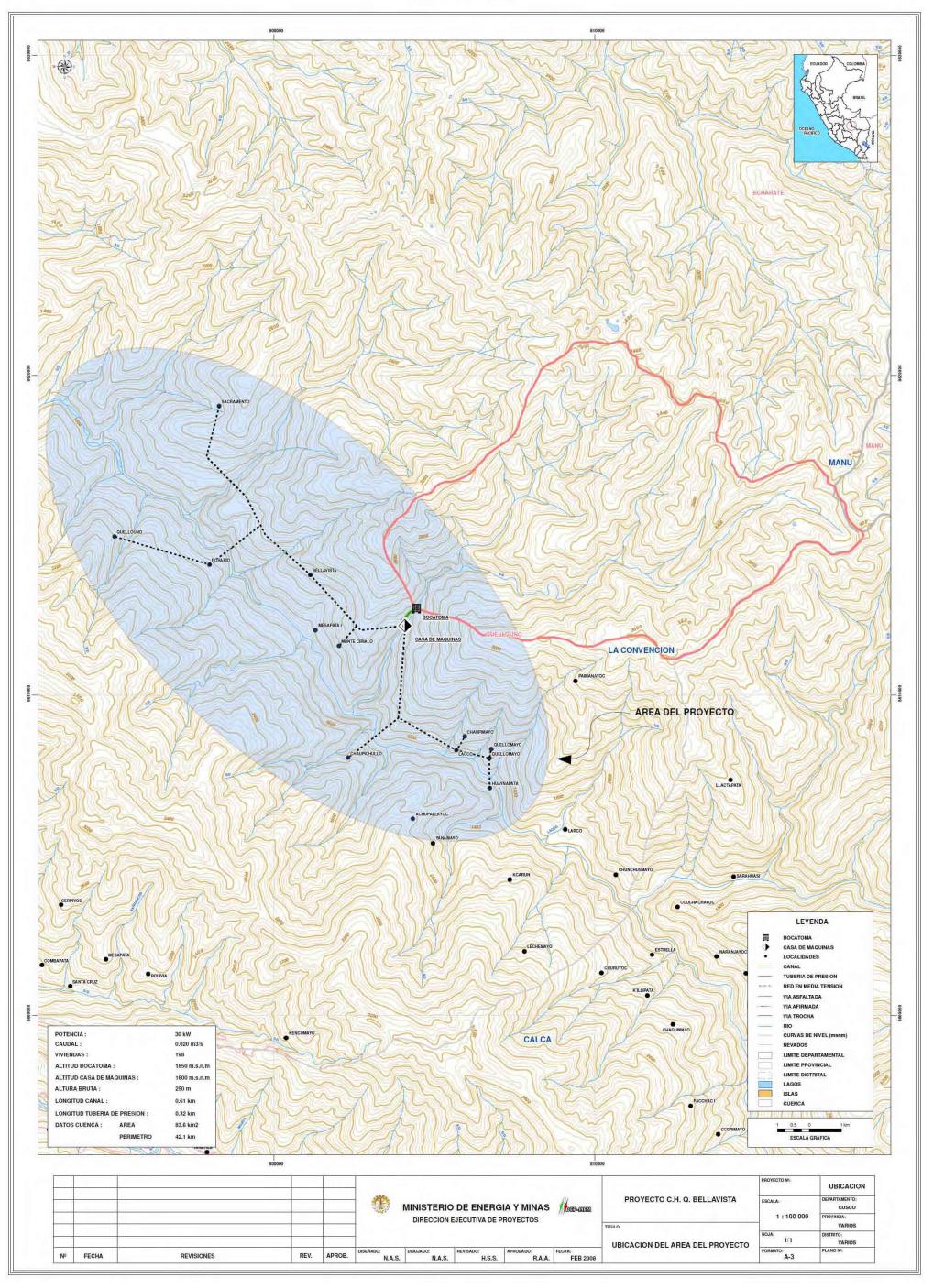
(1) Civil Works				
 Excavation				
Open	:	5.53	(US\$/m ³)	* (8.70+2.35) x 0.5 = \$5.53/m ³ , from CAPAECO and Fainal study on Omia <human and="" excavation="" machine="" power=""></human>
 Tunnel	:	-	(US\$/m ³)	
 Concrete				
 Open	:	93.05	(US\$/m ³)	* from CAPAECO (average of foundation, wall and structure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

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

(2) Hydraulic Equipm	ent			
Gate & Screen	:	8,811.04	(US\$/ton)	* from final study on Omia
Steel Penstock	:	3,100.00	(US\$/ton)	including installation
ΡVC (φ300)		17.13	(US\$/m)	RIB LOC for Headrace
PVC (φ150)	:	30.39	(US\$/m)	80% of TUBOPLAST(ϕ 315) for Penstock (C-10) = 43.42 x 0.7 = 30.39

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

(4) Transportation Cost				
Cusco to the site	:	13.83	(US\$/ton)	156km



Appendix I-7 Construction Cost for Sarapampa Power Station

I. Summary of Construction Cost for Sarapampa Power Station

		Unit:
Work Item	Construction Cost	Remarks
1. Preliminary Works	8,186	
(1) Access Road	0	
(2) Facilities for Construction Office	2,636	Cost of Civil Works x 0.05
(3) Transportation cost	5,550	345.41ton x \$16.07/ton
2. Cost for Environmental Mesures	527	Cost of Civil Works x 0.01
3. Civil Works	52,727	
(1) Weir	2,221	
(2) Intake	4,835	
(3) Settling Basin	3,667	
(4) Headrace	7,299	
(5) Head Tank	8,428	
(6) Penstock & Spillway Channel	13,857	
(7) Power House	10,440	
(8) Outlet	1,980	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	65,000	
(1) Gate & Screen	3,158	
(2) Penstock	0	
(3) PVC (φ500)	45,837	
(4) PVC (φ200)	5,211	
(5) Others	10,794	
5. Electrical Equipment	41,100	
6. Direct Cost	167,540	1.+2.+3.+4.+5.
7. Engineering Cost	16,754	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	16,706	6. x 0.100
9. IGV	38,190	19.00%
10. Total Cost	239,190	

II. Detailed Statement of Transportation Cost for Sarapampa Power Station

Items	Unit	Quantity	Remarks
(1) Wier		17.05	
a. Cements		3.57	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	13.24	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.23	
(2) Intake		44.67	
a. Gate		0.24	
b. Screen		0.12	
c. Cements	ton	9.24	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		34.22	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.84	
(3) Settling Basin		23.91	
a. Cements		4.79	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	17.74	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.37	
(4) Headrace		9.45	
a. PVC (φ500)	ton	9.45	Weight: 1,100m x 51.522kg/6m
(5) Head Tank		46.41	
a. Cements		9.49	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	35.13	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.79	
(6) Penstock & Spillway Channel		134.83	
a. Penstock Steel (φ200)		0.00	
b. Penstock PVC (\u03c6200)		1.25	Weight: 150m x 50.000kg/6m
c. Cements	ton	28.40	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		105.18	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.00	
(7) Power House		62.23	
a. Cements	tor	12.67	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	46.94	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		2.62	
(8) Outlet		6.88	
a. Cements	46.5	1.31	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	4.84	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.73	
(9) Subtotal	-	345.41	
(10) Transportation Cost		5,551	(9) x \$16.07/ton

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

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				4,835	
a. Excavation	m ³	5.53	21.7	119	
b. Concrete	m ³	93.05	34.2	3,184	
c. Reinforcement Bars	ton	1,070.00	0.8	902	
d. Others	-			630	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				3,667	(including concer work, etc.)
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				7,299	
a. Excavation	m ³	5.53	1100.0	6,083	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,216	(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				13,857	(inerading gate, sereen)
a. Excavation	m ³	5.53	508.5	2,812	
b. Concrete	m ³	93.05	105.2	9,786	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,259	(a+b+c) x 0.10 (including filling works)
(7) Power House				10,440	(
a. Excavation	m ³	5.53	156.3	864	
b. Concrete	m ³	93.05	46.9	4,367	
c. Reinforcement Bars	ton	1,070.00	2.6	2,800	
d. Others	-			2,409	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				1,980	
a. Excavation	m ³	5.53	89.4	494	
b. Concrete	m ³	93.05	4.8	450	
c. Reinforcement Bars	ton	1,070.00	0.7	778	
d. Others	-			258	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			0	$\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal		1	1	52,727	

			-		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				3,158	
a. Gate	ton	8,811.04	0.24	2,142	
b. Screen	ton	8,811.04	0.12	1,016	
(3) Penstock Steel (φ200)	ton	3,100.00	0.00	0	
(4) PVC (φ500) for headrace	m	41.67	1,100	45,837	
(5) Penstock PVC (φ200) C-10	m	34.74	150	5,211	
(6) Subtotal				54,206	
(7) Others				10,794	19.91%
(8) Total				65,000	

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

V. Quantity

Excavation:	$V_e =$	8.69 x (H _d x L) ^{1.14}	= (67.01 (m ³)	
Concrete:	$V_c =$	8.64 x $(H_d^2 x L)^{0.726}$		13.24 (m ³)	
Reinforcement Bars	W _r =	$0.0274 \text{ x V}_{c}^{0.830}$	=	0.23 (ton)	
Weight of Gate:	$\mathbf{W}_{\mathbf{g}} =$	0.145 x Q _f ^{0.692}	=	0.00 (ton)	(unconsidered)
Where,	U				· · · · ·
H _d :	Height of Dam $=$	0.30 (m)			
L:	Length of Dam =	20.00 (m)			
2) Intake					
Excavation:	V _e =	171 x (R x Q) ^{0.666}	=	21.68 (m^3)	
Concrete:	$V_c =$	$147 \text{ x} (\text{R x Q})^{0.470}$		34.22 (m^3)	
Reinforcement Bars	W _r =	$0.0145 \text{ x V}_{c}^{1.15}$	=	0.84 (ton)	
Weight of Gate:	$W_{\rm g} =$	$1.27 \times (R \times Q)^{0.533}$	=	0.24 (ton)	
Weight of Screen:	-	$0.701 \text{ x } (\text{R x } \text{Q})^{0.582}$		0.12 (ton)	
Weight of Screen: Where,	$W_s =$	0.701 X (K X Q)	=	0.12 (1011)	
	Diameter of Waterway =	1.00 (m)			
R:	Radius of Waterway =	0.50 (m) D/2	Assu	mption; Water	way Gradient = $1/1,00$
Q:	Maximum Discharge =	0.090 (m ³ /s)			
3) Settling Basin					
Excavation:	$V_e =$	515 x Q ^{1.07}	=	39.16 (m^3)	
Concrete:	$V_c =$	169 x Q ^{0.936}	= 1	(m^3)	
Reinforcement Bars	$W_r =$	0.120 x V _c ^{0.847}	=	1.37 (ton)	
Weight of Gate:	$W_g =$	0.910 x Q ^{0.613}		0.21 (ton)	
weight of Gale.	•• g =	0.910 X Q	=	(1011)	
Weight of Screen:	$\mathbf{W}_{s} = \mathbf{W}_{s}$	$0.910 \times Q$ $0.879 \times Q^{0.785}$	=	0.13 (ton)	
-	$\mathbf{W}_{s} =$	0.879 x Q ^{0.785}			
Weight of Screen:	$\mathbf{W}_{s} =$				
Weight of Screen: Where,	$W_s =$	0.879 x Q ^{0.785}			
Weight of Screen: Where,	$W_s =$	0.879 x Q ^{0.785}			
Weight of Screen: Where, Q:	W _s =	0.879 x Q ^{0.785}			
Weight of Screen: Where, Q: 4) Headrace	W _s = Maximum Discharge =	0.879 x Q ^{0.785}	=		
Weight of Screen: Where, Q: 4) Headrace In the case of PVC \$	$W_s =$ Maximum Discharge = 00: $V_e = I$ $V_c = 0$	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$	=	0.13 (ton)	
Weight of Screen: Where, Q: 4) Headrace In the case of PVCφ5 Excavation:	$W_s =$ Maximum Discharge = 00: $V_e = I$ $V_c = 0$	0.879 x Q ^{0.785} 0.090 (m ³ /s)	= 1,10	0.13 (ton)	
Weight of Screen: Where, Q: 4) Headrace In the case of PVCφ5 Excavation: Concrete:	$W_s =$ Maximum Discharge = 00: $V_e = I$ $V_c = 0$ $W_r = 0$	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$	= = 1,10 =	0.13 (ton) 00.00 (m ³) - (m ³)	
Weight of Screen: Where, Q: 4) Headrace In the case of PVC \$ Excavation: Concrete: Reinforcement Bars	$W_s =$ Maximum Discharge = 00: $V_e = I$ $V_c = 0$ $W_r = 0$	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$	= = 1,10 =	0.13 (ton) 00.00 (m ³) - (m ³)	
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)}$	= 1,10 = =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton)	
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel = Width of Channel =	$0.879 \ge Q^{0.785}$ $0.090 \pmod{m^3/s}$ $3 \ge H \ge L$ $(H \ge t \ge 2) + (B + 2t) \ge t) \ge L$ $0.577 \ge (V_c/L)^{0.888} \ge L$ $0.090 \pmod{m^3/s}$ $1,100.00 \pmod{m}$ for excave	= 1,1(= =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton) from RIBLOCC	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)}$ $1.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$	= 1,1(= =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton)	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel = Width of Channel =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)}$ for excavations of the excavation of the exc	= 1,1(= =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton) from RIBLOCC	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)}$ $1.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$	= 1,1(= =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton) from RIBLOCC	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I_{e})$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)}$ $1.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$	= 1,1(= =	0.13 (ton) 00.00 (m ³) - (m ³) - (ton) from RIBLOCC	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVCo5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = 0$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete =	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$ $- \text{ (m)}$	= 1,1(= = = 2 ation (2D + ation (2D +	0.13 (ton) 0.000 (m ³) - (ton) from RIBLOC from RIBLOC	,
Weight of Screen: Where, Q: 4) Headrace In the case of PVC ϕ 5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank Excavation:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = 0$ Wr = 0 Maximum Discharge = Length of Channel = Height of Channel = Height of Channel = Height of Channel = Width of Channel = Height of Channel = Width of Channel = Height of Channel = Width of Channel = Height	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$ $- \text{ (m)}$ $808 \times Q^{0.697}$	= 1,1(= 1,1(= 1 ,1(= 1 ,1()))))))))))))))))))))))))))))))))))	0.13 (ton) 0.000 (m ³) - (m ³) - (ton) from RIBLOC from RIBLOC	· ·
Weight of Screen: Where, Q: 4) Headrace In the case of PVC $\varphi 5$ Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank Excavation: Concrete:	$W_{s} =$ Maximum Discharge = $W_{e} = I$ $V_{e} = I$ $V_{e} = 0$ Maximum Discharge = Length of Channel = Height of Channel = Height of Channel = Thickness of Concrete = $V_{e} =$ $V_{e} =$ $V_{c} =$	$0.879 \ge Q^{0.785}$ $0.090 \pmod{(m^3/s)}$ $3 \ge H \ge L$ $(H \ge t \ge 2t) \ge (H \ge 2t) \ge 2t) \ge 2t \ge 2t$ $0.090 \pmod{(m^3/s)}$ $1,100 \pmod{(m)} \qquad \text{for excave}$ $1.00 \pmod{(m)} \qquad \text{for excave}$ $- \pmod{(m)}$ $808 \ge Q^{0.697}$ $197 \ge Q^{0.716}$	= 1,1(= 1,1(= 1 ,1(= 1 ,1() = 1 ,1() = 1 ,1() = 1 ,1()	0.13 (ton) 0.000 (m ³) - (m ³) - (ton) from RIBLOCC from RIBLOCC 50.84 (m ³) 35.13 (m ³)	<i>'</i>
Weight of Screen: Where, Q: 4) Headrace In the case of PVC ϕ 5 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank Excavation:	$W_{s} =$ Maximum Discharge = $V_{e} = I$ $V_{c} = (I)$ Maximum Discharge = $Length of Channel =$ $Width of Channel =$ $Height of Channel =$ $Height of Channel =$ $Width of Channel =$ $Width of Channel =$ $W_{c} =$ $W_{c} =$ $W_{r} =$	$0.879 \times Q^{0.785}$ $0.090 \text{ (m}^{3}\text{/s)}$ $3 \times H \times L$ $(H \times t \times 2) + (B + 2t) \times t) \times L$ $0.577 \times (V_c/L)^{0.888} \times L$ $0.090 \text{ (m}^{3}\text{/s)}$ $1,100.00 \text{ (m)} \text{ for excava}$ $1.00 \text{ (m)} \text{ for excava}$ $- \text{ (m)}$ $808 \times Q^{0.697}$	= 1,1(= 1,1(= 1 ,1(= 1 ,1()))))))))))))))))))))))))))))))))))	0.13 (ton) 0.000 (m ³) - (m ³) - (ton) from RIBLOC from RIBLOC	<i>'</i>

	ay Channel						
Penstock (Steel) \varphi 200			10.5	1.33 -			. 3.
Excavation:	$V_{e1} =$		10.9 x D	^{1.33} x L	=	0.00	
Concrete:	$V_{c1} =$		2.14 x D		=	0.00	· /
Reinforcement Bars	$W_{r1} =$		0.018 x Y	V _c	=	0.00	(ton)
Where,							
	vg. Diameter of Penstock =	0.00					
L:	Length of Penstock =	0.00	(m)				
Weight of Penstock	W . –	7.85x π x I	D v t v	10^{-3} v 1 15 v	I –	0.00	(ton)
Thickness of Penstock:		0.0362 x H			=		(mm)
Where.			m · -			2.00	(iiiii)
	Weight of Penstock	0.00	(ton)	(Tensil	allowab	le Stress:	1,150 kgf/cm ²)
1	Thickness of Penstock		(mm)				, ,
D _m : .	vg. Diameter of Penstock =	0.00	(m)				
H:	Design Head =	97.50		(Intake	Water L	evel - Tai	lrace Water Level)
L:	Length of Penstock =	0.00	(m)				
Penstock (PVC)ø200	•						
Excavation:		BxHxL			=	113.54	(m^3)
Where.	e				_	115.54	(
Q:	Maximum Discharge =	0.090	(m^3/s)				
L:	Length of Channel =	150.00					
B:	Width of Channel =	0.87	(m)			AST Brock	
H:	Height of Channel =	0.87	(m)	from TU	JBOPLA	AST Brock	hure
Spillway Channel:							
	$(B x H)^{0.5} =$	1.09 x O ^{0.3}	79		=	0.44	
Excavation:	V _e =	6.22 x ((B	$(x H)^{0.5})^{1.0}$	⁰⁴ x L	=	395.01	(m^3)
Concrete:		H x t x 2 +			=	105.18	
Reinforcement Bars	-	0.577 x (V			=		(ton)
Where.			0-)				(1011)
Q:	Maximum Discharge =	0.090	(m^3/s)				
L:	Length of Channel =	150.00					
B:	Width of Channel =	0.40	(m)				
			(III)				
H:	Height of Channel =	0.60	(m)				
H:	Height of Channel = Thickness of Concrete =	0.60	(m)				
H:	-	0.60	(m)				
H:	-	0.60	(m)				
H: t: Fotal Quantity of Per	Thickness of Concrete =	0.60 0.15	(m) (m)				
H: t: Fotal Quantity of Per Excavation:	Thickness of Concrete = nstock and Spillway Cha V _e =	0.60 0.15	(m) (m) $V_{e1} + V_{e}$	-	=	508.55	
H: t: Total Quantity of Per Excavation: Concrete:	Thickness of Concrete = nstock and Spillway Cha V _e = V _c =	0.60 0.15	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$	2	=	105.18	(m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$	2	=	105.18 0.00	(m ³) (ton)
H: t: Total Quantity of Per Excavation: Concrete:	Thickness of Concrete = nstock and Spillway Cha V _e = V _c =	0.60 0.15	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$	2	=	105.18 0.00	(m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$	2	=	105.18 0.00	(m ³) (ton)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$	2	=	105.18 0.00	(m ³) (ton)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p =	0.60 0.15 annel:	(m)	2 r2	=	105.18 0.00 0.00	(m ³) (ton) (ton)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p = V _e =	0.60 0.15 annel: 97.8 x (Q 2	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1}	2 r2 n ^{1/2}) ^{0.727}	=	105.18 0.00	(m ³) (ton) (ton)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _e = V _e =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x T$	2 r2 n ^{1/2}) ^{0.727}	= =	105.18 0.00 0.00	(m ³) (ton) (ton) (m ³)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = V _c = W _r = W _r =	0.60 0.15 annel: 97.8 x (Q 2	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x T$	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where,	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x V _c	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $\overline{x He^{23} x 1}$ $x He^{23} x 1$	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q:	Thickness of Concrete = nstock and Spillway Cha Ve = Vc = Wr = Wp = Ve = Vc = Vc = Vr = Wr = W	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x f^{1/3}$ (m ³ /s)	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Total Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = astock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x f^{1/3}$ (m ³ /s)	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Total Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = nstock and Spillway Cha Ve = Vc = Wr = Wp = Ve = Vc = Vc = Vr = Wr = W	0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x f^{1/3}$ (m ³ /s)	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = astock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x f^{1/3}$ (m ³ /s)	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Total Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = astock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $x He^{2/3} x f^{1/3}$ (m ³ /s)	2 r2 n ^{1/2}) ^{0.727}	= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (m ³)
H: t: Total Quantity of Pen Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = V _c = V _c = R _r = Effective Head = hantity Unit of Turbine =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} $\overline{x He^{23} x 1}$ 1.05 (m)	n ^{1/2} ,0.727 n ^{1/2} ,0.795	= = =	105.18 0.00 0.00 156.34 46.94 2.62	(m ³) (ton) (ton) (m ³) (ton)
H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t	Thickness of Concrete = astock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m ³ /s) (m) $395 \times (R$	- 2 (r2 (r2) (r2) (r2) (r27) (= = =	105.18 0.00 0.00 156.34 46.94	(m ³) (ton) (ton) (m ³) (ton)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: to) Outlet	Thickness of Concrete = nstock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = V _c = V _c = R _r = Effective Head = hantity Unit of Turbine =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m ³ /s) (m) $395 \times (R$ $40.4 \times (F$	$\frac{1}{12}$		105.18 0.00 0.00 156.34 46.94 2.62	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t Outlet Excavation:	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2 0.046 x Vc 0.090 97.50	(m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m ³ /s) (m) $395 \times (R$	$\frac{1}{12}$		105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Where, Reinforcement Bars Where,	Thickness of Concrete = astock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = lantity Unit of Turbine = $V_e =$ $V_e =$ $V_r =$	0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.090 97.50 1.00	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m ³ /s) (m) $395 \times (R$ $40.4 \times (F$ $0.278 \times V$	$\frac{1}{12}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, D: D	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = hantity Unit of Turbine = $V_e =$ $V_e =$ $V_r = V_r = V_r$ $V_r =$ $V_r = V_r = V_r$ $V_r =$ $V_r = V_r$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (F)})$ (m)	$\frac{1}{r^2} \frac{1}{r^2} \frac{1}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Where, Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $V_e =$ $W_r = W_r =$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00 1.00 0.50	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x + 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (FO)})$ (m) (m) (m)	$\frac{1}{12}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, D: D	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = hantity Unit of Turbine = $V_e =$ $V_e =$ $V_r = V_r = V_r$ $V_r =$ $V_r = V_r = V_r$ $V_r =$ $V_r = V_r$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x + 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (FO)})$ (m) (m) (m)	$\frac{1}{r^2} \frac{1}{r^2} \frac{1}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Where, Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $V_e =$ $W_r = W_r =$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00 1.00 0.50	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x + 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (FO)})$ (m) (m) (m)	$\frac{1}{r^2} \frac{1}{r^2} \frac{1}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Where, Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $V_e =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00 1.00 0.50	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x + 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (FO)})$ (m) (m) (m)	$\frac{1}{r^2} \frac{1}{r^2} \frac{1}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)
H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Concrete: Reinforcement Bars	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $V_e =$ $W_r = W_r =$	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 97.50 1.00 1.00 0.50	(m) (m) (m) $V_{e1} + V_e$ $V_{c1} + V_c$ $W_{r1} + W$ W_{p1} (m) $\frac{x He^{2/3} x + 1}{1.05}$ (m) $\frac{395 x (R}{40.4 x (FO)})$ (m) (m) (m)	$\frac{1}{r^2} \frac{1}{r^2} \frac{1}$	= = = = = =	105.18 0.00 0.00 156.34 46.94 2.62 89.43 4.84	(m ³) (ton) (ton) (m ³) (ton) (m ³)

VI. Unit Price 1USD =	3.00 S/. (as of November, 2007)
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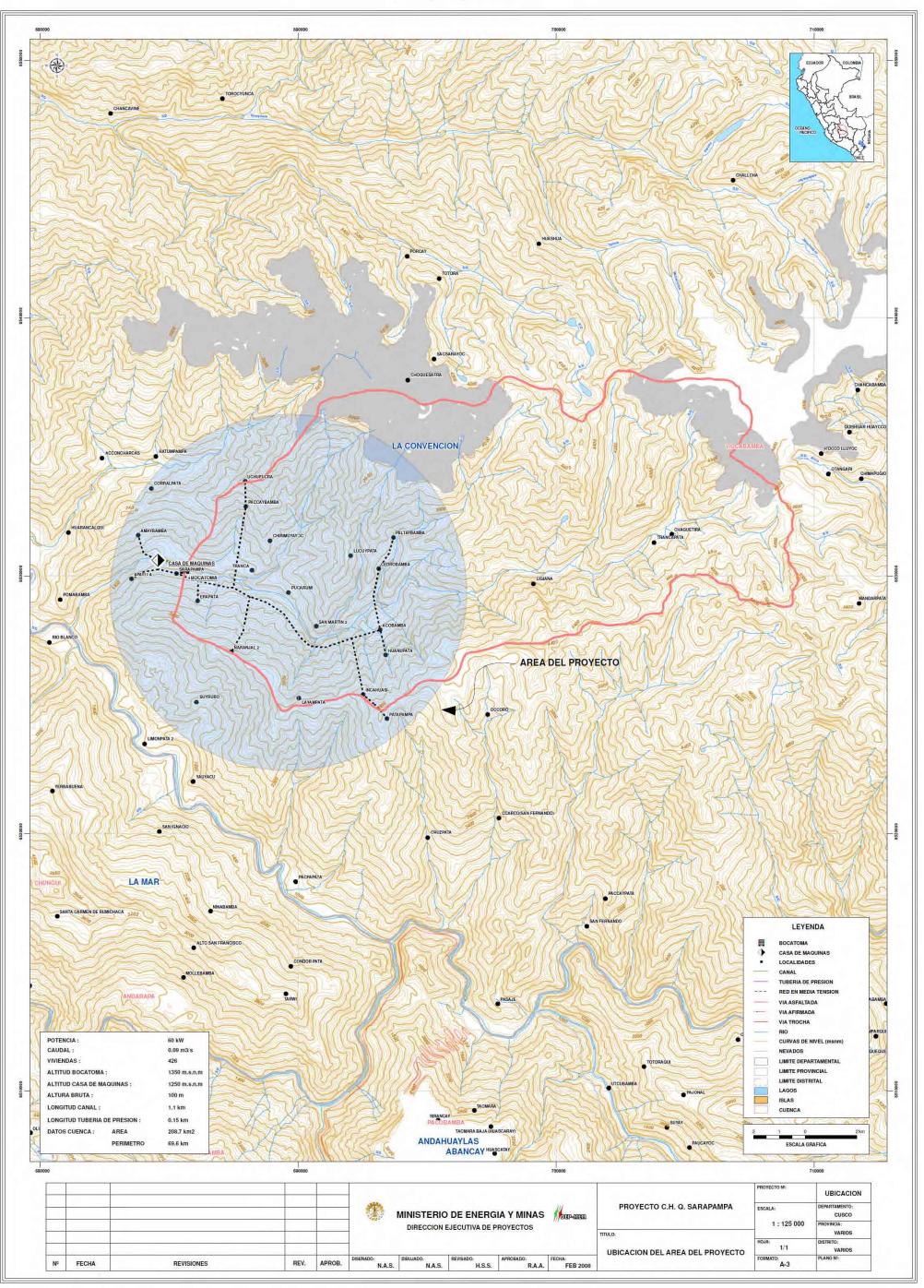
Excavation				
Open	:	5.53	(US\$/m ³)	* (8.70+2.35) x 0.5 = \$5.53/m ³ , from CAPAECO and Fainal study on Omia <human and="" excavation="" machine="" power=""></human>
Tunnel	:	-	(US\$/m ³)	
Concrete				
Open	:	93.05	(US\$/m ³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US\$/m ³)	
Reinforcement Bar	:	1.070.00	(US\$/ton)	*\$1.07/kg, from CAPAECO

(2) Hydraulic Equipn	nent			
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(ϕ 315) for Penstock (C-10) = 43.42 x 0.8 = 34.74

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

(4) Transportation Co	st			
Cusco to the site	:	16.07	(US\$/ton)	221km (road)

Sarapampa Map



Appendix I-8 Construction Cost for Yanama Power Station

I. Summary of Construction Cost for Yanama Power Station

Work Item	Construction Cost	Remarks
1. Preliminary Works	5,197	
(1) Access Road	0	
(2) Facilities for Construction Office	1,597	Cost of Civil Works x 0.05
(3) Transportation cost	3,600	224.02ton x \$16.07/ton
2. Cost for Environmental Mesures	319	Cost of Civil Works x 0.01
3. Civil Works	31,948	
(1) Weir	1,282	
(2) Intake	2,582	
(3) Settling Basin	2,185	
(4) Headrace	2,972	
(5) Head Tank	5,539	
(6) Penstock & Spillway Channel	9,803	
(7) Power House	6,539	
(8) Outlet	1,046	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	28,500	
(1) Gate & Screen	1,564	
(2) Penstock	0	
(3) PVC (φ400)	18,431	
(4) PVC (φ200)	3,821	
(5) Others	4,684	
5. Electrical Equipment	24,800	
6. Direct Cost	90,764	1.+2.+3.+4.+5.
7. Engineering Cost	9,076	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	8,160	6. x 0.090
9. IGV	20,520	19.00%
10. Total Cost	128,520	

II. Detailed Statement of Transportation Cost for Yanama Power Station

Items	Unit	Quantity	Remarks
(1) Wier		9.48	
a. Cements		1.98	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	7.35	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.14	
(2) Intake		24.40	
a. Gate		0.12	
b. Screen		0.05	
c. Cements	ton	5.06	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		18.74	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.42	
(3) Settling Basin		13.86	
a. Cements		2.76	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	10.24	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.86	
(4) Headrace		4.81	
a. PVC (φ400)	ton	4.81	Weight: 700m x 41.214kg/6m = 4.81ton
(5) Head Tank		30.47	
a. Cements		6.23	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	23.06	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.18	
(6) Penstock & Spillway Channel		98.94	
a. Penstock Steel (φ200)		0.00	
b. Penstock PVC (φ200)		0.92	Weight: 110m x 50.000kg/6m =0.92ton
c. Cements	ton	20.84	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		77.18	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.00	
(7) Power House		39.09	
a. Cements		7.97	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	29.51	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.61	
(8) Outlet		2.99	
a. Cements		0.54	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	2.02	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.43	
(9) Subtotal		224.02	
(10) Transportation Cost		3,600	(9) x \$16.07/ton

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

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				2,582	
a. Excavation	m ³	5.53	9.2	51	
b. Concrete	m ³	93.05	18.7	1,744	
c. Reinforcement Bars	ton	1,070.00	0.4	451	
d. Others	-			336	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				2,185	
a. Excavation	m ³	5.53	20.9	115	
b. Concrete	m ³	93.05	10.2	952	
c. Reinforcement Bars	ton	1,070.00	0.9	920	
d. Others	-			198	(a+b+c) x 0.10 (including other works)
(4) Headrace				2,972	
a. Excavation	m ³	5.53	448.0	2,477	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			495	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				5,539	(
a. Excavation	m ³	5.53	100.1	553	
b. Concrete	m ³	93.05	23.1	2,146	
c. Reinforcement Bars	ton	1,070.00	1.2	1,258	
d. Others	-			1,582	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				9,803	(inordaning gate, sereen)
a. Excavation	m ³	5.53	313.0	1,731	
b. Concrete	m ³	93.05	77.2	7,181	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			891	(a+b+c) x 0.10 (including filling works)
(7) Power House				6,539	
a. Excavation	m ³	5.53	102.3	565	
b. Concrete	m ³	93.05	29.5	2,745	
c. Reinforcement Bars	ton	1,070.00	1.6	1,720	
d. Others	-			1,509	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				1,046	
a. Excavation	m ³	5.53	48.4	267	
b. Concrete	m ³	93.05	2.0	187	
c. Reinforcement Bars	ton	1,070.00	0.4	456	
d. Others	-			136	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			0	$\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal		1		31,948	

IV. Detailed Statement of Hydraulic Equipment Cost for Yanama Power Statio	IV. Detailed Statement of	of Hydraulic H	Equipment Cost fo	or Yanama Power Station
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		•			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				1,564	
a. Gate	ton	8,811.04	0.12	1,082	
b. Screen	ton	8,811.04	0.05	482	
(3) Penstock Steel (\u03c6200)	ton	3,100.00	0.00	0	
(4) PVC (φ400) for headrace	m	26.33	700	18,431	
(5) Penstock PVC (φ200) C-10	m	34.74	110	3,821	
(6) Subtotal			-	23,816	
(7) Others				4,684	19.67%
(8) Total				28,500	

V. Quantity

(1) Weir						
Excavation:	$V_e =$	8.69 x (H _d x L) ^{1.14}	=	42.21	(m ³)	
Concrete:	$V_c =$	8.64 x $(H_d^2 x L)^{0.726}$	=	7.35	(m ³)	
Reinforcement Bars	$W_r =$	$0.0274 \text{ x V}_{c}^{0.830}$	=	0.14	(ton)	
Weight of Gate:	$W_g =$	0.145 x Q _f ^{0.692}	=	0.00	(ton) (unconsi	dered)
Where,						
H _d :	Height of Dam =	0.20 (m)				
L:	Length of $Dam =$	20.00 (m)				
(2) Intake						
Excavation:	$V_e =$	171 x (R x Q) ^{0.666}	=	9.24	(m ³)	
Concrete:	$V_c =$	147 x (R x Q) ^{0.470}	=	18.74	(m^{3})	
Reinforcement Bars	$W_r =$	0.0145 x V _c ^{1.15}	=	0.42	(ton)	
Weight of Gate:	$W_g =$	1.27 x (R x Q) ^{0.533}	=	0.12	(ton)	
Weight of Screen:	$\mathbf{W}_{s} =$	$0.701 \text{ x} (\text{R x Q})^{0.582}$	=	0.05		
Where,						
	Diameter of Waterway =	0.50 (m)				
R:	Radius of Waterway =	0.25 (m) D/2	Α	ssumptio	n; Waterway Gradie	nt = 1/1,00
Q:	Maximum Discharge =	0.050 (m ³ /s)				
(3) Settling Basin						
Excavation:	$V_e =$	515 x Q ^{1.07}	=	20.88	(m ³)	
Concrete:	$V_c =$	169 x Q ^{0.936}	=	10.24	(m ³)	
Reinforcement Bars	$W_r =$	0.120 x V _c ^{0.847}	=	0.86	(ton)	
Weight of Gate:	$W_g =$	0.910 x Q ^{0.613}	=	0.15	(ton)	
Weight of Screen:	$W_s =$	0.879 x Q ^{0.785}	=	0.08	(ton)	
Where,						
Q:	Maximum Discharge =	$0.050 (m^3/s)$				
(4) Headrace						
In the case of PVCq4			_		_	
Excavation:		3 x H x L	=	448.00	(m ³)	
Concrete:		(H x t x 2) + (B + 2t) x t) x L	=	-	(m ³)	
Reinforcement Bars	$W_r = 0$	0.577 x (V _c /L) ^{0.888} x L	=	-	(ton)	
Where,	_					
Q:	Maximum Discharge =	$0.050 (m^3/s)$				
L: P.	Length of Channel =	700.00 (m) for avaav	ntion ()	D factor T		
B: H:	Width of Channel = Height of Channel =	· · ·			RIBLOC Brochure)RIBLOC Brochure)	
	Thickness of Concrete =	- (m)	auon (2			
		()				
(5) Head Tank						
Excavation:	$V_e =$	808 x Q ^{0.697}	=	100.14	(m ³)	
Concrete:	$V_c =$	197 x Q ^{0.716}	=	23.06	(m ³)	
Reinforcement Bars	$W_r =$	0.051 x V _c	=	1.18	(ton)	
Where,	_					
Q:	Maximum Discharge =	$0.050 (m^3/s)$				

-	ay Channel							
Penstock (Steel) \operatorname{200}					_			
Excavation:	$V_{e1} =$		10.9 x D _m ¹	^{1.33} x L	=	0.00	(m ³)	
Concrete:	$V_{c1} =$		$2.14 \text{ x } D_{m}^{m}$	^{1.68} x L	=	0.00	(m ³)	
Reinforcement Bars	$W_{r1} =$		0.018 x V _c		=	0.00	(ton)	
Where								
	vg. Diameter of Penstock =	0.00	(m)					
L:	Length of Penstock =							
	U							
Weight of Penstock	$W_{p1} =$	7.85x π x l	$D_m \ge t_m \ge 10$	⁻³ x1.15 x L	=	0.00	(ton)	
Thickness of Penstock:		0.0362 x H			=		(mm)	
Where								
W _{p1} :	Weight of Penstock	0.00	(ton)	(Tensil all	owab	le Stress:	$1,150 \text{ kgf/cm}^2$)	
1	Thickness of Penstock		(mm)	、 · · · · · · · ·			, /	
	vg. Diameter of Penstock =	0.00						
H:	Design Head =	98.10		(Intake Wa	ater L	evel - Tai	lrace Water Level)	
L:	Length of Penstock =	0.00						
	-							
Penstock (PVC)								
Excavation:	$V_e =$	BxHxL			=	83.26	(m ³)	
Where	,							
Q:	Maximum Discharge =	0.050	(m ³ /s)					
L:	Length of Channel =	110.00	(m)					
B:	Width of Channel =	0.87	(m)	from TUB	OPL	AST Brock	nure	
H:	Height of Channel =	0.87	(m)	from TUB	OPL	AST Brock	nure	
Spillway Channel:		- 03	379					
	$(B \times H)^{0.5} =$				=	0.35		
Excavation:			x H) ^{0.5}) ^{1.04}		=	229.77	(m ³)	
Concrete:			$(\mathbf{B} + 2\mathbf{t}) \mathbf{x}$		=	77.18	(m ³)	
Reinforcement Bars	$W_r =$	0.577 x (V	$(L)^{0.888} \times L$	_	=		(ton)	
Where			- /					
Q:	Maximum Discharge =	0.050	(m^3/s)					
٧.		5.000						
Τ·	Length of Channel -	110.00	· /					
L: B:	Length of Channel = Width of Channel =	110.00 0.40	(m)					
	0	0.40	(m) (m)					
B: H:	Width of Channel =	0.40 0.60	(m) (m) (m)					
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $v_e = v_c = v_c = w_r = w_r =$	0.40 0.60 0.15 annel:					(m ³) (ton)	
B: H: t: Fotal Quantity of Per Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Cha V _e = V _c =	0.40 0.60 0.15 annel:	$(m) \\ (m) \\ (m) \\ (m) \\ V_{e1} + V_{e2} \\ V_{c1} + V_{c2}$		=	77.18 0.00	(m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $v_e = v_c = v_c = w_r = w_r =$	0.40 0.60 0.15 annel:			= =	77.18 0.00	(m ³) (ton)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $v_e = v_c = v_c = w_r = w_r =$	0.40 0.60 0.15 annel:			= =	77.18 0.00	(m ³) (ton)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = $v_e = v_c = v_c = w_r = w_r =$	0.40 0.60 0.15 annel:			= =	77.18 0.00	(m ³) (ton)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = $V_e = V_e = V_c = V_r = W_r = W_p =$	0.40 0.60 0.15	$(m) \\ (m) \\ (m) \\ (m) \\ (m) \\ V_{c1} + V_{c2} \\ V_{c1} + V_{c2} \\ W_{r1} + W_{r2} \\ W_{p1}$		=	77.18 0.00 0.00	(m ³) (ton) (ton)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$	0.40 0.60 0.15 annel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	^{/2}) ^{0.727}	= =	77.18 0.00 0.00 102.28	(m ³) (ton) (ton) (m ³)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q :	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_c =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel:	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$	^{/2}) ^{0.727}	= =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where.	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = W_p =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ¹ x He ^{2/3} x n ¹	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.046 x V _c	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s)	^{/2}) ^{0.727}	= = = =	77.18 0.00 0.00 102.28 29.51	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = W_p = V_c = W_r = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c = V_c	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m)	/2 ₂ 0.727 /2 ₂ 0.795	-	77.18 0.00 0.00	(m ³) (ton) (ton) (m ³) (ton)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation:	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = V_c = W_r = V_c = V_c = V_c = W_r = V_c = W_r = V_c = W_r = V_c = W_r = W_r =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x)	⁽²) ^{0.727} (²) ^{0.795}		77.18 0.00 0.00 102.28 29.51 1.61 48.42	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t) Outlet Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = teffective Head = tentity Unit of Turbine = $V_e =$ $V_c =$ $V_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) $x He^{2/3} x n^{1}$ (m) $(m)^{3/5}$ (m) 395 x (R x)	$(2, 0.727)^{(2)}(0.795)^{(2)}$	-	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = tantity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x)	$(2, 0.727)^{(2)}(0.795)^{(2)}$		77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. 0) Outlet Excavation: Concrete: Reinforcement Bars Where.	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = tentity Unit of Turbine = $V_e =$ $V_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) $x He^{2/3} x n^{1}$ (m) $(m)^{3/5}$ (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c2}$	$(2, 0.727)^{(2, 0.795)}$	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where. Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = tantity Unit of Turbine = $V_e =$ $V_r =$ $W_r =$ $V_r =$ $W_r =$ $V_r =$ $W_r =$ $W_r =$ $V_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $x He^{2/3} x n^{1}$ $x He^{2/3} x n^{1}$ (m) (m^{3}/s) (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c}$ (m)	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = tantity Unit of Turbine = $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $x He^{2/3} x n^{1}$ $x He^{2/3} x n^{1}$ (m) (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c}$ (m) (m)	$(2, 0.727)^{(2, 0.795)}$	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where. Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = tantity Unit of Turbine = $V_e =$ $V_r =$ $W_r =$ $V_r =$ $V_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $x He^{2/3} x n^{1}$ $x He^{2/3} x n^{1}$ (m) (m^{3}/s) (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c}$ (m)	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where, Reinforcement Bars Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = tantity Unit of Turbine = $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $x He^{2/3} x n^{1}$ $x He^{2/3} x n^{1}$ (m) (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c}$ (m) (m)	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Newer House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t O Outlet Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $x He^{2/3} x n^{1}$ $x He^{2/3} x n^{1}$ (m) (m) 395 x (R x) 40.4 x (R x) $0.278 x V_{c}$ (m) (m)	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Newer House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t O Outlet Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = W_p = W_r	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $\frac{V_{e1} + V_{e2}}{W_{p1}}$ $\frac{V_{e1} + V_{e2}}{W_{p1}}$ $\frac{V_{e2} + V_{e2}}{W_{p1}}$ $\frac{V_{e2} + V_{e2}}{W_{$	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where. Q: He: n: t) Outlet Excavation: Concrete: Reinforcement Bars Where. D: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.050 98.10 1.00	(m) (m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} (m) $\frac{V_{e1} + V_{e2}}{W_{p1}}$ $\frac{V_{e1} + V_{e2}}{W_{p1}}$ $\frac{V_{e2} + V_{e2}}{W_{p1}}$ $\frac{V_{e2} + V_{e2}}{W_{$	⁽²)0.727 ⁽²)0.795 (2	= = = = =	77.18 0.00 0.00 102.28 29.51 1.61 48.42 2.02	(m ³) (ton) (ton) (m ³) (ton) (m ³)	

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

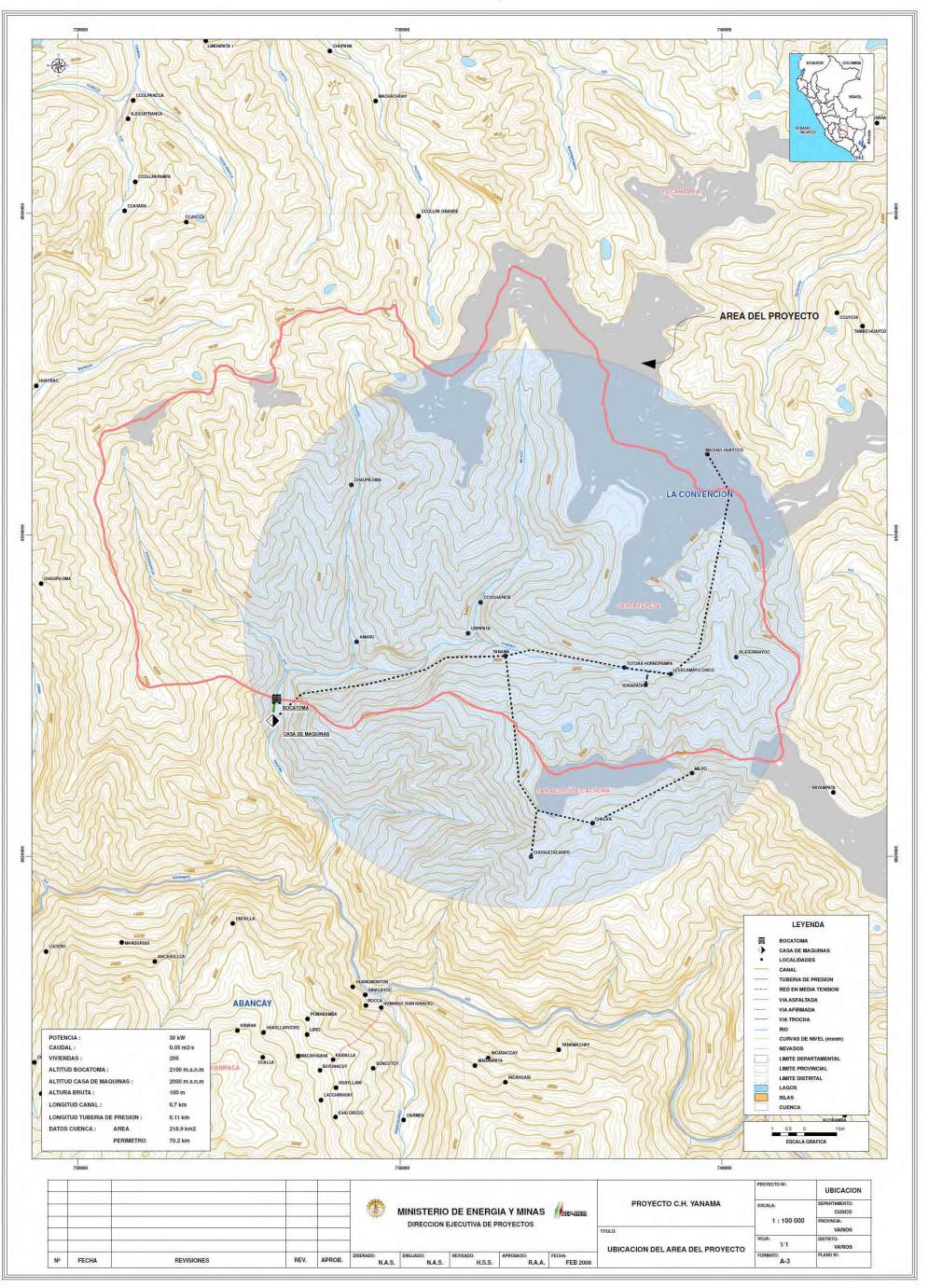
Excavation				
Open	:	5.53	(US\$/m ³)	* (8.70+2.35) x $0.5 = $ \$5.53/m ³ , from CAPAECO and Fainal study on Omia
open	•		(000,111)	<human and="" excavation="" machine="" power=""></human>
Tunnel	:	-	(US\$/m ³)	
Concrete				
Open	:	93.05	(US\$/m ³)	* from CAPAECO (average of foundation, wall and structure concrete)
Tunnel	:	-	(US\$/m ³)	

(2) Hydraulic Eq	uipment			
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	:	-	(US\$/m)	

(4) Transportation C	Cost			
to the site	:	16.07	(US\$/ton)	221km (same as the Sarapampa case)

Yanama Map



Appendix I-9 Construction Cost for Cayay Power Station

I. Summary of Construction Cost for Cayay Power Station

Work Item	Construction Cost	Remarks
1. Preliminary Works	7,662	
(1) Access Road	0	
(2) Facilities for Construction Office	2,670	Cost of Civil Works x 0.05
(3) Transportation cost	4,992	347.18ton x \$14.38/ton
2. Cost for Environmental Mesures	534	Cost of Civil Works x 0.01
3. Civil Works	53,411	
(1) Weir	2,221	
(2) Intake	5,569	
(3) Settling Basin	4,727	
(4) Headrace	6,019	
(5) Head Tank	10,346	
(6) Penstock & Spillway Channel	11,386	
(7) Power House	10,852	
(8) Outlet	2,291	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	55,800	
(1) Gate & Screen	3,698	
(2) Penstock	0	
(3) PVC (φ600)	37,592	
(4) PVC (φ315)	5,210	
(5) Others	9,300	
5. Electrical Equipment	41,100	
6. Direct Cost	158,507	1.+2.+3.+4.+5.
7. Engineering Cost	15,851	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	15,642	6. x 0.099
9. IGV	36,100	19.00%
10. Total Cost	226,100	

II. Detailed Statement of Transportation Cost for Cayay Power Station

Items	Unit	Quantity	Remarks
(1) Wier		17.05	
a. Cements		3.57	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	13.24	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.23	
(2) Intake		51.16	
a. Gate		0.28	
b. Screen		0.14	
c. Cements	ton	10.58	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		39.18	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.98	
(3) Settling Basin		31.22	
a. Cements		6.27	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	23.23	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.72	
(4) Headrace		8.38	
a. PVC (φ600)	ton	8.38	Weight: 630m x 79.8kg/6m
(5) Head Tank		57.02	
a. Cements		11.66	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	43.17	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		2.20	
(6) Penstock & Spillway Channel		109.37	
a. Penstock Steel (q300)		0.00	
b. Penstock PVC (q315)	40.0	2.46	Weight: 120m x 122.833kg/6m
c. Cements	ton	22.73	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		84.18	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.00	
(7) Power House		64.67	
a. Cements	ton	13.17	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	48.78	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		2.73	
(8) Outlet		8.31	
a. Cements	ton	1.59	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	5.90	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.82	
(9) Subtotal		347.18	
(10) Transportation Cost		4,992	(9) x \$14.38/ton

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

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				5,569	
a. Excavation	m ³	5.53	26.3	145	
b. Concrete	m ³	93.05	39.2	3,645	
c. Reinforcement Bars	ton	1,070.00	1.0	1,053	
d. Others	-			726	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				4,727	(including concer work, etc.)
a. Excavation	m ³	5.53	53.3	294	
b. Concrete	m ³	93.05	23.2	2,161	
c. Reinforcement Bars	ton	1,070.00	1.7	1,843	
d. Others	-			429	(a+b+c) x 0.10 (including other works)
(4) Headrace				6,019	
a. Excavation	m ³	5.53	907.2	5,016	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	_			1,003	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				10,346	(including inning works)
a. Excavation	m ³	5.53	184.3	1,019	
b. Concrete	m ³	93.05	43.2	4,016	
c. Reinforcement Bars	ton	1,070.00	2.2	2,355	
d. Others	-			2,956	(a+b+c) x 0.40 (including acts corpor)
(6) Penstock & Spillway Channel				11,386	(including gate, screen)
a. Excavation	m ³	5.53	455.5	2,519	
b. Concrete	m ³	93.05	84.2	7,832	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,035	(a+b+c) x 0.10 (including filling works)
(7) Power House				10,852	(including inning works)
a. Excavation	m ³	5.53	161.9	895	
b. Concrete	m ³	93.05	48.8	4,538	
c. Reinforcement Bars	ton	1,070.00	2.7	2,915	
d. Others	_			2,504	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				2,291	(including dramage work, wooden
a. Excavation	m ³	5.53	102.6	567	
b. Concrete	m ³	93.05	5.9	548	
c. Reinforcement Bars	ton	1,070.00	0.8	878	
d. Others	-			298	(a+b+c) x 0.15
(9) Miscellaneous Work	-			0	(including coffer work, etc.) $\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal				53,411	

	_	-			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				3,698	
a. Gate	ton	8,811.04	0.28	2,497	
b. Screen	ton	8,811.04	0.14	1,201	
(3) Penstock Steel (ø315)	ton	3,100.00	0.00	0	
(4) PVC (φ600) for headrace	m	59.67	630	37,592	
(5) Penstock PVC (<i>q</i> 315) C-10	m	43.42	120	5,210	
(6) Subtotal				46,500	
(7) Others				9,300	20.00%
(8) Total				55,800	

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

TT . TTOO

V. Quantity

Excavation:	$V_e =$	8.69 x (H _d x L) ^{1.14}	= 67.0	$1 (m^3)$	
Concrete:	$V_c =$	$8.64 \text{ x} ({H_d}^2 \text{ x L})^{0.726}$	= 13.2	4 (m^3)	
Reinforcement Bars	$W_r =$	$0.0274 \text{ x V}_{c}^{0.830}$	= 0.2	3 (ton)	
Weight of Gate:	$W_g =$	0.145 x Q _f ^{0.692}	= 0.0	0 (ton) (uncor	nsidered)
Where,					
H _d :	Height of Dam =	0.30 (m)			
L:	Length of Dam =	20.00 (m)			
2) Intake					
Excavation:	$V_e =$	171 x (R x Q) ^{0.666}	= 26.2	6 (m^3)	
Concrete:	$V_c =$	147 x (R x Q) ^{0.470}	= 39.1	8 (m^3)	
Reinforcement Bars	$W_r =$	$0.0145 \text{ x V}_{c}^{-1.15}$	= 0.9	8 (ton)	
Weight of Gate:	$W_g =$	$1.27 \text{ x} (\text{R x Q})^{0.533}$		8 (ton)	
Weight of Screen:	$W_s =$	$0.701 \text{ x} (\text{R x Q})^{0.582}$		4 (ton)	
Where,					
	Diameter of Waterway =	1.00 (m)			
R:	Radius of Waterway =	0.50 (m) D/2	Assumpt	tion; Waterway Grad	lient = $1/1,0$
Q:	Maximum Discharge =	0.120 (m ³ /s)			
3) Settling Basin Excavation:	V _e =	515 x Q ^{1.07}	= 53.2	8 (m^3)	
Concrete:	V _c =	$169 \ge Q^{0.936}$		3 (m ³)	
Reinforcement Bars	$W_r =$	$0.120 \ge V_c^{0.847}$		2 (ton)	
Weight of Gate:	$W_g =$	$0.910 \ge Q^{0.613}$		5 (ton)	
Weight of Screen:	$W_s =$	$0.879 \ge Q^{0.785}$		7 (ton)	
Where,					
Q:	Maximum Discharge =	$0.120 (m^3/s)$			
4) Headrace					
In the case of PVCq6				a (3)	
In the case of PVCφ6 Excavation:	$V_e = B$	x H x L	= 907.2	0 (m ³)	
In the case of PVCφ6 Excavation: Concrete:	$V_e = B$ $V_c = (($	(H x t x 2) + (B + 2t) x t) x L	= 907.2 = -	(m ³)	
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars	$V_e = B$ $V_c = (($ $W_r = 0.$				
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where,	$V_e = B$ $V_c = (($ $W_r = 0.$	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L	= -	(m ³)	
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q:	$V_e = B$ $V_c = (($ $W_r = 0.$ Maximum Discharge =	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m^3/s)	= -	(m ³)	
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where,	$V_e = B$ $V_c = (($ $W_r = 0.$	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m^3/s) 630.00 (m)	= -	(m ³))
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L:	$V_e = B$ $V_c = (($ $W_r = 0.$ Maximum Discharge = Length of Channel =	H x t x 2) + (B + 2t) x t) x L 577 x (V_c/L) ^{0.888} x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava	= - = -	(m ³) (ton)	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel =	H x t x 2) + (B + 2t) x t) x L 577 x (V_c/L) ^{0.888} x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava	= - = -	(m ³) (ton)	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava 1.20 (m) for excava	= - = -	(m ³) (ton)	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: ΄	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel =	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava 1.20 (m) for excava	= - = -	(m ³) (ton)	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: ΄	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete =	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava 1.20 (m) for excava - (m)	ation (2D from	(m ³) (ton) n RIBLOC Brochure n RIBLOC Brochure	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: ⁷ 5) Head Tank Excavation:	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete = $V_e = V_e = V_e$	H x t x 2) + (B + 2t) x t) x L 577 x (V_c/L) ^{0.888} x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava 1.20 (m) for excava - (m) 808 x Q ^{0.697}	= - = - ation (2D from ation (2D from = 184.3	(m ³) (ton) n RIBLOC Brochure n RIBLOC Brochure 3 (m ³)	/
In the case of PVCφ6 Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: ΄	$V_e = B$ $V_c = ((W_r = 0))$ Maximum Discharge = Length of Channel = Width of Channel = Height of Channel = Thickness of Concrete =	H x t x 2) + (B + 2t) x t) x L 577 x $(V_c/L)^{0.888}$ x L 0.120 (m ³ /s) 630.00 (m) 1.20 (m) for excava 1.20 (m) for excava - (m)	= - = - ation (2D from ation (2D from = 184.3 = 43.1	(m ³) (ton) n RIBLOC Brochure n RIBLOC Brochure	/

Q: Maximum Discharge = $0.120 \text{ (m}^3/\text{s)}$

	y Channel						
enstock (Steel) ø315				22	_		
Excavation:	$V_{e1} =$		10.9 x D _m ⁻¹ 2.14 x D _m ⁻¹	x L	=	0.00	(m ³)
Concrete:	V _{c1} =		2.14 x D _m ⁻¹	⁶⁸ x L	=	0.00	(m ³)
Reinforcement Bars	$W_{r1} =$		$0.018 \ge V_c$		=	0.00	(ton)
Where,							
	vg. Diameter of Penstock =						
L:	Length of Penstock =	0.00	(m)				
W. L. CD			- ·	3			())
Weight of Penstock			$D_m \ge t_m \ge 10^{\circ}$	⁻ x1.15 x L			(ton)
Thickness of Penstock:		0.0362 x H	$\mathbf{I} \mathbf{x} \mathbf{D}_{\mathbf{m}} + 2$		=	2.00	(mm)
Where,		0.00	<i>6</i> 5				
	Weight of Penstock			(Tensil all	owabl	e Stress:	1,150 kgf/cm ²)
	Thickness of Penstock		(mm)				
D _m . () H:	vg. Diameter of Penstock = Design Head =			(Intoko W	otor L	wal Tai	lrace Water Level)
L:	Length of Penstock =			(Intake w			
2.	Longin of Fensioen	0.00	()				
enstock (PVC) ø315	:						
Excavation:	$V_e =$	BxHxL			=	101.57	(m ³)
Where,							-
Q:	Maximum Discharge =	0.120	(m ³ /s)				
L:	Length of Channel =						
B:	Width of Channel =		. ,	from TUB			
H:	Height of Channel =	0.92	(m)	from TUB	OPLA	ST Brock	hure
pillway Channel:							
	$(B \times H)^{0.5} =$	1.09 x O ^{0.3}	379		=	0.49	
Excavation:			$(x H)^{0.5})^{1.04}$	хL	=	353.95	(m^{3})
Concrete:			-(B+2t) x		=	84.18	
Reinforcement Bars			$(L)^{0.888} \times L$		_		(iii) (ton)
Where,		J.J. I. I. A. (V	υ μ , ΑL		-	0.00	(1011)
Q:	Maximum Discharge =	0.120	(m^{3}/s)				
Q: L:	Length of Channel =		· ·				
		120.00	(m)				
B:			(m) (m)				
	Width of Channel = Height of Channel =	0.40	(m)				
B: H:	Width of Channel =	0.40 0.60	(m) (m)				
B: H: t: * Cotal Quantity of Per Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	455.52 84.18 0.00	(m ³)
B: H: t: Yotal Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$			84.18 0.00	(m ³) (ton)
B: H: t: * 'otal Quantity of Per Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	84.18 0.00	(m ³)
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$		=	84.18 0.00	(m ³) (ton)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$		=	84.18 0.00	(m ³) (ton)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	2\0.727	=	84.18 0.00 0.00	(m ³) (ton) (ton)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = W_p =	0.40 0.60 0.15 annel: 97.8 x (Q :	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}		= = =	84.18 0.00 0.00 161.95	(m ³) (ton) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q :	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$	0.40 0.60 0.15 annel: 97.8 x (Q :	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where,	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_c =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m ³ /s)		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_c =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120 68.10	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$ (m ³ /s) (m)		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120 68.10	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$ (m ³ /s) (m)		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_c =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120 68.10	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$ (m ³ /s) (m)		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_c =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120 68.10	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1/3}}$ (m ³ /s) (m)		= = =	84.18 0.00 0.00 161.95 48.78	(m ³) (ton) (ton) (m ³) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = V_e $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m)	2)0.795		84.18 0.00 0.00 161.95 48.78 2.73	(m ³) (ton) (ton) (m ³) (ton)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation:	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = V_c = W_r = W_p = V_c =	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 28.1 x (Q 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m) (m) 395 x (R x)	²) ^{0.795} <u>Q</u>) ^{0.479}		84.18 0.00 0.00 161.95 48.78 2.73	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = iantity Unit of Turbine = $V_e =$ $V_c =$ $V_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m ³ /s) (m) 395 x (R x)	Q) ^{0.479} Q) ^{0.684}		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m) (m) 395 x (R x)	Q) ^{0.479} Q) ^{0.684}		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Otulet Excavation: Concrete: Reinforcement Bars Where,	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_e =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q ± 28.1 x (Q ± 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1/3}$ (m) $x He^{2/3} x n^{1/3}$ (m) 395 x (R x + 40.4 x (R x + 10.2))	Q) ^{0.479} Q) ^{0.684}		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dewer House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOULLE Excavation: Concrete: Reinforcement Bars Concrete: Reinforcement Bars Concrete: Reinforcement Bars DOULLE	Width of Channel = Height of Channel = Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c =$ $W_r =$ Diameter of Waterway =	0.40 0.60 0.15 annel: 97.8 x (Q = 28.1 x (Q = 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m) 395 x (R x 40.4 x (R x 0.278 x V _c ² (m)	Q 0.479 Q 0.479 Q 0.684 0.610		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u OUtlet Excavation: Concrete: Reinforcement Bars Where, Concrete: Reinforcement Bars Where, Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $W_r =$ Diameter of Waterway = Radius of Waterway =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_c^{-1}))$	Q) ^{0.479} Q) ^{0.684}		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dewer House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOULLE Excavation: Concrete: Reinforcement Bars Concrete: Reinforcement Bars Concrete: Reinforcement Bars DOULLE	Width of Channel = Height of Channel = Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_c =$ $V_c =$ $W_r =$ Diameter of Waterway =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m) 395 x (R x 40.4 x (R x 0.278 x V _c ² (m)	Q 0.479 Q 0.479 Q 0.684 0.610		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: 'otal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u OUtlet Excavation: Concrete: Reinforcement Bars Where, Concrete: Reinforcement Bars Where, Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $W_r =$ Diameter of Waterway = Radius of Waterway =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_c^{-1}))$	Q 0.479 Q 0.479 Q 0.684 0.610		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: Cotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Diameter of Waterway = Radius of Waterway = Maximum Discharge =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_c^{-1}))$	Q 0.479 Q 0.479 Q 0.684 0.610		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Outlet Excavation: Concrete: Reinforcement Bars Where, D: I R: Q:	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $W_r =$ Diameter of Waterway = Radius of Waterway =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V _c 0.120 68.10 1.00	(m) (m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} x He ^{2/3} x n ^{1/} x He ^{2/3} x n ^{1/} (m ³ /s) (m) $395 x (R x 40.4 x (R x 0.278 x V_c^{-1}))$	Q 0.479 Q 0.479 Q 0.684 0.610		84.18 0.00 0.00 161.95 48.78 2.73 102.64 5.90	(m ³) (ton) (ton) (m ³) (ton) (m ³)

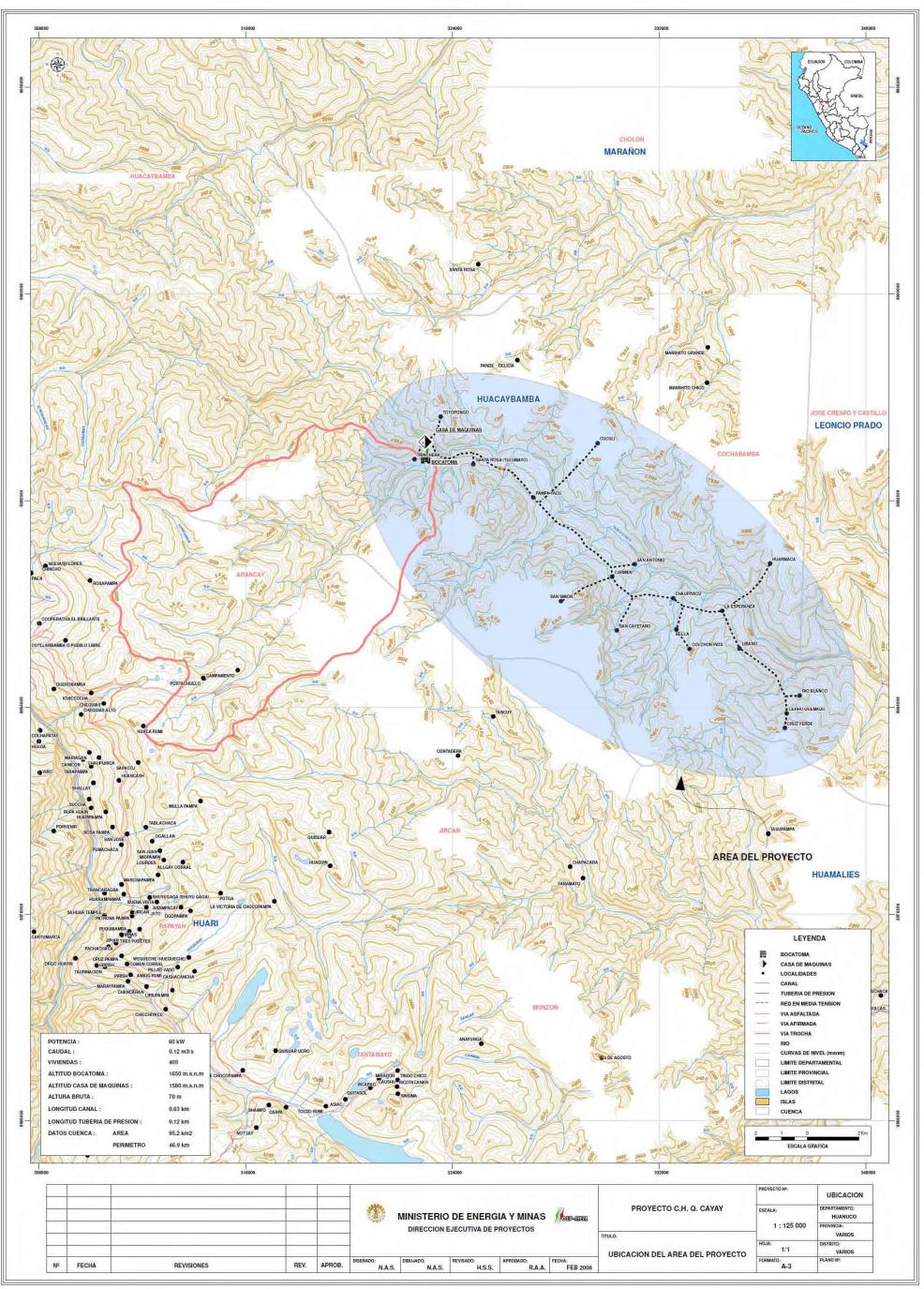
(1) Civil Works				
Excavation				
Open	:	5.53	(US\$/m ³)	* (8.70+2.35) x 0.5 = \$5.53/m ³ , from CAPAECO and Fainal study on Omia <human and="" excavation="" machine="" power=""></human>
Tunnel	:	-	(US\$/m ³)	
Concrete				
Open	:	93.05	(US\$/m ³)	* from CAPAECO (average of foundation, wall and structure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

<i>VI. Unit Price</i> 1USD = 3.	3.00 S/. (as of November, 2007)
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2) Hydraulic Equipm	nent			
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), $30 \ge 2.7 = 81$, 81 / $190m = 0.43$ /m, 42.99 /m (PVC) + 0.43 /m (joint) = 43.42 /m

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

(4) Transportation Cost				
Huaraz to the site	:	14.38	(US\$/ton)	172 km (road)



Appendix I-10 Construction Cost for Chontabamba Power Station

I. Summary of Construction Cost for Chontabamba Power Station

Work Item	Construction Cost	Remarks
1. Preliminary Works	19,131	
(1) Access Road	12,931	
(2) Facilities for Construction Office	2,509	Cost of Civil Works x 0.05
(3) Transportation cost	3,691	358.41ton x \$10.30/ton
2. Cost for Environmental Mesures	501	Cost of Civil Works x 0.01
3. Civil Works	50,195	
(1) Weir	2,221	
(2) Intake	3,443	
(3) Settling Basin	3,667	
(4) Headrace	3,051	
(5) Head Tank	8,428	
(6) Penstock & Spillway Channel	16,960	
(7) Power House	11,026	
(8) Outlet	1,399	
(9) Miscellaneous Work	0	
4. Hydraulic Equipment	33,300	
(1) Gate & Screen	2,158	
(2) Penstock	782	
(3) PVC (φ500)	19,168	
(4) PVC (φ200)	5,697	
(5) Others	5,495	
5. Electrical Equipment	43,000	
6. Direct Cost	146,127	1.+2.+3.+4.+5.
7. Engineering Cost	14,613	6. x 0.1: Detailed Design and Supervision
8. Contingent Budget	14,260	6. x 0.098
9. IGV	33,250	19.00%
10. Total Cost	208,250	

Items	Unit	Quantity	Remarks
(1) Wier		17.05	
a. Cements		3.57	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	13.24	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.23	
(2) Intake		32.20	
a. Gate		0.17	
b. Screen		0.08	
c. Cements	ton	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		23.91	
a. Cements		4.79	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	17.74	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.37	
(4) Headrace		3.95	
a. PVC (φ500)	ton	3.95	Weight: 460m x 51.522kg/6m
(5) Head Tank		46.41	
a. Cements		9.49	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	35.13	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		1.79	
(6) Penstock & Spillway Channel		164.82	
a. Penstock Steel (φ200)		0.25	
b. Penstock PVC (φ200)		1.37	Weight: 164m x 50.000kg/6m
c. Cements	ton	34.69	Cement: 0.27ton per concrete 1m ³
d. Coarse aggregate		128.47	Coarse aggregate: 1ton per concrete 1m ³
e. Reinforcement Bars		0.04	
(7) Power House		65.70	
a. Cements		13.38	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	49.55	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		2.77	
(8) Outlet		4.37	
a. Cements	40.00	0.81	Cement: 0.27ton per concrete 1m ³
b. Coarse aggregate	ton	3.01	Coarse aggregate: 1ton per concrete 1m ³
c. Reinforcement Bars		0.55	
(9) Subtotal		358.41	
(10) Transportation Cost		3,692	(9) x \$10.30/ton

II. Detailed Statement of Transportation Cost for Chontabamba Power Station

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				3,051	
a. Excavation	m ³	5.53	460.0	2,543	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			508	(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				16,960	
a. Excavation	m ³	5.53	618.7	3,421	
b. Concrete	m ³	93.05	128.5	11,954	
c. Reinforcement Bars	ton	1,070.00	0.0	44	
d. Others	-			1,541	(a+b+c) x 0.10 (including filling works)
(7) Power House				11,026	
a. Excavation	m ³	5.53	164.3	908	
b. Concrete	m ³	93.05	49.6	4,610	
c. Reinforcement Bars	ton	1,070.00	2.8	2,964	
d. Others	-			2,544	(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	$\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal		1	I	50,195	

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

			<u> </u>		Unit: USS	
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 (\u03c6200)	ton	3,100.00	0.25	782		
(4) PVC (φ500) for headrace	m	41.67	460	19,168		
(5) Penstock PVC (φ200) C-10	m	34.74	164	5,697		
(6) Subtotal				27,805		
(7) Others				5,495	19.76%	
(8) Total				33,300		

V. Quantity

1) Weir						
Excavation:	$V_e =$	8.69 x (H _d x L) ^{1.14}	=	67.01	(m ³)	
Concrete:	$V_c =$	$8.64 \text{ x} (\text{H}_{d}^{2} \text{ x L})^{0.726}$	=	13.24	(m ³)	
Reinforcement Bars	$W_r =$	0.0274 x V _c ^{0.830}	=	0.23	(ton)	
Weight of Gate:	$W_g =$	0.145 x Q _f ^{0.692}	=	0.00	(ton)	(unconsidered)
Where,	-					
H _d :	Height of Dam =	0.30 (m)				
L:	Length of Dam =	<mark>20.00</mark> (m)				
2) Intake						
Excavation:	$V_e =$	171 x (R x Q) ^{0.666}	=	13.66	(m ³)	
Concrete:	$V_c =$	147 x (R x Q) ^{0.470}	=	24.71		
Reinforcement Bars	$W_r =$	$0.0145 \ge V_c^{1.15}$	=	0.58		
Weight of Gate:	$W_{g} =$	$1.27 \text{ x} (\text{R x Q})^{0.533}$	=	0.17		
Weight of Screen:	$W_s =$	$0.701 \text{ x} (\text{R x Q})^{0.582}$	=	0.08		
Where,				0.00	()	
	Diameter of Waterway =	0.50 (m)				
R:	Radius of Waterway =	0.25 (m) D/2		Assumptio	n; Waterv	way Gradient = 1/1,0
Q:	Maximum Discharge =	0.090 (m ³ /s)				
Excavation: Concrete:	$V_e = V_c =$	515 x Q ^{1.07} 169 x Q ^{0.936}	=	39.16 17.74		
			=	17.74		
Reinforcement Bars	$W_r =$	$0.120 \times V_c^{0.847}$	=	1.37		
Weight of Gate:	$W_g =$	$0.910 \ge Q^{0.613}$	=	0.21		
Weight of Screen: Where,	$\mathbf{W}_{\mathrm{s}} =$	0.879 x Q ^{0.785}	=	0.13	(ton)	
Q:		(m^{3}/s)				
X .	Maximum Disenaige –	(11/3)				
4) Headrace In the case of PVCφ5	00:					
	$V_e = B \times I$	НхL	=	460.00	(m ³)	
Excavation:					. ,	
-	$V_c = ((H))$	(x t x 2) + (B + 2t) x t) x L	=	-	(m ²)	
Excavation:		(x t x 2) + (B + 2t) x t) x L 7 x $(V_{0}/L)^{0.888} x L$	=		(m^3) (ton)	
Excavation: Concrete:	$W_{r} = 0.57'$	(x t x 2) + (B + 2t) x t) x L 7 x $(V_c/L)^{0.888} x L$			(m ³) (ton)	
Excavation: Concrete: Reinforcement Bars	$W_{r} = 0.57^{\circ}$	7 x (V _c /L) ^{0.888} x L				
Excavation: Concrete: Reinforcement Bars Where,	$W_r = 0.57'$ Maximum Discharge =					
Excavation: Concrete: Reinforcement Bars Where, Q:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 40 Width of Channel = 1	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava	=	- (2D from F	(ton) RIBLOC I	, ·
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 46 Width of Channel = Height of Channel =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava	=	-	(ton) RIBLOC I	, ·
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 40 Width of Channel = Height of Channel =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava	=	- (2D from F	(ton) RIBLOC I	,
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 46 Width of Channel = Height of Channel =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava	=	- (2D from F	(ton) RIBLOC I	,
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 40 Width of Channel = Height of Channel = Thickness of Concrete =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava - (m)	=	- (2D from F	(ton) RIBLOC I	,
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t:	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 46 Width of Channel = Height of Channel =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava - (m) 808 x Q ^{0.697}	=	- (2D from R (2D from R 150.84	(ton) RIBLOC I RIBLOC I (m ³)	, ·
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank	$W_r = 0.57'$ Maximum Discharge = 0 Length of Channel = 40 Width of Channel = Height of Channel = Thickness of Concrete =	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava - (m) 808 x Q ^{0.697} 197 x Q ^{0.716}	= ation (ation (- (2D from R (2D from R	(ton) RIBLOC I RIBLOC I (m ³)	· · ·
Excavation: Concrete: Reinforcement Bars Where, Q: L: B: H: t: 5) Head Tank Excavation:	$W_r = 0.57'$ Maximum Discharge = 10 Length of Channel = 40 Width of Channel = Height of Channel = Thickness of Concrete = $V_e = 10^{-10}$	7 x (V _c /L) ^{0.888} x L 0.090 (m ³ /s) 60.00 (m) 1.00 (m) for excava 1.00 (m) for excava - (m) 808 x Q ^{0.697}	= ation (ation (- (2D from R (2D from R 150.84	(ton) RIBLOC I RIBLOC I (m ³) (m ³)	· · · · · · · · · · · · · · · · · · ·

Q: Maximum Discharge = $0.090 \text{ (m}^3/\text{s)}$

Demote aly (Steel) a 200	ay Channel						
Penstock (Steel) 200:				1.22	_		
Excavation:	$V_{e1} =$		10.9 x D _m	^{1.33} x L	=	20.51	(m ³)
Concrete:	$V_{c1} =$		2.14 x D _m	^{1.68} x L	=	2.29	(m ³)
Reinforcement Bars	$W_{r1} =$		0.018 x V	c	=	0.04	(ton)
Where,							
	vg. Diameter of Penstock =	0.20					
L:	Length of Penstock =	16.00	(m)				
W. 1. CD . 1	***			-3		0.05	6 N
Weight of Penstock		7.85x π x I		J°x1.15 x			(ton)
Thickness of Penstock:		0.0362 x H	$1 \times D_m + 2$		=	2.78	(mm)
Where,		0.05	<i>a</i> >	(T. 11			1 1 50 1 6 2
	Weight of Penstock		(ton)	(Tensil a	llowabl	e Stress:	1,150 kgf/cm ²)
	Thickness of Penstock vg. Diameter of Penstock =	0.20	(mm)				
H:	Design Head =	108.00	· ·	(Intake V	/ater L	evel - Tai	Irace Water Level)
L:	Length of Penstock =	16.00		(Intake)			
2.	Deligin of Felistoen	10.00	()				
Penstock (PVC) \u03c6200:	:						
Excavation:	$V_e =$	BxHxL			=	124.13	(m ³)
Where,							
Q:	Maximum Discharge =	0.090	(m ³ /s)				
L:	Length of Channel =	164.00					
B:	Width of Channel =	0.87				AST Brock	
H:	Height of Channel =	0.87	(m)	from TU	BOPLA	AST Brock	hure
Spillway Channel:							
	$(B x H)^{0.5} =$				=	0.44	
Excavation:	$V_e =$	6.22 x ((B	$(x H)^{0.5})^{1.04}$	хL	=	474.01	(m^3)
Concrete:		H x t x 2 +			=	126.18	
Reinforcement Bars		0.577 x (V			=		(ton)
Where,		0.077	02) 11			0.00	(1011)
Q:	Maximum Discharge =	0.090	(m^{3}/s)				
L:	Length of Channel =	180.00	× /				
B:	Width of Channel =	0.40					
H:	Height of Channel =	0.60					
	Height of Channel = Thickness of Concrete =	0.60	(m)				
	-	0.60	(m)				
	-	0.60	(m)				
t: T	Thickness of Concrete =	0.60 0.15	(m)				
t: T	-	0.60 0.15	(m) (m)		=	618.65	(m ³)
t: ' Fotal Quantity of Per	Thickness of Concrete = nstock and Spillway Cha V _e =	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$			618.65 128.47	
t: [*] Fotal Quantity of Pen Excavation: Concrete:	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	128.47	(m ³)
t: ' Fotal Quantity of Pen Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r1}$		=	128.47 0.04	(m ³) (ton)
t: [*] Fotal Quantity of Pen Excavation: Concrete:	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	128.47 0.04	(m ³)
t: ' Fotal Quantity of Pen Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r1}$		=	128.47 0.04	(m ³) (ton)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r1}$		=	128.47 0.04	(m ³) (ton)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House	Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$	0.60 0.15	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	2	=	128.47 0.04 0.25	(m ³) (ton) (ton)
t: ⁷ Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation:	Thickness of Concrete = nstock and Spillway Cha Ve = Vc = Wr = Wp = Ve = Ve = Ve =	0.60 0.15 annel:	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	2. 1/2) ^{0.727}	=	128.47 0.04 0.25 164.29	(m ³) (ton) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House	Thickness of Concrete = nstock and Spillway Cha Ve = Vc = Wr = Wp = Ve =	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n$ $x He^{2/3} x n$	2. 1/2) ^{0.727}	= =	128.47 0.04 0.25	(m ³) (ton) (ton) (m ³)
t: ⁷ Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation:	Thickness of Concrete = nstock and Spillway Cha Ve = Vc = Wr = Wp = Ve =	0.60 0.15 annel:	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n$ $x He^{2/3} x n$	2. 1/2) ^{0.727}	= = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete:	Thickness of Concrete = hstock and Spillway Cha $V_e =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$	0.60 0.15 annel: 97.8 x (Q) 28.1 x (Q) 0.046 x V _c	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} $x He^{2/3} x n$ 1.05	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = hstock and Spillway Cha $V_e =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$	0.60 0.15 annel: 97.8 x (Q 2 28.1 x (Q 2	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} $x He^{2/3} x n$ 1.05	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: * Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: * Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = hstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q) 28.1 x (Q) 0.046 x V _c 0.090	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: * Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: * Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: * Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2. 1/2) ^{0.727}	= = = =	128.47 0.04 0.25 164.29 49.55	(m ³) (ton) (ton) (m ³) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} W_{p1} (m) (m) (m) (m)	2 1/2 ₂ 0.727 1/2 ₂ 0.795	= = = =	128.47 0.04 0.25 164.29 49.55 2.77	(m ³) (ton) (ton) (m ³) (ton)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Thickness of Concrete = Instock and Spillway Cha Ve = Vc = Wr = Wr = Wr = Ve = Vc = Wr = Maximum Discharge = Effective Head = Effective Head = Effective Head = Ve	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n}$ 1.05 (m ³ /s) (m) $\overline{395 x (R)}$	2 1/2 ₀ 0.727 1/2 ₀ 0.795		128.47 0.04 0.25 164.29 49.55 2.77 64.16	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete:	Thickness of Concrete = Instock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = W _r = Maximum Discharge = Effective Head = Iantity Unit of Turbine = V _e = V _c	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00 1.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n$ $x He^{2/3} x n$ (m ³ /s) (m) 395 x (R = 40.4 x (R = 10.4 x (R	$(Q)^{0.727}$ $(Q)^{0.795}$ $(Q)^{0.479}$ $(Q)^{0.684}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars	Thickness of Concrete = Instock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = W _r = Maximum Discharge = Effective Head = Effective Head = Iantity Unit of Turbine = V _e = V _c = V _c = W _r = V _e = V	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00 1.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n}$ 1.05 (m ³ /s) (m) $\overline{395 x (R)}$	$(Q)^{0.727}$ $(Q)^{0.795}$ $(Q)^{0.479}$ $(Q)^{0.684}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, Mere, N: u	Thickness of Concrete = Instock and Spillway Cha V _e = V _c = W _r = W _p = V _e = V _c = V _c = W _r = Maximum Discharge = Effective Head = Effective Head = Iantity Unit of Turbine = V _e = V _c = V _c = W _r = V _e = V	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00 1.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n$ $x He^{2/3} x n$ (m) (m) 395 x (R) 40.4 x (R) 0.278 x V	$(Q)^{0.727}$ $(Q)^{0.795}$ $(Q)^{0.479}$ $(Q)^{0.684}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, Mere, N: u	Thickness of Concrete = istock and Spillway Chi $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = Effective Head = iantity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ $V_r =$ $V_r =$ $V_r =$ $W_r =$	0.60 0.15 annel: 97.8 x (Q > 28.1 x (Q > 0.046 x V _c 0.090 108.00 1.00	(m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n$ $x He^{2/3} x n$ (m ³ /s) (m) $395 x (R \pm 40.4 x (R + 0.278 x V))$ (m)	$(Q)^{0.727}$ $(Q)^{0.795}$ $(Q)^{0.479}$ $(Q)^{0.684}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Total Quantity of Perr Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: Hei: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, D: I	Thickness of Concrete = hstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = hantity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Diameter of Waterway =	0.60 0.15 annel: 97.8 x (Q) 28.1 x (Q) 0.046 x V _c 0.090 108.00 1.00	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) ³ (s) (m) $395 \text{ x } (\text{R} \times \text{I} \times \text{I}$	$\frac{1/2}{2}0.727}$ $\frac{1/2}{2}0.795}$ $\frac{1/2}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Total Quantity of Perr Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars Where, Reinforcement Bars	Thickness of Concrete = hstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_r =$ Maximum Discharge = Effective Head = hantity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Diameter of Waterway = Radius of Waterway =	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 108.00 1.00 0.50 0.25	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) ³ (s) (m) $395 \text{ x } (\text{R} \times \text{I} \times \text{I}$	$\frac{1/2}{2}0.727}$ $\frac{1/2}{2}0.795}$ $\frac{1/2}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Total Quantity of Perr Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars Where, Reinforcement Bars	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r $	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 108.00 1.00 0.50 0.25	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) ³ (s) (m) $395 \text{ x } (\text{R} \times \text{I} \times \text{I}$	$\frac{1/2}{2}0.727}$ $\frac{1/2}{2}0.795}$ $\frac{1/2}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: ' Total Quantity of Perr Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u) Outlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars Where, Reinforcement Bars	Thickness of Concrete = istock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = Effective Head = iantity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Diameter of Waterway = Radius of Waterway = Maximum Discharge = Input Cell	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 108.00 1.00 0.50 0.25	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) ³ (s) (m) $395 \text{ x } (\text{R} \times \text{I} \times \text{I}$	$\frac{1/2}{2}0.727}$ $\frac{1/2}{1/2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)
t: '	Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r $	0.60 0.15 annel: 97.8 x (Q ; 28.1 x (Q ; 0.046 x V _c 0.090 108.00 1.00 0.50 0.25	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} (m) (m) ³ (s) (m) $395 \text{ x } (\text{R} \times \text{I} \times \text{I}$	$\frac{1/2}{2}0.727}$ $\frac{1/2}{1/2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$ $\frac{1}{2}0.795}$		128.47 0.04 0.25 164.29 49.55 2.77 64.16 3.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)

(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 and="" excavation="" machine="" power=""></human>
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

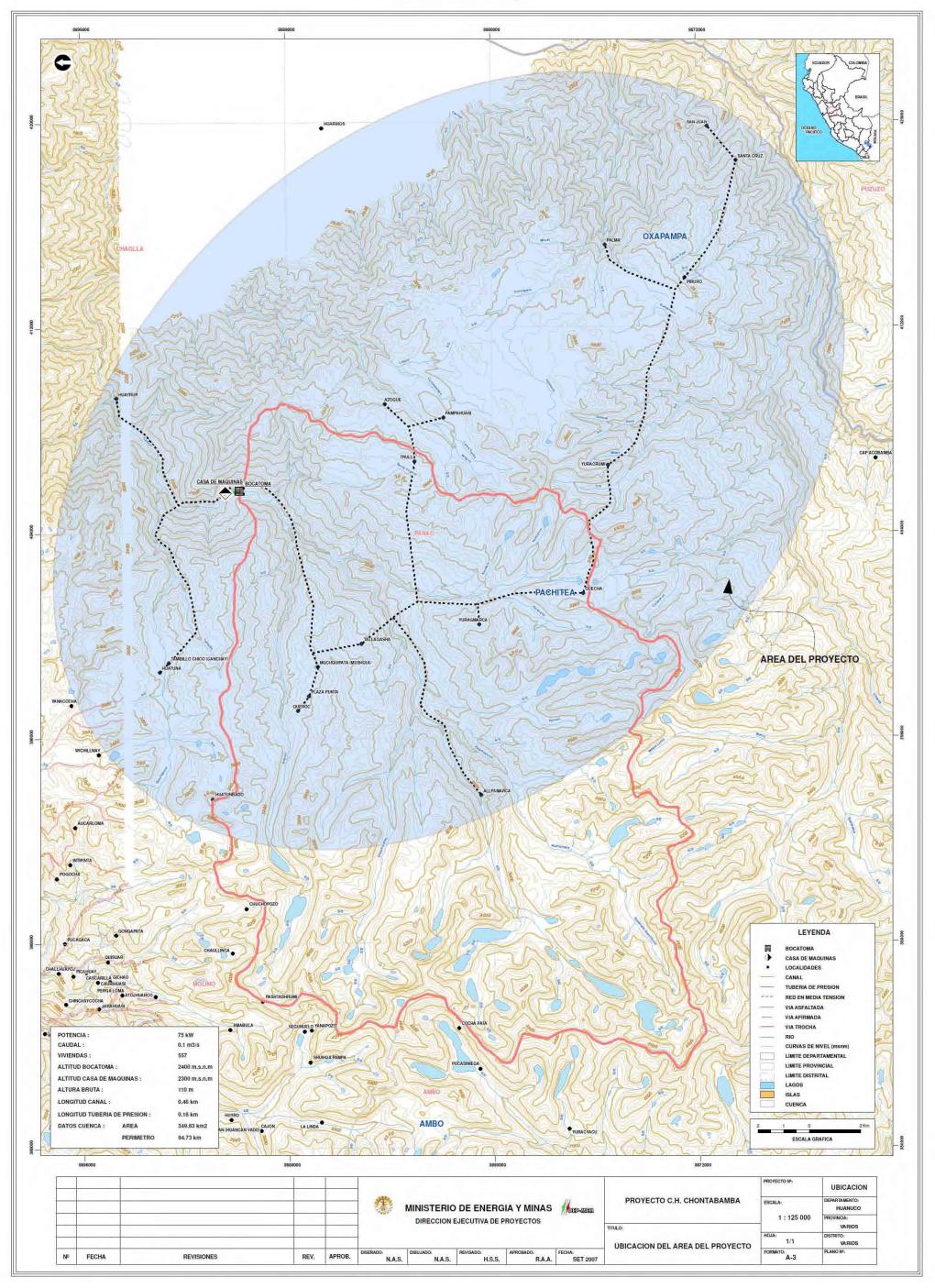
VI. Unit Price 1USD = 3.00 S/. (as of November, 2007)

(2) Hydraulic Equipme	ent			
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(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				
Huanuco to the site	:	10.30	(US\$/ton)	54km (road)

Chontabamba Map



Appendix I-11 Construction Cost for Quechuarpata Power Station

I. Summary of Construction Cost for Quechuarpata Power Station

Work Item	Construction Cost	Remarks		
1. Preliminary Works	20,185			
(1) Access Road	8,229			
(2) Facilities for Construction Office	4,749	Cost of Civil Works x 0.05		
(3) Transportation cost	7,207	611.34ton x \$11.79/ton		
2. Cost for Environmental Mesures	949	Cost of Civil Works x 0.01		
3. Civil Works	94,991			
(1) Weir	3,284			
(2) Intake	8,148			
(3) Settling Basin	9,384			
(4) Headrace	7,803			
(5) Head Tank	17,963			
(6) Penstock & Spillway Channel	19,201			
(7) Power House	25,799			
(8) Outlet	3,409			
(9) Miscellaneous Work	0			
4. Hydraulic Equipment	71,400			
(1) Gate & Screen	5,654			
(2) Penstock	1,657			
(3) PVC (φ700)	43,002			
(4) PVC (φ350)	9,257			
(5) Others	11,830			
5. Electrical Equipment	107,800			
6. Direct Cost	295,325	1.+2.+3.+4.+5.		
7. Engineering Cost	29,533	6. x 0.1: Detailed Design and Supervision		
8. Contingent Budget	29,143	6. x 0.099		
9. IGV	67,260	19.00%		
10. Total Cost	421,260			

Items	Unit	Quantity	Remarks			
(1) Wier		25.86				
a. Cements	4	5.43	Cement: 0.27ton per concrete 1m ³			
b. Coarse aggregate	ton	20.10	Coarse aggregate: 1ton per concrete 1m ³			
c. Reinforcement Bars		0.33				
(2) Intake		73.70				
a. Gate		0.43				
b. Screen		0.21				
c. Cements	ton	15.21	Cement: 0.27ton per concrete 1m ³			
d. Coarse aggregate		56.35	Coarse aggregate: 1ton per concrete 1m ³			
e. Reinforcement Bars		1.50				
(3) Settling Basin		64.01				
a. Cements		12.93	Cement: 0.27ton per concrete 1m ³			
b. Coarse aggregate	ton	47.90	Coarse aggregate: 1ton per concrete 1m ³			
c. Reinforcement Bars		3.18				
(4) Headrace		9.31				
a. PVC (φ700)	ton	9.31	Weight: 600m x 93.102kg/6m			
(5) Head Tank		99.20				
a. Cements		20.27	Cement: 0.27ton per concrete 1m ³			
b. Coarse aggregate	ton	75.09	Coarse aggregate: 1ton per concrete 1m ³			
c. Reinforcement Bars		3.83				
6) Penstock & Spillway Channel		172.60				
a. Penstock Steel (q350)		0.53				
b. Penstock PVC (φ350)		4.26	Weight: 164m x 155.748kg/6m			
c. Cements	ton	35.65	Cement: 0.27ton per concrete 1m ³			
d. Coarse aggregate		132.05	Coarse aggregate: 1ton per concrete 1m ³			
e. Reinforcement Bars		0.11				
7) Power House		152.83				
a. Cements	46.7	31.06	Cement: 0.27ton per concrete 1m ³			
b. Coarse aggregate	ton	115.05	Coarse aggregate: 1ton per concrete 1m ³			
c. Reinforcement Bars		6.71				
(8) Outlet		13.84				
a. Cements	tor	2.70	Cement: 0.27ton per concrete 1m ³			
b. Coarse aggregate	ton	10.01	Coarse aggregate: 1ton per concrete 1m ³			
c. Reinforcement Bars		1.13				
(9) Subtotal		611.34				
(10) Transportation Cost		7,208	(9) x \$11.79/ton			

Work Items	Unit	Unit Price	Quantity	Cost	Remarks
(1) Wier				3,284	
a. Excavation	m ³	5.53	93.0	514	
b. Concrete	m ³	93.05	20.1	1,870	
c. Reinforcement Bars	ton	1,070.00	0.3	353	
d. Others	-			547	(a+b+c) x 0.2 (including coffer dam construction, etc.)
(2) Intake				8,148	
a. Excavation	m ³	5.53	43.9	243	
b. Concrete	m ³	93.05	56.3	5,243	
c. Reinforcement Bars	ton	1,070.00	1.5	1,600	
d. Others	-			1,062	(a+b+c) x 0.15 (including coffer work, etc.)
(3) Settling Basin				9,384	
a. Excavation	m ³	5.53	121.9	673	
b. Concrete	m ³	93.05	47.9	4,456	
c. Reinforcement Bars	ton	1,070.00	3.2	3,402	
d. Others	-			853	(a+b+c) x 0.10 (including other works)
(4) Headrace				7,803	
a. Excavation	m ³	5.53	1176.0	6,503	
b. Concrete	m ³	93.05	0.0	0	
c. Reinforcement Bars	ton	1,070.00	0.0	0	
d. Others	-			1,300	(a+b+c) x 0.20 (including filling works)
(5) Head Tank				17,963	(including mining works)
a. Excavation	m ³	5.53	316.0	1,747	
b. Concrete	m ³	93.05	75.1	6,987	
c. Reinforcement Bars	ton	1,070.00	3.8	4,097	
d. Others	-			5,132	(a+b+c) x 0.40 (including gate, screen)
(6) Penstock & Spillway Channel				19,201	(including gale, sereen)
a. Excavation	m ³	5.53	914.4	5,056	
b. Concrete	m ³	93.05	132.0	12,287	
c. Reinforcement Bars	ton	1,070.00	0.1	113	
d. Others	-			1,745	(a+b+c) x 0.10 (including filling works)
(7) Power House				25,799	(including inning works)
a. Excavation	m ³	5.53	354.9	1,962	
b. Concrete	m ³	93.05	115.1	10,705	
c. Reinforcement Bars	ton	1,070.00	6.7	7,179	
d. Others	-			5,953	(a+b+c) x 0.30 (including drainage work, wooden
(8) Outlet				3,409	Including dramage work, wooden
a. Excavation	m ³	5.53	148.7	822	
b. Concrete	m ³	93.05	10.0	931	
c. Reinforcement Bars	ton	1,070.00	1.1	1,212	
d. Others	-			444	(a+b+c) x 0.15 (including coffer work, etc.)
(9) Miscellaneous Work	-			0	$\Sigma(1)$ -(8) x 0.05 not consider
(10) Subtotal		1	I I	94,991	

III. Detailed Statement of Civil Works Cost for Quechuarpata 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				5,654	
a. Gate	ton	8,811.04	0.43	3,771	
b. Screen	ton	8,811.04	0.21	1,883	
(3) Penstock Steel (ø350)	ton	3,100.00	0.53	1,657	
(4) PVC (φ700) for headrace	m	71.67	600	43,002	
(5) Penstock PVC (φ350) C-10	m	56.45	164	9,257	
(6) Subtotal				59,570	
(7) Others				11,830	19.86%
(8) Total				71,400	

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

Unit: US\$

V. Quantity

(1) Weir						
Excavation:	$V_e =$	8.69 x (H _d x L) ^{1.14}	=	93.01	(m ³)	
Concrete:	$V_c =$	8.64 x $(H_d^2 x L)^{0.726}$	=	20.10	(m ³)	
Reinforcement Bars	$W_r =$	0.0274 x V _c ^{0.830}	=	0.33	(ton)	
Weight of Gate:	$\mathbf{W}_{\mathrm{g}} =$	0.145 x Q _f ^{0.692}	=	0.00	(ton)	(unconsidered)
Where,						
H _d :	Height of Dam =	0.40 (m)				
L:	Length of Dam =	20.00 (m)				
(2) Intake						
Excavation:	$V_e =$	171 x (R x Q) ^{0.666}	=	43.94	(m ³)	
Concrete:	$V_c =$	147 x (R x Q) ^{0.470}	=	56.35	(m ³)	
Reinforcement Bars	$W_r =$	0.0145 x V _c ^{1.15}	=	1.50	(ton)	
Weight of Gate:	$W_g =$	$1.27 \text{ x} (\text{R x Q})^{0.533}$	=	0.43	(ton)	
Weight of Screen:	$\mathbf{W}_{s}^{s} =$	$0.701 \text{ x} (\text{R x Q})^{0.582}$	=		(ton)	
Where,		······································				
	Diameter of Waterway =	1.00 (m)				
R:	Radius of Waterway =	0.50 (m) D/2		Assumptio	on; Wate	rway Gradient = 1/1,0
Q:	Maximum Discharge =	0.260 (m ³ /s)				
(3) Settling Basin						
Excavation:	$V_e =$	515 x Q ^{1.07}	=	121.85	(m^3)	
Concrete:	$V_c =$	$169 \ge Q^{0.936}$	=	47.90		
Reinforcement Bars	$\mathbf{W}_{r} =$	$0.120 \times V_c^{0.847}$	=		(ton)	
Weight of Gate:	$\mathbf{W}_{\mathbf{g}} =$	$0.120 \times V_{c}$ 0.910 x Q ^{0.613}			(ton)	
-	-	$0.910 \times Q$ 0.879 x Q ^{0.785}	=			
Weight of Screen: Where,	$W_s =$	0.879 x Q	=	0.31	(ton)	
Q:	Maximum Discharge =	$0.260 \text{ (m}^{3}/\text{s)}$				
C.						
(4) Headrace	00					
In the case of PVCφ7 Excavation:	$V_e = B$	v H v I	_	1,176.00	(m^3)	
Concrete:		H x t x 2) + (B + 2t) x t) x L	_	1,170.00		
Reinforcement Bars		$(V_c/L)^{0.888} \times L$	=		(m^3)	
		$S / I X (V_c/L) X L$	=	-	(ton)	
Where,		$0.260 \text{ (m}^{3}\text{/s)}$				
Q: L:	Maximum Discharge = Length of Channel =	600.00 (m)				
E. B:	Width of Channel =		ation	(2D from	RIBLOC	Brochure)
H:	Height of Channel =			(2D from)		,
	Thickness of Concrete =	- (m)				,
(5) Head Tank	• •	- 0.697			. 3	
Excavation:	$V_e =$	808 x Q ^{0.697}	=	315.97		
Concrete:	$V_c =$	197 x Q ^{0.716}	=	75.09		
Reinforcement Bars Where,	$W_r =$	0.051 x V _c	=	3.83	(ton)	
Q:	Maximum Discharge =	$0.260 \text{ (m}^{3}\text{/s)}$				
	-					

	y Channel							
Penstock (Steel) \oppi350				1.22	_			
Excavation:	$V_{e1} =$		10.9 x D _m 2.14 x D _m	^{1.33} x L	=	43.17	(m ³)	
Concrete:	$V_{c1} =$		2.14 x D _m	^{1.68} x L	=	5.87	(m ³)	
Reinforcement Bars	$W_{r1} =$		0.018 x V		=	0.11	(ton)	
Where,								
	g. Diameter of Penstock =							
L:	Length of Penstock =	16.00	(m)					
	XX 7			.3			L	
Weight of Penstock			$D_m x t_m x 10$) x1.15 x 1			(ton)	
Thickness of Penstock:		0.0362 x H	$1 \times D_m + 2$		=	3.37	(mm)	
Where,		0.50	<i>6</i>			_		
	Weight of Penstock Thickness of Penstock		(ton)	(Tensil al	lowabl	le Stress:	1,150 kgf/cm ²)	
			(mm)					
D _m . N H:	g. Diameter of Penstock = Design Head =	0.35 107.80		(Intaka W	ator L	aval Tai	lrace Water Leve	D.
L:	Length of Penstock =	16.00		(IIIIake w				1)
2.	Longar of Tenstoen	10.00	()					
Penstock (PVC)ø350	:							
Excavation:	$V_e =$	B x H x L			=	151.14	(m ³)	
Where,								
Q:	Maximum Discharge =	0.260	(m ³ /s)					
L:	Length of Channel =	164.00						
B:	Width of Channel =	0.96		from TUE				
H:	Height of Channel =	0.96	(m)	from TUE	SOPLA	AST Brock	hure	
Spillway Channel:								
	$(B \times H)^{0.5} =$	1.09 x O ^{0.3}	379		=	0.65		
Excavation:			x H) ^{0.5}) ^{1.04}	хL	=	720.10	(m^3)	
Concrete:			-(B+2t)x		_	126.18		
Reinforcement Bars			$(L)^{0.888} \times L$		=		(ton)	
Where,		0.577 X (*	_c /L) XI	_	_	0.00	(1011)	
,	Maximum Discharge =	0 260	(m^3/s)					
	-		(111 / 5)					
Ŀ	Length of Channel =	180.00	(m)					
L: B:	Length of Channel = Width of Channel =	180.00 0.40						
	Length of Channel = Width of Channel = Height of Channel =		(m)					
B: H:	Width of Channel =	0.40 0.60	(m) (m)					
B: H:	Width of Channel = Height of Channel =	0.40 0.60	(m) (m)					
B: H:	Width of Channel = Height of Channel =	0.40 0.60	(m) (m)					
B: H: t:	Width of Channel = Height of Channel =	0.40 0.60 0.15	(m) (m) (m)					
B: H: t:	Width of Channel = Height of Channel = Thickness of Concrete =	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$		=	914.41	(m ³)	
B: H: t: [*] Total Quantity of Per	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Cha	0.40 0.60 0.15 annel:	(m) (m) (m)		=	914.41 132.05		
B: H: t: [•] Total Quantity of Per Excavation:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch V _e =	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$			132.05		
B: H: t: * Total Quantity of Per Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = $v_{\rm c}$ hstock and Spillway Ch V _e = V _c =	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$		=	132.05 0.11	(m ³)	
B: H: t: ⁷ Total Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$		= =	132.05 0.11	(m ³) (ton)	
B: H: t: Fotal Quantity of Per Excavation: Concrete: Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$		= =	132.05 0.11	(m ³) (ton)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Ch $V_e =$ $V_c =$ $V_c =$ $W_r =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$		= =	132.05 0.11	(m ³) (ton)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_e = V_c = W_r = W_p =	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}		= =	132.05 0.11 0.53	(m ³) (ton) (ton)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_e = V_c = W_r = W_p =	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1}	/2)0.727	= = =	132.05 0.11 0.53 354.95	(m ³) (ton) (ton) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete:	Width of Channel = Height of Channel = Thickness of Concrete = nstock and Spillway Cha $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q :	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = Instock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_p =$	0.40 0.60 0.15 annel:	(m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock	Width of Channel = Height of Channel = Thickness of Concrete = $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock D Power House Excavation: Concrete: Reinforcement Bars Where, Q:	Width of Channel = Height of Channel = Thickness of Concrete = $V_c =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s)	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s)	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_c =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_p =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s)	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He:	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s)	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m ³ /s)	/2)0.727	= = =	132.05 0.11 0.53 354.95 115.05	(m ³) (ton) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock ') Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = Instock and Spillway Channel = $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1}}$ (m)	¹² ,0.727 12,0.795	= = =	132.05 0.11 0.53 354.95 115.05 6.71	(m ³) (ton) (ton) (m ³) (ton)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = Instock and Spillway Character $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine =	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m) (m) 395 x (R x)	² ,0.727 (2,0.795 (2,0.795 (2,0.795	= = =	132.05 0.11 0.53 354.95 115.05 6.71 148.65	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock) Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = Instock and Spillway Channel = $V_c =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $V_c =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^1}$ (m) $\frac{105}{395 x (R x)^3}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock ') Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u	Width of Channel = Height of Channel = Thickness of Concrete = Instock and Spillway Character $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine =	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{e2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m) (m) 395 x (R x)	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock () Power House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u () Outlet Excavation: Concrete: Reinforcement Bars Where,	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q 28.1 x (Q 0.046 x V _c 0.260 107.80 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $\overline{x He^{2/3} x n^{1}}$ (m ³ /s) (m) $\overline{395 x (R x)}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Doutlet Excavation: Concrete: Reinforcement Bars Where, D: I	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m) 395 x (R x) 40.4 x (R) (m)	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOULEE Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $W_r =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x) 40.4 x (R) $0.278 x V_{c2}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u Doutlet Excavation: Concrete: Reinforcement Bars Where, D: I	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $V_c =$ $W_r =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$ $V_c =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m) 395 x (R x) 40.4 x (R) (m)	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOULEE Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = $V_e =$ $V_c =$ $W_r =$ $W_p =$ $W_p =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $W_r =$ $V_e =$ $V_c =$ $W_r =$ $W_r =$	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x) 40.4 x (R) $0.278 x V_{c2}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOutlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = astock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum discharge = $V_c =$ $W_r =$ $V_c =$ $W_r =$ Maximum Discharge = Maximum Discharge =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x) 40.4 x (R) $0.278 x V_{c2}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOutlet Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = V_e = V_c = W_r = W_p = W_p = W_r = W_r = Maximum Discharge = Effective Head = antity Unit of Turbine = V_e = V_c = W_r = Diameter of Waterway = Radius of Waterway = Maximum Discharge = Maximum Discharge = Input Cell	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x) 40.4 x (R) $0.278 x V_{c2}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	
B: H: t: Total Quantity of Per Excavation: Concrete: Reinforcement Bars Weight of Penstock Dever House Excavation: Concrete: Reinforcement Bars Where, Q: He: n: u DOULEE Excavation: Concrete: Reinforcement Bars Where, D: I Reinforcement Bars	Width of Channel = Height of Channel = Thickness of Concrete = hstock and Spillway Ch $V_e =$ $V_c =$ $W_r =$ $W_p =$ $V_e =$ $W_r =$ Maximum Discharge = Effective Head = antity Unit of Turbine = $V_e =$ $V_c =$ $W_r =$ Maximum discharge = $V_c =$ $W_r =$ $V_c =$ $W_r =$ Maximum discharge = Maximum Discharge =	0.40 0.60 0.15 annel: 97.8 x (Q : 28.1 x (Q : 0.046 x V, 0.260 107.80 1.00 1.00	(m) (m) (m) (m) $V_{e1} + V_{e2}$ $V_{c1} + V_{c2}$ $W_{r1} + W_{r2}$ W_{p1} $x He^{2/3} x n^{1}$ (m ³ /s) (m) 395 x (R x) 40.4 x (R) $0.278 x V_{c2}$	(2,0.727) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.795) (2,0.727) (2,0.727) (2,0.795)		132.05 0.11 0.53 354.95 115.05 6.71 148.65 10.01	(m ³) (ton) (ton) (m ³) (ton) (m ³) (m ³)	

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

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 and="" excavation="" machine="" power=""></human>
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 Equipm	ent			
Gate & Screen	•	8,811.04	(US\$/ton)	* from final study on Omia
Steel Penstock	:	3,100.00	(US\$/ton)	including installation
PVC (φ700)		71.67	(US\$/m)	RIB LOC for Headrace
PVC (φ350)	:	56.45	(US\$/m)	130% of TUBOPLAST(φ315) for Penstock (C-10) = 43.42 x 1.3 = 56.45

(3) Others				
Access Road	:	979.65	US\$/m) Repair W	ork for Existing Unpaved Road

(4) Transportation Cost				
Huanuco to the site	:	11.79	(US\$/ton)	97 km (road)

