

ANNEX A: HYDROLOGICAL STUDIES

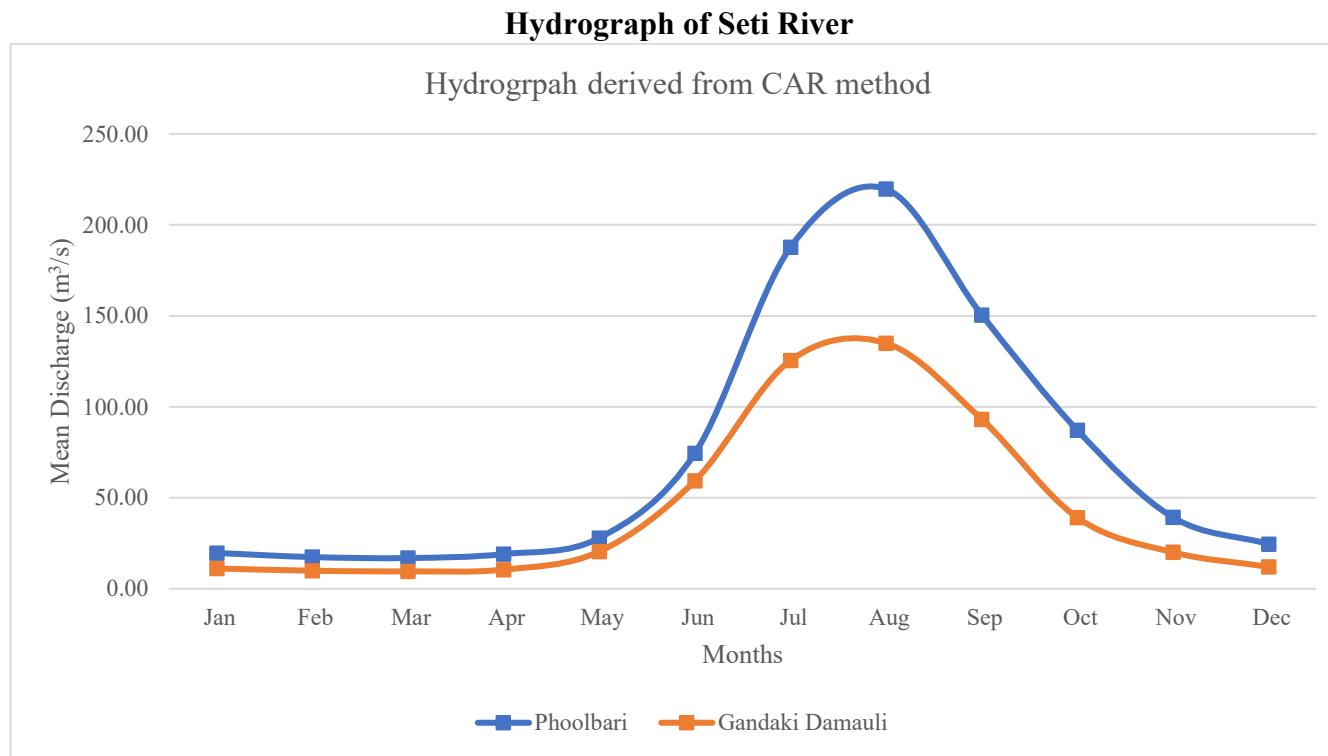
HYDROLOGICAL DATA

Discharge of Seti River at Gandaki Damauli Gauge Station

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Year	max
2000	10.63	8.57	8.19	9.65	32.80	131.49	173.14	172.76	117.56	39.87	21.45	13.01	61.59	173.14
2001	9.72	8.09	7.01	6.12	17.42	66.99	114.15	256.39	114.10	49.60	25.46	14.46	57.46	256.39
2002	10.50	9.00	8.07	11.20	30.49	67.54	205.59	153.79	82.26	45.80	25.72	16.57	55.54	205.59
2003	13.99	11.78	10.75	12.86	15.59	79.13	223.00	157.89	131.52	49.02	23.59	13.99	61.93	223.00
2004	8.83	8.14	10.30	18.17	57.11	153.17	126.54	133.10	62.49	25.44	14.50	14.50	52.69	153.17
2005	11.34	8.74	9.14	8.27	15.69	28.33	102.86	114.87	72.99	50.45	26.99	14.51	38.68	114.87
2006	9.95	8.22	7.57	7.88	26.56	56.86	94.91	93.37	93.90	46.48	24.01	14.60	40.36	94.91
2007	10.45	11.85	10.89	13.95	17.57	61.35	128.00	107.62	173.64	53.84	24.92	14.28	52.36	173.64
2008	10.60	8.49	8.13	9.06	13.05	63.57	96.23	155.59	92.63	41.51	22.21	5.11	43.85	155.59
2009	11.86	9.11	8.15	10.32	14.57	22.52	86.22	122.01	63.68	46.28	19.44	12.32	35.54	122.01
2010	9.61	8.44	8.71	7.65	10.48	26.62	135.69	157.04	145.97	45.78	22.66	13.84	49.37	157.04
2011	16.33	13.88	12.41	12.25	17.48	47.75	149.56	125.51	79.90	32.10	21.05	13.30	45.13	149.56
2012	10.40	9.48	8.57	9.90	11.70	30.04	103.16	91.95	80.77	26.05	12.83	8.45	33.61	103.16
2013	11.12	10.47	9.05	8.71	17.96	56.47	121.96	85.88	55.69	29.98	18.87	14.65	36.73	121.96
2014	15.63	15.29	10.82	11.45	18.73	37.48	85.40	144.55	75.54	37.48	16.63	9.66	39.89	144.55
2015	7.74	8.96	15.32	10.66	10.39	19.73	61.08	87.00	48.18	5.77	0.25	0.00	22.92	87.00
Average	11.17	9.91	9.57	10.51	20.48	59.32	125.47	134.96	93.18	39.09	20.03	12.08		134.96

Monthly Average Discharge of Seti River at Gandaki Damauli Gauge Station:

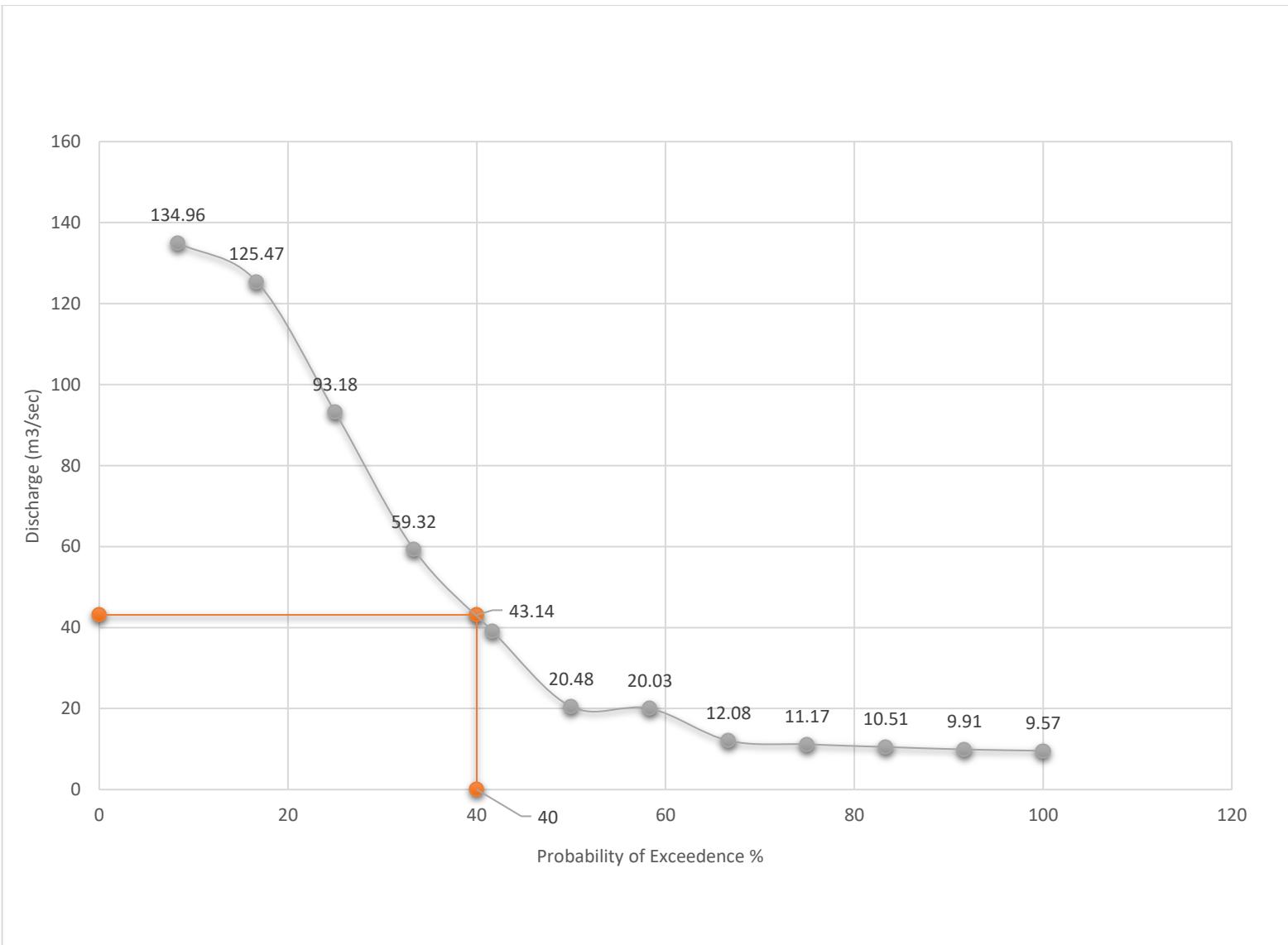
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Q (m³/sec) at Gauzing Sataion	11.17	9.91	9.57	10.51	20.48	59.32	125.47	134.96	93.18	39.09	20.03	12.08



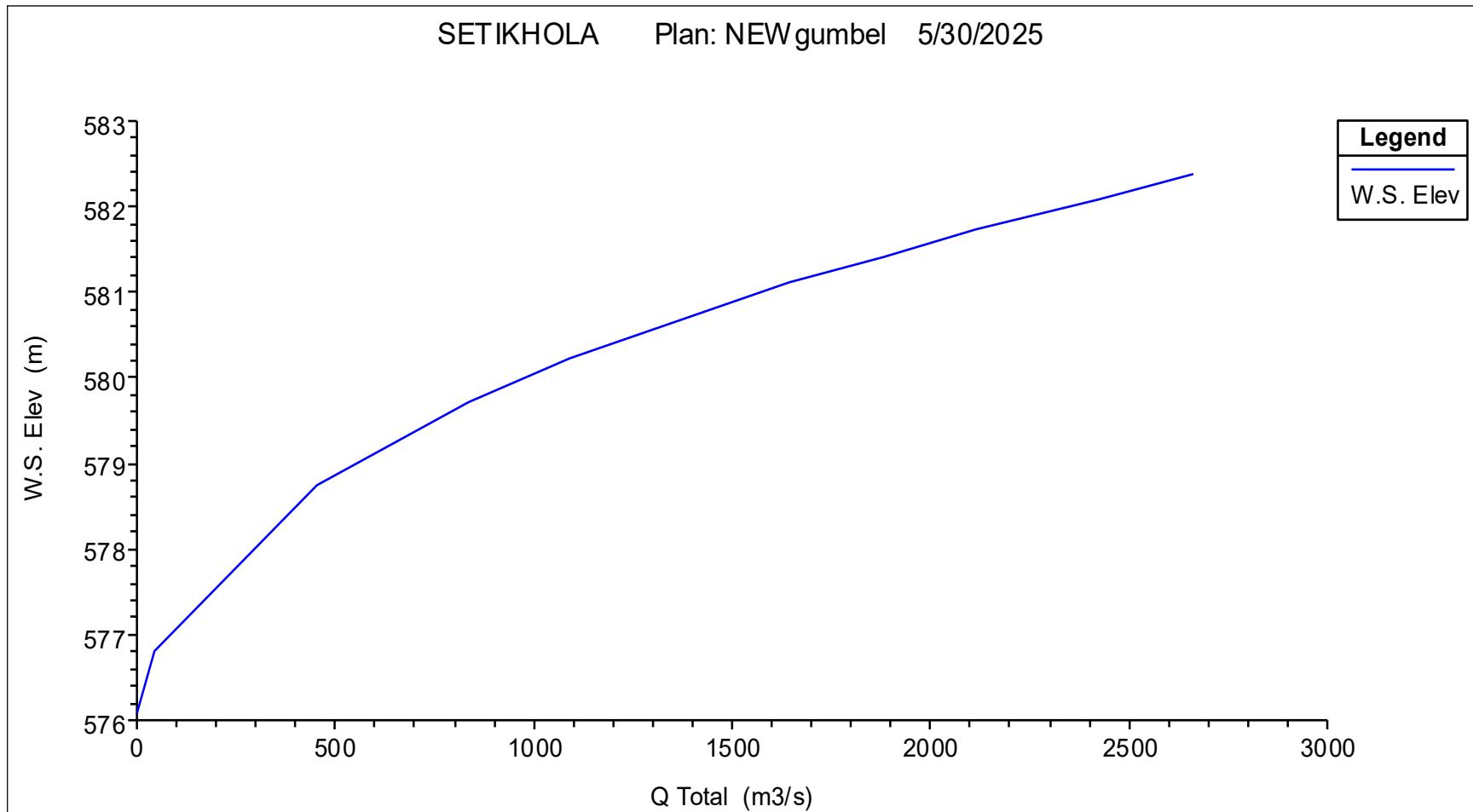
Flow Duration Curve Calculation of Seti River at Gandaki Gauge Station

Month	Q (cumecs)	Q in Desec. Order	Rank	Frequency	Probability of Exceedence
January	11.17	134.96	1	12.00	8.33
February	9.91	125.47	2	6.00	16.67
March	9.57	93.18	3	4.00	25.00
April	10.51	59.32	4	3.00	33.33
May	20.48	39.09	5	2.40	41.67
June	59.32	20.48	6	2.00	50.00
July	125.47	20.03	7	1.71	58.33
August	134.96	12.08	8	1.50	66.67
September	93.18	11.17	9	1.33	75.00
October	39.09	10.51	10	1.20	83.33
November	20.03	9.91	11	1.09	91.67
December	12.08	9.57	12	1.00	100.00

Flow Duration Curve



Rating Curve of Seti River at Intake



FLOOD ANALYSIS

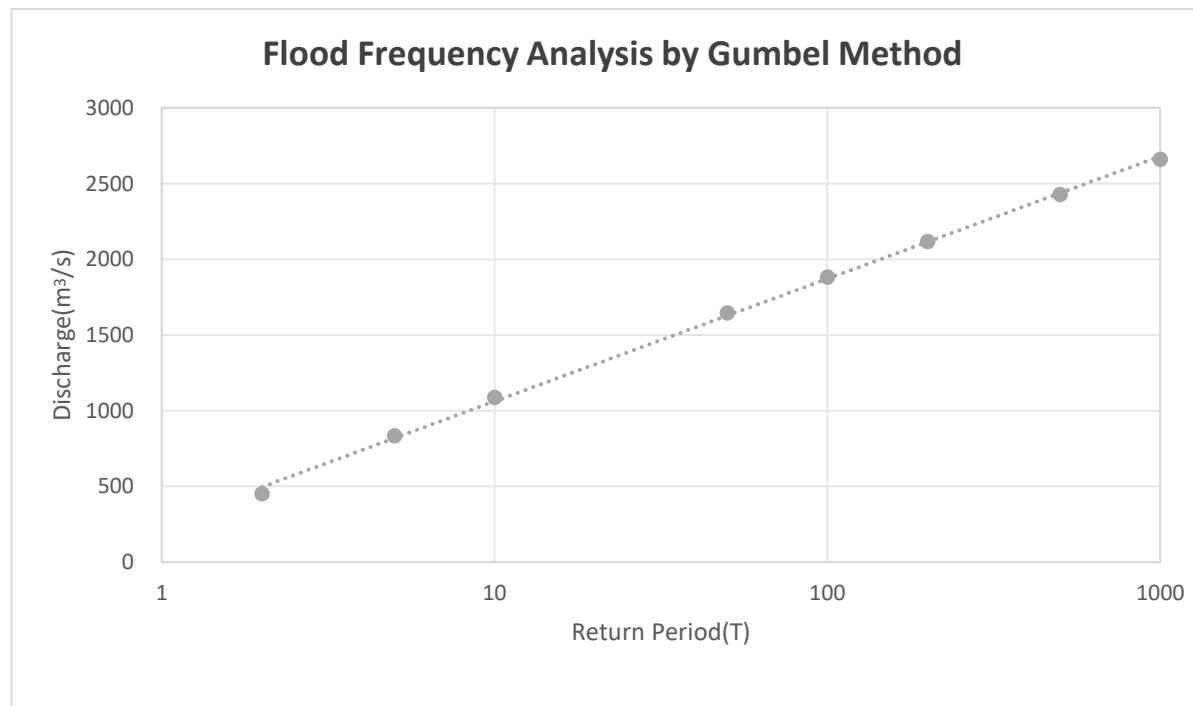
Gumbel's Method:

Table A. Discharge values

Gumbel's extreme-value distribution		
SN	Year	Q(max)
1	2000	423.8974
2	2001	1516.911
3	2002	502.5348
4	2003	1149.316
5	2004	299.1943
6	2005	383.4154
7	2006	188.9159
8	2007	479.2693
9	2008	369.9215
10	2009	228.9325
11	2010	458.3304
12	2011	615.6051
13	2012	245.6837
14	2013	433.6689
15	2014	368.9908
16	2015	366.199

Table B. Return Period Flood from Gumbel's Method

T	YT	K	XT (m ³ /s)
2	0.3665	-0.1446	451.5190096
5	1.4999	0.9541	834.4641818
10	2.2504	1.6815	1088.007207
50	3.9019	3.2825	1646.015116
100	4.6001	3.9593	1881.91593
200	5.2958	4.6337	2116.95598
500	6.2136	5.5234	2427.0467
1000	6.9073	6.1958	2661.4059



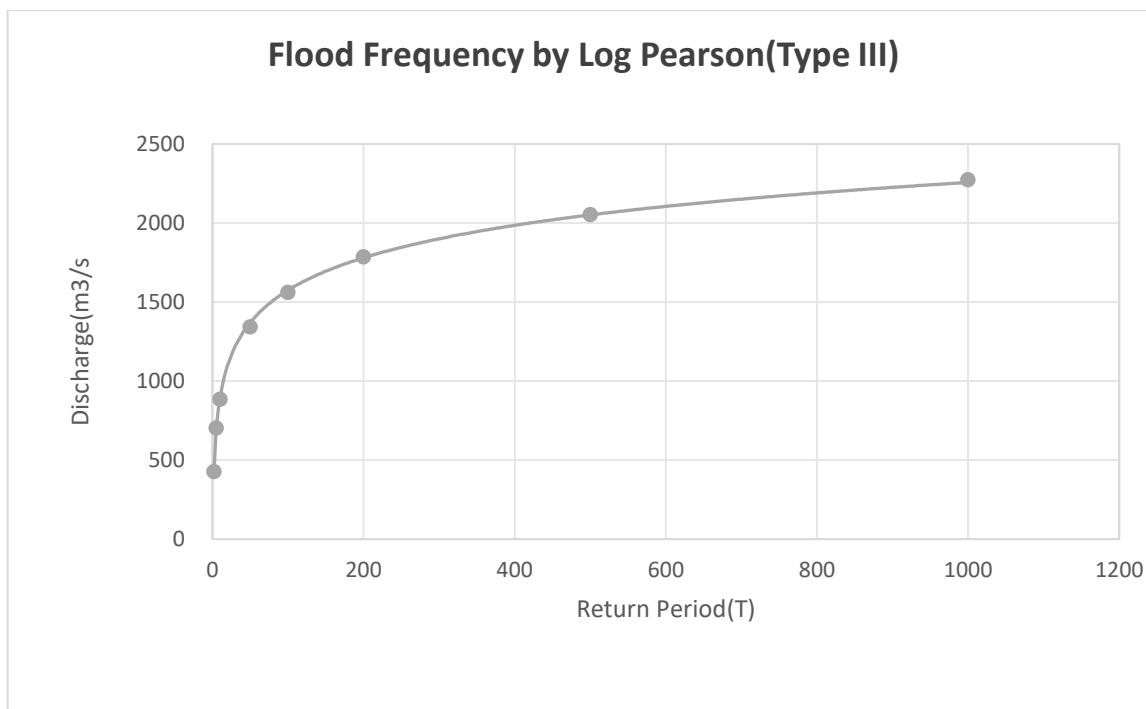
Log Pearson Type III method:

Table A. Log Pearson Type III Distribution

Log-Pearson Type III Distribution						
SN	Year	Q	Ranked (Q)	Rank (m)	P=m/(n+1)	Log(Q)
1	2000	423.89741	1516.9106	1	0.0588	3.1810
2	2001	1516.9106	1149.3157	2	0.1176	3.0604
3	2002	502.5348	615.60513	3	0.1765	2.7893
4	2003	1149.3157	502.5348	4	0.2353	2.7012
5	2004	299.19433	479.2693	5	0.2941	2.6806
6	2005	383.41544	458.33035	6	0.3529	2.6612
7	2006	188.91586	433.66892	7	0.4118	2.6372
8	2007	479.2693	423.89741	8	0.4706	2.6273
9	2008	369.92145	383.41544	9	0.5294	2.5837
10	2009	228.93252	369.92145	10	0.5882	2.5681
11	2010	458.33035	368.99083	11	0.6471	2.5670
12	2011	615.60513	366.19897	12	0.7059	2.5637
13	2012	245.68368	299.19433	13	0.7647	2.4760
14	2013	433.66892	245.68368	14	0.8235	2.3904
15	2014	368.99083	228.93252	15	0.8824	2.3597
16	2015	366.19897	188.91586	16	0.9412	2.2763
Median	2.6055					
Mean	2.6327					

Table B. Return Period from Log Pearson Type III method

T (Return Period)	K	Y _T	X _T (m ³ /s)
2	-0.007	2.6310	427.6080
5	0.915	2.8461	701.6927
10	1.345	2.9465	884.0265
50	2.123	3.1280	1342.6768
100	2.403	3.1933	1560.6124
200	2.654	3.2519	1785.8828
500	2.914	3.3125	2053.5749
1000	3.103	3.3566	2273.0237



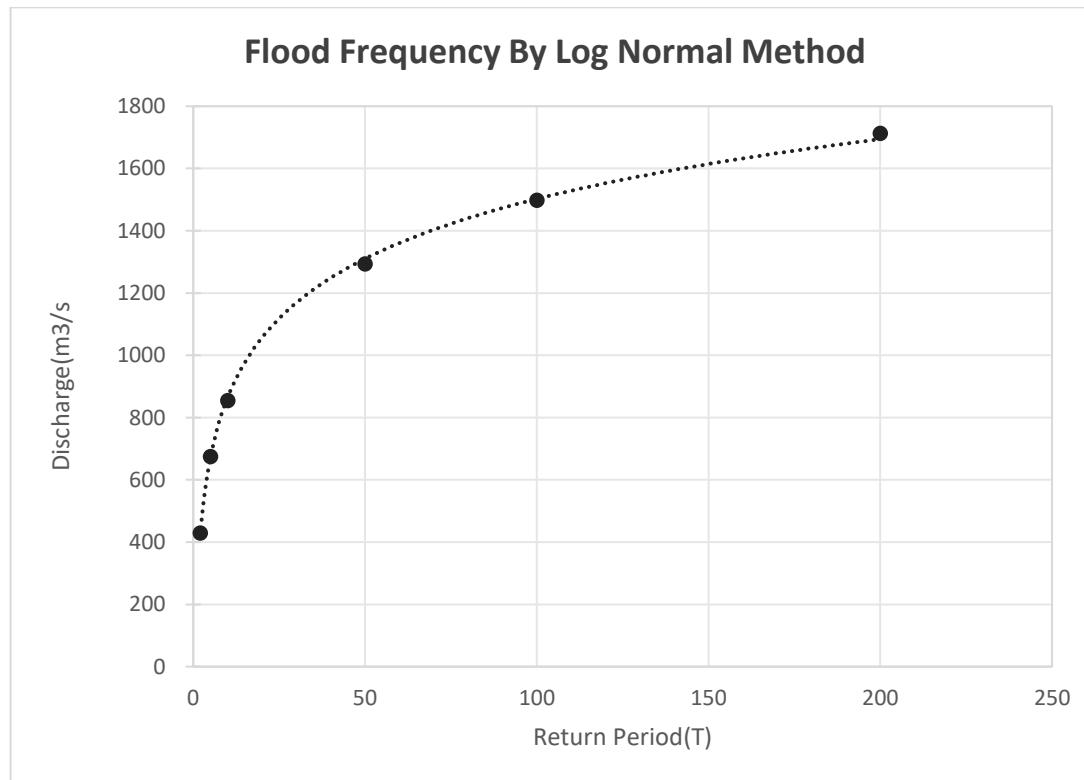
Log Normal Method:

Table A. Log Normal Table

Log Normal Method										
SN	Year	Q	Ranked (Q)	Rank (m)	P=m/(n+1)	Log(Q)	1-1/T	Z value	Y	X (m^3/s)
1	2000	423.8974	1516.9106	1	0.0588	3.1810	0.0000			
2	2001	1516.911	1149.3157	2	0.1176	3.0604	0.5000	0	2.6327	429.2190
3	2002	502.5348	615.60513	3	0.1765	2.7893	0.6667	0.4307	2.7332	540.9622
4	2003	1149.316	502.5348	4	0.2353	2.7012	0.7500	0.6745	2.7900	616.6465
5	2004	299.1943	479.2693	5	0.2941	2.6806	0.8000	0.8416	2.8290	674.5712
6	2005	383.4154	458.33035	6	0.3529	2.6612	0.8333	0.9674	2.8584	721.7335
7	2006	188.9159	433.66892	7	0.4118	2.6372	0.8571	1.0676	2.8817	761.6254
8	2007	479.2693	423.89741	8	0.4706	2.6273	0.8750	1.1503	2.9011	796.2576
9	2008	369.9215	383.41544	9	0.5294	2.5837	0.8889	1.2206	2.9175	826.8988
10	2009	228.9325	369.92145	10	0.5882	2.5681	0.9000	1.2816	2.9317	854.4032
11	2010	458.3304	368.99083	11	0.6471	2.5670	0.9091	1.3352	2.9442	879.3743
12	2011	615.6051	366.19897	12	0.7059	2.5637	0.9167	1.3830	2.9553	902.2549
13	2012	245.6837	299.19433	13	0.7647	2.4760	0.9231	1.4261	2.9654	923.3799
14	2013	433.6689	245.68368	14	0.8235	2.3904	0.9286	1.4652	2.9745	943.0086
15	2014	368.9908	228.93252	15	0.8824	2.3597	0.9333	1.5011	2.9829	961.3464
16	2015	366.199	188.91586	16	0.9412	2.2763	0.9375	1.5341	2.9906	978.5586
mean		2.6327								

Table B. Return Period Table

R period	(1-1/T)	Z value	Y value	X (m^3/s)
2	0.5000	0.0000	2.6327	429.2190
5	0.8000	0.8416	2.8290	674.5712
10	0.9000	1.2816	2.9317	854.4032
50	0.9800	2.0537	3.1118	1293.6456
100	0.9900	2.3263	3.1754	1497.6565
200	0.9950	2.5758	3.2336	1712.4419



ANNEX B: DESIGN OF COMPONENTS OF HYDROPOWER

Table B.1. Design of Weir and Under sluice

S.N	Paramenter	Symbol/Equation	Value	Remarks
Given				
A	High Flood Discharge 100 yrs (m^3/s)	Q_{hf}	1882	m^3/s (VERIFIED WITH HEC-RAS)
	Bed level of river (m)	BL	576.082031 3	CONSULTANCY DATA+HEC-RAS
	Water Surface Elevation for Q_{40} (m)	Q_{40}	576.82	HEC-RAS
	High flood level before weir construction (m)	HFL	581.424682 6	Taken E.G. Elev of 100yrs flood for safe
	Permissible afflux (m)		1.2	Desirable limit of afflux is 1-1.2m. More commonly 1.0 m. However, in steep reaches with rocky bed, higher afflux is permitted.
	Pond level (m)	PL	579.76	Generally obtained by adding 1 to 1.2 m to canal FSL(i.e. FSL Q_{45})
	Channel Depth (m)		3.68	
	Free board (m)	FB	1	Not kept
	Height of weir (m)	H	3.00	keep 3
	Safe exit Gradient	G_E	0.20	

				0.14 to 0.17 for fine sand 0.17 to 0.20 for coarse sand 0.020 to 0.25 for shingle
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Assumptions

B	Average grain size (mm)	d_{mm}	1	
	Lacey's silt factor	f	1.76	$1.76*(d)^{1/2}$
	Coefficient of discharge for weir	C_d	2	broad Crested weir
	Specific gravity of concrete (tons cu.m ⁻¹)	G_c	2.4	
	Specific gravity of boulders (tons cu.m ⁻¹)	G_b	2.65	
	Specific gravity of plum concrete (tons cu.m ⁻¹)	G_p	2.525	

Fixing the Crest level and Waterways

S.N	Parameter	Symbol/Equation	Value	Remarks
A	Weir crest level (m)	Average bed level+height of weir	579.082031 3	
	Undersluice crest level (m)	bed level of river	576.082031 3	
	Waterways (P) in m	$4.75*\sqrt{Q}$	206.06	Lacey's Wetted Perimeter equation
	Number of gated bay		2	3 m each
	Length of total piers		3	3 piers of 1m each

	Total under sluice portion (m)	L_u	9	2 bays of 3m each
	Weir Portion (m)	L_w	55	Assumed waterways
	Divide wall portion (m)	L_d	2	Assumed waterways
	Total waterways (m)	$L_u + L_w + L_d$	66	

Check for the Maximum Flood Passage Over this Waterways with Afflux

S.N	Parameter	Symbol/Equation	Value	Remarks
A	Head over the weir (H_o)	$Q/(C_w * (L)^{2/3})$	5.88	
	u/s TEL (m)	weir crest level + H_o	584.96	
	u/s HFL (m)	u/s TEL - velocity head	584.58	
	d/s HFL (m)	HFL before weir construction	581.424682 6	
	d/s TEL (m)	Rl before weir construction+ velocity head	581.81	
	Average discharge intensity (cumecs/meter)	$q = \frac{Q \cdot hf}{Total\ waterways}$	28.52	
	Scour depth (m)	$R = 1.35 \left(\frac{q^2}{f} \right)^{1/3}$	10.44	
	Velocity of approach (m/s)		2.73	
	Velocity head (m)	$\frac{V^2}{2g}$	0.38	
	u/s TEL (m)	u/s HFL+Velocity head+afflux	584.96	
	Head over the undersluice crest (m)	$H_u = u/s\ TEL - undersluice\ crest\ level$	8.88	

	Head over the weir crest (m)	$H_w = u/s \text{ TEL} - \text{weir crest level}$	5.88	
	Discharge through undersluice (m^3/s)	$Q_u = 1.7(L_u - KnH_u)H_u^{3/2}$	245.07	K=0.1, n=2*no. of gated bays
	Discharge through weir (m^3/s)	$Q_w = C_d L_w H_w^{3/2}$	1568.33	Baral book, page 275, 3rd Edition
	Total discharge	$Q = Q_u + Q_w$	1813.41	$Q > Q_{hf}$; Hence safe.
Design of Weir				
S.N	Parameter	Symbol/Equation	Value	Remarks
1A	1. High Flood Condition			
	a) Assuming no concentration and retrogression			
	d/s TEL (m)	d/s HFL+Velocity head	581.81	
	u/s TEL (m)	u/s HFL+ velocity head +Afflux	583.39	
	Head loss (m)	$H_L = u/s \text{ TEL} - d/s \text{ TEL}$	4.30	
1B	Discharge intensity (cumecs/meter)	$q_p = C_d H_w^{3/2}$	28.52	
	b) High flood with 20% concentration and 0.5 m retrogression			
	New discharge intensity (m^3/s)	$q_n = 1.2 * q_p$	34.22	
	New velocity head (m)	$(\frac{\text{New discharge intensity}}{C_d})^{2/3}$	6.64	
	u/s TEL (m)	weir level of river + new velocity head	585.72	
	d/s TEL (m)	d/s TEL-retrogression depth	581.31	
	Head loss(m)		4.42	

Undersluice Portion of Weir			
S. N	Items	High Flood Level	
		Without concentration and Retrogression	With concentration and retrogression
1	Discharge Intensity, q (cumecs/meter)	28.52	34.22
2	u/s TEL (in m)	583.39	585.72
3	d/s TEL (in m)	581.81	581.31
4	Head loss Hl (in m)	4.30	4.42
5	E_f2 (from plate no. 10.1) (in m)	10.18	10
6	Level at which jump will form (in m)	571.63	571.31
7	$Ef1 = Ef2 + Hl$ (in m)	14.48	14.42
8	y_1 (Plate No. 10.2) (in m)	2.82	3.1
9	y_2 (Plate No. 10.2) (in m)	9.2	7.85
10	Length of concrete floor (in m)	31.9	23.75
11	Froude No , $Fr1$ (in m)	1.92	2.00
	Length of d/s floor, m		31.9
	R.L of d/s floor, m		571.3
	take		571

TABLE B.2. DESIGN OF INTAKE

Parameter of intake				
SN	Description	values	unit	Remarks
1	Design discharge(Q_{40})	43.136	m^3/s	
2	Design discharge(Q_d)	56.0768	m^3/s	30% for flushing and losses
3	Maximum discharge($Q_{100 \text{ years}}$)	1882	m^3/s	
4	Rl of NWL	576.817	m	MASL
5	weir crest level (h_r)	578.82	m	MASL
6	Canal water level (h_h)	578.7	m	MASL
7	River bed level	576.082	m	MASL
8	Invert level	2	m	As per sediment
9	coefficient of discharge	0.6		
Assumed values				
1	Velocity at intake entry	0.9	m/s	
2	Depth of intake	2	m	
3	Total numbers of Bays	4	no	
4	Intake loss due to sudden contraction (Ki)	0.04		Bell mouth
5	Gradual contraction losses(Kt)	0.04		45^0
6	Intake loss coefficient (K)	0.08		Ki+Kt
7	Thickness of bar(t)	20	mm	
8	Clear spacing between the bars (b)	100	mm	
9	Angle of inclination of trash rack(α)	72	Degree	

10	Factor depending on bar shape(k_r)	1.67		Rounded bars
11	width of pier(end)	1	m	For one side groove only
12	width of pier(center)	1.5	m	For both side grooves
Dimension of intake				
S.N	Description	Values	Formula	Remarks
1	Area of intake required	62.308	$A = Q_d/V$	
2	Width of intake	31.154		
3	Total width adopted	32.000		
4	Total area adopted	64		
5	Discharge in intake	58.921	$A * C_d \sqrt{2g(h_r - h_h)}$	Discharge in intake $> Q_d$
6	Velocity at inlet	0.921	Q/A	$< 1 \text{ m/s}$ (ok)
Loss in intake				
1	Intake losses	0.003456	$k * v^2 / 2g$	
2	Loss in entrance			
Calculation of trash rack				
1	Total submerged width of trash rack	37.5		
2	Area of submerged trash rack	78.860		
3	Percentage of area opening	0.833		
4	Net area opening	65.716		
5	Approach velocity	0.853		
Loss in Trash rack				
1	Head loss through trash rack	0.00689	$\text{Head loss}(H_r) = k * (t/a)^{(4/3)} * (v^2/2g) * \sin\alpha$	

TABLE B.3. DESIGN OF APPROACH CANAL

Parameters of approach canal				
S.N.	Description	Value	Unit	Remark
1	Type of approach Canal	Trapezoidal		
2	Design discharge (Q_d)	43.136	m^3	
3	Flushing discharge(in %)	10%		$\geq 10\%$
4	Total discharge (Q_t)	47.4496	m^3	
5	Critical velocity	2.7	m/s	
6	Limiting velocity	1	m/s	
7	Freeboard	0.75	m	
8	Manning's coefficient(n)	0.015		Trowel float finish
9	Bed slope	0.001		
10	Side slope	1		H:V
11	No. of canals	2		
12	Critical velocity (v_c)	0.804984472	m/s	$a * \sqrt{d}$

Calculation of Approach canal

S.N.	Description	Value	Unit	Remark
1	Discharge in one canal	23.7248	m^3	$Q_t/\text{no of canal}$
2	Depth of canal	2.351	m	$Q = A * V$
3	Width of canal	1.946	m	$0.828Y$
4	Top width of canal	6.648	m	$b + 2ny$
5	Area of flow	10.102	m^2	$1.828y^2$
6	Adopted depth (including free board)	3.101	m	$y + FB$
7	Area of canal	15.650	m^2	$(b + ny)y$

8	Velocity in canal	2.3486373	m/s	$V_{\text{lim}} < V_{\text{canal}} < V_{\text{critical}}$
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TABLE B.4. DESIGN OF GRAVEL TRAP

Parameters of Gravel trap				
S.N.	Description	Value	Unit	Remark
1	Design discharge (Q_d)	43.136	m^3/s	
2	Flushing discharge in %	30%		30% extra discharge for flushing
3	Total discharge (Q_t)	56.0768	m^3/s	
4	No of bays	2		
5	Discharge in each bays	28.038	m^3/s	
6	Diameter of particle to settle	5	mm	
7	coefficient of turbulence(K)	1.5		
8	Specific gravity of particle(S)	2.65		
9	Width of one bay Gravel trap	7.5	m	15m both way
10	velocity in gravel trap	0.3		
11	Critical velocity	0.805		$a\sqrt{d}, a=0.36 \text{ for } d>1\text{mm}$
Particle fall velocity				
	According to Newton's equation	0.519	m/s	

	According to Zanke.	0.309	m/s	
	Adopted particle fall velocity	0.309	m/s	

Calculation of Gravel trap				
S.N.	Description	Value	Unit	Remark
1	Area of gravel trap	136.067		$A_s = k \times Q / w_t$
2	Depth of gravel trap	12.462		flowing velocity
3	Depth of gravel trap	4.644		critical velocity
4	Adopted depth	13.000		Adopted max of both
5	Length of gravel trap	18.142		On the basis of $A_s = L * B$
6	Length of gravel trap	13.082		On the basis of turbulence
7	Adopted length	21.000		max of both
8	Actual area of gravel trap	157.5		$L * B$
9	Efficiency of gravel trap	0.8238		$\eta = 1 - e^{(-\omega * A_s) / Q}$

Exist transition length				
S.N.	Description	Value	Unit	Remark
1	Width of settling basin(B)	7.5000	m	
2	Width of approach culvert(B')	3.4525	m	
3	Opening angle of inlet transition	30	degree	

4	Length of horizontal transition	3.50523782	m	
5	vertical angle	45		
6	Length of vertical transition			

Calculation of trash rack

1	Total submerged width of trash rack	30	m	Width of transited end
2	Total width trash rack excluding piers	28.6		
3	Depth of trash rack	1.5	m	
4	Angle of inclination of trash rack	70	Degree	
5	Bar thickness of trash rack	20	mm	
6	Clear spacing between bars	50	mm	
7	Net area of trash rack	45.653	m ²	
8	% of opening	0.714		
9	Net area of trash rack	32.609	m ²	
10	velocity in trash rack	0.860	m/s	
11	Factor depending on bar shape(kr)	1.67		Rounded bars

Check the length of spillway in Main gravel trap

	Limiting head over crest	0.6	m	
	Adopt broad crested weir, C	2.6	m	
	Length of spillway, L = Q / (C *H ^{3/2})	23.2	m	

Loss in Trash rack

1	Head loss through trash rack	0.01743	Head loss(Hr) = $k \cdot (t/a)^{4/3} \cdot (v^2/2g) \cdot \sin\alpha$	
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TABLE B.5. DESIGN OF SETTLING BASIN

Parameters of settling basin				
S.N.	Description	Value	Unit	Remark
1	Design discharge(Q_d)	43.136	m^3/s	
2	Flushing discharge in %	15%		
3	Total discharge(Q_t)	49.6064	m^3/s	
4	No of bays	2		
5	Discharge in each bay(Q)	24.8032	m^3/s	
6	Diameter of particle size to settle	0.15	mm	
7	Coefficient of Turbulence(K)	1.5		
8	Specific gravity of particle(S)	2.65		
10	velocity in Settling basin(v)	0.2	m/s	
11	Critical velocity (V_c)	0.170411267	m/s	$a\sqrt{d}$
12	Adopted flow velocity	0.170411267	m/s	
Particle fall velocity				
	According to Newton's equation	0.09	m/s	
	According to Zanke.	0.0175	m/s	
	Adopted particle fall velocity	0.0175	m/s	
Parameters of settling basin				
S.N.	Description	Value	Unit	Remark
1	Area of Settling basin	2120.324	m^2	$A_s = k \times Q/w_t$
2	Length of settling basin	144	m	As per iteration performed
3	Depth of settling basin	10	m	As per iteration performed

4	Width of settling basin	18	m	As per iteration performed
5	Actual area of Settling basin	2592.000	m^2	$L*B$
6	Efficiency of Settling basin	0.840		$\eta=1-e^{(-\omega*As)/Q}$
Transition length				
Entry transition length				
S.N.	Description	Value	Unit	Remark
1	Width of settling basin(B)	18.0000	m	
2	Width of approach culvert(B')	5	m	
3	Opening angle of inlet transition	10	degree	
4	Length of horizontal transition	37	m	
5	vertical angle	12	degree	
6	Depth of approach culvert	2.5	m	
7	Remaining depth from bottom of culvert	7.5	m	
6	Length of vertical transition	36.07300759	m	
Exist transition length				
S.N.	Description	Value	Unit	Remark
1	Width of settling basin(B)	32.0000	m	
2	Width of approach culvert(B')	2.5	m	
3	Opening angle of inlet transition	15	degree	
4	Length of horizontal transition	56	m	
5	vertical angle	30	degree	
6	Length of vertical transition	8	m	improvise needed
Calculation of trash rack				
S.N.	Description	Value	Unit	Remark
1	Total submerged width of trash rack	18	m	Width of transited end
2	Total width trash rack excluding piers	16.6		
3	Depth of trash rack	1.5	m	
4	Angle of inclination of trash rack	70	Degree	

5	Bar thickness of trash rack	20	mm	
6	Clear spacing between bars	50	mm	
7	Net area of trash rack	26.498	m ²	
8	% of opening	0.714		
9	Net area of trash rack	18.927	m ²	
10	velocity in trash rack	1.310	m/s	

Check the length of spillway in head pond

	Limiting head over crest	1	m	
	Adopt broad crested weir, C	1.7	m	
	Length of spillway, L = Q / (C *H ^{3/2})	29.2	m	Less than length of head pond 30 m, OK

Calculation Of Dimension Of Settling Basin

L/B=8		Depth	length based on turbulence
Width	Length	D=Q/Bv	L=H ^{3/2} V/(ω√H-0.132V)
13	104	11.19608	176.2672646
22.03341	176.2673	6.605835	127.9980855
15.99976	127.9981	9.096952	153.6590571
19.20738	153.6591	7.577767	137.7388407
17.21736	137.7388	8.453625	146.8473117
18.35591	146.8473	7.929273	141.3660414
17.67076	141.366	8.23672	144.5709267
18.07137	144.5709	8.054126	142.6642221
17.83303	142.6642	8.161769	143.7871489
17.97339	143.7871	8.098029	143.1218133
17.89023	143.1218	8.135675	143.5146273

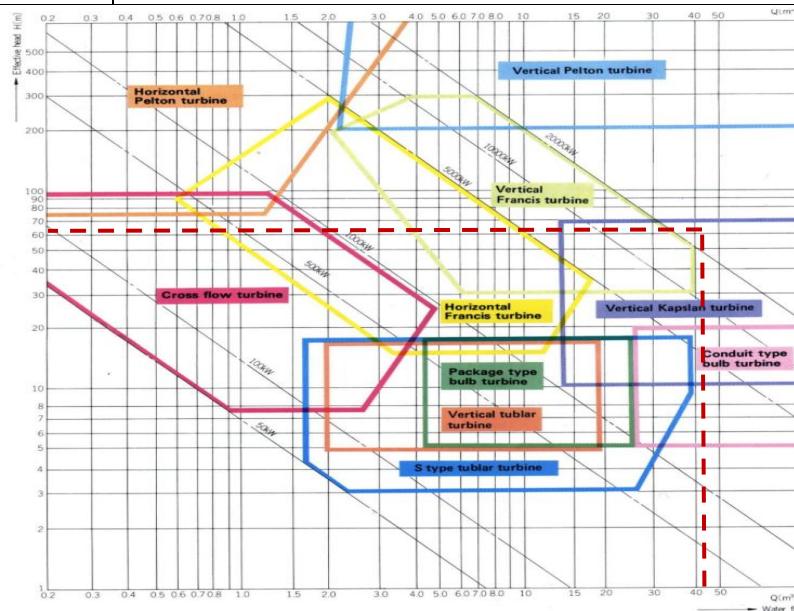
TABLE B.6. DESIGN OF HEADPOND

Design of Headpond				
S. N	Description	Values	Units	Remarks
1	Available Data			
	Design Discharge (Q_d)	43.136		
	Detention time (t)	2	minutes	
	Adopted discharge (Q_t) = 2 * Q_d	86.272		
	Diameter of the pipe (D)	4	m	
2	Assumptions			
	Depth of settling zone	0.3	m	Baral, S. (2013) Fundamentals of Hydropower Engineering
	Freeboard	0.5	m	
	Velocity (v)	0.25	m/s	
3	Calculations			
	Volume stored in head pond (V) =	10352.64		
		3.433	m/s	
		0.901	m	
		3.433	m	
	Adopted submergence head, h_s	6	m	
	Effective depth of head pond(h_e) = Pipe diameter + Submergence head	10	m	Baral, S. (2013) Fundamentals of Hydropower Engineering

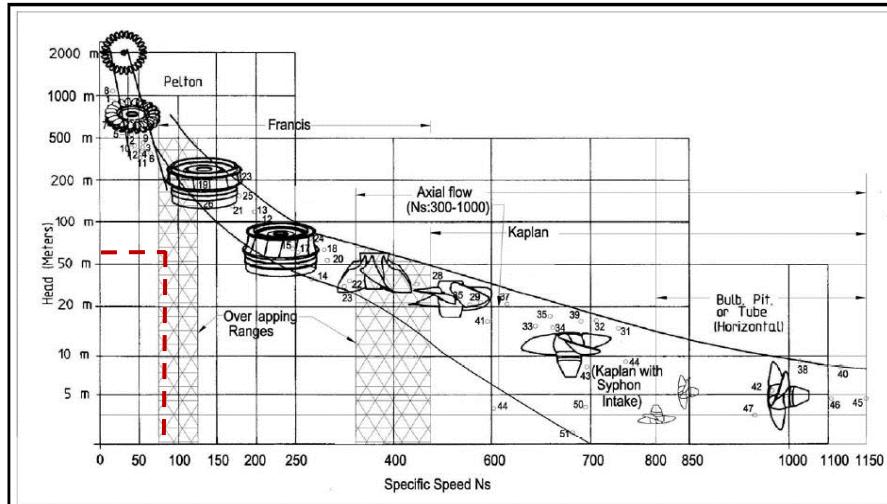
	Total depth (h) = effective depth + depth of settling zone + freeboard	10.8	m	
	Width of head pond (b) = $Q_t/(v * h_e)$	31.953	m	
	Adopted width of head pond = Width of desanding basin	32.000	m	1/2(A+B)
	Length = Volume / (Width * total height)	29.96	m	
	Adopted length of head pond (L)	30	m	
4	Checking the limiting velocity in the Headpond			
	$v = Q/(BH)$	0.250		> (0.2 m/s), OK
5	Final Dimensions			
	Submergence head (h_s)	6	m	
	Effective depth of head pond(h_e)	10.000	m	
	Total depth (h)	10.8	m	
	Width of head pond (b)	32	m	
	Length of head pond (L)	30	m	
	Velocity in head pond (v)	0.250	m/s	

TABLE B.7. DESIGN OF POWERHOUSE

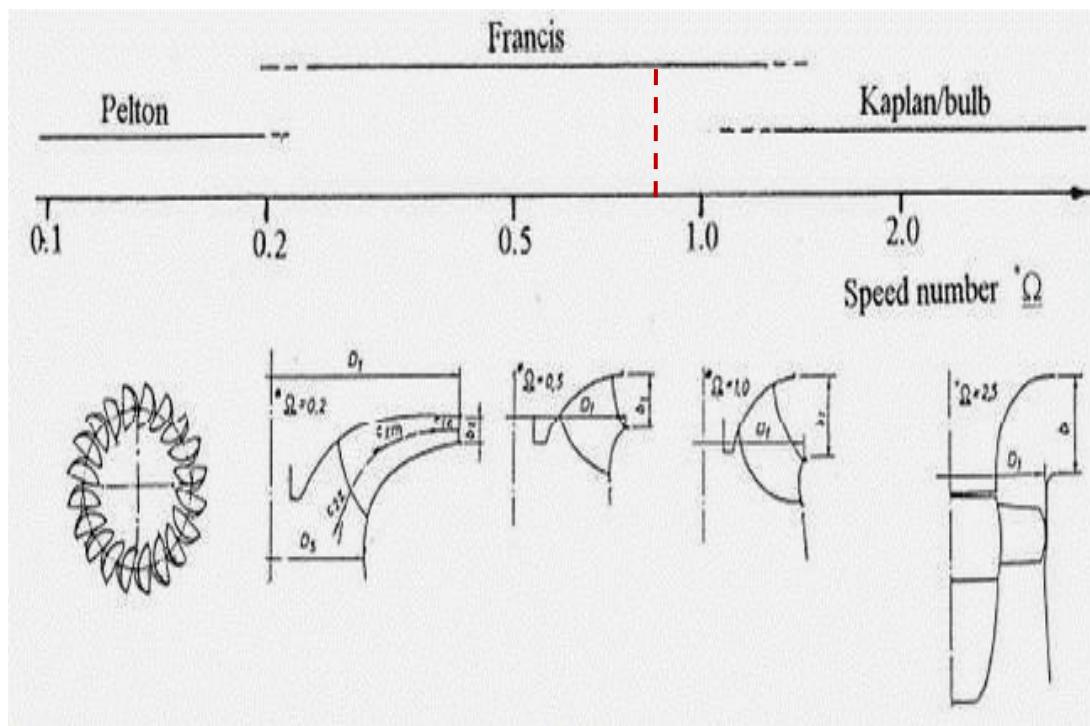
SELECTION OF TURBINE ACCORDING TO THE HEAD AND DISCHARGE			
	VALUE	UNIT	REMARKS
GROSS HEAD(H_G)	68.00	METRES	LOW HEAD AND HIGH DISCHARGE
NET HEAD (H_N)	63.90	METRES	
DISCHARGE (Q)	43.14	CUMECS	
CHOICE OF TURBINE BASED ON HEAD VS DISCHARGE GRAPH	FRANCIS TURBINE		



According to the specific speed			
	Value	Unit	Remarks
Turbine efficiency	0.90		Assumption
Generator efficiency	0.97		Assumption
Transformer efficiency	0.99		Assumption
Overall efficiency	0.87		
No. of units (n)	2.00		
Discharge per unit (q)	21.57	cumecs	
Power generated by each unit (P)	11,694.88	kW	23389.7642
Frequency (f)	50.00	Hz	
No. of poles (p)	8.00		Assumption
Speed in rpm (N)	375.00	rpm	
Specific Speed (N_q)	77.06		
Choice of turbine based on head vs specific speed graph	Francis Turbine		



According to the speed number			
	Value	Unit	Remarks
ω	39.27		Angular velocity
σ	1.11		Speed factor
Q	0.61		
Ω	0.87		Speed number
Choice of turbine based on Speed number			Francis Turbine



Synchronous Speed			
Particular	Value	Unit	Remarks
Machine type			Francis
No of units	2.00		
Unit capacity			
Maximum Head	68.00	m	
Rated Head	63.90	m	
Power	11,694.88	KW	
Take, specific speed	230.00		Fig. 1.1
Synchronous speed of machine	329.73		
Synchronous speed for 10 pairs	300.00		
Synchronous speed for 8 pairs	375.00		
Assuming the head variation less than 10% (higher synchronous speed i.e 375)			
Corrected specific speed	261.58		

Turbine setting			
Particular	Value	Unit	Remarks
H _b	10.30	m	atm pressure (absolute)
H _v	0.40	m	Vapour pressure
σ (from formula)	0.29		Thoma's coefficient
σ (from graph)	0.18		Thoma's coefficient
H _s	-1.60	m	Suction head
	-2.10	m	0.5m extra

Runner Diameter			
Particular	Value	Unit	Remarks
K _u	0.84		Fig. 1.3
D	2.24	m	

Spiral Casing			
Particular	Constant	Value	Unit
A	1.15	2.58	m
B	1.30	2.91	m
C	1.50	3.36	m
D	1.70	3.81	m
E	1.20	2.69	m
F	1.48	3.32	m
G	1.22	2.73	m
H	1.10	2.46	m
I	0.28	0.63	m
L	1.00	2.24	m
M	0.61	1.37	m

IS 12800 (Part 1) : 1993

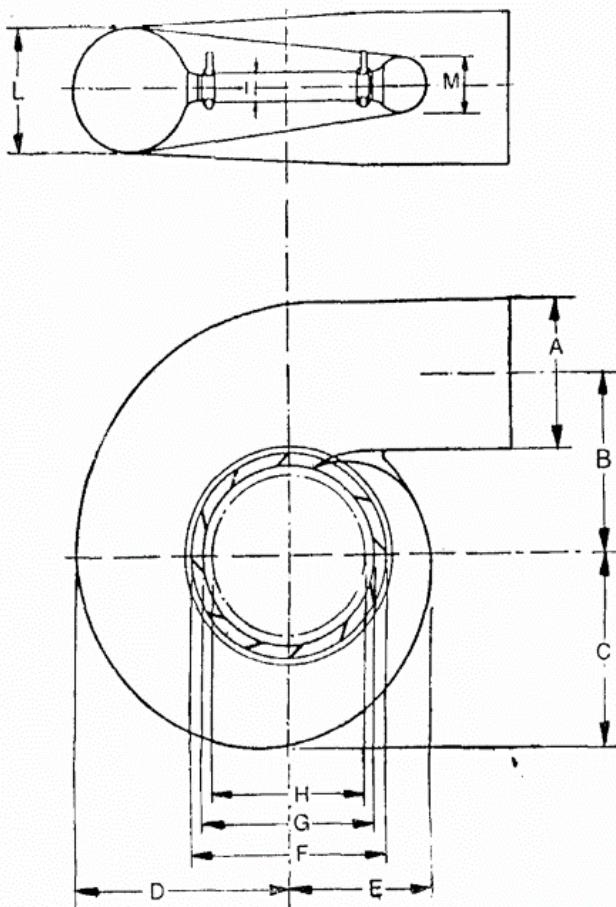


FIG. 8 MAJOR DIMENSIONS OF THE SPIRAL CASING

Size of draft tube			
Particular	Constant	Value	Unit
h	0.94	2.11	m
H	2.50	5.60	m
L	4.00	8.96	m
B	2.60	5.82	(no pier)
Particular	Value	Unit	Remarks
v	3.52	m/s	
Min Submergence	0.63	m	
Keeping bed slope 1 vertical to 10 horizontals at the bottom of the draft-tube, the exit end of draft-tube	0.90	m	above the bottom of draft-tube.
Top of exit end of draft-tube	3.00	m	above bottom of draft tube
Top of the exit end of the draft-tube	-2.60	m	below the minimum tail water level

IS 5496 : 1993

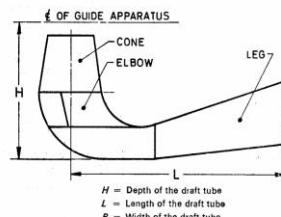
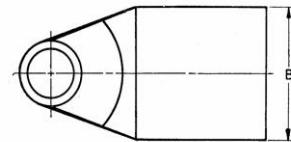


FIG. 1 DRAFT TUBE DESIGN TYPE I (FOR HEADS UP TO 200-250 m)

Generator parameters			
Particular	Value	Unit	Remarks
no. of pole	8.00		
Rated KVA of generator	12,994.31		power factor 0.9
peripheral rotor velocity (Vt)	83.00	m/s	Fig. 15
Air gap diameter (Dg)	6.06	m	
Outer core diameter (Do)	7.25	m	
Stator frame diameter (Df)	8.45	m	
Inner diameter of generator barrel (Db)	10.25	m	
Core length of stator (Le)	0.22	m	
Length of stator frame (Lf)	1.72	m	
Axial hydraulic thrust (Ph)	88.72	tonnes	
Weight of generator rotar (Wr)	37.70	tonnes	
Weight of turbine runner	10.00	tonnes	
Total load	136.42	tonnes	
Load per arm	34.11	tonnes	4 arms
k	0.65		for less than 50 tonnes
Height of load bearing bracket (hj)	1.89	m	Suspended type construction
	1.60	m	umbrella type construction

Overall dimension			
Particular	Value	Unit	Remarks
Spiral inlet	4.20	m	
Opposite side	5.62	m	
unit spacing	11.75	m	
	15.00	m	say
length of erection bay	12.00	m	0.7 to 1.5 time unit bay size
Space required for the E.O.T crane	3.50	m	preliminary purpose (3 to 5)
Total length of machine hall	45.50	m	
d/s width from c/l	7.62	m	
u/s width from c/l	9.62	m	
Total width of machine hall	17.25	m	
Height of draft tube (H1)	5.60	m	
Height of Generator (H2)	9.11	m	for suspended type
Total height (machine)	14.71	m	
Clearance height	1.00	m	
Height form erection bay to E.O.T crane	7.00	m	IS 12800 part 1
Height between EOT and ceiling	4.00	m	
Total height (superstructure)	12.00	m	
Total Height (all)	26.71	m	

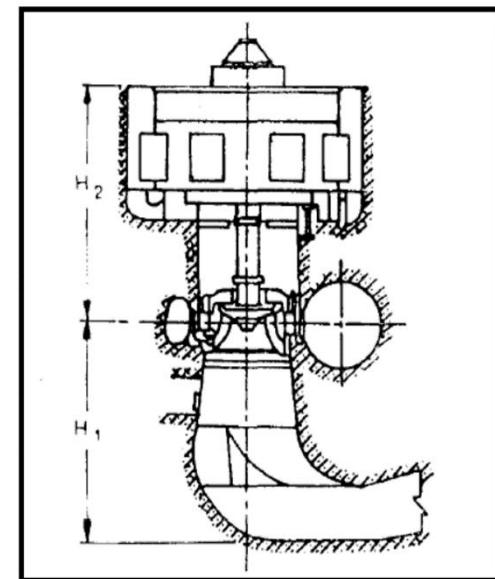


Figure-1. 6 Cross Section through Generating Unit

(Source IS 12800 (Part-1):1993)

Preliminary Design of Beam (Machine & Erection Bay)			
Beam Along Y-axis			
Particulars	Value	Unit	Reference
Longest Span of Beam, L	5.75	m	
L/D _{eff} = 26 * Modification factor			
For Modification Factor,			
Compressive Strength, f _{ck}	25.00	Mpa	Assume
Yield Stress, f _y	500.00	Mpa	Assume
$f_s = 0.58 \times f_y \times \frac{\text{Area of steel required}}{\text{Area of steel provided}}$	290.00		Assume Area of steel provided is same as that of required
Minimum requirement of 2% steel for tension requirement, P _{st}			
Modification Factor, α	0.70		IS456: Fig.4
Effective Depth of Beam, D _{eff}	315.93	mm	
Adopting Effective depth of beam	320.00	mm	
Effective cover	40.00	mm	
Overall Depth of beam, D	360.00	mm	
<i>Width of the beam = $\frac{1}{2} \times D$ to $\frac{2}{3} \times D$</i>	240.00	mm	assuming 2/3 * D
Adopted Depth of Beam	360.00	mm	

Adopted Width of Beam	240.00	mm	
Preliminary Design of Beam (Machine & Erection Bay)			
Beam Along X-axis			
Particulars	Value	Unit	Reference
Longest Span of Beam, L	6.50	m	
L/D _{eff} = 26 *Modification factor			
For Modification Factor,			
Compressive Strength, f _{ck}	25.00	Mpa	Assume
Yield Stress, f _y	500.00	Mpa	Assume
$f_s = 0.58 \times f_y \times \frac{\text{Area of steel required}}{\text{Area of steel provided}}$	290.00		Assume Area of steel provided is same as that of required
Modification Factor, α	0.70		IS456: Fig.4
Effective Depth of Beam, D _{eff}	357.14	mm	
Adopting Effective depth of beam	360.00	mm	
Effective Cover	40.00	mm	
Overall Depth of beam, D	400.00	mm	
Width of the beam	266.67	mm	assuming 2/3 * D
Adopted Depth of Beam	400.00	mm	
Adopted Width of Beam	270.00	mm	

Preliminary Design of Machine Hall Column			
Particulars	Value	Unit	Remarks/ Reference
Wt. from crane	500.00	kN	Powerhouse Design Guideline
Load from gantry	5.00	kN	
Total Load on rail runway	2,500.00	kN	
Load from gantry on each column	12.80	kN	
Truss Load	80.00	kN	assume
Self Wt of beam	2.70	kN/m	
Weight of beam on column	17.55	kN	
Load Transferred to Column	3,115.35	kN	
Factored Load, Pu	4,673.03	kN	Assuming factor 1.5
Gross Area	236,608.86	sq. mm	Cl. No. 39.3, IS 456:2000
Dims. Of Column	486.42	mm	
Adopted Size of Column	500x500	mmxmm	
Unsupported Length of Column, L	4.00	m	
Effective Length of Column, L_e	2.60	m	both fixed support
D_{min}	500.00	mm	
<i>Check for Short Column</i>			
Ratio (L_e/D)	5.20		short column (<12)

TABLE B.8. DESIGN OF SURGE TANK

Design of Surge Tank					
SN	Descriptions	Formulae	Value	Unit	Remarks
1	Data Available:				
	Acceleration due to gravity (g)	g	9.81	m/s ²	
	Discharge through Headrace Hunnel (HRT)=(Q)	Q	43.136	m ³ /s	
	Length of Headrace Tunnel (HRT)= (L)	L	3050	m	
	Diameter of Headrace Tunnel (HRT)=(d)	d	4.8	m	
	Manning's Coefficient (n)	f	0.015		Tunnel design, Range, (0.012-0.018)
	Bend coefficent (K _b)	b	0.1		Assume
	Gross Head (H _g)	H _g	68	m	
	No. of bends in Tunnel (N)	n	1		say
	Head loss in head works	sum of each loss (intake:pipe)	0.2	m (say)	still to sum
	Free Board of Surge tank	F.B	2	m	assume (As per Baral's Book)
	Entrance Coefficient (K _e)		0.5		

	Transient Coefficient (Kt)		0.2		
2	Head loss in Tunnel loss				
	Area of Headrace Tunnel (At)= $((\pi d^2)/8)+(d^2)/2$	$A_p=(\pi d^2)/4$	20.57	m^2	
	Velocity in Headrace Tunnel (v)=Q/A	$v=Q/A$	2.10	m/s	
	Wetted perimeter (P)=(2d)+($\pi d/2$)	$loss1 = (Q*f*v^2)/2g$	17.1398		
	Hydraulic Radius (R) =At/P	$loss2 = (f*L*v^2)/2gd$	1.20		
	Manning's Head Loss = $(v^2)*(n^2)*(L/(R^{(4/3)}))$	$loss3 = (b*n*v^2)/2g$	2.37		
	$(V^2/2g)*(K_{entrance} + K_{bend} + K_{transition})$	loss	0.18	m	
	Total Head loss in headrace Tunnel		2.55	m	
	Head loss upto Surge Tank (hf)= Head loss in (head works+Tunnel)		2.75	m	
	Net Head (Ho) = Hg-hf	$Ho = Hg - hf$	65.25	m	
	Min. area of surge tank $A_{st}>(A_p*L*V^2)/(2g*hf*Ho)$	$A_{st}>(A_p*L*V^2)/(2g*hf*Ho)$	78.47	m^2	Thomas formula of surgetank
	Area of Surge tank $A_{st}=$ $(45*d^{(10/3)})/Ho$	$A_{st} = (45*d^{(10/3)})/Ho$	128.65	m^2	Baral (2013), page 452
	Diameter of Surge tank (Dst) $Dst=\sqrt{4*A_{st}/\pi}$	$Dst=\sqrt{4*A_{st}/\pi}$	12.80	m	

	Final area of Surge tank considering FOS =1.6 (say)	Fos =2 (say)	205.84	m^2	Assume FOS From IS:7396
	Final diameter of surge tank= Dst	Dst	16.19	m	
	Maximum amplitude, Zmax $Z_{max} = (Q/A_{st}) * ((L \cdot A_{st}) / (g \cdot A_t))^{0.5}$	$Z_{max} = (Q/A_{st}) * ((L \cdot A_{st}) / (g \cdot A_t))^{0.5}$	11.69	m	
	Head Loss correction Factor (Po) = (Total hf / Zmax)	$Po = (\text{Total hf} / Z_{max})$	0.23	m	
	$Z_{max,upsurge} Z_{up} = Z_{max} * (1 - (2/3)Po - (1/9)Po^2)$	$Z_{up} = Z_{max} * (1 - (2/3)Po - (1/9)Po^2)$	9.79	m	
	$Z_{max,downsurge} Z_{down} = Z_{max} * (-1 + 2 * Po)$	$Z_{down} = Z_{max} * (-1 + 2 * Po)$	-6.20	m	
	Since the upsurge and downsurge height is very high, the dia. of surge tank needs to be increased to deduct those heights				
	From Table:				
	Taking diameter of surge tank Dst	Dst	18	m	
	Upsurge head from Static level Zupsurge	Zupsurge	8.76	m	

	Downsurge head from static level Zdownsurge	Zdownsurge	5.02	m	
	Normal Water level at Intake RL of NWL at intake	RL of NWL at intake	576.817	amsl	from intake design
	Due headloss, RL of static level at surge tank = RLoF NWL at intake - head loss(hf)	RLoF NWL at intake - head loss(hf)	574.07	amsl	
	RL of Crown level of Headrace Tunnel		562	amsl	Tunnel Design
	Area of surge tank (Ast)		254.47		
3	From Penstock Design:		4.4		
	Diameter of penstock	Dp	4.4	m	
	Area of Penstock Ap = $(\pi * Dp^2)/4$	Ap = $(\pi * Dp^2)/4$	15.21	m^2	
	Velocity in penstock Vp= Q/Ap	Vp= Q/Ap	2.84	m/s	
	Min. submergence head req. in ST Hsub = $1.5 * (Vp^2/2g)$ or $1.5 Dp$, whichever is greater	Hsub = $1.5 * (Vp^2/2g)$ or $1.5 Dp$, whichever is greater	6.6	m	
4	Final Output				
	Therefore, RL of min. submergence level req.= RL of crown level of HRT+ Hsub	RL of crown level of HRP+ Hsub	568.6	amsl	

	RL of downsurge from static level = RL at static level of surgetank - Z _{down,surge}	RL at static level of surgetank - Z _{down,surge}	569.05	amsl	OK
	Min. submergence head available		7.05	m	OK
	RL of top level of Surge Tank= RL of static level+Z _{up,surge} +F.B+2m extra	RL of static level+Z _{up,surge} +F.B	586.83		
	RL of Crown level of Headrace Tunnel		562	amsl	
	Min. submergence head available = RL of Z _{down,surge} - RL of Crown level of HRT	RL of Z _{down,surge} - RL of Crown level of HRP	7.05	m	OK
	Total Height of Surge Tank (Hst) =Top level of ST- Crown level of HRT	Top level of ST- Crown level of HRP	24.83		
	Adopted height of Surge Tank (Hst) is	Adopted height of Surge Tank (Hst) is	24.80	m	
	Optimised diameter of Surge Tank Dst	Dst	18	m	
	Time of oscillation T= $2\pi^* \left(\frac{A_{st} * L}{g * A_p} \right)^{0.5}$	T= $2\pi^* \left(\frac{A_{st} * L}{g * A_p} \right)^{0.5}$	389.69	sec	

	In 100 sec, Surge height		3.35	m	
	Invert level		562.45	amsl	
5	Restricted Orifice Design				
	Coefficient of Resistanc for Orifice (η)		2.4		Range, (1.2-2.8)&(1.5- 4) (water In & Out)
	Coefficient of discharge of Orifice (Cd)		0.8		Range, (0.6-0.9)
	Head loss in Orifice (Hor) = $\eta^*(V_t - V_p)^2$		1.31	m	
	Area of Orifice (Ao) = $((Q^2)/(Cd^2*2*g*Hor))^{0.5}$		5.31	m^2	
	Diameter of Orifice (Do) = $((Ao*4)/\pi)^{0.5}$		2.60	m	
	Number of Turbine (N)		2		
	Discharge of Turbine (Qo) = Qt/N		21.568	m^3/s	
	Adopted diameter of Orifice (Do)		3	m	

TABLE B.9. DESIGN OF PRESSURE SHAFT

S. N	Description	Values	Units	Remarks
1	Assumption Data			
	Allowable stress	1300.00	kg/cm ²	
	Density of steel	7850.00	kg/m ³	
	Bulk Modulus of water	1.96 x 10 ⁹	N/m ²	
	Ultimate tensile strength	410 x 10 ⁶	N/m ²	
	Young's Modulus	2 x 10 ¹¹	N/m ²	
	Density of water	1000	kg/m ³	
	Modulus of Elasticity	2 x 10 ⁵	N/m ²	
2	Calculated Data			
	Design discharge	43.14	m ³ /s	
	Length of Penstock	610.00	m	
	Gross Head (H _g)	68.00	m	
	Net Head (H) (Calculated by subtracting head loss upto penstock)	67.80	m	
	Rated Head (h)	67.80	m	
	Static head (h _s)	67.80	m	
	Dynamic head (h _d) (20 % of h _s)	13.56	m	h _d = 20% of h _s
3	Calculations			
	Design Pressure (p) = 9.81 kN/m ²	8.14	kg/cm ²	
	Economic diameter (D_e)			
	From Design guideline by JNN:	4.38	m	
	From USBR method:			
	V _{eco} = 0.125 x $\sqrt{2gH}$	4.56	m/s	
	Diameter	3.47	m	
	From Sarkaria Fromula,	1.13	m	
	P = Power in HP =	25247.67	kW	33857.68

	From these first estimates, general idea for economic diameter of penstock is obtained and we shall use diameter of 4.40 m for the optimization study of the penstock.			
	Optimum Diameter of Penstock	4.40	m	
	Thickness of the shell (t) =	0.04	m	
	Velocity of flow in penstock (v_p)	3.10	m/s	
4	Headloss			
	Total Head loss in Penstock	3.60	m	
5	Final Dimensions			
	Length of Penstock	610.00	m	
	Velocity of flow in penstock (v_p)	3.10	m/s	
	Optimum Diameter of Penstock	4.40	m	
	Thickness of the shell (t)	40.00	mm	

ANNEX C: STABILITY ANALYSIS

TABLE A. STABILITY ANALYSIS OF WEIR

Assumptions made			
The soil are assumed in saturated condition which is extreme condition			
Earthquake force and silt pressure are not considered in this analysis			
Assumed Values			
Description	Symbol	Values	Unit
Unit weight of Boulder	γ_b	26.00	KN/m ³
Unit weight of concrete	γ_c	24.00	KN/m ³
Mean Unit weight of concrete	γ_{mean}	24.28	KN/m ³
Average Unit weight of concrete	$\gamma_{average}$	24.85	KN/m ³
Unit weight of Water	γ_w	9.81	
Unit weight of submerged soil	γ_{sub}	12.00	
angle of internal friction of silt	Φ	30.00	
coefficient of friction`	μ	0.65	0.65-0.75
angle made by u/s face with vertical (2H:1V)	i	26.57	
$\tan(i)$		0.50	
$\tan^2(i)$		0.25	
$\sec^2(i)$		1.25	

angle made by d/s face with vertical(3H:1V)	α	0.32	radian
	α	71.57	degree
$\tan\alpha$		3.00	
$\tan^2(\alpha)$		9.00	
$\sec^2(\alpha)$		10.00	
Length of weir	L	27.83	m
Bearing capacity of soil	q	150.00	KN/m ²
Horizontal seismic coefficient		0.1	
Vertical seismic coefficient		0.05	

Force calculations

Name of the Force	Designation	Area (sq.m)	γ	Force(A*G)		Lever arm (m)	Moment(KNm) per meter width	
				Vertical	Horizontal		Anticlockwise	clockwise
Vertical Force calculation								

Self-weight force calculaiton(w)

Weir body	W1	142.0 0	24.0 0	3408.0 0		13.33	45428.64	
Weight of water during pool level	W2	6.85	9.81	67.15		18.31	1229.51	
Weight of water during high flood level	W3	36.13	9.81	354.39		23.00	8150.88	

Hydrostatic forces								
Pool level condition(H=3.7m)	H1	6.85	9.81		-67.15	6.31		423.94
High flow condition (H=8.5m)	H2	36.13	9.81		-354.39	7.91		2804.38
Uplift pressure								
For pool level	U1	51.49	9.81	-505.07		18.55		9370.78
High flood level	U2	118.2 8	9.81	1160.3 0		18.55		21527.47
Earthquake forces								
Horizontal earthquake force	P1				-340.80	6.34		2160.67
Vertical earthquake forces	P2			-170.40		13.33		2271.43
				1993.7 6	-762.3357		54809.03018	38558.6754 4

No water Condition with no earthquake				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	3408.00	KN	
Sum of horizontal forces	ΣH	0.00	KN	

Sum of resisting moment	ΣM_R	45428.64	KNm	
Sum of overturning moment	ΣM_0	0.00	KNm	
Sum of moments	ΣM	45428.64	KNm	
Centroid	x	13.33		
Eccentricity	e	0.58		Within middle third
Maximum vertical stress	P_{max}	137.90	KN/m	Toe
Minimum vertical stress	P_{min}	107.01	KN/m	Heel
Principal stress at toe		1379.03	KN/m ²	Safe
Principal stress at heel		133.766	KN/m ²	Safe
Shear Stress at toe		413.708	KN/m ²	Safe
Shear Stress at heel		53.5065	KN/m ²	Safe

No water condition with Earthquake				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	3237.60	KN	
Sum of horizontal forces	ΣH	-340.80	KN	
Sum of resisting moment	ΣM_R	45428.64	KNm	
Sum of overturning moment	ΣM_0	2160.67	KNm	
Sum of moments	ΣM	43267.97	KNm	
Centroid	x	13.36		

Eccentricity	e	0.55		Within middle third
Maximum vertical stress	P_{max}	130.15	KN/m	at toe
Minimum vertical stress	P_{min}	102.52	KN/m	at heel
Principal Stress at toe		1301.49	KN/m ²	Safe
Principal Stress at heel		128.15	KN/m ²	Safe
Shear Stress at toe		390.45	KN/m ²	Safe
Shear Stress at heel		51.26	KN/m ²	Safe

Pond Level				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	2970.08	KN	
Sum of horizontal forces	ΣH	-67.15	KN	
Sum of resisting moment	ΣM_R	46658.15	KNm	
Sum of overturning moment	ΣM_0	9794.72	KNm	
Sum of moments	ΣM	36863.4	KNm	
Centroid	x	12.4116		
Eccentricity	e	1.50339		Within middle third
Maximum vertical stress	P_{max}	141.313	KN/m	at toe
Minimum vertical stress	P_{min}	72.131	KN/m	at heel
Principal Stress at toe		1413.13	KN/m ²	Safe
Principal Stress at heel		90.1637	KN/m ²	Safe
Shear Stress at toe		423.94	KN/m ²	Safe
Shear Stress at heel		36.0655	KN/m ²	Safe
Fos against Overturning		4.7636		>1.5, Safe
FoS against Sliding		28.75		>1, Safe

Pond level with Earthquake				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	2799.68	KN	
Sum of horizontal forces	ΣH	-407.95	KN	
Sum of resisting moment	ΣM_R	46658.15	KNm	
Sum of overturning moment	ΣM_0	14226.82	KNm	
Sum of moments	ΣM	32431.32	KNm	
Centroid	x	11.58		
Eccentricity	e	2.33		Within middle third
Maximum vertical stress	P_{max}	151.16	KN/m	
Minimum vertical stress	P_{min}	50.04	KN/m	
Principal Stress at toe		1511.57	KN/m ²	Safe
Principal Stress at heel		62.55	KN/m ²	Safe
Shear Stress at toe		453.47	KN/m ²	Safe
Shear Stress at heel		25.02	KN/m ²	Safe
FoS against Overturning		3.28		>1.5, Safe
FoS against Sliding		4.46		>1, Safe

High Flood Level				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	2602.08	KN	
Sum of horizontal forces	ΣH	-354.39	KN	

Sum of resisting moment	ΣM_R	53579.5	KNm	
Sum of overturning moment	ΣM_0	24331.9	KNm	
Sum of moments	ΣM	29247.7	KNm	
Centroid	x	11.2401		
Eccentricity	e	2.6749		Within middle third
Maximum vertical stress	P_{max}	147.42	KN/m	at toe
Minimum vertical stress	P_{min}	39.5787	KN/m	at heel
Principal Stress at toe		1474.2	KN/m ²	Safe
Principal Stress at heel		49.4734	KN/m ²	Safe
Shear Stress at toe		442.259	KN/m ²	Safe
Shear Stress at heel		19.7893	KN/m ²	Safe
FoS against Overturning		2.20203		>1.5, Safe
FoS against Sliding		4.77263		>1, Safe

High Flood Level with Earthquake				
Designation	Symbol	Value	Unit	Remarks
Sum of vertical forces	ΣV	2431.68	KN	
Sum of horizontal forces	ΣH	-695.19	KN	
Sum of resisting moment	ΣM_R	53579.52	KNm	
Sum of overturning moment	ΣM_0	26492.52	KNm	
Sum of moments	ΣM	27087.00	KNm	
Centroid	x	11.14		

Eccentricity	e	2.78		Within middle third
Maximum vertical stress	P _{max}	139.67	KN/m	
Minimum vertical stress	P _{min}	35.09	KN/m	
Principal Stress at toe		1396.67	KN/m ²	Safe
Principal Stress at heel		43.86	KN/m ²	Safe
Shear Stress at toe		419.00	KN/m ²	Safe
Shear Stress at heel		17.54	KN/m ²	Safe
FoS against Overturning		2.02		>1.5, Safe
FoS against Sliding		2.27		>1, Safe

ANNEX D: OPTIMIZATION

OPTIMIZATION OF HEADRACE TUNNEL

Table A. Available data for tunnel optimization

Gross head (m)	68
Head loss (m)	4.2
Efficiency (%)	0.84
Net head (m)	63.9
Wet Outage (%) = 5%	0.05
Dry Outage (%) = 5%	0.05
Design Flow (m ³ /s)	43.136
10% D/S release (m ³ /s) =	1.622
Tunnel Excavation rate including mucking and explosives (NRs) = 7992.5 per m ³	8000
Shotcrete rate (NRs) = 4897.57 per m ²	4900
PCC rate (NRs) per m ²	12330.54
Length of tunnel (m)	3050
Interest rate(i) = 10	0.1
Life of project = 50 years	50
Wet season Energy rate(NRs) = 4.8 per unit	4.8
Dry season Energy rate(NRs) = 8.4 per unit	8.4
Manning's coefficient (n) = 0.01	0.012
Absolute roughness for concrete (e) = 0.3	0.3
Capital recovery factor (CRF)	0.100859

Table B. Total Annual Cost Calculation

Tunnel Diameter, D (m)	Inside area, A (m ²)	Wetted Perimeter (m)	Hydraulic Radius, R (m)	Total Excavation Area (m ²)	Excavation Cost (MNRs.)	Rock bolt + Shotcrete Cost (MNRs.)	RCC Cost (MNRs.)	PCC Cost (MNRs.)	Total Annual Cost (MNRs.)
3.3	9.72	11.78	0.34	12.04	293.68	481.55	136.56	76.90	99.72
3.4	10.32	12.14	0.33	12.70	309.89	496.14	140.70	79.23	103.48
3.5	10.94	12.50	0.32	13.38	326.54	510.73	144.83	81.56	107.28
3.6	11.57	12.85	0.31	14.08	343.63	525.33	148.97	83.89	111.13
3.7	12.22	13.21	0.30	14.80	361.15	539.92	153.11	86.22	115.02
3.8	12.89	13.57	0.29	15.54	379.11	554.51	157.25	88.55	118.95
3.9	13.58	13.93	0.29	16.29	397.50	569.10	161.39	90.88	122.93
4	14.28	14.28	0.28	17.06	416.33	583.70	165.52	93.21	126.96
4.1	15.01	14.64	0.27	17.85	435.59	598.29	169.66	95.54	131.02
4.2	15.75	15.00	0.27	18.66	455.29	612.88	173.80	97.87	135.14
4.3	16.51	15.35	0.26	19.48	475.43	627.47	177.94	100.20	139.29
4.4	17.28	15.71	0.25	20.33	496.00	642.07	182.08	102.53	143.49
4.5	18.08	16.07	0.25	21.19	517.00	656.66	186.21	104.86	147.73
4.6	18.89	16.43	0.24	22.07	538.45	671.25	190.35	107.19	152.02
4.7	19.72	16.78	0.24	22.96	560.32	685.84	194.49	109.52	156.35
4.8	20.57	17.14	0.23	23.88	582.64	700.44	198.63	111.85	160.72
4.9	21.43	17.50	0.23	24.81	605.39	715.03	202.77	114.18	165.14
5	22.32	17.85	0.22	25.76	628.57	729.62	206.91	116.51	169.61
5.1	23.22	18.21	0.22	26.73	652.19	744.21	211.04	118.85	174.11
5.2	24.14	18.57	0.22	27.72	676.25	758.80	215.18	121.18	178.66
5.3	25.08	18.93	0.21	28.72	700.74	773.40	219.32	123.51	183.26
5.4	26.03	19.28	0.21	29.74	725.67	787.99	223.46	125.84	187.90

5.5	27.00	19.64	0.20	30.78	751.03	802.58	227.60	128.17	192.58
5.6	28.00	20.00	0.20	31.84	776.83	817.17	231.73	130.50	197.30
5.7	29.00	20.35	0.20	32.91	803.06	831.77	235.87	132.83	202.07
5.8	30.03	20.71	0.19	34.01	829.73	846.36	240.01	135.16	206.89
5.9	31.07	21.07	0.19	35.12	856.84	860.95	244.15	137.49	211.75
6	32.14	21.42	0.19	36.24	884.38	875.54	248.29	139.82	216.65

Table C. Energy Lost Calculation

Tunnel Diameter, D (m)	3.3	3.4	3.5	3.6	3.7	3.8
X-sectional area, A (m ²)	9.72	10.32	10.94	11.57	12.22	12.89
Wetted Perimeter, P (m)	11.78	12.14	12.50	12.85	13.21	13.57
Hydraulic Radius, R (m)	0.83	0.85	0.88	0.90	0.93	0.95
Flow velocity (m/s)	4.44	4.18	3.94	3.73	3.53	3.35
Constant	0.176	0.147	0.124	0.106	0.090	0.077
Max. Power Lost (P _{max})	14130.36	11802.06	9955.48	8510.33	7225.75	6182.03
Month	Design Flow (m ³ /s)	Energy Lost (kWh)				
Jan	17.31	645164.82	538859.25	454547.94	388565.18	329913.83
Feb	15.17	392203.37	327578.95	276325.10	236213.39	200558.54
Mar	14.60	387088.35	323306.74	272721.34	233132.75	197942.90
Apr	16.19	510821.50	426652.05	359896.97	307653.86	261215.54
						223484.41

May	33.09	4507560.56	3764837.52	3175781.31	2714780.79	2305002.56	1972057.75
Jun	43.14	9665163.20	8072607.90	6809546.80	5821064.20	4942413.00	4228508.90
Jul	43.14	9987335.31	8341694.83	7036531.70	6015099.68	5107160.10	4369459.20
Aug	43.14	9987335.31	8341694.83	7036531.70	6015099.68	5107160.10	4369459.20
Sep	43.14	9665163.20	8072607.90	6809546.80	5821064.20	4942413.00	4228508.90
Oct	43.14	9987335.31	8341694.83	7036531.70	6015099.68	5107160.10	4369459.20
Nov	32.34	4072199.54	3401212.11	2869049.68	2452574.72	2082374.76	1781587.30
Dec	19.87	975871.14	815074.19	687545.57	587740.57	499025.01	426943.62
Wet Season Energy Lost		53364531.88	44571512.42	37597738.37	32140002.15	27288681.07	23346982.70
Dry Season Energy Lost		7418709.74	6196308.70	5226818.22	4468086.55	3793658.39	3245685.51
Total Energy Lost (TEL)		60783241.61	50767821.12	42824556.59	36608088.70	31082339.46	26592668.21
Total Energy Lost Cost		318466914.8	265992252.7	224374417.2	191803937.3	162852399.6	139329275.2
TEL Cost (MNRs.)		318.47	265.99	224.37	191.80	162.85	139.33

3.9	4	4.1	4.2	4.3	4.4	4.5	4.6
13.58	14.28	15.01	15.75	16.51	17.28	18.08	18.89
13.93	14.28	14.64	15.00	15.35	15.71	16.07	16.43
0.98	1.00	1.03	1.05	1.08	1.10	1.13	1.15
3.18	3.02	2.87	2.74	2.61	2.50	2.39	2.28
0.066	0.057	0.050	0.043	0.038	0.033	0.029	0.026
5298.88	4576.31	4014.31	3452.30	3050.87	2649.44	2328.30	2087.44
Energy Lost (kWh)							

241936.81	208945.43	183285.46	157625.50	139296.95	120968.40	106305.57	95308.44
147076.26	127020.41	111421.41	95822.41	84680.27	73538.13	64624.42	57939.13
145158.13	125363.84	109968.28	94572.72	83575.89	72579.07	63781.60	57183.51
191558.06	165436.51	145119.74	124802.98	110291.01	95779.03	84169.45	75462.27
1690335.21	1459834.96	1280556.98	1101279.00	973223.30	845167.61	742723.05	665889.63
3624436.20	3130194.90	2745785.00	2361375.10	2086796.60	1812218.10	1592555.30	1427808.20
3745250.74	3234534.73	2837311.17	2440087.60	2156356.49	1872625.37	1645640.48	1475401.81
3745250.74	3234534.73	2837311.17	2440087.60	2156356.49	1872625.37	1645640.48	1475401.81
3624436.20	3130194.90	2745785.00	2361375.10	2086796.60	1812218.10	1592555.30	1427808.20
3745250.74	3234534.73	2837311.17	2440087.60	2156356.49	1872625.37	1645640.48	1475401.81
1527074.83	1318837.35	1156874.87	994912.39	879224.90	763537.41	670987.42	601574.93
365951.68	316049.18	277236.12	238423.06	210699.45	182975.84	160796.95	144162.78
20011699.45	17282831.35	15160378.37	13037925.40	11521887.56	10005849.73	8793019.46	7883396.75
2782016.15	2402650.31	2107587.99	1812525.67	1601766.87	1391008.08	1222401.04	1095945.76
22793715.61	19685481.66	17267966.37	14850451.08	13123654.44	11396857.80	10015420.49	8979342.51
119425093	103139853.1	90473555.34	77807257.59	68759902.06	59712546.52	52474662.1	47046248.78
119.43	103.14	90.47	77.81	68.76	59.71	52.47	47.05

4.7	4.8	4.9	5	5.1	5.2	5.3	5.4
19.72	20.57	21.43	22.32	23.22	24.14	25.08	26.03
16.78	17.14	17.50	17.85	18.21	18.57	18.93	19.28
1.18	1.20	1.23	1.25	1.28	1.30	1.33	1.35
2.19	2.10	2.01	1.93	1.86	1.79	1.72	1.66
0.023	0.021	0.022	0.020	0.019	0.017	0.016	0.015
1846.58	1686.01	1726.15	1605.72	1509.38	1332.75	1268.52	1188.23

Energy Lost (kWh)	Energy Lost (kWh)	Energy Lost (kWh)	Energy Lost (kWh)				
84311.31	76979.89	78812.75	73314.18	68915.33	60850.77	57918.21	54252.50
51253.85	46796.99	47911.21	44568.56	41894.45	36991.91	35209.17	32980.74
50585.41	46186.68	47286.36	43987.31	41348.07	36509.47	34749.98	32550.61
66755.08	60950.29	62401.49	58047.90	54565.02	48179.76	45857.84	42955.44
589056.21	537833.93	550639.50	512222.79	481489.42	425144.92	404656.01	379044.87
1263061.10	1153229.70	1180687.55	1098314.00	1032415.16	911600.62	867668.06	812752.36
1305163.14	1191670.69	1220043.80	1134924.47	1066829.00	941987.31	896590.33	839844.11
1305163.14	1191670.69	1220043.80	1134924.47	1066829.00	941987.31	896590.33	839844.11
1263061.10	1153229.70	1180687.55	1098314.00	1032415.16	911600.62	867668.06	812752.36
1305163.14	1191670.69	1220043.80	1134924.47	1066829.00	941987.31	896590.33	839844.11
532162.44	485887.44	497456.19	462749.95	434984.95	384082.46	365572.46	342434.96
127528.61	116439.17	119211.53	110894.45	104240.78	92042.39	87606.61	82061.89
6973774.05	6367358.92	6518962.70	6064151.35	5700302.27	5033245.62	4790679.57	4487472.00
969490.48	885186.96	906262.84	843035.20	792453.09	699719.21	665997.81	623846.05
7943264.53	7252545.87	7425225.54	6907186.55	6492755.35	5732964.83	5456677.37	5111318.04
41617835.46	37998893.24	38903628.8	36189422.14	34018056.81	30037220.37	28589643.49	26780172.38
41.62	38.00	38.90	36.19	34.02	30.04	28.59	26.78

5.5	5.6	5.7	5.8	5.9	6
27.00	28.00	29.00	30.03	31.07	32.14
19.64	20.00	20.35	20.71	21.07	21.42
1.38	1.40	1.43	1.45	1.48	1.50
1.60	1.54	1.49	1.44	1.39	1.34
0.014	0.013	0.012	0.012	0.011	0.010

1098.31	1027.66	995.55	923.29	907.23	802.86
Energy Lost (kWh)					
50146.90	46921.08	45454.79	42155.66	41422.51	36657.09
30484.90	28523.88	27632.51	25626.92	25181.24	22284.28
30087.32	28151.88	27272.13	25292.70	24852.83	21993.66
39704.76	37150.65	35989.70	33377.54	32797.06	29023.95
350360.39	327822.59	317578.13	294528.11	289405.88	256111.40
751246.78	702920.96	680954.68	631530.55	620547.41	549157.00
776288.34	726351.66	703653.17	652581.57	641232.32	567462.23
776288.34	726351.66	703653.17	652581.57	641232.32	567462.23
751246.78	702920.96	680954.68	631530.55	620547.41	549157.00
776288.34	726351.66	703653.17	652581.57	641232.32	567462.23
316520.96	296159.97	286904.97	266081.22	261453.72	231374.97
75851.80	70972.45	68754.56	63764.31	62655.36	55447.22
4147879.52	3881056.86	3759773.84	3486887.03	3426245.51	3032075.67
576636.07	539542.53	522681.82	484745.24	476314.89	421517.60
4724515.60	4420599.39	4282455.66	3971632.26	3902560.40	3453593.27
24753564.74	23161230.17	22437441.72	20808917.73	20447023.51	18094711.07
24.75	23.16	22.44	20.81	20.45	18.09

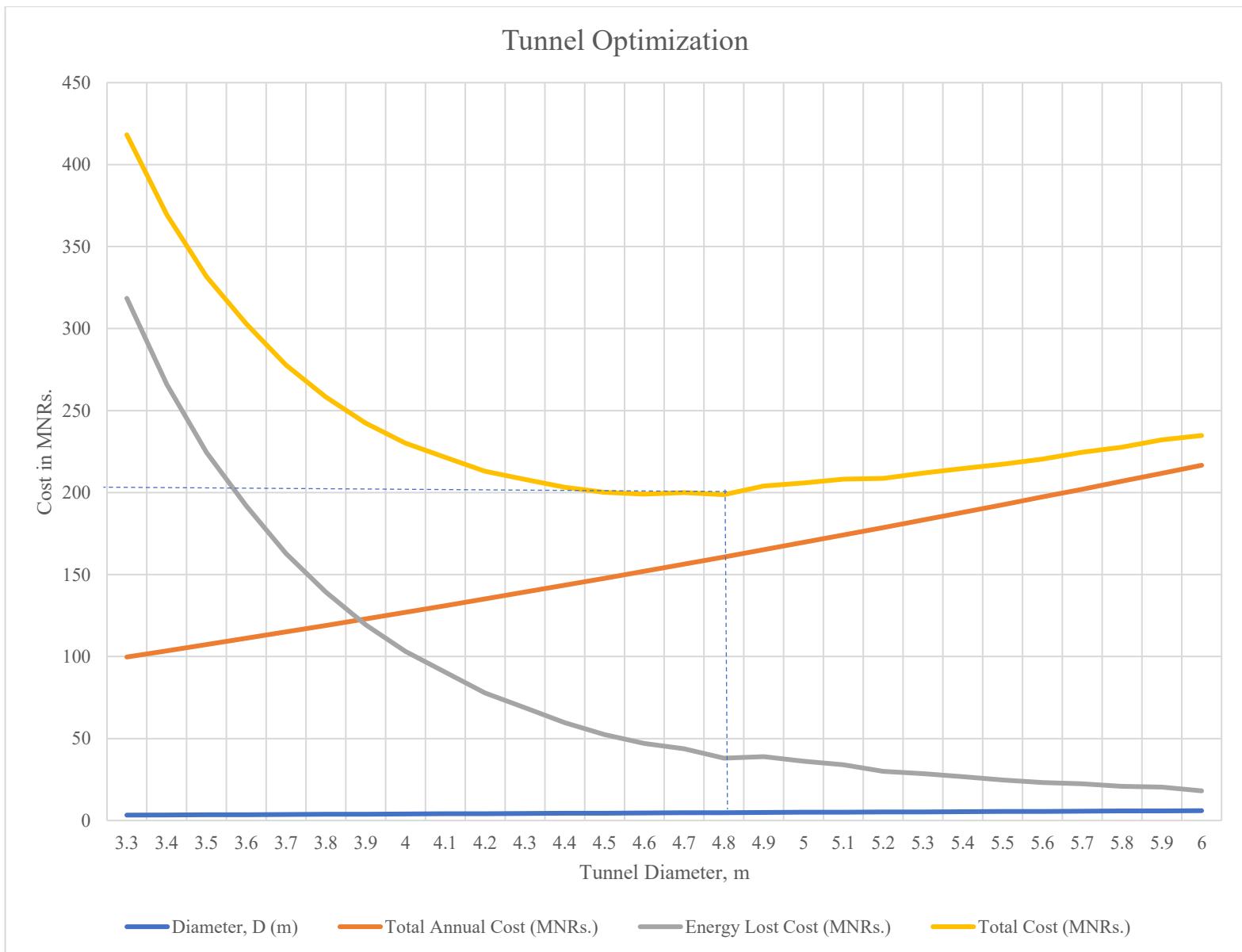
Table D. Total cost calculation for tunnel optimization

Diameter, D (m)	Total Annual Cost (MNRs.)	Energy Lost Cost (MNRs.)	Total Cost (MNRs.)
3.3	99.72	318.47	418.19
3.4	103.48	265.99	369.47
3.5	107.28	224.37	331.65
3.6	111.13	191.80	302.93
3.7	115.02	162.85	277.87
3.8	118.95	139.33	258.28
3.9	122.93	119.43	242.36
4	126.96	103.14	230.10
4.1	131.02	90.47	221.49
4.2	135.14	77.81	212.95
4.3	139.29	68.76	208.05
4.4	143.49	59.71	203.20
4.5	147.73	52.47	200.20
4.6	152.02	47.05	199.07
4.7	156.35	43.68	200.03
4.8	160.72	38.00	198.72
4.9	165.14	38.90	204.04
5	169.61	36.19	205.80
5.1	174.11	34.02	208.13
5.2	178.66	30.04	208.70
5.3	183.26	28.59	211.85
5.4	187.90	26.78	214.68

5.5	192.58	24.75	217.33
5.6	197.30	23.16	220.46
5.7	202.07	22.44	224.51
5.8	206.89	20.81	227.70
5.9	211.75	20.45	232.20
6	216.65	18.09	234.74

Table E. Optimized Tunnel Properties

Optimized Diameter (Dtunnel)	4.8	m
Velocity through tunnel (Vtunnel)	4.8	m/s
Check: For concrete-lined tunnel,		
Critical velocity = 1 m/s	OK	
Average Permissible velocity = 4.5 m/s	OK	
(IS 10430: 2000)		
Total headlosses in tunnel	1.39	m
Slope of tunnel	500	
(Assuming energy grade line is equal to longitudinal slope)	1 in 500	



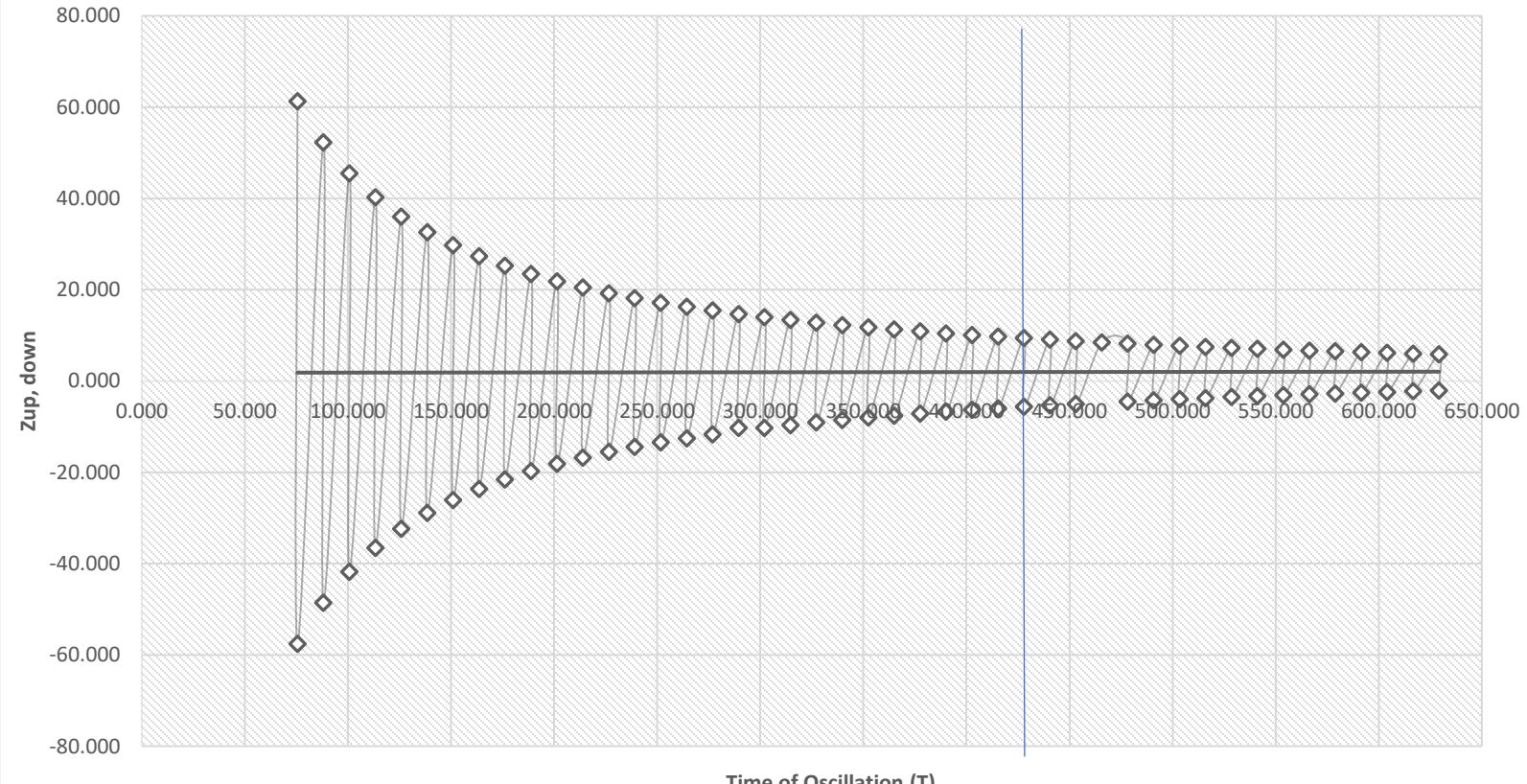
OPTIMIZATION OF SURGE TANK:

Optimization of Surge Shaft														
SN	hf	Area of HRT (A)	length of HRT (L)	Discharge (Q)	Dia. of Surge tank (m)	Ast (m ²)	Zmax	Po	Zup	Zdown	Hst	Available submergence	Time of Oscillation	Remarks
1	2.75	20.57	3050	43.136	3	7.067	63.086	0.044	61.269	- 57.594	118.862	-104.045	75.516	
2	2.75	20.57	3050	43.136	3.5	9.619	54.074	0.051	52.259	- 48.581	100.840	-86.023	88.102	
3	2.75	20.57	3050	43.136	4	12.564	47.315	0.058	45.502	- 41.822	87.324	-72.507	100.688	
4	2.75	20.57	3050	43.136	4.5	15.901	42.058	0.065	40.247	- 36.565	76.811	-61.994	113.275	
5	2.75	20.57	3050	43.136	5	19.631	37.852	0.073	36.043	- 32.359	68.402	-53.585	125.861	
6	2.75	20.57	3050	43.136	5.5	23.754	34.411	0.080	32.604	- 28.918	61.522	-46.705	138.447	
7	2.75	20.57	3050	43.136	6	28.269	31.543	0.087	29.739	- 26.050	55.789	-40.972	151.033	
8	2.75	20.57	3050	43.136	6.5	33.177	29.117	0.094	27.315	- 23.624	50.939	-36.122	163.619	
9	2.75	20.57	3050	43.136	7	38.477	27.037	0.102	25.237	- 21.544	46.781	-31.964	176.205	
10	2.75	20.57	3050	43.136	7.5	44.170	25.235	0.109	23.437	- 19.742	43.179	-28.362	188.791	

11	2.75	20.57	3050	43.136	8	50.256	23.657	0.116	21.862	- 18.165	40.026	-25.209	201.377	
12	2.75	20.57	3050	43.136	8.5	56.734	22.266	0.123	20.473	- 16.773	37.245	-22.428	213.963	
13	2.75	20.57	3050	43.136	9	63.605	21.029	0.131	19.238	- 15.536	34.774	-19.957	226.549	
14	2.75	20.57	3050	43.136	9.5	70.869	19.922	0.138	18.133	- 14.429	32.562	-17.745	239.135	
15	2.75	20.57	3050	43.136	10	78.525	18.926	0.145	17.139	- 13.433	30.572	-15.755	251.721	
16	2.75	20.57	3050	43.136	10.5	86.574	18.025	0.152	16.240	- 12.532	28.772	-13.955	264.307	
17	2.75	20.57	3050	43.136	11	95.015	17.205	0.160	15.423	- 11.713	27.136	-12.319	276.893	
18	2.75	20.57	3050	43.136	11.5	103.849	16.457	0.167	14.677	- 10.964	25.642	-10.825	289.479	
19	2.75	20.57	3050	43.136	12	113.076	15.772	0.174	13.994	- 10.279	24.273	-9.456	302.065	
20	2.75	20.57	3050	43.136	12.5	122.695	15.141	0.181	13.365	-9.648	23.013	-8.196	314.651	
21	2.75	20.57	3050	43.136	13	132.707	14.558	0.189	12.785	-9.066	21.851	-7.034	327.237	
22	2.75	20.57	3050	43.136	13.5	143.112	14.019	0.196	12.248	-8.526	20.774	-5.957	339.824	
23	2.75	20.57	3050	43.136	14	153.909	13.519	0.203	11.750	-8.026	19.775	-4.958	352.410	
24	2.75	20.57	3050	43.136	14.5	165.099	13.052	0.210	11.286	-7.560	18.845	-4.028	364.996	
25	2.75	20.57	3050	43.136	15	176.681	12.617	0.218	10.853	-7.124	17.977	-3.160	377.582	
26	2.75	20.57	3050	43.136	15.5	188.656	12.210	0.225	10.448	-6.717	17.165	-2.348	390.168	
27	2.75	20.57	3050	43.136	16	201.024	11.829	0.232	10.069	-6.336	16.404	-1.587	402.754	
28	2.75	20.57	3050	43.136	16.5	213.784	11.470	0.239	9.712	-5.977	15.690	-0.873	415.340	
29	2.75	20.57	3050	43.136	17	226.937	11.133	0.247	9.377	-5.640	15.017	-0.200	427.926	
30	2.75	20.57	3050	43.136	17.5	240.483	10.815	0.254	9.061	-5.322	14.383	0.434	440.512	

31	2.75	20.57	3050	43.136	18	254.421	10.514	0.261	8.763	-5.022	13.785	1.032	453.098	Trial1
32	2.75	20.57	3050	43.136	18.5	268.752	10.230	0.268	8.481	-4.737	13.219	1.598	465.684	Trial2
33	2.75	20.57	3050	43.136	19	283.475	9.961	0.276	8.214	-4.468	12.682	2.135	478.270	Trial3
34	2.75	20.57	3050	43.136	19.5	298.591	9.706	0.283	7.961	-4.213	12.174	2.643	490.856	Trial4
35	2.75	20.57	3050	43.136	20	314.100	9.463	0.290	7.721	-3.970	11.691	3.126	503.442	Trial-5
36	2.75	20.57	3050	43.136	20.5	330.001	9.232	0.297	7.492	-3.739	11.231	3.586	516.028	Trial-6
37	2.75	20.57	3050	43.136	21	346.295	9.012	0.305	7.274	-3.520	10.794	4.023	528.614	Trial-7
38	2.75	20.57	3050	43.136	21.5	362.982	8.803	0.312	7.067	-3.310	10.377	4.440	541.200	Trial-8
39	2.75	20.57	3050	43.136	22	380.061	8.603	0.319	6.869	-3.110	9.979	4.838	553.787	Trial-9
40	2.75	20.57	3050	43.136	22.5	397.533	8.412	0.327	6.680	-2.919	9.599	5.218	566.373	
41	2.75	20.57	3050	43.136	23	415.397	8.229	0.334	6.500	-2.736	9.235	5.582	578.959	
42	2.75	20.57	3050	43.136	23.5	433.654	8.054	0.341	6.327	-2.561	8.887	5.930	591.545	
43	2.75	20.57	3050	43.136	24	452.304	7.886	0.348	6.161	-2.393	8.554	6.263	604.131	
44	2.75	20.57	3050	43.136	24.5	471.346	7.725	0.356	6.002	-2.232	8.234	6.583	616.717	
45	2.75	20.57	3050	43.136	25	490.781	7.570	0.363	5.850	-2.078	7.928	6.889	629.303	

Oscillation of Water level in Surge Tank



OPTIMIZATION OF PENSTOCK

Assumption Data		
Data	Value	Unit
Design Discharge	43.136	m ³ /s
Length of Pipe	610	m
Overall Efficiency of system	84%	%
Project Life Period	50	years
Interest Rate	10%	%
Capital Recovery Factor	0.110	
Dry season energy rate	8.4	Rs per kWhr
Wet season energy rate	4.8	Rs per kWhr
Dry season outage	5%	%
Wet season outage	5%	%
Environmental flow	10%	%
Pipe material	Galvanized Commercial Steel	
Roughness coefficient of commercial steel	0.15	mm

Month	No of days	Monthly flow (m³/s)	Available Flow (m³/s)	Design Flow (m³/s)	Operating (hrs.)
Jan	31	18.93	17.31	17.31	707
Feb	28	16.79	15.17	15.17	638
Mar	31	16.22	14.60	14.60	707
Apr	30	17.81	16.19	16.19	684
May	31	34.71	33.09	33.09	707
Jun	30	100.55	98.93	43.14	684
Jul	31	212.68	211.06	43.14	707
Aug	31	228.77	227.15	43.14	707
Sep	30	157.95	156.33	43.14	684
Oct	31	66.26	64.64	43.14	707
Nov	30	33.96	32.34	32.34	684
Dec	31	21.49	19.87	19.87	707

Diameter (m)	2.8	2.80	2.85	2.90	2.95	3.00	3.05
Cross Sectional Area (A), m²	6.16	6.16	6.38	6.61	6.83	7.07	7.31
Wetted Perimeter (P), m	8.80	8.80	8.95	9.11	9.27	9.42	9.58
Velocity (v), m/s	7.01	7.01	6.76	6.53	6.31	6.10	5.90
Reynolds Number, Re	19537016.6	19537016.6	19194261.9	18863326.4	18543609.0	18234548.8	17935621.8
e/D	5.35714E-05	5.35714E-05	5.26316E-05	5.17241E-05	5.08475E-05	5.00000E-05	4.91803E-05
f(moody's Diagram)	0.0118	0.0119	0.012	0.0121	0.0122	0.0123	0.0124
Head loss (hf), m	6.43	6.48	5.99	5.53	5.12	4.75	4.41
Gross Head, m	68	68	68	68	68	68	68
hf%	9.46	9.54	8.80	8.14	7.53	6.98	6.48

3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45
7.55	7.79	8.04	8.30	8.55	8.81	9.08	9.35
9.74	9.90	10.05	10.21	10.37	10.52	10.68	10.84
5.72	5.54	5.36	5.20	5.04	4.89	4.75	4.61
17646337.6	17366237.0	17094889.5	16831891.2	16576862.6	16329446.7	16089307.8	15856129.4
4.83871E-05	4.76190E-05	4.68750E-05	4.61538E-05	4.54545E-05	4.47761E-05	4.41176E-05	4.34783E-05
0.0125	0.0126	0.0127	0.0128	0.0129	0.013	0.0131	0.0132
4.09	3.81	3.55	3.31	3.09	2.89	2.70	2.53
68	68	68	68	68	68	68	68
6.02	5.60	5.22	4.87	4.55	4.25	3.98	3.72

3.50	3.55	3.60	3.65	3.70	3.75	3.80	3.85
9.62	9.90	10.18	10.46	10.75	11.04	11.34	11.64
11.00	11.15	11.31	11.47	11.62	11.78	11.94	12.10
4.48	4.36	4.24	4.12	4.01	3.91	3.80	3.71
15629613.3	15409477.9	15195457.3	14987300.4	14784769.3	14587639.0	14395696.4	14208739.3
4.28571E-05	4.22535E-05	4.16667E-05	4.10959E-05	4.05405E-05	4.00000E-05	3.94737E-05	3.89610E-05
0.0133	0.0134	0.0135	0.0136	0.0137	0.0138	0.0139	0.014
2.37	2.23	2.09	1.97	1.85	1.75	1.65	1.55
68	68	68	68	68	68	68	68
3.49	3.28	3.08	2.90	2.72	2.57	2.42	2.28

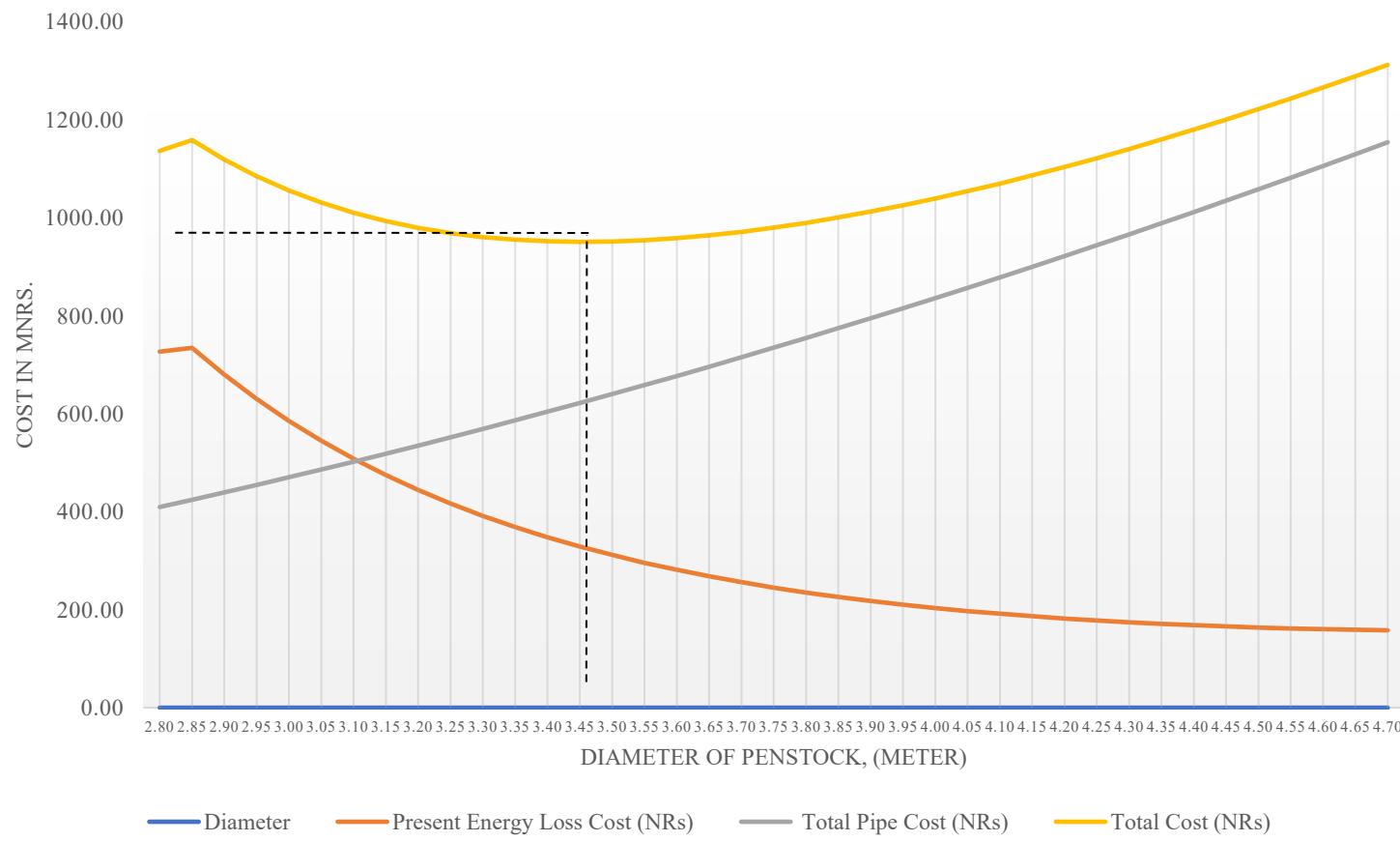
3.90	3.95	4.00	4.05	4.10	4.15	4.20	4.25
11.95	12.25	12.57	12.88	13.20	13.53	13.85	14.19
12.25	12.41	12.57	12.72	12.88	13.04	13.19	13.35
3.61	3.52	3.43	3.35	3.27	3.19	3.11	3.04
14026576.0	13849024.4	13675911.6	13507073.2	13342352.8	13181601.5	13024677.7	12871446.2
3.84615E-05	3.79747E-05	3.75000E-05	3.70370E-05	3.65854E-05	3.61446E-05	3.57143E-05	3.52941E-05
0.0141	0.0142	0.0143	0.0144	0.0145	0.0146	0.0147	0.0148
1.47	1.38	1.31	1.24	1.17	1.11	1.05	1.00

68	68	68	68	68	68	68	68
2.16	2.04	1.93	1.82	1.73	1.64	1.55	1.47
4.30	4.35	4.40	4.45	4.50	4.55	4.60	4.65
14.52	14.86	15.21	15.55	15.90	16.26	16.62	16.98
13.51	13.67	13.82	13.98	14.14	14.29	14.45	14.61
2.97	2.90	2.84	2.77	2.71	2.65	2.60	2.54
12721778.2	12575550.9	12432646.9	12292954.3	12156365.9	12022779.4	11892097.0	11764225.0
3.48837E-05	3.44828E-05	3.40909E-05	3.37079E-05	3.33333E-05	3.29670E-05	3.26087E-05	3.22581E-05
0.0149	0.015	0.0151	0.0152	0.0153	0.0154	0.0155	0.0156
0.95	0.90	0.86	0.82	0.78	0.74	0.71	0.67
68	68	68	68	68	68	68	68
1.40	1.33	1.26	1.20	1.14	1.09	1.04	0.99

Diameter	Present Energy Loss Cost (NRs)	Total Pipe Cost (NRs)	Total Cost (NRs)
2.80	726423463	409452424	1135875887
2.85	734202519	424206290	1158408809
2.90	679443112	439221287	1118664399
2.95	629974199	454497413	1084471612
3.00	585223193	470034671	1055257864
3.05	544688352	485833058	1030521410
3.10	507928998	501892576	1009821574
3.15	474557220	518213224	992770444
3.20	444230821	534795003	979025824
3.25	416647300	551637912	968285212
3.30	391538706	568741951	960280657
3.35	368667227	586107121	954774348
3.40	347821403	603733421	951554824

3.45	328812858	621620852	950433710
3.50	311473482	639769413	951242895
3.55	295652990	658179104	953832094
3.60	281216810	676849926	958066736
3.65	268044238	695781878	963826116
3.70	256026845	714974960	971001805
3.75	245067073	734429173	979496246
3.80	235077016	754144516	989221532
3.85	225977350	774120989	1000098339
3.90	217696393	794358593	1012054986
3.95	210169283	814857328	1025026611
4.00	203337243	835617192	1038954435
4.05	197146949	856638187	1053785136
4.10	191549957	877920313	1069470270
4.15	186502205	899463568	1085965773
4.20	181963565	921267954	1103231519
4.25	177897452	943333471	1121230923
4.30	174270470	965660118	1139930588
4.35	171052102	988247895	1159299997
4.40	168214429	1011096803	1179311232
4.45	165731885	1034206840	1199938725
4.50	163581030	1057578009	1221159039
4.55	161740355	1081210308	1242950663
4.60	160190100	1105103737	1265293837
4.65	158912095	1129258296	1288170391
4.70	157889620	1153673986	1311563606

Penstock Optimization



ANNEX E: COST ESTIMATION

EXCAVATION OF EARTH SOIL (SOFT SOIL)

S.No	Description	Unit	Quantity	Unit Rate (NRs)	Amount (NRs)	Remarks
A	Manpower					
	Operator	Hr	0.03	150.00	4.50	
	Driver	Hr	25% of Operator Cost		1.13	
				Sub Total	5.63	
B	Materials					
	Diesel	Ltr.	0.54	143.00	77.65	
	Lubricant	Ltr.	25% of Diesel Cost		19.41	
	Diesel for Dump Truck	Ltr.	25% of Diesel Cost		19.41	
				Sub Total	116.47	
C	Equipment					
	Excavator	Hr.	0.02	2500.00	50.00	
	Dump Truck	Hr.	20% of Excavator Cost		10.00	
				Sub Total	60.00	
D	Others				10.00	
				Sub Total	10.00	
E	Sub Total of (A+B+C+D)				192.10	
F	Contractor Overhead and Profit		@	0.15	28.82	
G	Total of (E+F)				220.92	
	Rate per Unit				220.92	

Earthwork Excavation in Common Material including disposal

S.No	Description	Unit	Quantity	Unit Rate	Amount	Remarks
A	Manpower					
	Skilled					

	Unskilled		0.75	700.00	525.00	
					0.00	
				Sub Total	525.00	
B	Materials					
				Sub Total	0.00	
C	Equipment					
	Add 3% for Tools and Plants				14.63	
				Sub Total	14.63	
D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				539.63	
F	Contractor Overhead and Profit	@	0.15	80.94		
G	Total of (E+F)			620.57		
	Rate per Unit			620.57		

Earthwork Excavation with boulder mix soil including disposal

S.No	Description	Unit	Quantity	Unit Rate	Amount	Remarks
A	Manpower					
	Operator	Hr	0.03	150.00	4.66	
	Driver	Hr	25% of Operator Cost		1.16	

				Sub Total	5.82	
B	Materials					
	Diesel	Ltr.	0.78	143.00	111.00	
	Lubricant	Ltr.	25% of Diesel Cost		27.75	
	Diesel for Dump Truck	Ltr.	25% of Diesel Cost		27.75	
				Sub Total	166.50	
C	Equipment					
	Excavator	Hr.	0.03	2500.00	77.62	
	Dump Truck	Hr.	20% of Excavator Cost		15.52	
				Sub Total	93.14	
D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				265.46	
F	Contractor Overhead and Profit		@	0.15	39.82	
G	Total of (E+ F)				305.28	
	Rate per Unit				305.28	
	Average				382.26	

PROVIDING AND PLACING M10 CEMENT CONCRETE

S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks
A	Manpower					
	Foreman					
	Skilled		0.50	800.00	400.00	
	Unskilled		3.50	700.00	2450.00	

				Sub Total	2850.00	
B	Materials					
	Cement	Bag	0.22	16000.00	3520.00	
	Coarse Sand	Cu.m..	0.48	2040.42	979.40	
	Coarse Aggregates 40mm down	Cu.m..	0.65	1940.42	1261.27	
	Coarse Aggregates 20mm down	Cu.m..	0.25	1940.42	485.10	
	Petrol	Ltr.	0.10	159.00	15.90	
	Diesel	Ltr.	3.00	143.00	429.00	
				Sub Total	6690.68	
C	Equipment					
	Mixture	Hr.	0.60	1860.00	1116.00	
	Vibrator	Hr.	0.25	100.00	25.00	
				Sub Total	1141.00	
D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				10681.68	
F	Contractor Overhead and Profit	@	0.15		1602.25	
G	Total of (E+ F)				12283.93	
	Rate per Unit				12283.93	
Providing and Placing M15 Cement Concrete						
S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks

A	Manpower					
	Foreman					
	Skilled		0.50	800.00	400.00	
	Unskilled		3.50	700.00	2450.00	
				Sub Total	2850.00	
B	Materials					
	Cement	Bag	0.26	16000.00	4160.00	
	Coarse Sand	Cu.m..	0.46	2040.42	938.59	
	Coarse Aggregates 40mm down	Cu.m..	0.53	1940.42	1028.42	
	Coarse Aggregates 20mm down	Cu.m..	0.24	1940.42	465.70	
	Coarse Aggregates 10mm down	Cu.m..	0.11	2140.42	235.45	
	Petrol	Ltr.	0.10	159.00	15.90	
	Diesel	Ltr.	3.00	143.00	429.00	
				Sub Total	7273.06	
C	Equipment					
	Mixture	Hr.	0.60	1860.00	1116.00	
	Vibrator	Hr.	0.25	100.00	25.00	
				Sub Total	1141.00	
D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				11264.06	
F	Contractor Overhead and Profit		@	0.15	1689.61	
G	Total of (E+ F)				12953.67	

	Rate per Unit				12953.67	
Providing and Placing M20 Cement Concrete						
S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks
A	Manpower					
	Foreman					
	Skilled		0.80	800.00	640.00	
	Unskilled		6.00	700.00	4200.00	
				Sub Total	4840.00	
B	Materials					
	Cement	Bag	0.32	16000.00	5120.00	
	Coarse Sand	m3	0.45	2040.42	918.19	
	Coarse Aggregates 40mm down	m3	0.52	1940.42	1009.02	
	Coarse Aggregates 20mm down	m3	0.22	1940.42	426.89	
	Coarse Aggregates 10mm down	m3	0.12	2140.42	256.85	
	Petrol	Lit.	0.10	159.00	15.90	
	Diesel	Lit.	3.00	143.00	429.00	
				Sub Total	8175.85	
C	Equipment					
	Mixture	Hr.	0.60	1860.00	1116.00	
	Vibrator	Hr.	0.25	100.00	25.00	
				Sub Total	1141.00	
D	Others					

				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				14156.85	
F	Contractor Overhead and Profit		@	0.15	2123.53	
G	Total of (E+F)				16280.38	
	Rate per Unit				16280.38	

Providing and Placing M25 Cement Concrete

S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks
A	Manpower					
	Foreman					
	Skilled		0.80	800.00	640.00	
	Unskilled		6.00	700.00	4200.00	
				Sub Total	4840.00	
B	Materials					
	Cement	Bag	0.38	16000.00	6000.00	
	Coarse Sand	Cu.m..	0.45	2040.42	918.19	
	Coarse Aggregates 20mm down	Cu.m..	0.58	1940.42	1125.44	
	Coarse Aggregates 10mm down	Cu.m..	0.30	2140.42	642.13	
	Petrol	Ltr.	0.10	159.00	15.90	
	Diesel	Ltr.	3.00	143.00	429.00	
				Sub Total	9130.65	
C	Equipment					
	Mixture	Hr.	0.60	1860.00	1116.00	
	Vibrator	Hr.	0.25	100.00	25.00	
				Sub Total	1141.00	

D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				15111.65	
F	Contractor Overhead and Profit		@	0.15	2266.75	
G	Total of (E+ F)				17378.40	
	Rate per Unit				17378.40	
	Average				14724.09	

FLOOD WALL: PANEL 19 BASE SLAB

Time	8:30 AM to 10:00 PM						
Duration	13 Hours 30 Minutes	13.50					
Quantity	121.46	cubic meter					
Rate Analysis							
S.N.	Description	Quantity	Unit	Rate (Rs.)	Unit	Cost	Remarks
A	Equipments						
1	Concrete Pump	1	Nos	550	per hour	7425	
2	Vibrator	2	Nos	250	Lump Sum	500	
3	Batching Plant	1	Nos	1000	per cubic meter	121460	
4	Transit Mixer	2	Nos	2500	per hour	67500	
5	Backhoe	1	Nos	3000	per hour	40500	
6	Miscellaneous	1	Nos	400	Lump Sum	400	Water Pump (200), Electricity (200)
B	Manpower						

1	Surveyor	2	Nos				
2	Electrician	1	Nos	200	Lump Sum	200	
3	Concrete Pump Operator	1	Nos				
4	Batching Plant Operator	1	Nos				
5	Lab Technician	1	Nos	200	Lump Sum	200	
6	Backhoe Operator	1	Nos				
7	Transit Mixer Operator	2	Nos				
8	Foreman	1	Nos	150	per hour	2025	
9	Skilled Workers	4	Nos	120	per hour	6480	
10	Unskilled Workers	9	Nos	90	per hour	10935	2 in Concrete Pump, 2 in Cement Hopper, 2 in Batching Plant Hopper
C	Construction Materials						
1	Cement	923	Bags	900	per Bag	830814	
2	Sand	54	Cubic Meter	1800	per cubic meter	96336	
3	Aggregate (5mm to 10mm)	46	Cubic Meter	1600	per cubic meter	72878	
4	Aggregate (10mm to 20mm)	36	Cubic Meter	1600	per cubic meter	57088	
5	Aggregate (20mm to 40mm)	13	Cubic Meter	1600	per cubic meter	20006	
Total Cost						1334747	
15% Increment						1534959	
Cost for per Cubic Meter Concreting						12638	

PROVIDING, FIXING AND REMOVING FORMWORKS FOR CONCRETING WORKS.

S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks
	Analysis based on 10 Sq.m..					
A	Manpower					
	Carpenter		2.60	800.00	2080.00	
	Unskilled Labour		2.80	700.00	1960.00	
				Sub Total	4040.00	
B	Materials					
	Plywood	Sq.m.	1.40	696.49	975.08	
	Struts, bellies	m3	0.50	41456.63	1727.36	
	Nails	Kg	3.50	112.00	392.00	
	Lubrication of Formwork Surface				50.00	
				Sub Total	3144.44	
C	Equipment					
				Sub Total	0.00	
D	Others					
				Sub Total	0.00	
E	Sub Total of (A+B+C+D)				7184.44	
F	Contractor Overhead and Profit	@		0.15	1077.67	
G	Total of (E+ F)				8262.11	
	Rate per Unit				826.21	per sqm

FLOOD WALL: PANEL 19 BASE SLAB

Time	8:00 PM to 4:00 AM						
Duration	8 Hours	8.00					
Area	18.681	Sq. meter					

Rate Analysis							
S.N.	Description	Quantity	Unit	Rate (Rs.)	Unit	Cost	Remarks
A	Equipments						
1	Electric Saw	1	Nos	550	per hour	4400	
2	Drilling Machine	2	Nos	250	Lump Sum	500	
6	Miscellaneous	1	Nos	400	Lump Sum	500	Electricity (200)
B	Manpower						
8	Foreman	1	Nos	150	per hour	1200	
9	Skilled Workers	2	Nos	120	per hour	1920	
10	Unskilled Workers	3	Nos	90	per hour	2160	
C	Materials						
1	Plywood	1040	Bags	900	per Sq. Meter	935712	
	Wooden Beam Bars						
	Mobil						
2	Nails	60	Cubic Meter	1800	per cubic meter	108500	
3	Tie Rods	51	Cubic Meter	1600	per cubic meter	82080	
4	Scaffoldings	40	Cubic Meter	1600	per cubic meter	64296	
5	Hydro Seal	14	Cubic Meter	1600	per cubic meter	22532	
Total Cost						1223799	
15% Increment						1407369	
Cost for per Square Meter						75337	

REINFORCEMENT STEEL WORKS

S.No	Description	Unit	Quantity	Unit Rate	Amount (NRs)	Remarks
A	Manpower					
	Foreman					
	Skilled-Bar bender		10.8	800	8640	

	Unskilled		10.8	700	7560	
				Sub Total	16200	
B	Materials					
	Reinforcement Steel Bar	MT	1.15	77000	88550	
	Binding Wire	Kg	9.6	112	1075.2	
					0	
				Sub Total	89625.2	
C	Equipment					
				Sub Total	0	
D	Others					
				Sub Total	0	
E	Sub Total of (A+B+C+D)				105825.2	
F	Contractor Overhead and Profit	@	0.15	15873.78		
G	Total of (E+F)			121698.98	per MT	
	Rate per Unit			121.69898	per kg	

FLOOD WALL: PANEL 18 BASE SLAB

Time	3 Days						
Duration	36 Hours	36.00					
Quantity	12000	Kg					
Rate Analysis							
S.N.	Description	Quantity	Unit	Rate (Rs.)	Unit	Cost	Remarks

A	Equipments						
2	Electric Rebar Cutter	1	Nos	300	Lump Sum	300	
6	Electricity	1	Nos	200	Lump Sum	200	Electricity (200)
B	Manpower						
8	Foreman	1	Nos	150	per hour	5400	
9	Skilled Workers	3	Nos	120	per hour	12960	
10	Unskilled Workers	7	Nos	90	per hour	22680	
C	Materials						
1	Steel Rebars (Fe 500)	12000	Kg	100	per Kg	1200000	
2	Miscellaneous	50	Kg	80	per Kg	4000	Binding Wire
Total Cost						1245540	
15% Increment						1432371	
Cost of Working per Kg						119	

QUANTITY CALCULATION SHEET (EXCAVATION)

Site: Weir and undersluice

Location: Headworks

Description: Cutting and Filling for Weir and Undersluice

S.N.	Description of Work	Chainage (m)		Area (m ²)		Average Area (m ²)	Distance (m)	Quantity (m ³)	Remarks
		A1	A2	A1	A2				
1.00	Excavation	0+000	0+002	142.91	142.64	142.78	2.00	285.55	
2.00	Excavation	0+002	0+004	143.14	143.02	143.08	2.00	286.16	
3.00	Excavation	0+004	0+006	142.61	140.65	141.63	2.00	283.26	
4.00	Excavation	0+006	0+008	144.13	143.33	143.73	2.00	287.46	
5.00	Excavation	0+008	0+010	144.22	142.95	143.59	2.00	287.18	
6.00	Excavation	0+010	0+012	140.01	141.82	140.92	2.00	281.84	
7.00	Excavation	0+012	0+014	143.29	144.25	143.77	2.00	287.54	

8.00	Excavation	0+014	0+016	140.00	142.59	141.30	2.00	282.60	
9.00	Excavation	0+016	0+018	143.24	144.34	143.79	2.00	287.58	
10.00	Excavation	0+018	0+020	142.89	144.29	143.59	2.00	287.18	
11.00	Excavation	0+020	0+022	141.69	143.97	142.83	2.00	285.66	
12.00	Excavation	0+022	0+024	140.81	143.71	142.26	2.00	284.52	
13.00	Excavation	0+024	0+026	143.97	143.09	143.53	2.00	287.06	
14.00	Excavation	0+026	0+028	141.85	141.47	141.66	2.00	283.32	
15.00	Excavation	0+028	0+030	142.91	143.81	143.36	2.00	286.72	
16.00	Excavation	0+030	0+032	141.05	143.45	142.25	2.00	284.50	
17.00	Excavation	0+032	0+034	143.47	141.22	142.35	2.00	284.70	
18.00	Excavation	0+034	0+036	142.05	143.51	142.78	2.00	285.56	
19.00	Excavation	0+036	0+038	141.08	140.69	140.89	2.00	281.78	
20.00	Excavation	0+038	0+040	144.45	149.88	147.17	2.00	294.34	
21.00	Excavation	0+040	0+042	147.52	149.16	148.34	2.00	296.68	
22.00	Excavation	0+042	0+044	147.16	150.63	148.90	2.00	297.80	
23.00	Excavation	0+044	0+046	144.78	149.84	147.31	2.00	294.62	
24.00	Excavation	0+046	0+048	146.29	151.43	148.86	2.00	297.72	
25.00	Excavation	0+048	0+050	144.97	151.35	148.16	2.00	296.32	
26.00	Excavation	0+050	0+052	145.76	151.91	148.84	2.00	296.68	
27.00	Excavation	0+052	0+054	145.84	148.41	147.13	2.00	294.26	
28.00	Excavation	0+054	0+056	144.99	151.30	148.15	2.00	296.30	
29.00	Excavation	0+056	0+058	145.95	149.10	147.53	2.00	295.06	
30.00	Excavation	0+058	0+060	147.44	149.80	148.62	2.00	297.24	
31.00	Excavation	0+060	0+062	148.13	149.65	148.89	2.00	297.78	
32.00	Excavation	0+062	0+064	147.16	151.88	149.52	2.00	299.04	
33.00	Excavation	0+064	0+066	146.51	150.99	148.75	2.00	297.50	
34.00	Excavation	0+066	0+068	146.37	150.50	148.44	2.00	296.88	
35.00	Excavation	0+068	0+070	147.31	150.31	148.81	2.00	297.62	

36.00	Excavation	0+070	0+072	147.15	150.39	148.77	2.00	297.54	
37.00	Excavation	0+072	0+074	145.55	151.35	148.45	2.00	296.90	
38.00	Excavation	0+074	0+076	145.25	151.18	148.22	2.00	296.44	
39.00	Excavation	0+076	0+078	147.51	148.81	148.16	2.00	296.32	
40.00	Excavation	0+078	0+080	146.46	150.39	148.43	2.00	296.86	
41.00	Excavation	0+080	0+082	145.89	149.28	147.59	2.00	295.18	
42.00	Excavation	0+082	0+084	144.49	151.44	147.63	2.00	295.26	
43.00	Excavation	0+084	0+086	144.55	148.58	146.70	2.00	293.40	
44.00	Excavation	0+086	0+088	144.87	148.52	148.85	2.00	297.70	
45.00	Excavation	0+088	0+090	147.97	150.49	148.59	2.00	297.18	
46.00	Excavation	0+090	0+092	147.64	149.55	148.67	2.00	297.34	
47.00	Excavation	0+092	0+094	147.04	150.29	147.01	2.00	294.02	
48.00	Excavation	0+094	0+096	145.03	148.97	148.58	2.00	297.16	
49.00	Excavation	0+096	0+098	146.26	150.89	147.74	2.00	295.48	
50.00	Excavation	0+098	0+100	146.86	148.61	149.51	2.00	299.02	
51.00	Excavation	0+100	0+102	147.81	151.20	151.23	2.00	302.46	
52.00	Excavation	0+102	0+104	151.66	150.80	149.84	2.00	299.68	
53.00	Excavation	0+104	0+106	149.54	150.13	149.37	2.00	298.74	
54.00	Excavation	0+106	0+108	148.41	150.33	150.04	2.00	300.08	
55.00	Excavation	0+108	0+110	151.67	148.41	149.81	2.00	299.62	
56.00	Excavation	0+110	0+112	150.30	149.32	149.70	2.00	299.40	
57.00	Excavation	0+112	0+114	149.75	149.65	149.63	2.00	299.26	
58.00	Excavation	0+114	0+116	150.60	148.66	149.61	2.00	299.22	
59.00	Excavation	0+116	0+118	149.15	150.94	150.89	2.00	301.78	
60.00	Excavation	0+118	0+120	150.25	151.53	150.89	2.00	301.78	
61.00	Excavation	0+120	0+122	150.23	148.82	149.32	2.00	298.64	
62.00	Excavation	0+122	0+124	151.32	151.23	151.28	2.00	302.56	
63.00	Excavation	0+124	0+126	150.37	148.27	149.32	2.00	298.64	

64.00	Excavation	0+126	0+128	148.37	149.86	149.12	2.00	298.24	
65.00	Excavation	0+128	0+130	151.89	150.32	151.11	2.00	302.22	
66.00	Excavation	0+130	0+132	149.66	149.29	149.48	2.00	298.96	
67.00	Excavation	0+132	0+134	149.41	151.07	150.24	2.00	300.48	
68.00	Excavation	0+134	0+136	151.35	149.27	149.99	2.00	299.98	
69.00	Excavation	0+136	0+138	149.62	149.23	149.43	2.00	298.86	
70.00	Excavation	0+138	0+140	148.31	151.68	150.21	2.00	300.42	
71.00	Excavation	0+140	0+142	148.76	151.67	149.38	2.00	298.76	
72.00	Excavation	0+142	0+144	149.51	149.25	149.47	2.00	298.94	
73.00	Excavation	0+144	0+146	149.57	150.90	150.46	2.00	300.92	
74.00	Excavation	0+146	0+148	151.69	149.23	150.58	2.00	301.16	
75.00	Excavation	0+148	0+150	150.03	151.14	150.46	2.00	300.92	
Total Payable Quantity								22113.53	

Site: Intake

Location: Headworks

Description: Cutting and Filling for Intake

S.N.	Description of Work	Chainage (m)		Area (m ²)		Average Area (m ²)	Distance (m)	Quantity (m ³)	Remarks
		A1	A2	A1	A2				
1.00	Excavation	0+000	0+001	38.56	37.05	37.81	1.00	37.81	
2.00	Excavation	0+001	0+002	34.06	34.38	34.22	1.00	34.22	
3.00	Excavation	0+002	0+003	34.18	35.91	35.05	1.00	35.05	
4.00	Excavation	0+003	0+004	35.10	38.32	36.71	1.00	36.71	
5.00	Excavation	0+004	0+005	37.61	34.84	36.23	1.00	36.23	
6.00	Excavation	0+005	0+006	36.83	34.90	35.87	1.00	35.87	
7.00	Excavation	0+006	0+007	35.81	34.77	35.29	1.00	35.29	
8.00	Excavation	0+007	0+008	37.43	33.02	35.23	1.00	35.23	
9.00	Excavation	0+008	0+009	33.67	33.24	33.46	1.00	33.46	

10.00	Excavation	0+009	0+010	33.34	37.61	35.48	1.00	35.48	
Total Payable Quantity								355.32	

CONCRETE QUANTITY CALCULATION SHEET

Weir and Undersluice

Hongshi OPC 53 Grade Cement (For 1 cubic meter)			
	Material	Value	Unit
1	Cement	380	Kg
2	Sand	705	Kg
3	Aggregate (20 to 40)	525	Kg
4	Aggregate (10 to 20)	470	Kg
5	Aggregate (5 to 10)	175	Kg
6	Water	171	litre (or Kg/m3)
Density Values			
	Material	Value	Unit
1	Cement	1440	Kg/m3
2	Sand	1600	Kg/m3
3	Aggregate (20 to 40)	1400	Kg/m3
4	Aggregate (10 to 20)	1600	Kg/m3
5	Aggregate (5 to 10)	1700	Kg/m3
6	Water		
Ratio Calculation			
	Material	Value	Unit
1	Cement	0.26389	
2	Sand	0.44063	
3	Aggregate (20 to 40)	0.375	
4	Aggregate (10 to 20)	0.29375	
5	Aggregate (5 to 10)	0.10294	
6	Water	171	litre
Sum of Dry Volume		1.476205065	

Quantity Calculation			
	Material	Value	Unit
1	Cement	6647.94	m3
		191461	Bags
2	Sand	11100.3	m3
3	Aggregate (20 to 40)	9447.08	m3
4	Aggregate (10 to 20)	7400.21	m3
5	Aggregate (5 to 10)	2593.31	m3
6	Water	171	litre
Cross Sectional Area		381.7	m2
Width		66	m
Total Quantity of Concrete		25192.2	m3

Weir and Undersluice Walls and Piers

Hongshi OPC 53 Grade Cement (For 1 cubic meter)			
	Material	Value	Unit
1	Cement	380	Kg
2	Sand	705	Kg
3	Aggregate (20 to 40)	525	Kg
4	Aggregate (10 to 20)	470	Kg
5	Aggregate (5 to 10)	175	Kg
6	Water	171	litre (or Kg/m3)

Density Values			
	Material	Value	Unit
1	Cement	1440	Kg/m3
2	Sand	1600	Kg/m3
3	Aggregate (20 to 40)	1400	Kg/m3
4	Aggregate (10 to 20)	1600	Kg/m3
5	Aggregate (5 to 10)	1700	Kg/m3

6	Water		
Ratio Calculation			
	Material	Value	Unit
1	Cement	0.26389	
2	Sand	0.44063	
3	Aggregate (20 to 40)	0.375	
4	Aggregate (10 to 20)	0.29375	
5	Aggregate (5 to 10)	0.10294	
6	Water	171	litre
Sum of Dry Volume		1.476205065	
Quantity Calculation			
	Material	Value	Unit
1	Cement	4330.42	m ³
		124716	Bags
2	Sand	7230.66	m ³
3	Aggregate (20 to 40)	6153.75	m ³
4	Aggregate (10 to 20)	4820.44	m ³
5	Aggregate (5 to 10)	1689.26	m ³
6	Water	171	litre
Area		1367.5	m ²
Height		12	m
Total Quantity of Concrete		16410	m ³

Intake Structure

Hongshi OPC 53 Grade Cement (For 1 cubic meter)			
	Material	Value	Unit
1	Cement	380	Kg
2	Sand	705	Kg

3	Aggregate (20 to 40)	525	Kg
4	Aggregate (10 to 20)	470	Kg
5	Aggregate (5 to 10)	175	Kg
6	Water	171	litre (or Kg/m3)
Density Values			
	Material	Value	Unit
1	Cement	1440	Kg/m3
2	Sand	1600	Kg/m3
3	Aggregate (20 to 40)	1400	Kg/m3
4	Aggregate (10 to 20)	1600	Kg/m3
5	Aggregate (5 to 10)	1700	Kg/m3
6	Water		
Ratio Calculation			
	Material	Value	Unit
1	Cement	0.26389	
2	Sand	0.44063	
3	Aggregate (20 to 40)	0.375	
4	Aggregate (10 to 20)	0.29375	
5	Aggregate (5 to 10)	0.10294	
6	Water	171	litre
Sum of Dry Volume		1.476205065	
Quantity Calculation			
	Material	Value	Unit
1	Cement	1813.02	m3
		52215	Bags
2	Sand	3027.27	m3
3	Aggregate (20 to 40)	2576.4	m3
4	Aggregate (10 to 20)	2018.18	m3

5	Aggregate (5 to 10)	707.247	m3
6	Water	171	litre
	Area	687.04	m2
	Width	10	m
	Total Quantity of Concrete	6870.4	m3

Intake Walls and Piers

Hongshi OPC 53 Grade Cement (For 1 cubic meter)			
	Material	Value	Unit
1	Cement	380	Kg
2	Sand	705	Kg
3	Aggregate (20 to 40)	525	Kg
4	Aggregate (10 to 20)	470	Kg
5	Aggregate (5 to 10)	175	Kg
6	Water	171	litre (or Kg/m3)
Density Values			
	Material	Value	Unit
1	Cement	1440	Kg/m3
2	Sand	1600	Kg/m3
3	Aggregate (20 to 40)	1400	Kg/m3
4	Aggregate (10 to 20)	1600	Kg/m3
5	Aggregate (5 to 10)	1700	Kg/m3
6	Water		
Ratio Calculation			
	Material	Value	Unit
1	Cement	0.26389	
2	Sand	0.44063	
3	Aggregate (20 to 40)	0.375	

4	Aggregate (10 to 20)	0.29375	
5	Aggregate (5 to 10)	0.10294	
6	Water	171	litre
Sum of Dry Volume		1.476205065	
Quantity Calculation			
	Material	Value	Unit
1	Cement	159.653	m ³
		4598	Bags
2	Sand	266.578	m ³
3	Aggregate (20 to 40)	226.875	m ³
4	Aggregate (10 to 20)	177.719	m ³
5	Aggregate (5 to 10)	62.2794	m ³
6	Water	171	litre
Area		55	m ²
Height		11	m
Total Quantity of Concrete		605	m ³

FORMWORK QUANTITY CALCULATION SHEET

Location: Headworks

Description: Formwork at Headworks					
S.N.	Particular	Concrete Quantity(m ³)	Length of Eqv. Cube (m)	Total Surface Area (m)	Remarks
1	Weir and Undersluice	25192.20	29.31	5156.19	
2	Weir and Undersluice Walls and Piers	16410.00	25.41	3874.57	
3	Intake Structure	6870.40	19.01	2168.40	
4	Intake Walls and Piers	605.00	8.46	429.20	
Grand Total				11628.35	

REINFORCEMENT QUANTITY CALCULATION SHEET

Location: Headworks

Description: Formwork at Headworks					
S.N.	Particular	Concrete Quantity(m3)	Volume of Reinforcement (m3)	Weight of Reinforcement (Kg)	Remarks
1	Barrage and Undersluice	25192.20	251.92	1977587.70	
2	Barrage and Undersluice Walls and Piers	16410.00	164.10	1288185.00	
3	Intake Structure	6870.40	68.70	539326.40	
4	Intake Walls and Piers	605.00	6.05	47492.50	
Total				3852591.60	Kg
				3852.59	Ton

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES OF INTAKE AND GRAVEL TRAP

S.N	Description of Work	No.	Dimensions					Quantities (Q)	Total Quantities	Unit	Rate	Cost
1			Length (m)	Breadth (m)	Depth (m)	Plan Area(m ²)	Sectional Area (m ²)					
	Site clearance											
	Gravel trap		21	7.5		157.500		157.500		m ²		
	Total site clearance							157.500	157.500	m ²	29.460	4639.950
	Earthwork in Excavation											
2	Gravel trap											

	section A-A	1	21				98.300	2064.300		m ³		
	Bottom part	1	21				12.000	252.000		m ³		
	Total Gravel trap	1						2316.300		m ³		
	Total Excavation							2316.300	m ³	383.260	887745.138	
	Binding Concrete(C15)											
3	Gravel Trap	1	21				5.200	109.200	109.200	m ³		
	Total Binding Concrete								109.200		12144.000	1326124.800
	300mm boulder packing											
4	Gravel trap	1	21				5.200	109.200				
	Total boulder packing								109.200	m ³	5739.130	626712.996
	Concrete(C25)											
5	Gravel Trap	1	21	7.5	0.3		2.250	47.250	47.250	m ³		
	Total Concrete								47.250	m ³	12638.000	597145.500
	Formworks											
	Gravel Trap											
	Outside Face	2	21		13			273.000	546.000	m ²		
6	Inside Face	4	21		13			273.000	1092.000	m ²		
	Formworks Total								1965.600	m ³	826.210	1623998.376
	Reinforcement(Total)								14.783	Tons	121700.000	1799048.213
	Total Cost											6865414.973

DETAILS OF MEASUREMENT AND CALCULATION OF QUANTITIES OF APPROACH CANAL

S.N	Description of Work	No.	Dimensions				Quantities (Q)	Total Quantities	Unit	Rate	Cost
			Length (m)	Breadth (m)	Height (m)	Sectional Area (m ²)					
1	Site clearance										
	Canal	2				16		31.300	m ²	29.460	922.098
2	Earthwork in Excavation										
	Canal	2	20.000	1.946	2.351		183.002		m ³		
	Total Excavation							183.002	m ³	1530.120	280014.775
	Backfill							2675.500	m ³	569.870	1524687.185
3	Binding concrete(C15)								m ³		
	Canal	2	20	1.946	2.351	2.89	115.6		m ³		
	Total Binding concrete							115.600	m ³	1397.350	161533.660
4	300 mm boulder packing								m ³		
	Canal	2	20			2.89	57.8		m ³		
	Total boulder packing							57.800	m ³	5739.130	331721.714
5	Concrete (C25)								m ³		
	Base slab	2	20.000			0.520	20.8		m3		
	Shear side Wall 1	2	20.000			1.030	41.2		m ³		
	Shear side Wall 2	2	20.000			1.030	41.2		m ³		
	Total Concrete							103.200	m ³	16677.090	1721075.688
6	Formworks	2	20		11.55		462.000	462.000	m ²	870.000	401940.000
7	Reinforcement(Total)							20.673974	ton	133885.450	2767944.366
	Total Cost										7189839.486

Cost Calculation Sheet					
Location: Headworks					
Description: Formwork at Headworks					
S.N.	Particular	Total Quantity	Rate (Rs.)	Cost (Rs.)	Remarks
1	Excavation	22468.85	383.26	8611409.53	
2	Concreting	49077.60	12638	620242708.80	
3	Formwork	11628.35	826.21	9607461.11	
4	Reinforcement	3852591.60	121.7	468860397.72	
Total Cost of Gravel Trap				6865414.97	
Total Cost Approach Canal				7189839.49	
Total Cost				1121377231.63	

PENSTOCK COST ESTIMATE

1. PENSTOCK ALIGNMENT COST ESTIMATE

SN	Description	Unit	Qty	Rate (NPR)	Amount (NPR)
1.1	Site Clearance	m ²	770	15	11,550.00
	Sub-total				11,550.00
1.2	Pipe Alignment Excavation (Soft Soil - 90%)	m ³	28,372.88	450	12,767,796.00
1.3	Excavation in Boulder Mix Soil (5%)	m ³	1,576.27	600	945,762.00
1.4	Excavation in Hard Rock (5%)	m ³	1,576.27	800	1,261,016.00
1.5	Backfilling with Compaction	m ³	670	400	268,000.00
	Sub-total				15,254,124.00
2.1	Dry Stone Soling	m ³	12.06	1,100.00	13,266.00

2.2	M10 Concrete	m ³	6.03	11,500.00	69,345.00
2.3	Random Rubble Masonry	m ³	62.65	8,500.00	532,525.00
2.4	Gabion Work	m ³	150.75	5,500.00	829,125.00
	Total				16,698,385.00

2. Detailed Cost Estimate – Anchor Block

SN	Description	Item Description	Unit	Quantity	Rate (NPR)	Amount (NPR)
1	Excavation Work					
1.1		Excavation in Soft Soil (90%)	m ³	1,589.82	450	715,419.00
1.2		Excavation in Boulder Mix (5%)	m ³	88.32	600	52,992.00
1.3		Excavation in Hard Rock (5%)	m ³	88.32	800	70,656.00
1.4		Backfilling with Compaction (20%)	m ³	353.29	400	141,316.00
		Subtotal (1)				980,383.00
2	Foundation Preparation					
2.1		Dry Stone Soling	m ³	156.72	1,100.00	172,392.00
		Subtotal (2)				172,392.00
3	Concrete Work					
3.1		M10 Concrete	m ³	78.36	11,500.00	901,140.00
3.2		M15 Concrete	m ³	2,737.02	13,500.00	36,949,770.00
		Subtotal (3)				37,850,910.00
4	Formwork and Reinforcement					

4.1		Formwork	m ²	2,198.90	1,200.00	2,638,680.00
4.2		Reinforcement Steel	MT	109.48	155,000.00	16,969,400.00
		Subtotal (4)				19,608,080.00

TOTAL ESTIMATED COST FOR ANCHOR BLOCK

Description	Amount (NPR)
1. Excavation Work	980,383.00
2. Foundation Preparation	172,392.00
3. Concrete Work	37,850,910.00
4. Formwork & Reinforcement	19,608,080.00
Total Estimated Cost	58,611,765.00

TOTAL COST

S.N.	Descriptions	Amount (NRs)	VAT @ 13% (NRs)	Amount With VAT (NRs)
A	Headworks			
A1	Weir, Under Sluice and Intake	1,10,73,21,980	143,951,858.40	12,51,27,383.40
A2	Desander and Headpond	22,94,12,413.40	29,82,3613.74	25,92,36,027.14
B	Headrace Tunnel (4.8m Dia.)			
B1	Class III rock support	38,85,20,046.05	5,05,07,605.99	43,90,27,652.04
B2	Class IV rock support	50,41,14,877.87	6,55,34,934.12	56,96,49,811.99
C	Surge Tank	5,92,28,561.00	76,99,712.93	6,69,28,273.93
D	Penstock Alignment			
D1	Alignment Excavation	1,66,98,385.00	21,70,789.05	1,88,69,174.05
D2	Anchor Block	5,86,11,765.00	76,19,529.45	6,62,31,294.45
E	Powerhouse			
E1	Powerhouse	1,02,03,06,787.00	13,26,39,882.30	11,52,94,669.30
	Total civil cost	2,04,74,80,421.76	26,61,72,925.98	2,31,53,46,740.52

ANNEX F: FINANCIAL ANALYSIS

TABLE F.1.ENERGY CALCULATION

Months of English Calendar	Seti River Discharge (m³/sec)	Environmental Flow (m³/ sec)	Available Qmax River (m³/ sec)	Max Plant Discharge (Q)m^{3/s}	Head loss	Net Head (m)	Days of Month	Power Output (kW)	Gross Energy (kWh)	Outage & Losses (%)	Deemed Generation & Contract Energy	Winter/Summer Energy	Remarks
Jan	18.93	1.62	17.31	17.31	1.07	66.93	31	10249	7625355	4%	7320341	48151669	33.4 %
Feb	16.79	1.62	15.17	15.17	0.84	67.16	28	9013	6056484	4%	5814225		
Mar	16.22	1.62	14.60	14.60	0.67	67.33	31	8695	6469426	4%	6210649		
Apr	17.81	1.62	16.19	16.19	0.84	67.16	30	9619	6925800	4%	6648768		
May	34.71	1.62	33.09	33.09	1.89	66.11	31	19355	14399873	4%	13823878		
Jun	100.55	1.62	98.93	43.14	4.96	63.04	30	23540	16948800	4%	16270848	95891861	66.6 %
Jul	212.68	1.62	211.06	43.14	4.1	63.90	31	23540	17513760	4%	16813210		
Aug	228.77	1.62	227.15	43.14	4.1	63.90	31	23540	17513760	4%	16813210		
Sep	157.95	1.62	156.33	43.14	4.1	63.90	30	23540	16948800	4%	16270848		
Oct	66.26	1.62	64.64	43.14	4.1	63.90	31	23540	17513760	4%	16813210		
Nov	33.96	1.62	32.34	32.34	2.72	65.28	30	18678	13448475	4%	12910536		
Dec	21.49	1.62	19.87	19.87	1.62	66.38	31	11668	8681050	4%	8333808		
Total Energy							365		150045343		144043530	144043530	100 %
							Pant Factor				74.7%		

TABLE F.2.GROSS REVENUE CALCULATION

				Projected Revenue Statement								
				Escalation @3% for 8 years		1	2	3	4	5	6	7
Months	Meter Energy	Rate	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	Revenue	
		Per										
		(KWhr)	NRs	Year 1	Year2	Year3	Year4	Year5	Year6	Year7	Year8	Year9
Jan	7320341	8.4	61,490,864	63,335,590	65,235,658	67,192,728	69,208,510	71,284,765	73,423,308	75,626,007	77,894,787	
Feb	5814225	8.4	48,839,490	50,304,675	51,813,815	53,368,229	54,969,276	56,618,355	58,316,905	60,066,412	61,868,405	
Mar	6210649	8.4	52,169,452	53,734,535	55,346,571	57,006,968	58,717,177	60,478,693	62,293,053	64,161,845	66,086,700	
Apr	6648768	4.8	31,914,086	32,871,509	33,857,654	34,873,384	35,919,585	36,997,173	38,107,088	39,250,301	40,427,810	
May	13823878	4.8	66,354,614	68,345,253	70,395,610	72,507,479	74,682,703	76,923,184	79,230,880	81,607,806	84,056,040	
Jun	16270848	4.8	72,990,720	75,180,442	77,435,855	79,758,930	82,151,698	84,616,249	87,154,737	89,769,379	92,462,460	
Jul	16813210	4.8	75,423,744	77,686,456	80,017,050	82,417,562	84,890,088	87,436,791	90,059,895	92,761,692	95,544,542	
Aug	16813210	4.8	75,423,744	77,686,456	80,017,050	82,417,562	84,890,088	87,436,791	90,059,895	92,761,692	95,544,542	
Sep	16270848	4.8	72,990,720	75,180,442	77,435,855	79,758,930	82,151,698	84,616,249	87,154,737	89,769,379	92,462,460	
Oct	16813210	4.8	75,423,744	77,686,456	80,017,050	82,417,562	84,890,088	87,436,791	90,059,895	92,761,692	95,544,542	
Nov	12910536	4.8	61,970,573	63,829,690	65,744,581	67,716,918	69,748,426	71,840,878	73,996,105	76,215,988	78,502,468	

Dec	8333808	8.4	70,003,987	72,104,107	74,267,230	76,495,247	78,790,104	81,153,807	83,588,422	86,096,074	88,678,957
Total Net revenue (NRS.)			764,995,739	787,945,611	811,583,979	835,931,499	861,009,444	886,839,727	913,444,919	940,848,266	969,073,714

TABLE F.3. TOTAL CIVIL COST

S.N.	Descriptions	Amount (NRs)	VAT @ 13% (NRs)	Amount With VAT (NRs)
A	Headworks			
A1	Weir, Under Sluice and Intake	1,10,73,21,980	143,951,858.40	12,51,27,383.40
A2	Desander and Headpond	22,94,12,413.40	29,82,3613.74	25,92,36,027.14
B	Headrace Tunnel (4.8m Dia.)			
B1	Class III rock support	38,85,20,046.05	5,05,07,605.99	43,90,27,652.04
B2	Class IV rock support	50,41,14,877.87	6,55,34,934.12	56,96,49,811.99
C	Surge Tank	5,92,28,561.00	76,99,712.93	6,69,28,273.93
D	Penstock Alignment			
D1	Alignment Excavation	1,66,98,385.00	21,70,789.05	1,88,69,174.05
D2	Anchor Block	5,86,11,765.00	76,19,529.45	6,62,31,294.45
E	Powerhouse			
E1	Powerhouse	1,02,03,06,787.00	13,26,39,882.30	11,52,94,669.30
	Total civil cost	2,04,74,80,421.76	26,61,72,925.98	2,31,53,46,740.52

TABLE F.4. PAY BACK PERIOD

PayBack Period Calculation				
Years	Operation and Maintenance Cost (NRs.)	Revenue Generated from energy (NRs.)	Net Cash Flow (NRs.)	Cumulative Cash Flow (NRs.)
0			-6,523,155,536	-6,523,155,536
1	97847333.04	764,995,739.00	667,148,406	-5,856,007,130
2	102739699.7	787,945,611.00	685,205,911	-5,170,801,219
3	107876684.7	811,583,979.00	703,707,294	-4,467,093,924
4	113270518.9	835,931,499.00	722,660,980	-3,744,432,944
5	118934044.9	861,009,444.00	742,075,399	-3,002,357,545
6	124880747.1	886,839,727.00	761,958,980	-2,240,398,565
7	131124784.5	913,444,919.00	782,320,135	-1,458,078,431
8	137681023.7	940,848,266.00	803,167,242	-654,911,188
9	144565074.9	969,073,714.00	824,508,639	169,597,451
10	151793328.6	998,145,926.00	846,352,597	1,015,950,048
11	159382995	1,028,090,304.00	868,707,309	1,884,657,357
12	167352144.8	1,058,933,013.00	891,580,868	2,776,238,225
13	175719752	1,090,701,003.00	914,981,251	3,691,219,476
14	184505739.6	1,123,422,033.00	938,916,293	4,630,135,770

15	193731026.6	1,157,124,694.00	963,393,667	5,593,529,437
16	203417577.9	1,191,838,435.00	988,420,857	6,581,950,294
17	213588456.8	1,227,593,588.00	1,014,005,131	7,595,955,425
18	224267879.7	1,264,421,396.00	1,040,153,516	8,636,108,942
19	235481273.7	1,302,354,037.00	1,066,872,763	9,702,981,705
20	247255337.3	1,341,424,659.00	1,094,169,322	10,797,151,027
21	259618104.2	1,381,667,398.00	1,122,049,294	11,919,200,320
22	272599009.4	1,423,117,420.00	1,150,518,411	13,069,718,731
23	286228959.9	1,465,810,943.00	1,179,581,983	14,249,300,714
24	300540407.9	1,509,785,271.00	1,209,244,863	15,458,545,577
25	315567428.3	1,555,078,829.00	1,239,511,401	16,698,056,978
26	331345799.7	1,601,731,194.00	1,270,385,394	17,968,442,372
27	347913089.7	1,649,783,130.00	1,301,870,040	19,270,312,413
28	365308744.2	1,699,276,624.00	1,333,967,880	20,604,280,292
29	383574181.4	1,750,254,923.00	1,366,680,742	21,970,961,034
30	402752890.4	1,802,762,570.00	1,400,009,680	23,370,970,714

ANNEX G: ECONOMIC ANALYSIS

PROJECT COST SUMMARY

S.N.	Description of work	Amount (NRs)	Coverage %
1	Civil Works	2,047,480,422	38.78
2	Hydro mechanical works	386,560,014	7.32
3	Electro-mechanical	699,680,089	13.25
4	Preliminary Expenses	102,720,056	1.95
5	Vehicles	78,432,046	1.49
6	Project Development Cost	284,000,011	5.38
7	Transmission line cost	343,760,023	6.51
8	Land Aquisition cost	305,280,079	5.78
Total Cost		4,247,912,741	
Contingency		424791274.1	10%
Total Project Cost excluding VAT		4,672,704,015	
Total Project Cost including VAT		5,280,155,536	13%

DETAILS AND ASSUMPTION

Total Construction Period	3	
Economic Life of Project	30	Years
Economic Life of Electromechanical equipment	25	Years
Economic Life of Transmission Line	25	Years
Discount Rate	12	%
Annual Cost of operation and Maintenance	2.5	%
Design Discharge	43.136	m ³ /s
Installed Capacity	22	MW
Gross Head	68	m
Net Head	63.9	m

Head Loss	4.1	m
Wet Months	16th of Jestha to 15th of Mangsir	
Dry Months	16th of Mangsir to 15th of Jestha	
Dry energy rate	8.4	Rs/KWhr
Wet energy rate	4.8	Rs/KWhr
Turbine Efficiency	90	%
Generator Efficiency	97	%
Hydraulic Efficiency	98	%
Transformer Efficiency	98.5	%
Overall efficiency	86	%
Transmission Efficiency	98	%
Riparian Release	10% of minimum flow	
Outage	4	%

DEPRECIATION OF HYDRO MECHANICAL COMPONENTS

Depreciation of Hydro mechanical components = 20%				
End of Year	Opening Balance	Depreciation	Cumulative Depreciation	Closing Balance
1	386,560,013.79	77,312,002.76	77,312,002.76	309,248,011
2	309,248,011.03	61,849,602.21	139,161,604.96	247,398,409
3	247,398,408.82	49,479,681.76	188,641,286.73	197,918,727
4	197,918,727.06	39,583,745.41	228,225,032.14	158,334,982
5	158,334,981.65	31,666,996.33	259,892,028.47	126,667,985
6	126,667,985.32	25,333,597.06	285,225,625.53	101,334,388
7	101,334,388.25	20,266,877.65	305,492,503.18	81,067,511
8	81,067,510.60	16,213,502.12	321,706,005.30	64,854,008
9	64,854,008.48	12,970,801.70	334,676,807.00	51,883,207
10	51,883,206.79	10,376,641.36	345,053,448.36	41,506,565

11	41,506,565.43	8,301,313.09	353,354,761.44	33,205,252
12	33,205,252.34	6,641,050.47	359,995,811.91	26,564,202
13	26,564,201.87	5,312,840.37	365,308,652.29	21,251,361
14	21,251,361.50	4,250,272.30	369,558,924.59	17,001,089
15	17,001,089.20	3,400,217.84	372,959,142.43	13,600,871
16	13,600,871.36	2,720,174.27	375,679,316.70	10,880,697
17	10,880,697.09	2,176,139.42	377,855,456.12	8,704,558
18	8,704,557.67	1,740,911.53	379,596,367.65	6,963,646
19	6,963,646.14	1,392,729.23	380,989,096.88	5,570,917
20	5,570,916.91	1,114,183.38	382,103,280.26	4,456,734
21	4,456,733.53	891,346.71	382,994,626.96	3,565,387
22	3,565,386.82	713,077.36	383,707,704.33	2,852,309
23	2,852,309.46	570,461.89	384,278,166.22	2,281,848
24	2,281,847.57	456,369.51	384,734,535.73	1,825,478
25	1,825,478.05	365,095.61	385,099,631.34	1,460,382

PRELIMINARY EXPENSES (SL METHOD)

Year	Opening Balance	Depreciation	Accumulated Depreciation	Closing Balance
1	102,720,056	10,272,006	10,272,006	92,448,051
2	92,448,051	13,365,000	23,637,006	79,083,051
3	79,083,051	13,365,000	37,002,006	65,718,051
4	65,718,051	13,365,000	50,367,006	52,353,051
5	52,353,051	13,365,000	63,732,006	38,988,051
6	38,988,051	13,365,000	77,097,006	25,623,051
7	25,623,051	13,365,000	90,462,006	12,258,051
8	12,258,051	13,365,000	103,827,006	-1,106,949

9	-1,106,949	13,365,000	117,192,006	-14,471,949
10	-14,471,949	13,365,000	130,557,006	

DEPRECIATION OF ELECTRO MECHANICAL COMPONENTS

Depreciation of Electro mechanical components = 20%				
End of Year	Opening Balance	Depreciation	Cumulative Depreciation	Closing Balance
1	699,680,089.32	139,936,017.86	139,936,017.86	559,744,071
2	559,744,071.46	111,948,814.29	251,884,832.16	447,795,257
3	447,795,257.17	89,559,051.43	341,443,883.59	358,236,206
4	358,236,205.73	71,647,241.15	413,091,124.74	286,588,965
5	286,588,964.59	57,317,792.92	470,408,917.65	229,271,172
6	229,271,171.67	45,854,234.33	516,263,151.99	183,416,937
7	183,416,937.33	36,683,387.47	552,946,539.45	146,733,550
8	146,733,549.87	29,346,709.97	582,293,249.43	117,386,840
9	117,386,839.89	23,477,367.98	605,770,617.41	93,909,472
10	93,909,471.92	18,781,894.38	624,552,511.79	75,127,578
11	75,127,577.53	15,025,515.51	639,578,027.30	60,102,062
12	60,102,062.03	12,020,412.41	651,598,439.70	48,081,650
13	48,081,649.62	9,616,329.92	661,214,769.62	38,465,320
14	38,465,319.70	7,693,063.94	668,907,833.56	30,772,256
15	30,772,255.76	6,154,451.15	675,062,284.72	24,617,805
16	24,617,804.61	4,923,560.92	679,985,845.64	19,694,244
17	19,694,243.68	3,938,848.74	683,924,694.37	15,755,395
18	15,755,394.95	3,151,078.99	687,075,773.36	12,604,316
19	12,604,315.96	2,520,863.19	689,596,636.55	10,083,453
20	10,083,452.77	2,016,690.55	691,613,327.11	8,066,762
21	8,066,762.21	1,613,352.44	693,226,679.55	6,453,410

22	6,453,409.77	1,290,681.95	694,517,361.50	5,162,728
23	5,162,727.82	1,032,545.56	695,549,907.07	4,130,182
24	4,130,182.25	826,036.45	696,375,943.52	3,304,146
25	3,304,145.80	660,829.16	697,036,772.68	2,643,317

DEPRECIATION OF TRANSMISSION LINE

Depreciation of Transmission Line = 5%				
End of Year	Opening Balance	Depreciation	Cumulative Depreciation	Closing Balance
1	343,760,023.12	17,188,001.16	17,188,001.16	326,572,022
2	326,572,021.96	16,328,601.10	33,516,602.25	310,243,421
3	310,243,420.87	15,512,171.04	49,028,773.30	294,731,250
4	294,731,249.82	14,736,562.49	63,765,335.79	279,994,687
5	279,994,687.33	13,999,734.37	77,765,070.16	265,994,953
6	265,994,952.96	13,299,747.65	91,064,817.80	252,695,205
7	252,695,205.32	12,634,760.27	103,699,578.07	240,060,445
8	240,060,445.05	12,003,022.25	115,702,600.32	228,057,423
9	228,057,422.80	11,402,871.14	127,105,471.46	216,654,552
10	216,654,551.66	10,832,727.58	137,938,199.04	205,821,824
11	205,821,824.08	10,291,091.20	148,229,290.25	195,530,733
12	195,530,732.87	9,776,536.64	158,005,826.89	185,754,196
13	185,754,196.23	9,287,709.81	167,293,536.70	176,466,486
14	176,466,486.42	8,823,324.32	176,116,861.02	167,643,162
15	167,643,162.10	8,382,158.10	184,499,019.13	159,261,004
16	159,261,003.99	7,963,050.20	192,462,069.33	151,297,954
17	151,297,953.79	7,564,897.69	200,026,967.02	143,733,056
18	143,733,056.10	7,186,652.81	207,213,619.82	136,546,403
19	136,546,403.30	6,827,320.16	214,040,939.99	129,719,083

20	129,719,083.13	6,485,954.16	220,526,894.14	123,233,129
21	123,233,128.98	6,161,656.45	226,688,550.59	117,071,473
22	117,071,472.53	5,853,573.63	232,542,124.22	111,217,899
23	111,217,898.90	5,560,894.95	238,103,019.16	105,657,004
24	105,657,003.96	5,282,850.20	243,385,869.36	100,374,154
25	100,374,153.76	5,018,707.69	248,404,577.05	95,355,446

DEPRECIATION OF CIVIL COMPONENTS

Depreciation of civil components = 3%				
End of Year	Opening Balance	Depreciation	Cumulative Depreciation	Closing Balance
1	2,047,480,422	61,424,412.65	61,424,412.65	1,986,056,009.11
2	1,986,056,009.11	59,581,680.27	121,006,092.93	1,926,474,328.83
3	1,926,474,328.83	57,794,229.87	178,800,322.79	1,868,680,098.97
4	1,868,680,098.97	56,060,402.97	234,860,725.76	1,812,619,696.00
5	1,812,619,696.00	54,378,590.88	289,239,316.64	1,758,241,105.12
6	1,758,241,105.12	52,747,233.15	341,986,549.79	1,705,493,871.97
7	1,705,493,871.97	51,164,816.16	393,151,365.95	1,654,329,055.81
8	1,654,329,055.81	49,629,871.67	442,781,237.63	1,604,699,184.13
9	1,604,699,184.13	48,140,975.52	490,922,213.15	1,556,558,208.61
10	1,556,558,208.61	46,696,746.26	537,618,959.41	1,509,861,462.35
11	1,509,861,462.35	45,295,843.87	582,914,803.28	1,464,565,618.48
12	1,464,565,618.48	43,936,968.55	626,851,771.83	1,420,628,649.93
13	1,420,628,649.93	42,618,859.50	669,470,631.33	1,378,009,790.43
14	1,378,009,790.43	41,340,293.71	710,810,925.04	1,336,669,496.72
15	1,336,669,496.72	40,100,084.90	750,911,009.95	1,296,569,411.81
16	1,296,569,411.81	38,897,082.35	789,808,092.30	1,257,672,329.46
17	1,257,672,329.46	37,730,169.88	827,538,262.18	1,219,942,159.58

18	1,219,942,159.58	36,598,264.79	864,136,526.97	1,183,343,894.79
19	1,183,343,894.79	35,500,316.84	899,636,843.82	1,147,843,577.94
20	1,147,843,577.94	34,435,307.34	934,072,151.15	1,113,408,270.61
21	1,113,408,270.61	33,402,248.12	967,474,399.27	1,080,006,022.49
22	1,080,006,022.49	32,400,180.67	999,874,579.95	1,047,605,841.81
23	1,047,605,841.81	31,428,175.25	1,031,302,755.20	1,016,177,666.56
24	1,016,177,666.56	30,485,330.00	1,061,788,085.20	985,692,336.56
25	985,692,336.56	29,570,770.10	1,091,358,855.29	956,121,566.47
26	956,121,566.47	28,683,646.99	1,120,042,502.29	927,437,919.47
27	927,437,919.47	27,823,137.58	1,147,865,639.87	899,614,781.89
28	899,614,781.89	26,988,443.46	1,174,854,083.33	872,626,338.43
29	872,626,338.43	26,178,790.15	1,201,032,873.48	846,447,548.28
30	846,447,548.28	25,393,426.45	1,226,426,299.93	821,054,121.83

PAYBACK PERIOD CALCULATION

Years	Operation and Maintenance Cost (NRs.)	Revenue Generated from energy (NRs.)	Net Cash Flow (NRs.)	Cumulative Cash Flow (NRs.)
0			-5,280,155,536	-5,280,155,536
1	79202333.04	764,995,739.00	685,793,406	-4,594,362,130
2	83162449.69	787,945,611.00	704,783,161	-3,889,578,969
3	87320572.18	811,583,979.00	724,263,407	-3,165,315,562
4	91686600.79	835,931,499.00	744,244,898	-2,421,070,664
5	96270930.82	861,009,444.00	764,738,513	-1,656,332,151
6	101084477.4	886,839,727.00	785,755,250	-870,576,901
7	106138701.2	913,444,919.00	807,306,218	-63,270,683
8	111445636.3	940,848,266.00	829,402,630	766,131,947
9	117017918.1	969,073,714.00	852,055,796	1,618,187,742

10	122868814	998,145,926.00	875,277,112	2,493,464,854
11	129012254.7	1,028,090,304.00	899,078,049	3,392,542,904
12	135462867.5	1,058,933,013.00	923,470,146	4,316,013,049
13	142236010.8	1,090,701,003.00	948,464,992	5,264,478,041
14	149347811.4	1,123,422,033.00	974,074,222	6,238,552,263
15	156815201.9	1,157,124,694.00	1,000,309,492	7,238,861,755
16	164655962	1,191,838,435.00	1,027,182,473	8,266,044,228
17	172888760.1	1,227,593,588.00	1,054,704,828	9,320,749,056
18	181533198.1	1,264,421,396.00	1,082,888,198	10,403,637,254
19	190609858	1,302,354,037.00	1,111,744,179	11,515,381,433
20	200140350.9	1,341,424,659.00	1,141,284,308	12,656,665,741
21	210147368.5	1,381,667,398.00	1,171,520,030	13,828,185,770
22	220654736.9	1,423,117,420.00	1,202,462,683	15,030,648,453
23	231687473.8	1,465,810,943.00	1,234,123,469	16,264,771,923
24	243271847.5	1,509,785,271.00	1,266,513,424	17,531,285,346
25	255435439.8	1,555,078,829.00	1,299,643,389	18,830,928,735
26	268207211.8	1,601,731,194.00	1,333,523,982	20,164,452,718
27	281617572.4	1,649,783,130.00	1,368,165,558	21,532,618,275
28	295698451	1,699,276,624.00	1,403,578,173	22,936,196,448
29	310483373.6	1,750,254,923.00	1,439,771,549	24,375,967,998
30	326007542.3	1,802,762,570.00	1,476,755,028	25,852,723,025

PROJECT IRR

Project Cost		5,280,155,536								
Total Revenue		764,995,739								
Year	Cost			Benefit		Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV	
0						-				
1	1584046661		1584046661	0	0	1584046661	1414327376		-1414327376	-1414327376
2	2112062214		2112062214	0	0	-2112062214	1885769834		-1885769834	-3300097210
3	1584046661		1584046661	0	0	-1584046661	1414327376		-1414327376	-4714424586
4		79202333.04	79202333.04	764995739	685793406	685793406	70716368.79	435834107.5	365117738.8	-4349306847
5		83162449.69	83162449.69	787945611.2	704783161.5	704783161.5	74252187.23	447902440.5	373650253.2	-3975656594
6		87320572.18	87320572.18	811583979.5	724263407.3	724263407.3	77964796.59	460282488.9	382317692.3	-3593338901
7		91686600.79	91686600.79	835931498.9	744244898.1	744244898.1	81863036.42	472981087.5	391118051.1	-3202220850
8		96270930.82	96270930.82	861009443.9	764738513	764738513	85956188.24	486005150.3	400048962	-2802171888
9		101084477.4	101084477.4	886839727.2	785755249.8	785755249.8	90253997.65	499361666.5	409107668.8	-2393064219
10		106138701.2	106138701.2	913444919	807306217.8	807306217.8	94766697.53	513057696.2	418290998.7	-1974773221
11		111445636.3	111445636.3	940848266.6	829402630.3	829402630.3	99505032.41	527100365.8	427595333.4	-1547177887
12		117017918.1	117017918.1	969073714.6	852055796.4	852055796.4	104480284	541496862.4	437016578.4	-1110161309
13		122868814	122868814	998145926	875277112	875277112	109704298.2	556254428.3	446550130	-663611178.9
14		129012254.7	129012254.7	1028090304	899078049.1	899078049.1	115189513.1	571380354.1	456190840.9	-207420338
15		135462867.5	135462867.5	1058933013	923470145.4	923470145.4	120948988.8	586881972.3	465932983.5	258512645.5
16		142236010.8	142236010.8	1090701003	948464992.4	948464992.4	126996438.2	602766649.4	475770211.2	734282856.7
17		149347811.4	149347811.4	1123422033	974074222	974074222	133346260.1	619041777.8	485695517.6	1219978374

18		156815201.9	156815201.9	1157124694	1000309492	1000309492	140013573.2	635714766.4	495701193.3	1715679568
19		164655962	164655962	1157124694	992468732.3	992468732.3	147014251.8	630731821.7	483717569.8	2199397137
20		172888760.1	172888760.1	1191838435	1018949675	1018949675	154364964.4	647560939.5	493195975.1	2692593113
21		181533198.1	181533198.1	1227593588	1046060390	1046060390	162083212.6	664790289	502707076.4	3195300189
22		190609858	190609858	1264421396	1073811538	1073811538	170187373.3	682426645.1	512239271.9	3707539461
23		200140350.9	200140350.9	1302354038	1102213687	1102213687	178696741.9	700476724.2	521779982.3	4229319443
24		210147368.5	210147368.5	1341424659	1131277290	1131277290	187631579	718947169.7	531315590.7	4760635034
25		220654736.9	220654736.9	1381667399	1161012662	1161012662	197013158	737844535.8	540831377.8	5301466412
26		231687473.8	231687473.8	1423117421	1191429947	1191429947	206863815.9	757175270.4	550311454.5	5851777866
27		243271847.5	243271847.5	1465810943	1222539096	1222539096	217207006.7	776945696.9	559738690.3	6411516556
28		255435439.8	255435439.8	1509785272	1254349832	1254349832	228067357	797161994.7	569094637.7	6980611194
29		268207211.8	268207211.8	1555078830	1286871618	1286871618	239470724.8	817830177.8	578359452.9	7558970647
30		281617572.4	281617572.4	1601731195	1320113622	1320113622	251444261.1	838956072.4	587511811.4	8146482458
Total		4329922360	9610077896	30650037742	26320115382		8580426693	16726909151	8146482458	

Year	IRR	B/C ratio	NPV
10	0%	0.85	-1974773221
20	11.41%	1.46	2692593113
30	13%	1.96	8146482458

COST INCREASE BY 5%

Project Cost		5,544,163,313									
Total Revenue		764,995,739									
Year	Cost			Benefit		Cash flow	Present Value			Cumulative Discounted Cash Flow	
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV		
0											
1	1663248994		1663248994	0	0	1663248994	1485043745		1485043745	1485043745	
2	2217665325		2217665325	0	0	2217665325	1980058326		1980058326	3465102071	
3	1663248994		1663248994	0	0	1663248994	1485043745		1485043745	4950145815	
4		83162449.69	83162449.69	764995739	681833289	681833289	74252187.23	433317381.8	359065194.6	4591080620	
5		87320572.18	87320572.18	787945611.2	700625039	700625039	77964796.59	445259878.5	367295081.9	4223785539	
6		91686600.79	91686600.79	811583979.5	719897378.7	719897378.7	81863036.42	457507798.8	375644762.4	3848140776	
7		96270930.82	96270930.82	835931498.9	739660568.1	739660568.1	85956188.24	470067662.9	384111474.7	3464029302	
8		101084477.4	101084477.4	861009443.9	759924966.5	759924966.5	90253997.65	482946054.4	392692056.8	3071337245	
9		106138701.2	106138701.2	886839727.2	780701025.9	780701025.9	94766697.53	496149615.8	401382918.3	2669954326	
10		111445636.3	111445636.3	913444919	801999282.7	801999282.7	99505032.41	509685043	410180010.6	2259774316	
11		117017918.1	117017918.1	940848266.6	823830348.4	823830348.4	104480284	523559080	419078795.9	1840695520	
12		122868814	122868814	969073714.6	846204900.5	846204900.5	109704298.2	537778512.3	428074214.1	1412621306	
13		129012254.7	129012254.7	998145926	869133671.3	869133671.3	115189513.1	552350160.6	437160647.5	975460658.3	

14		135462867.5	135462867.5	1028090304	892627436.3	892627436.3	120948988.8	567280873.1	446331884.3	-529128774
15		142236010.8	142236010.8	1058933013	916697002.1	916697002.1	126996438.2	582577517.2	455581079	-73547695.04
16		149347811.4	149347811.4	1090701003	941353191.9	941353191.9	133346260.1	598246971.6	464900711.5	391353016.4
17		156815201.9	156815201.9	1123422033	966606831.4	966606831.4	140013573.2	614296116.1	474282542.9	865635559.4
18		164655962	164655962	1157124694	992468732.3	992468732.3	147014251.8	630731821.7	483717569.8	1349353129
19		172888760.1	172888760.1	1157124694	984235934.2	984235934.2	154364964.4	625499729.6	471134765.2	1820487894
20		181533198.1	181533198.1	1191838435	1010305237	1010305237	162083212.6	642067242.9	479984030.2	2300471925
21		190609858	190609858	1227593588	1036983730	1036983730	170187373.3	659021907.6	488834534.3	2789306459
22		200140350.9	200140350.9	1264421396	1064281045	1064281045	178696741.9	676369844.6	497673102.7	3286979562
23		210147368.5	210147368.5	1302354038	1092206669	1092206669	187631579	694117083.7	506485504.7	3793465066
24		220654736.9	220654736.9	1341424659	1120769922	1120769922	197013158	712269547.2	515256389.2	4308721455
25		231687473.8	231687473.8	1381667399	1149979925	1149979925	206863815.9	730833032.1	523969216.2	4832690672
26		243271847.5	243271847.5	1423117421	1179845573	1179845573	217207006.7	749813191.5	532606184.8	5365296857
27		255435439.8	255435439.8	1465810943	1210375503	1210375503	228067357	769215514.1	541148157.1	5906445014
28		268207211.8	268207211.8	1509785272	1241578060	1241578060	239470724.8	789045302.7	549574577.9	6456019591
29		281617572.4	281617572.4	1555078830	1273461257	1273461257	251444261.1	809307651.2	557863390.1	7013882982
30		295698451	295698451	1601731195	1306032744	1306032744	264016474.1	830007419.5	565990945.4	7579873927
Total		4546418478	10090581791	30650037742	26103619264		9009448027	16589321954	7579873927	

Year	IRR	B/C ratio	NPV
10	-1%	0.81	-2259774316
20	10.66%	1.38	2300471925
30	13%	1.85	7579873927

COST INCREASE BY 10%

Project Cost		5,808,171,090									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1742451327		1742451327	0	0	1	-1742451327	1555760113		-1555760113	-1555760113
2	2323268436		2323268436	0	0	2	-2323268436	2074346818		-2074346818	-3630106931
3	1742451327		1742451327	0	0	3	-1742451327	1555760113		-1555760113	-5185867044
4		87122566.34	87122566.34	764995739	677873173	4	677873173	77788005.66	430800656.1	353012650.4	-4832854394
5		91478694.66	91478694.66	787945611.2	696466916.5	5	696466916.5	81677405.95	442617316.5	360939910.5	-4471914483
6		96052629.39	96052629.39	811583979.5	715531350.1	6	715531350.1	85761276.24	454733108.7	368971832.4	-4102942651
7		100855260.9	100855260.9	835931498.9	735076238	7	735076238	90049340.06	467154238.3	377104898.2	-3725837753
8		105898023.9	105898023.9	861009443.9	755111419.9	8	755111419.9	94551807.06	479886958.6	385335151.5	-3340502601
9		111192925.1	111192925.1	886839727.2	775646802.1	9	775646802.1	99279397.41	492937565.2	393658167.8	-2946844433
10		116752571.4	116752571.4	913444919	796692347.6	10	796692347.6	104243367.3	506312389.8	402069022.6	-2544775411
11		122590199.9	122590199.9	940848266.6	818258066.6	11	818258066.6	109455535.6	520017794.1	410562258.5	-2134213152
12		128719709.9	128719709.9	969073714.6	840354004.6	12	840354004.6	114928312.4	534060162.2	419131849.8	-1715081303
13		135155695.4	135155695.4	998145926	862990230.6	13	862990230.6	120674728.1	548445893	427771165	-1287310138
14		141913480.2	141913480.2	1028090304	886176823.6	14	886176823.6	126708464.5	563181392	436472927.6	-850837210
15		149009154.2	149009154.2	1058933013	909923858.7	15	909923858.7	133043887.7	578273062.2	445229174.5	-405608035.6
16		156459611.9	156459611.9	1090701003	934241391.4	16	934241391.4	139696082.1	593727293.8	454031211.7	48423176.19
17		164282592.5	164282592.5	1123422033	959139440.9	17	959139440.9	146680886.2	609550454.4	462869568.2	511292744.4
18		172496722.1	172496722.1	1157124694	984627972.2	18	984627972.2	154014930.5	625748876.9	471733946.4	983026690.8

19		181121558.2	181121558.2	1157124694	976003136.1	19	976003136.1	161715677	620267637.6	458551960.6	1441578651
20		190177636.1	190177636.1	1191838435	1001660799	20	1001660799	169801460.8	636573546.2	466772085.4	1908350737
21		199686518	199686518	1227593588	1027907070	21	1027907070	178291533.9	653253526.1	474961992.2	2383312729
22		209670843.9	209670843.9	1264421396	1054750552	22	1054750552	187206110.6	670313044	483106933.5	2866419662
23		220154386	220154386	1302354038	1082199652	23	1082199652	196566416.1	687757443.1	491191027	3357610689
24		231162105.3	231162105.3	1341424659	1110262554	24	1110262554	206394736.9	705591924.6	499197187.7	3856807877
25		242720210.6	242720210.6	1381667399	1138947188	25	1138947188	216714473.8	723821528.4	507107054.6	4363914932
26		254856221.1	254856221.1	1423117421	1168261199	26	1168261199	227550197.5	742451112.6	514900915.1	4878815847
27		267599032.2	267599032.2	1465810943	1198211911	27	1198211911	238927707.3	761485331.2	522557623.9	5401373471
28		280978983.8	280978983.8	1509785272	1228806288	28	1228806288	250874092.7	780928610.7	530054518	5931427989
29		295027933	295027933	1555078830	1260050897	29	1260050897	263417797.3	800785124.6	537367327.2	6468795316
30		309779329.7	309779329.7	1601731195	1291951865	30	1291951865	276588687.2	821058766.6	544470079.4	7013265395
Total		4762914596	10571085685	30650037742	25887123146	Total		9438469362	16451734757	7013265395	

Year	IRR	B/C ratio	NPV
10	-2%	0.77	-2544775411
20	9.96%	1.31	1908350737
30	12%	1.75	7013265395

COST INCREASE BY 15%

Project Cost		6,072,178,866									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1821653660		1821653660	0	0	1	-1821653660	1626476482		-1626476482	-1626476482
2	2428871547		2428871547	0	0	2	-2428871547	2168635309		-2168635309	-3795111792
3	1821653660		1821653660	0	0	3	-1821653660	1626476482		-1626476482	-5421588274
4		91082683	91082683	764995739	673913056	4	673913056	81323824.1	428283930.4	346960106.3	-5074628167
5		95636817.15	95636817.15	787945611.2	692308794	5	692308794	85390015.31	439974754.4	354584739.1	-4720043428
6		100418658	100418658	811583979.5	711165321.5	6	711165321.5	89659516.07	451958418.5	362298902.5	-4357744526
7		105439590.9	105439590.9	835931498.9	730491908	7	730491908	94142491.88	464240813.7	370098321.8	-3987646204
8		110711570.4	110711570.4	861009443.9	750297873.4	8	750297873.4	98849616.47	476827862.7	377978246.3	-3609667958
9		116247149	116247149	886839727.2	770592578.2	9	770592578.2	103792097.3	489725514.5	385933417.2	-3223734540
10		122059506.4	122059506.4	913444919	791385412.6	10	791385412.6	108981702.2	502939736.7	393958034.5	-2829776506
11		128162481.7	128162481.7	940848266.6	812685784.8	11	812685784.8	114430787.3	516476508.3	402045721	-2427730785
12		134570605.8	134570605.8	969073714.6	834503108.7	12	834503108.7	120152326.6	530341812.1	410189485.4	-2017541299
13		141299136.1	141299136.1	998145926	856846789.9	13	856846789.9	126159943	544541625.4	418381682.4	-1599159617
14		148364092.9	148364092.9	1028090304	879726210.8	14	879726210.8	132467940.1	559081911	426613970.9	-1172545646
15		155782297.6	155782297.6	1058933013	903150715.3	15	903150715.3	139091337.1	573968607.1	434877270	-737668376.1
16		163571412.4	163571412.4	1090701003	927129590.8	16	927129590.8	146045904	589207616	443161712	-294506664.1
17		171749983.1	171749983.1	1123422033	951672050.3	17	951672050.3	153348199.2	604804792.7	451456593.5	156949929.4

18		180337482.2	180337482.2	1157124694	976787212.1	18	976787212.1	161015609.1	620765932.1	459750322.9	616700252.4
19		189354356.3	189354356.3	1157124694	967770338	19	967770338	169066389.6	615035545.6	445969156	1062669408
20		198822074.2	198822074.2	1191838435	993016361	20	993016361	177519709.1	631079849.6	453560140.5	1516229549
21		208763177.9	208763177.9	1227593588	1018830410	21	1018830410	186395694.5	647485144.6	461089450.1	1977318999
22		219201336.8	219201336.8	1264421396	1045220059	22	1045220059	195715479.2	664256243.5	468540764.3	2445859763
23		230161403.6	230161403.6	1302354038	1072192634	23	1072192634	205501253.2	681397802.6	475896549.4	2921756313
24		241669473.8	241669473.8	1341424659	1099755185	24	1099755185	215776315.9	698914302	483137986.1	3404894299
25		253752947.5	253752947.5	1381667399	1127914451	25	1127914451	226565131.7	716810024.6	490244893	3895139192
26		266440594.8	266440594.8	1423117421	1156676826	26	1156676826	237893388.2	735089033.7	497195645.4	4392334837
27		279762624.6	279762624.6	1465810943	1186048319	27	1186048319	249788057.7	753755148.4	503967090.7	4896301928
28		293750755.8	293750755.8	1509785272	1216034516	28	1216034516	262277460.5	772811918.7	510534458.2	5406836386
29		308438293.6	308438293.6	1555078830	1246640536	29	1246640536	275391333.6	792262598	516871264.4	5923707650
30		323860208.3	323860208.3	1601731195	1277870986	30	1277870986	289160900.2	812110113.7	522949213.4	6446656864
Total		4979410714	11051589580	30650037742	25670627028	Total		9867490697	16314147561	6446656864	

Year	IRR	B/C ratio	NPV
10	-3%	0.73	-2829776506
20	9.30%	1.25	1516229549
30	11%	1.66	6446656864

COST INCREASE BY 20%

Project Cost		6,336,186,643									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	

0						0					
1	1900855993		1900855993	0	0	1	-1900855993	1697192851		-1697192851	-1697192851
2	2534474657		2534474657	0	0	2	-2534474657	2262923801		-2262923801	-3960116652
3	1900855993		1900855993	0	0	3	-1900855993	1697192851		-1697192851	-5657309503
4		95042799.65	95042799.65	764995739	669952939	4	669952939	84859642.54	425767204.6	340907562.1	-5316401941
5		99794939.63	99794939.63	787945611.2	688150671.5	5	688150671.5	89102624.67	437332192.4	348229567.8	-4968172373
6		104784686.6	104784686.6	811583979.5	706799292.9	6	706799292.9	93557755.9	449183728.4	355625972.5	-4612546400
7		110023920.9	110023920.9	835931498.9	725907577.9	7	725907577.9	98235643.7	461327389	363091745.3	-4249454655
8		115525117	115525117	861009443.9	745484326.9	8	745484326.9	103147425.9	473768766.9	370621341	-3878833314
9		121301372.8	121301372.8	886839727.2	765538354.3	9	765538354.3	108304797.2	486513463.9	378208666.7	-3500624647
10		127366441.5	127366441.5	913444919	786078477.5	10	786078477.5	113720037	499567083.5	385847046.5	-3114777601
11		133734763.6	133734763.6	940848266.6	807113503	11	807113503	119406038.9	512935222.5	393529183.6	-2721248417
12		140421501.7	140421501.7	969073714.6	828652212.8	12	828652212.8	125376340.8	526623462	401247121.1	-2320001296
13		147442576.8	147442576.8	998145926	850703349.2	13	850703349.2	131645157.9	540637357.8	408992199.9	-1911009096
14		154814705.7	154814705.7	1028090304	873275598.1	14	873275598.1	138227415.8	554982430	416755014.3	-1494254082
15		162555440.9	162555440.9	1058933013	896377571.9	15	896377571.9	145138786.6	569664152	424525365.5	-1069728717
16		170683213	170683213	1090701003	920017790.3	16	920017790.3	152395725.9	584687938.2	432292212.3	-637436504.3
17		179217373.6	179217373.6	1123422033	944204659.7	17	944204659.7	160015512.2	600059131	440043618.8	-197392885.5
18		188178242.3	188178242.3	1157124694	968946452	18	968946452	168016287.8	615782987.3	447766699.5	250373814
19		197587154.4	197587154.4	1157124694	959537539.9	19	959537539.9	176417102.2	609803453.5	433386351.4	683760165.3
20		207466512.2	207466512.2	1191838435	984371923	20	984371923	185237957.3	625586153	440348195.7	1124108361
21		217839837.8	217839837.8	1227593588	1009753750	21	1009753750	194499855.2	641716763.2	447216908	1571325269
22		228731829.7	228731829.7	1264421396	1035689566	22	1035689566	204224847.9	658199443	453974595.1	2025299864
23		240168421.1	240168421.1	1302354038	1062185617	23	1062185617	214436090.3	675038162	460602071.7	2485901936
24		252176842.2	252176842.2	1341424659	1089247817	24	1089247817	225157894.8	692236679.4	467078784.6	2952980720
25		264785684.3	264785684.3	1381667399	1116881714	25	1116881714	236415789.6	709798520.9	473382731.4	3426363452
26		278024968.5	278024968.5	1423117421	1145092452	26	1145092452	248236579	727726954.8	479490375.7	3905853827
27		291926216.9	291926216.9	1465810943	1173884726	27	1173884726	260648408	746024965.5	485376557.5	4391230385

28		306522527.8	306522527.8	1509785272	1203262744	28	1203262744	273680828.4	764695226.7	491014398.3	4882244783
29		321848654.2	321848654.2	1555078830	1233230176	29	1233230176	287364869.8	783740071.4	496375201.6	5378619985
30		337941086.9	337941086.9	1601731195	1263790108	30	1263790108	301733113.3	803161460.8	501428347.5	5880048332
Total		5195906832	11532093475	30650037742	25454130910	Total		10296512031	16176560364	5880048332	

Year	IRR	B/C ratio	NPV
10	-4%	0.70	-3114777601
20	8.68%	1.19	1124108361
30	11%	1.58	5880048332

COST DECREASE BY 5%

Project Cost		5,016,147,759									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1504844328		1504844328	0	0	1	-1504844328	1343611007		-1343611007	-1343611007
2	2006459104		2006459104	0	0	2	-2006459104	1791481343		-1791481343	-3135092350
3	1504844328		1504844328	0	0	3	-1504844328	1343611007		-1343611007	-4478703356
4		75242216.39	75242216.39	764995739	689753523	4	689753523	67180550.35	438350833.3	371170282.9	-4107533074
5		79004327.21	79004327.21	787945611.2	708941284	5	708941284	70539577.86	450545002.5	380005424.6	-3727527649
6		82954543.57	82954543.57	811583979.5	728629435.9	6	728629435.9	74066556.76	463057179	388990622.2	-3338537027
7		87102270.75	87102270.75	835931498.9	748829228.1	7	748829228.1	77769884.59	475894512.1	398124627.5	-2940412399
8		91457384.28	91457384.28	861009443.9	769552059.6	8	769552059.6	81658378.82	489064246.1	407405867.3	-2533006532
9		96030253.5	96030253.5	886839727.2	790809473.7	9	790809473.7	85741297.77	502573717.1	416832419.3	-2116174112
10		100831766.2	100831766.2	913444919	812613152.8	10	812613152.8	90028362.65	516430349.4	426401986.7	-1689772126

11		105873354.5	105873354.5	940848266.6	834974912.1	11	834974912.1	94529780.79	530641651.6	436111870.9	-1253660255
12		111167022.2	111167022.2	969073714.6	857906692.3	12	857906692.3	99256269.83	545215212.6	445958942.7	-807701312.2
13		116725373.3	116725373.3	998145926	881420552.7	13	881420552.7	104219083.3	560158695.9	455939612.6	-351761699.6
14		122561642	122561642	1028090304	905528661.8	14	905528661.8	109430037.5	575479835.1	466049797.6	114288098
15		128689724.1	128689724.1	1058933013	930243288.8	15	930243288.8	114901539.4	591186427.3	476284888	590572986
16		135124210.3	135124210.3	1090701003	955576793	16	955576793	120646616.3	607286327.2	486639710.9	1077212697
17		141880420.8	141880420.8	1123422033	981541612.6	17	981541612.6	126678947.1	623787439.5	497108492.4	1574321189
18		148974441.8	148974441.8	1157124694	1008150253	18	1008150253	133012894.5	640697711.2	507684816.7	2082006006
19		156423163.9	156423163.9	1157124694	1000701530	19	1000701530	139663539.2	635963913.7	496300374.5	2578306380
20		164244322.1	164244322.1	1191838435	1027594113	20	1027594113	146646716.2	653054636.1	506407919.9	3084714300
21		172456538.2	172456538.2	1227593588	1055137050	21	1055137050	153979052	670558670.5	516579618.5	3601293919
22		181079365.1	181079365.1	1264421396	1083342031	22	1083342031	161678004.6	688483445.6	526805441	4128099360
23		190133333.4	190133333.4	1302354038	1112220704	23	1112220704	169761904.8	706836364.8	537074460	4665173820
24		199640000.1	199640000.1	1341424659	1141784659	24	1141784659	178250000.1	725624792.3	547374792.3	5212548612
25		209622000.1	209622000.1	1381667399	1172045399	25	1172045399	187162500.1	744856039.5	557693539.5	5770242152
26		220103100.1	220103100.1	1423117421	1203014321	26	1203014321	196520625.1	764537349.3	568016724.2	6338258876
27		231108255.1	231108255.1	1465810943	1234702688	27	1234702688	206346656.3	784675879.8	578329223.5	6916588099
28		242663667.8	242663667.8	1509785272	1267121604	28	1267121604	216663989.1	805278686.7	588614697.6	7505202797
29		254796851.2	254796851.2	1555078830	1300281978	29	1300281978	227497188.6	826352704.3	598855515.7	8104058313
30		267536693.8	267536693.8	1601731195	1334194501	30	1334194501	238872048	847904725.4	609032677.3	8713090990
Total		4113426242	9129574001	30650037742	26536611500	Total		8151405358	16864496348	8713090990	

Year	IRR	B/C ratio	NPV
10	1%	0.90	-1689772126
20	12.21%	1.55	3084714300
30	14%	2.08	8713090990

COST DECREASE BY 10%

Project Cost		4,752,139,982									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1425641995		1425641995	0	0	1	-1425641995	1272894638		-1272894638	-1272894638
2	1900855993		1900855993	0	0	2	-1900855993	1697192851		-1697192851	-2970087489
3	1425641995		1425641995	0	0	3	-1425641995	1272894638		-1272894638	-4242982127
4		71282099.74	71282099.74	764995739	693713639	4	693713639	63644731.91	440867559	377222827.1	-3865759300
5		74846204.72	74846204.72	787945611.2	713099406.4	5	713099406.4	66826968.5	453187564.5	386360596	-3479398704
6		78588514.96	78588514.96	811583979.5	732995464.5	6	732995464.5	70168316.93	465831869.1	395663552.2	-3083735152
7		82517940.71	82517940.71	835931498.9	753413558.2	7	753413558.2	73676732.77	478807936.7	405131204	-2678603948
8		86643837.74	86643837.74	861009443.9	774365606.1	8	774365606.1	77360569.41	492123342	414762772.6	-2263841175
9		90976029.63	90976029.63	886839727.2	795863697.5	9	795863697.5	81228597.88	505785767.7	424557169.9	-1839284006
10		95524831.11	95524831.11	913444919	817920087.9	10	817920087.9	85290027.78	519803002.5	434512974.8	-1404771031
11		100301072.7	100301072.7	940848266.6	840547193.9	11	840547193.9	89554529.17	534182937.5	444628408.3	-960142622.4
12		105316126.3	105316126.3	969073714.6	863757588.3	12	863757588.3	94032255.62	548933562.7	454901307.1	-505241315.4
13		110581932.6	110581932.6	998145926	887563993.4	13	887563993.4	98733868.41	564062963.5	465329095.1	-39912220.24
14		116111029.2	116111029.2	1028090304	911979274.5	14	911979274.5	103670561.8	579579316.1	475908754.3	435996534
15		121916580.7	121916580.7	1058933013	937016432.2	15	937016432.2	108854089.9	595490882.4	486636792.5	922633326.5
16		128012409.7	128012409.7	1090701003	962688593.5	16	962688593.5	114296794.4	611806005.1	497509210.6	1420142537
17		134413030.2	134413030.2	1123422033	989009003.1	17	989009003.1	120011634.1	628533101.2	508521467.1	1928664004
18		141133681.7	141133681.7	1157124694	1015991013	18	1015991013	126012215.8	645680656	519668440.2	2448332444
19		148190365.8	148190365.8	1157124694	1008934329	19	1008934329	132312826.6	641196005.7	508883179.1	2957215623
20		155599884.1	155599884.1	1191838435	1036238551	20	1036238551	138928468	658548332.8	519619864.8	3476835488
21		163379878.3	163379878.3	1227593588	1064213710	21	1064213710	145874891.4	676327051.9	530452160.6	4007287649

22		171548872.2	171548872.2	1264421396	1092872524	22	1092872524	153168635.9	694540246.2	541371610.2	4548659259
23		180126315.9	180126315.9	1302354038	1122227722	23	1122227722	160827067.7	713196005.4	552368937.6	5101028197
24		189132631.6	189132631.6	1341424659	1152292027	24	1152292027	168868421.1	732302414.9	563433993.8	5664462191
25		198589263.2	198589263.2	1381667399	1183078135	25	1183078135	177311842.2	751867543.2	574555701.1	6239017892
26		208518726.4	208518726.4	1423117421	1214598694	26	1214598694	186177434.3	771899428.2	585721993.9	6824739886
27		218944662.7	218944662.7	1465810943	1246866281	27	1246866281	195486306	792406062.6	596919756.7	7421659642
28		229891895.8	229891895.8	1509785272	1279893376	28	1279893376	205260621.3	813395378.7	608134757.4	8029794400
29		241386490.6	241386490.6	1555078830	1313692339	29	1313692339	215523652.4	834875230.9	619351578.6	8649145978
30		253455815.2	253455815.2	1601731195	1348275379	30	1348275379	226299835	856853378.3	630553543.3	9279699522
Total		3896930124	8649070106	30650037742	26753107618	Total		7722384023	17002083545	9279699522	

Year	IRR	B/C ratio	NPV
10	2%	0.95	-1404771031
20	13.07%	1.65	3476835488
30	15%	2.21	9279699522

COST DECREASE BY 15%

Project Cost		4,488,132,206									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1346439662		1346439662	0	0	1	-1346439662	1202178269		-1202178269	-1202178269
2	1795252882		1795252882	0	0	2	-1795252882	1602904359		-1602904359	-2805082629
3	1346439662		1346439662	0	0	3	-1346439662	1202178269		-1202178269	-4007260898
4		67321983.08	67321983.08	764995739	697673756	4	697673756	60108913.47	443384284.7	383275371.2	-3623985527

5		70688082.24	70688082.24	787945611.2	717257528.9	5	717257528.9	63114359.14	455830126.5	392715767.4	-3231269759
6		74222486.35	74222486.35	811583979.5	737361493.2	6	737361493.2	66270077.1	468606559.2	402336482.1	-2828933277
7		77933610.67	77933610.67	835931498.9	757997888.2	7	757997888.2	69583580.95	481721361.4	412137780.4	-2416795497
8		81830291.2	81830291.2	861009443.9	779179152.7	8	779179152.7	73062760	495182437.8	422119677.8	-1994675819
9		85921805.76	85921805.76	886839727.2	800917921.4	9	800917921.4	76715898	508997818.4	432281920.4	-1562393899
10		90217896.05	90217896.05	913444919	823227022.9	10	823227022.9	80551692.9	523175655.7	442623962.8	-1119769936
11		94728790.85	94728790.85	940848266.6	846119475.7	11	846119475.7	84579277.55	537724223.3	453144945.8	-666624990
12		99465230.39	99465230.39	969073714.6	869608484.2	12	869608484.2	88808241.42	552651912.8	463843671.4	-202781318.6
13		104438491.9	104438491.9	998145926	893707434.1	13	893707434.1	93248653.49	567967231.2	474718577.7	271937259.1
14		109660416.5	109660416.5	1028090304	918429887.3	14	918429887.3	97911086.17	583678797.1	485767710.9	757704970
15		115143437.3	115143437.3	1058933013	943789575.5	15	943789575.5	102806640.5	599795337.5	496988697	1254693667
16		120900609.2	120900609.2	1090701003	969800394.1	16	969800394.1	107946972.5	616325682.9	508378710.4	1763072377
17		126945639.7	126945639.7	1123422033	996476393.7	17	996476393.7	113344321.1	633278762.9	519934441.8	2283006819
18		133292921.6	133292921.6	1157124694	1023831773	18	1023831773	119011537.2	650663600.8	531652063.6	2814658883
19		139957567.7	139957567.7	1157124694	1017167127	19	1017167127	124962114	646428097.7	521465983.7	3336124867
20		146955446.1	146955446.1	1191838435	1044882989	20	1044882989	131210219.7	664042029.4	532831809.6	3868956676
21		154303218.4	154303218.4	1227593588	1073290370	21	1073290370	137770730.7	682095433.4	544324702.7	4413281379
22		162018379.3	162018379.3	1264421396	1102403017	22	1102403017	144659267.3	700597046.7	555937779.4	4969219158
23		170119298.3	170119298.3	1302354038	1132234739	23	1132234739	151892230.6	719555645.9	567663415.3	5536882574
24		178625263.2	178625263.2	1341424659	1162799396	24	1162799396	159486842.2	738980037.5	579493195.4	6116375769
25		187556526.4	187556526.4	1381667399	1194110872	25	1194110872	167461184.3	758879047	591417862.7	6707793632
26		196934352.7	196934352.7	1423117421	1226183068	26	1226183068	175834243.5	779261507.1	603427263.6	7311220895
27		206781070.3	206781070.3	1465810943	1259029873	27	1259029873	184625955.7	800136245.5	615510289.8	7926731185
28		217120123.9	217120123.9	1509785272	1292665148	28	1292665148	193857253.4	821512070.7	627654817.2	8554386002
29		227976130	227976130	1555078830	1327102700	29	1327102700	203550116.1	843397757.5	639847641.4	9194233644
30		239374936.6	239374936.6	1601731195	1362356258	30	1362356258	213727621.9	865802031.2	652074409.3	9846308053
Total		3680434006	8168566211	30650037742	26969603736	Total		7293362689	17139670742	9846308053	

Year	IRR	B/C ratio	NPV
10	3%	1.01	-1119769936
20	14.00%	1.76	3868956676
30	16%	2.36	9846308053

COST DECREASE BY 20%

Project Cost		4,224,124,429									
Total Revenue		764,995,739									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
Capital Cost		O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1267237329		1267237329	0	0	1	-1267237329	1131461901		-1131461901	-1131461901
2	1689649772		1689649772	0	0	2	-1689649772	1508615867		-1508615867	-2640077768
3	1267237329		1267237329	0	0	3	-1267237329	1131461901		-1131461901	-3771539669
4		63361866.43	63361866.43	764995739	701633873	4	701633873	56573095.03	445901010.4	389327915.4	-3382211753
5		66529959.75	66529959.75	787945611.2	721415651.4	5	721415651.4	59401749.78	458472688.5	399070938.7	-2983140814
6		69856457.74	69856457.74	811583979.5	741727521.8	6	741727521.8	62371837.27	471381249.3	409009412.1	-2574131402
7		73349280.63	73349280.63	835931498.9	762582218.3	7	762582218.3	65490429.13	484634786	419144356.8	-2154987046
8		77016744.66	77016744.66	861009443.9	783992699.2	8	783992699.2	68764950.59	498241533.7	429476583.1	-1725510462
9		80867581.89	80867581.89	886839727.2	805972145.3	9	805972145.3	72203198.12	512209869	440006670.9	-1285503792
10		84910960.99	84910960.99	913444919	828533958	10	828533958	75813358.02	526548308.9	450734950.9	-834768840.7
11		89156509.04	89156509.04	940848266.6	851691757.5	11	851691757.5	79604025.93	541265509.1	461661483.2	-373107357.5
12		93614334.49	93614334.49	969073714.6	875459380.1	12	875459380.1	83584227.22	556370262.9	472786035.7	99678678.25
13		98295051.21	98295051.21	998145926	899850874.8	13	899850874.8	87763438.58	571871498.8	484108060.2	583786738.5
14		103209803.8	103209803.8	1028090304	924880500	14	924880500	92151610.51	587778278.1	495626667.6	1079413406
15		108370294	108370294	1058933013	950562718.9	15	950562718.9	96759191.04	604099792.5	507340601.5	1586754008

16		113788808.7	113788808.7	1090701003	976912194.6	16	976912194.6	101597150.6	620845360.7	519248210.1	2106002218
17		119478249.1	119478249.1	1123422033	1003943784	17	1003943784	106677008.1	638024424.6	531347416.5	2637349634
18		125452161.5	125452161.5	1157124694	1031672533	18	1031672533	112010858.5	655646545.6	543635687.1	3180985321
19		131724769.6	131724769.6	1157124694	1025399925	19	1025399925	117611401.5	651660189.8	534048788.3	3715034110
20		138311008.1	138311008.1	1191838435	1053527427	20	1053527427	123491971.5	669535726	546043754.5	4261077864
21		145226558.5	145226558.5	1227593588	1082367030	21	1082367030	129666570.1	687863814.9	558197244.8	4819275109
22		152487886.4	152487886.4	1264421396	1111933509	22	1111933509	136149898.6	706653847.2	570503948.6	5389779057
23		160112280.8	160112280.8	1302354038	1142241757	23	1142241757	142957393.5	725915286.5	582957893	5972736950
24		168117894.8	168117894.8	1341424659	1173306764	24	1173306764	150105263.2	745657660.1	595552396.9	6568289347
25		176523789.5	176523789.5	1381667399	1205143609	25	1205143609	157610526.4	765890550.7	608280024.3	7176569372
26		185349979	185349979	1423117421	1237767442	26	1237767442	165491052.7	786623586	621132533.3	7797701905
27		194617478	194617478	1465810943	1271193465	27	1271193465	173765605.3	807866428.3	634100823	8431802728
28		204348351.9	204348351.9	1509785272	1305436920	28	1305436920	182453885.6	829628762.7	647174877.1	9078977605
29		214565769.5	214565769.5	1555078830	1340513060	29	1340513060	191576579.9	851920284.1	660343704.3	9739321309
30		225294057.9	225294057.9	1601731195	1376437137	30	1376437137	201155408.9	874750684.1	673595275.3	10412916585
Total		3463937888	7688062317	30650037742	27186099854	Total		6864341354	17277257939	10412916585	

Year	IRR	B/C ratio	NPV
10	5%	1.08	-834768840.7
20	15.01%	1.88	4261077864
30	16%	2.53	10412916585

REVENUE INCREASE BY 5%

Project Cost		5,280,155,536										
Total Revenue		803,245,526										
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow	
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV		
0						0						
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	803245526	724043193	4	724043193	70716368.79	460142538.6	389426169.9	-4324998416	
5		83162449.69	83162449.69	827342891.7	744180442	5	744180442	74252187.23	472940124.5	398687937.3	-3926310479	
6		87320572.18	87320572.18	852163178.5	764842606.3	6	764842606.3	77964796.59	486071303.4	408106506.9	-3518203972	
7		91686600.79	91686600.79	877728073.8	786041473	7	786041473	81863036.42	499543566.5	417680530.1	-3100523442	
8		96270930.82	96270930.82	904059916	807788985.2	8	807788985.2	85956188.24	513364503.6	427408315.4	-2673115126	
9		101084477.4	101084477.4	931181713.5	830097236.2	9	830097236.2	90253997.65	527541800.4	437287802.8	-2235827323	
10		106138701.2	106138701.2	959117164.9	852978463.7	10	852978463.7	94766697.53	542083234.2	447316536.6	-1788510787	
11		111445636.3	111445636.3	987890679.9	876445043.6	11	876445043.6	99505032.41	556996669.9	457491637.5	-1331019149	
12		117017918.1	117017918.1	1017527400	900509482.2	12	900509482.2	104480284	572290055.7	467809771.7	-863209377.6	
13		122868814	122868814	1048053222	925184408.3	13	925184408.3	109704298.2	587971417.3	478267119.1	-384942258.5	
14		129012254.7	129012254.7	1079494819	950482564.2	14	950482564.2	115189513.1	604048852.8	488859339.6	103917081.1	
15		135462867.5	135462867.5	1111879664	976416796.1	15	976416796.1	120948988.8	620530526	499581537.2	603498618.3	
16		142236010.8	142236010.8	1145236053	1003000043	16	1003000043	126996438.2	637424659.7	510428221.5	1113926840	
17		149347811.4	149347811.4	1179593135	1030245324	17	1030245324	133346260.1	654739528.4	521393268.2	1635320108	
18		156815201.9	156815201.9	1214980929	1058165727	18	1058165727	140013573.2	672483449.6	532469876.4	2167789984	
19		164655962	164655962	1214980929	1050324967	19	1050324967	147014251.8	667500504.8	520486252.9	2688276237	
20		172888760.1	172888760.1	1251430357	1078541597	20	1078541597	154364964.4	685432683.1	531067718.7	3219343956	
21		181533198.1	181533198.1	1288973268	1107440070	21	1107440070	162083212.6	703798184.9	541714972.3	3761058928	

22		190609858	190609858	1327642466	1137032608	22	1137032608	170187373.3	722604777.9	552417404.6	4313476333
23		200140350.9	200140350.9	1367471740	1167331389	23	1167331389	178696741.9	741860201	563163459.1	4876639792
24		210147368.5	210147368.5	1408495892	1198348523	24	1198348523	187631579	761572150.8	573940571.8	5450580364
25		220654736.9	220654736.9	1450750769	1230096032	25	1230096032	197013158	781748266.3	584735108.3	6035315472
26		231687473.8	231687473.8	1494273292	1262585818	26	1262585818	206863815.9	802396112.8	595532297	6630847769
27		243271847.5	243271847.5	1539101490	1295829643	27	1295829643	217207006.7	823523164.6	606316158	7237163927
28		255435439.8	255435439.8	1585274535	1329839095	28	1329839095	228067357	845136786.4	617069429.4	7854233357
29		268207211.8	268207211.8	1632832771	1364625559	29	1364625559	239470724.8	867244213.2	627773488.4	8482006845
30		281617572.4	281617572.4	1681817754	1400200182	30	1400200182	251444261.1	889852529	638408267.9	9120415113
Total		4329922360	9610077896	32182539629	27852617269	Total		8580426693	17700841806	9120415113	

Year	IRR	B/C ratio	NPV
10	1%	0.89	-1788510787
20	12.17%	1.54	3219343956
30	14%	2.07	9120415113

REVENUE INCREASE BY 10%

Project Cost		5,280,155,536									
Total Revenue		841,495,313									
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV	
0						0					
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586
4		79202333.04	79202333.04	84149513	762292980	4	762292980	70716368.79	484450969.7	413734601	-4300689985
5		83162449.69	83162449.69	866740172.3	783577722.6	5	783577722.6	74252187.23	497977808.5	423725621.3	-3876964363
6		87320572.18	87320572.18	892742377.5	805421805.3	6	805421805.3	77964796.59	511860118	433895321.4	-3443069042
7		91686600.79	91686600.79	919524648.8	827838048	7	827838048	81863036.42	526106045.5	444243009.1	-2998826033
8		96270930.82	96270930.82	947110388.2	850839457.4	8	850839457.4	85956188.24	540723857	454767668.8	-2544058364
9		101084477.4	101084477.4	975523699.9	874439222.5	9	874439222.5	90253997.65	555721934.4	465467936.7	-2078590427
10		106138701.2	106138701.2	1004789411	898650709.7	10	898650709.7	94766697.53	571108772.2	476342074.6	-1602248353
11		111445636.3	111445636.3	1034933093	923487456.9	11	923487456.9	99505032.41	586892974.1	487387941.6	-1114860411
12		117017918.1	117017918.1	1065981086	948963167.9	12	948963167.9	104480284	603083248.9	498602964.9	-616257446.3
13		122868814	122868814	1097960519	975091704.6	13	975091704.6	109704298.2	619688406.4	509984108.1	-106273338.1
14		129012254.7	129012254.7	1130899334	1001887079	14	1001887079	115189513.1	636717351.5	521527838.4	415254500.2
15		135462867.5	135462867.5	1164826314	1029363447	15	1029363447	120948988.8	654179079.6	533230090.8	948484591.1
16		142236010.8	142236010.8	1199771104	1057535093	16	1057535093	126996438.2	672082670	545086231.8	1493570823
17		149347811.4	149347811.4	1235764237	1086416425	17	1086416425	133346260.1	690437279	557091018.8	2050661842
18		156815201.9	156815201.9	1272837164	1116021962	18	1116021962	140013573.2	709252132.7	569238559.5	2619900401
19		164655962	164655962	1272837164	1108181202	19	1108181202	147014251.8	704269187.9	557254936.1	3177155337
20		172888760.1	172888760.1	1311022279	1138133519	20	1138133519	154364964.4	723304426.7	568939462.3	3746094800

21		181533198.1	181533198.1	1350352947	1168819749	21	1168819749	162083212.6	742806080.8	580722868.2	4326817668
22		190609858	190609858	1390863535	1200253677	22	1200253677	170187373.3	762782910.7	592595537.4	4919413205
23		200140350.9	200140350.9	1432589442	1232449091	23	1232449091	178696741.9	783243677.8	604546935.9	5523960141
24		210147368.5	210147368.5	1475567125	1265419756	24	1265419756	187631579	804197131.9	616565552.9	6140525694
25		220654736.9	220654736.9	1519834139	1299179402	25	1299179402	197013158	825651996.8	628638838.9	6769164533
26		231687473.8	231687473.8	1565429163	1333741689	26	1333741689	206863815.9	847616955.2	640753139.4	7409917672
27		243271847.5	243271847.5	1612392038	1369120190	27	1369120190	217207006.7	870100632.3	652893625.7	8062811298
28		255435439.8	255435439.8	1660763799	1405328359	28	1405328359	228067357	893111578.2	665044221.2	8727855519
29		268207211.8	268207211.8	1710586713	1442379501	29	1442379501	239470724.8	916658248.7	677187523.9	9405043043
30		281617572.4	281617572.4	1761904314	1480286742	30	1480286742	251444261.1	940748985.5	689304724.5	10094347767
Total		4329922360	9610077896	33715041516	29385119157	Total		8580426693	18674774460	10094347767	

Year	IRR	B/C ratio	NPV
10	2%	0.92	-1602248353
20	12.91%	1.62	3746094800
30	15%	2.19	10094347767

REVENUE INCREASE BY 15%

Project Cost		5,280,155,536									
Total Revenue		879,745,100									
Year	Cost		Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow	
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV		
0					0						
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	
4		79202333.04	79202333.04	879745100	800542767	4	800542767	70716368.79	508759400.8	438043032.1	
5		83162449.69	83162449.69	906137452.8	822975003.2	5	822975003.2	74252187.23	523015492.6	448763305.4	
6		87320572.18	87320572.18	933321576.4	846001004.3	6	846001004.3	77964796.59	537648932.6	459684136	
7		91686600.79	91686600.79	961321223.7	869634622.9	7	869634622.9	81863036.42	552668524.5	470805488.1	
8		96270930.82	96270930.82	990160860.4	893889929.6	8	893889929.6	85956188.24	568083210.4	482127022.1	
9		101084477.4	101084477.4	1019865686	918781208.9	9	918781208.9	90253997.65	583902068.3	493648070.7	
10		106138701.2	106138701.2	1050461657	944322955.6	10	944322955.6	94766697.53	600134310.1	505367612.6	
11		111445636.3	111445636.3	1081975507	970529870.2	11	970529870.2	99505032.41	616789278.2	517284245.8	
12		117017918.1	117017918.1	1114434772	997416853.6	12	997416853.6	104480284	633876442.2	529396158.2	
13		122868814	122868814	1147867815	1024999001	13	1024999001	109704298.2	651405395.4	541701097.2	
14		129012254.7	129012254.7	1182303849	1053291595	14	1053291595	115189513.1	669385850.2	554196337.1	
15		135462867.5	135462867.5	1217772965	1082310097	15	1082310097	120948988.8	687827633.3	566878644.5	
16		142236010.8	142236010.8	1254306154	1112070143	16	1112070143	126996438.2	706740680.3	579744242.1	
17		149347811.4	149347811.4	1291935338	1142587527	17	1142587527	133346260.1	726135029.6	592788769.4	
18		156815201.9	156815201.9	1330693399	1173878197	18	1173878197	140013573.2	746020815.8	606007242.6	
19		164655962	164655962	1330693399	1166037436	19	1166037436	147014251.8	741037871	594023619.2	
20		172888760.1	172888760.1	1370614200	1197725440	20	1197725440	154364964.4	761176170.3	606811205.9	

21		181533198.1	181533198.1	1411732626	1230199428	21	1230199428	162083212.6	781813976.8	619730764.1	4892576407
22		190609858	190609858	1454084605	1263474747	22	1263474747	170187373.3	802961043.5	632773670.2	5525350077
23		200140350.9	200140350.9	1497707143	1297566792	23	1297566792	178696741.9	824627154.6	645930412.7	6171280490
24		210147368.5	210147368.5	1542638358	1332490989	24	1332490989	187631579	846822113	659190534	6830471024
25		220654736.9	220654736.9	1588917508	1368262772	25	1368262772	197013158	869555727.3	672542569.4	7503013593
26		231687473.8	231687473.8	1636585034	1404897560	26	1404897560	206863815.9	892837797.7	685973981.8	8188987575
27		243271847.5	243271847.5	1685682585	1442410737	27	1442410737	217207006.7	916678100	699471093.4	8888458669
28		255435439.8	255435439.8	1736253062	1480817622	28	1480817622	228067357	941086369.9	713019012.9	9601477681
29		268207211.8	268207211.8	1788340654	1520133442	29	1520133442	239470724.8	966072284.2	726601559.4	10328079241
30		281617572.4	281617572.4	1841990874	1560373301	30	1560373301	251444261.1	991645442.1	740201181	11068280422
Total		4329922360	9610077896	35247543404	30917621044	Total		8580426693	19648707115	11068280422	

Year	IRR	B/C ratio	NPV
10	3%	0.96	-1415985919
20	13.63%	1.70	4272845643
30	15%	2.30	11068280422

REVENUE INCREASE BY 20%

Project Cost		5,280,155,536										
Total Revenue		917,994,887										
Year	Cost		Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow		
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV			
0					0							
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	917994887	838792554	4	838792554	70716368.79	533067831.9	462351463.2	-4252073123	
5		83162449.69	83162449.69	945534733.4	862372283.7	5	862372283.7	74252187.23	548053176.6	473800989.4	-3778272133	
6		87320572.18	87320572.18	973900775.4	886580203.2	6	886580203.2	77964796.59	563437747.1	485472950.5	-3292799183	
7		91686600.79	91686600.79	1003117799	911431197.9	7	911431197.9	81863036.42	579231003.5	497367967.1	-2795431216	
8		96270930.82	96270930.82	1033211333	936940401.8	8	936940401.8	85956188.24	595442563.7	509486375.5	-2285944840	
9		101084477.4	101084477.4	1064207673	963123195.2	9	963123195.2	90253997.65	612082202.3	521828204.7	-1764116635	
10		106138701.2	106138701.2	1096133903	989995201.6	10	989995201.6	94766697.53	629159848.1	534393150.6	-1229723485	
11		111445636.3	111445636.3	1129017920	1017572284	11	1017572284	99505032.41	646685582.3	547180549.9	-682542934.9	
12		117017918.1	117017918.1	1162888457	1045870539	12	1045870539	104480284	664669635.4	560189351.4	-122353583.5	
13		122868814	122868814	1197775111	1074906297	13	1074906297	109704298.2	683122384.4	573418086.2	451064502.7	
14		129012254.7	129012254.7	1233708365	1104696110	14	1104696110	115189513.1	702054348.9	586864835.8	1037929338	
15		135462867.5	135462867.5	1270719615	1135256748	15	1135256748	120948988.8	721476187	600527198.2	1638456537	
16		142236010.8	142236010.8	1308841204	1166605193	16	1166605193	126996438.2	741398690.6	614402252.3	2252858789	
17		149347811.4	149347811.4	1348106440	1198758629	17	1198758629	133346260.1	761832780.2	628486520	2881345309	
18		156815201.9	156815201.9	1388549633	1231734431	18	1231734431	140013573.2	782789498.9	642775925.7	3524121235	
19		164655962	164655962	1388549633	1223893671	19	1223893671	147014251.8	777806554.1	630792302.3	4154913537	
20		172888760.1	172888760.1	1430206122	1257317362	20	1257317362	154364964.4	799047913.9	644682949.5	4799596487	
21		181533198.1	181533198.1	1473112306	1291579108	21	1291579108	162083212.6	820821872.7	658738660.1	5458335147	

22		190609858	190609858	1517305675	1326695817	22	1326695817	170187373.3	843139176.3	672951803	6131286950
23		200140350.9	200140350.9	1562824845	1362684494	23	1362684494	178696741.9	866010631.3	687313889.4	6818600839
24		210147368.5	210147368.5	1609709591	1399562222	24	1399562222	187631579	889447094.1	701815515	7520416354
25		220654736.9	220654736.9	1658000878	1437346141	25	1437346141	197013158	913459457.8	716446299.9	8236862654
26		231687473.8	231687473.8	1707740905	1476053431	26	1476053431	206863815.9	938058640.1	731194824.2	8968057478
27		243271847.5	243271847.5	1758973132	1515701284	27	1515701284	217207006.7	963255567.7	746048561.1	9714106039
28		255435439.8	255435439.8	1811742326	1556306886	28	1556306886	228067357	989061161.6	760993804.6	10475099844
29		268207211.8	268207211.8	1866094596	1597887384	29	1597887384	239470724.8	1015486320	776015594.8	11251115439
30		281617572.4	281617572.4	1922077434	1640459861	30	1640459861	251444261.1	1042541899	791097637.5	12042213076
Total		4329922360	9610077896	36780045291	32450122931	Total		8580426693	20622639769	12042213076	

Year	IRR	B/C ratio	NPV
10	4%	0.99	-1229723485
20	14.33%	1.79	4799596487
30	16%	2.41	12042213076

REVENUE DECREASE BY 5%

Project Cost		5,280,155,536										
Total Revenue		726,745,952										
Year	Cost		Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow		
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV			
0					0							
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	726745952	647543619	4	647543619	70716368.79	411525676.4	340809307.7	-4373615278	
5		83162449.69	83162449.69	748548330.6	665385880.9	5	665385880.9	74252187.23	422864756.4	348612569.2	-4025002709	
6		87320572.18	87320572.18	771004780.5	683684208.4	6	683684208.4	77964796.59	434493674.3	356528877.7	-3668473831	
7		91686600.79	91686600.79	794134923.9	702448323.2	7	702448323.2	81863036.42	446418608.5	364555572.1	-3303918259	
8		96270930.82	96270930.82	817958971.7	721688040.8	8	721688040.8	85956188.24	458645796.9	372689608.7	-2931228650	
9		101084477.4	101084477.4	842497740.8	741413263.4	9	741413263.4	90253997.65	471181532.5	380927534.8	-2550301115	
10		106138701.2	106138701.2	867772673	761633971.8	10	761633971.8	94766697.53	484032158.2	389265460.7	-2161035655	
11		111445636.3	111445636.3	893805853.2	782360216.9	11	782360216.9	99505032.41	497204061.7	397699029.3	-1763336626	
12		117017918.1	117017918.1	920620028.8	803602110.7	12	803602110.7	104480284	510703669.2	406223385.2	-1357113240	
13		122868814	122868814	948238629.7	825369815.7	13	825369815.7	109704298.2	524537439.2	414833141	-942280099.3	
14		129012254.7	129012254.7	976685788.6	847673533.9	14	847673533.9	115189513.1	538711855.4	423522342.2	-518757757.1	
15		135462867.5	135462867.5	1005986362	870523494.8	15	870523494.8	120948988.8	553233418.6	432284429.8	-86473327.31	
16		142236010.8	142236010.8	1036165953	893929942.3	16	893929942.3	126996438.2	568108639.1	441112200.9	354638873.6	
17		149347811.4	149347811.4	1067250932	917903120.3	17	917903120.3	133346260.1	583344027.2	449997767	804636640.6	
18		156815201.9	156815201.9	1099268460	942453257.7	18	942453257.7	140013573.2	598946083.3	458932510.2	1263569151	
19		164655962	164655962	1099268460	934612497.6	19	934612497.6	147014251.8	593963138.5	446948886.7	1710518038	
20		172888760.1	172888760.1	1132246513	959357753.3	20	959357753.3	154364964.4	609689195.9	455324231.5	2165842269	
21		181533198.1	181533198.1	1166213909	984680710.7	21	984680710.7	162083212.6	625782393.1	463699180.5	2629541450	

22		190609858	190609858	1201200326	1010590468	22	1010590468	170187373.3	642248512.3	472061139.1	3101602589
23		200140350.9	200140350.9	1237236336	1037095985	23	1037095985	178696741.9	659093247.5	480396505.6	3581999094
24		210147368.5	210147368.5	1274353426	1064206057	24	1064206057	187631579	676322188.7	488690609.7	4070689704
25		220654736.9	220654736.9	1312584029	1091929292	25	1091929292	197013158	693940805.3	496927647.3	4567617351
26		231687473.8	231687473.8	1351961550	1120274076	26	1120274076	206863815.9	711954428	505090612.1	5072707963
27		243271847.5	243271847.5	1392520396	1149248549	27	1149248549	217207006.7	730368229.2	513161222.6	5585869186
28		255435439.8	255435439.8	1434296008	1178860568	28	1178860568	228067357	749187203	521119846	6106989032
29		268207211.8	268207211.8	1477324888	1209117676	29	1209117676	239470724.8	768416142.3	528945417.4	6635934449
30		281617572.4	281617572.4	1521644635	1240027062	30	1240027062	251444261.1	788059615.9	536615354.8	7172549804
Total		4329922360	9610077896	29117535855	24787613495	Total		8580426693	15752976497	7172549804	

Year	IRR	B/C ratio	NPV
10	-1%	0.82	-2161035655
20	10.63%	1.38	2165842269
30	13%	1.85	7172549804

REVENUE DECREASE BY 10%

Project Cost		5,280,155,536										
Total Revenue		688,496,165										
Year	Cost		Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow		
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit		PV cost	PV Benefit	NPV			
0					0							
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	688496165	609293832	4	609293832	70716368.79	387217245.3	316500876.5	-4397923709	
5		83162449.69	83162449.69	709151050.1	625988600.4	5	625988600.4	74252187.23	397827072.4	323574885.2	-4074348824	
6		87320572.18	87320572.18	730425581.6	643105009.4	6	643105009.4	77964796.59	408704859.8	330740063.2	-3743608761	
7		91686600.79	91686600.79	752338349	660651748.2	7	660651748.2	81863036.42	419856129.5	337993093.1	-3405615668	
8		96270930.82	96270930.82	774908499.5	678637568.6	8	678637568.6	85956188.24	431286443.6	345330255.3	-3060285412	
9		101084477.4	101084477.4	798155754.5	697071277.1	9	697071277.1	90253997.65	443001398.5	352747400.9	-2707538011	
10		106138701.2	106138701.2	822100427.1	715961725.9	10	715961725.9	94766697.53	455006620.2	360239922.7	-2347298089	
11		111445636.3	111445636.3	846763439.9	735317803.6	11	735317803.6	99505032.41	467307757.6	367802725.2	-1979495364	
12		117017918.1	117017918.1	872166343.1	755148425	12	755148425	104480284	479910476	375430191.9	-1604065172	
13		122868814	122868814	898331333.4	775462519.4	13	775462519.4	109704298.2	492820450.2	383116152	-1220949020	
14		129012254.7	129012254.7	925281273.4	796269018.7	14	796269018.7	115189513.1	506043356.6	390853843.5	-830095176.2	
15		135462867.5	135462867.5	953039711.6	817576844.1	15	817576844.1	120948988.8	519584864.9	398635876.1	-431459300.1	
16		142236010.8	142236010.8	981630902.9	839394892.1	16	839394892.1	126996438.2	533450628.9	406454190.6	-25005109.48	
17		149347811.4	149347811.4	1011079830	861732018.7	17	861732018.7	133346260.1	547646276.6	414300016.5	389294907	
18		156815201.9	156815201.9	1041412225	884597023	18	884597023	140013573.2	562177400.2	422163827.1	811458734	
19		164655962	164655962	1041412225	876756262.9	19	876756262.9	147014251.8	557194455.4	410180203.6	1221638938	
20		172888760.1	172888760.1	1072654592	899765831.5	20	899765831.5	154364964.4	571817452.3	417452487.9	1639091426	
21		181533198.1	181533198.1	1104834229	923301031.3	21	923301031.3	162083212.6	586774497.2	424691284.6	2063782710	

22		190609858	190609858	1137979256	947369398.3	22	947369398.3	170187373.3	602070379.5	431883006.3	2495665716
23		200140350.9	200140350.9	1172118634	971978283.1	23	971978283.1	178696741.9	617709770.7	439013028.8	2934678745
24		210147368.5	210147368.5	1207282193	997134824.5	24	997134824.5	187631579	633697207.6	446065628.6	3380744374
25		220654736.9	220654736.9	1243500659	1022845922	25	1022845922	197013158	650037074.8	453023916.8	3833768291
26		231687473.8	231687473.8	1280805679	1049118205	26	1049118205	206863815.9	666733585.5	459869769.7	4293638060
27		243271847.5	243271847.5	1319229849	1075958001	27	1075958001	217207006.7	683790761.5	466583754.9	4760221815
28		255435439.8	255435439.8	1358806744	1103371305	28	1103371305	228067357	701212411.3	473145054.3	5233366869
29		268207211.8	268207211.8	1399570947	1131363735	29	1131363735	239470724.8	719002106.8	479531382	5712898251
30		281617572.4	281617572.4	1441558075	1159940503	30	1159940503	251444261.1	737163159.4	485718898.3	6198617150
Total		4329922360	9610077896	27585033968	23255111608	Total		8580426693	14779043842	6198617150	

Year	IRR	B/C ratio	NPV
10	-3%	0.78	-2347298089
20	9.81%	1.30	1639091426
30	12%	1.73	6198617150

REVENUE DECREASE BY 15%

Project Cost		5,280,155,536										
Total Revenue		650,246,378										
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow	
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV		
0						0						
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	650246378	571044045	4	571044045	70716368.79	362908814.2	292192445.4	-4422232140	
5		83162449.69	83162449.69	669753769.5	586591319.8	5	586591319.8	74252187.23	372789388.4	298537201.1	-4123694939	
6		87320572.18	87320572.18	689846382.6	602525810.4	6	602525810.4	77964796.59	382916045.2	304951248.6	-3818743690	
7		91686600.79	91686600.79	710541774.1	618855173.3	7	618855173.3	81863036.42	393293650.5	311430614.1	-3507313076	
8		96270930.82	96270930.82	731858027.3	635587096.5	8	635587096.5	85956188.24	403927090.2	317970902	-3189342174	
9		101084477.4	101084477.4	753813768.1	652729290.7	9	652729290.7	90253997.65	414821264.6	324567266.9	-2864774908	
10		106138701.2	106138701.2	776428181.1	670289479.9	10	670289479.9	94766697.53	425981082.2	331214384.7	-2533560523	
11		111445636.3	111445636.3	799721026.6	688275390.3	11	688275390.3	99505032.41	437411453.4	337906421	-2195654102	
12		117017918.1	117017918.1	823712657.4	706694739.3	12	706694739.3	104480284	449117282.7	344636998.7	-1851017103	
13		122868814	122868814	848424037.1	725555223.1	13	725555223.1	109704298.2	461103461.1	351399162.9	-1499617940	
14		129012254.7	129012254.7	873876758.2	744864503.5	14	744864503.5	115189513.1	473374857.9	358185344.8	-1141432595	
15		135462867.5	135462867.5	900093061	764630193.5	15	764630193.5	120948988.8	485936311.3	364987322.5	-776445272.9	
16		142236010.8	142236010.8	927095852.8	784859842	16	784859842	126996438.2	498792618.6	371796180.3	-404649092.6	
17		149347811.4	149347811.4	954908728.4	805560917	17	805560917	133346260.1	511948526	378602265.9	-26046826.7	
18		156815201.9	156815201.9	983555990.2	826740788.3	18	826740788.3	140013573.2	525408717.1	385395143.9	359348317.2	
19		164655962	164655962	983555990.2	818900028.2	19	818900028.2	147014251.8	520425772.3	373411520.5	732759837.8	
20		172888760.1	172888760.1	1013062670	840173909.8	20	840173909.8	154364964.4	533945708.7	379580744.3	1112340582	
21		181533198.1	181533198.1	1043454550	861921351.9	21	861921351.9	162083212.6	547766601.3	385683388.7	1498023971	

22		190609858	190609858	1074758187	884148328.5	22	884148328.5	170187373.3	561892246.7	391704873.5	1889728844
23		200140350.9	200140350.9	1107000932	906860581.2	23	906860581.2	178696741.9	576326293.9	397629552	2287358396
24		210147368.5	210147368.5	1140210960	930063591.6	24	930063591.6	187631579	591072226.5	403440647.5	2690799044
25		220654736.9	220654736.9	1174417289	953762552	25	953762552	197013158	606133344.3	409120186.3	3099919230
26		231687473.8	231687473.8	1209649808	977962333.8	26	977962333.8	206863815.9	621512743.1	414648927.3	3514568157
27		243271847.5	243271847.5	1245939302	1002667454	27	1002667454	217207006.7	637213293.8	420006287.2	3934574444
28		255435439.8	255435439.8	1283317481	1027882041	28	1027882041	228067357	653237619.5	425170262.5	4359744707
29		268207211.8	268207211.8	1321817005	1053609793	29	1053609793	239470724.8	669588071.3	430117346.5	4789862053
30		281617572.4	281617572.4	1361471515	1079853943	30	1079853943	251444261.1	686266702.8	434822441.7	5224684495
Total		4329922360	9610077896	26052532081	21722609721	Total		8580426693	13805111188	5224684495	

Year	IRR	B/C ratio	NPV
10	-4%	0.75	-2533560523
20	8.97%	1.22	1112340582
30	11%	1.62	5224684495

REVENUE DECREASE BY 20%

Project Cost		5,280,155,536										
Total Revenue		611,996,591										
Year	Cost			Benefit		Year	Cash flow	Present Value			Cumulative Discounted Cash Flow	
	Capital Cost	O&M cost	Total cost	Total Benefit	Net Benefit			PV cost	PV Benefit	NPV		
0						0						
1	1584046661		1584046661	0	0	1	-1584046661	1414327376		-1414327376	-1414327376	
2	2112062214		2112062214	0	0	2	-2112062214	1885769834		-1885769834	-3300097210	
3	1584046661		1584046661	0	0	3	-1584046661	1414327376		-1414327376	-4714424586	
4		79202333.04	79202333.04	611996591	532794258	4	532794258	70716368.79	338600383.1	267884014.3	-4446540571	
5		83162449.69	83162449.69	630356488.9	547194039.2	5	547194039.2	74252187.23	347751704.3	273499517.1	-4173041054	
6		87320572.18	87320572.18	649267183.6	561946611.4	6	561946611.4	77964796.59	357127230.7	279162434.1	-3893878620	
7		91686600.79	91686600.79	668745199.1	577058598.3	7	577058598.3	81863036.42	366731171.5	284868135.1	-3609010485	
8		96270930.82	96270930.82	688807555.1	592536624.3	8	592536624.3	85956188.24	376567736.8	290611548.6	-3318398936	
9		101084477.4	101084477.4	709471781.7	608387304.4	9	608387304.4	90253997.65	386641130.6	296387133	-3022011804	
10		106138701.2	106138701.2	730755935.2	624617234	10	624617234	94766697.53	396955544.3	302188846.7	-2719822957	
11		111445636.3	111445636.3	752678613.2	641232977	11	641232977	99505032.41	407515149.3	308010116.9	-2411812840	
12		117017918.1	117017918.1	775258971.6	658241053.5	12	658241053.5	104480284	418324089.5	313843805.4	-2097969034	
13		122868814	122868814	798516740.8	675647926.8	13	675647926.8	109704298.2	429386472.1	319682173.9	-1778286861	
14		129012254.7	129012254.7	822472243	693459988.3	14	693459988.3	115189513.1	440706359.2	325516846.1	-1452770014	
15		135462867.5	135462867.5	847146410.3	711683542.9	15	711683542.9	120948988.8	452287757.6	331338768.8	-1121431246	
16		142236010.8	142236010.8	872560802.6	730324791.8	16	730324791.8	126996438.2	464134608.3	337138170.1	-784293075.6	
17		149347811.4	149347811.4	898737626.7	749389815.3	17	749389815.3	133346260.1	476250775.4	342904515.3	-441388560.4	
18		156815201.9	156815201.9	925699755.5	768884553.6	18	768884553.6	140013573.2	488640034	348626460.8	-92762099.53	
19		164655962	164655962	925699755.5	761043793.5	19	761043793.5	147014251.8	483657089.2	336642837.4	243880737.9	
20		172888760.1	172888760.1	953470748.2	780581988	20	780581988	154364964.4	496073965.1	341709000.7	585589738.5	
21		181533198.1	181533198.1	982074870.6	800541672.5	21	800541672.5	162083212.6	508758705.4	346675492.7	932265231.3	

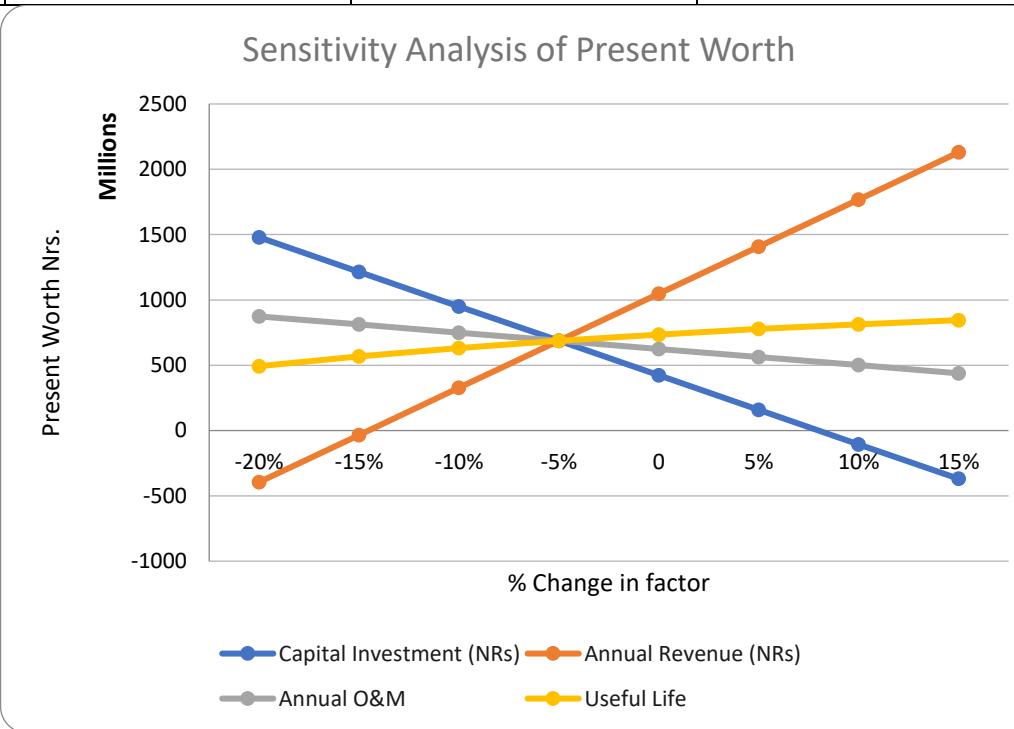
22		190609858	190609858	1011537117	820927258.7	22	820927258.7	170187373.3	521714113.9	351526740.7	1283791972
23		200140350.9	200140350.9	1041883230	841742879.3	23	841742879.3	178696741.9	534942817.1	356246075.2	1640038047
24		210147368.5	210147368.5	1073139727	862992358.6	24	862992358.6	187631579	548447245.4	360815666.4	2000853714
25		220654736.9	220654736.9	1105333919	884679182	25	884679182	197013158	562229613.8	365216455.8	2366070169
26		231687473.8	231687473.8	1138493937	906806462.7	26	906806462.7	206863815.9	576291900.7	369428084.8	2735498254
27		243271847.5	243271847.5	1172648755	929376907.2	27	929376907.2	217207006.7	590635826.1	373428819.5	3108927074
28		255435439.8	255435439.8	1207828217	952392777.4	28	952392777.4	228067357	605262827.8	377195470.8	3486122545
29		268207211.8	268207211.8	1244063064	975855851.9	29	975855851.9	239470724.8	620174035.8	380703311	3866825856
30		281617572.4	281617572.4	1281384956	999767383.3	30	999767383.3	251444261.1	635370246.3	383925985.2	4250751841
Total		4329922360	9610077896	24520030194	20190107834	Total		8580426693	12831178533	4250751841	

Year	IRR	B/C ratio	NPV
10	-5%	0.71	-2719822957
20	8.08%	1.14	585589738.5
30	10%	1.51	4250751841

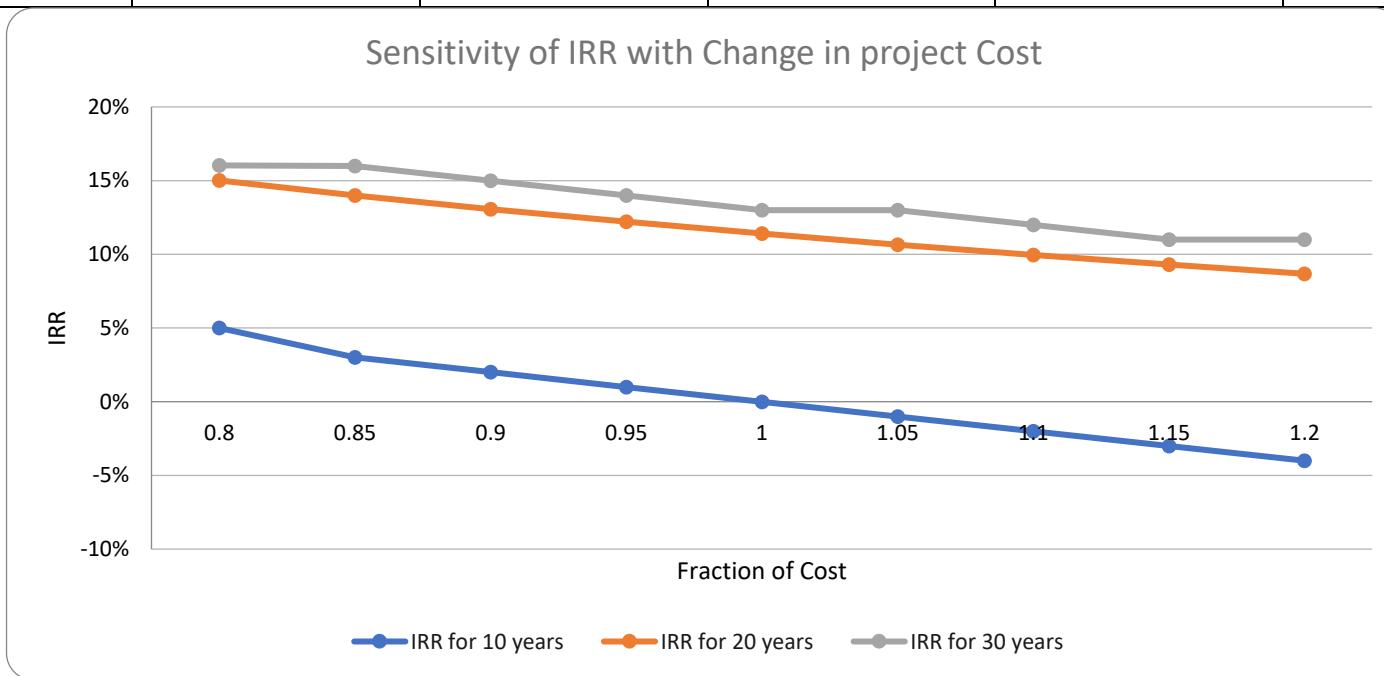
SENSITIVITY ANALYSIS

Sensitivity Analysis	
Capital Investment	5,280,155,536
Annual Revenue	764,995,739
Annual Operation and maintenance	132,003,888.40
Useful Life	30
MARR	10%

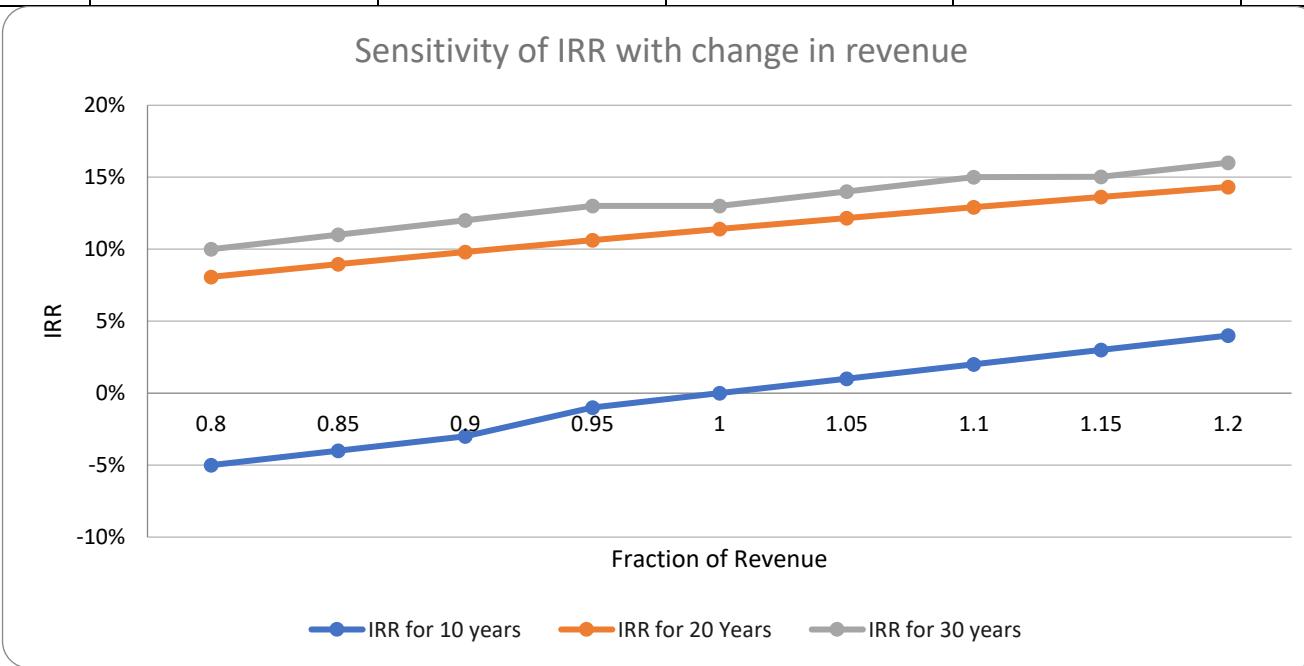
%Change in Factor	Capital Investment (NRs)	Annual Revenue (NRs)	Annual O&M	Useful Life
-20%	1743035605.11	-755305381.93	935882370.96	407114208.42
-15%	1479027828.31	-394727911.97	873662902.70	492725195.28
-10%	1215020051.51	-34150442.01	811443434.43	566931443.64
-5%	951012274.71	326427027.95	749223966.17	631252245.19
0	687004497.91	687004497.91	687004497.91	687004497.91
5%	422996721.11	1047581967.87	624785029.64	735329668.12
10%	158988944.31	1408159437.82	562565561.38	777217160.76
15%	-105018832.49	1768736907.78	500346093.12	813524576.40
20%	-369026609.29	2129314377.74	438126624.86	844995269.60



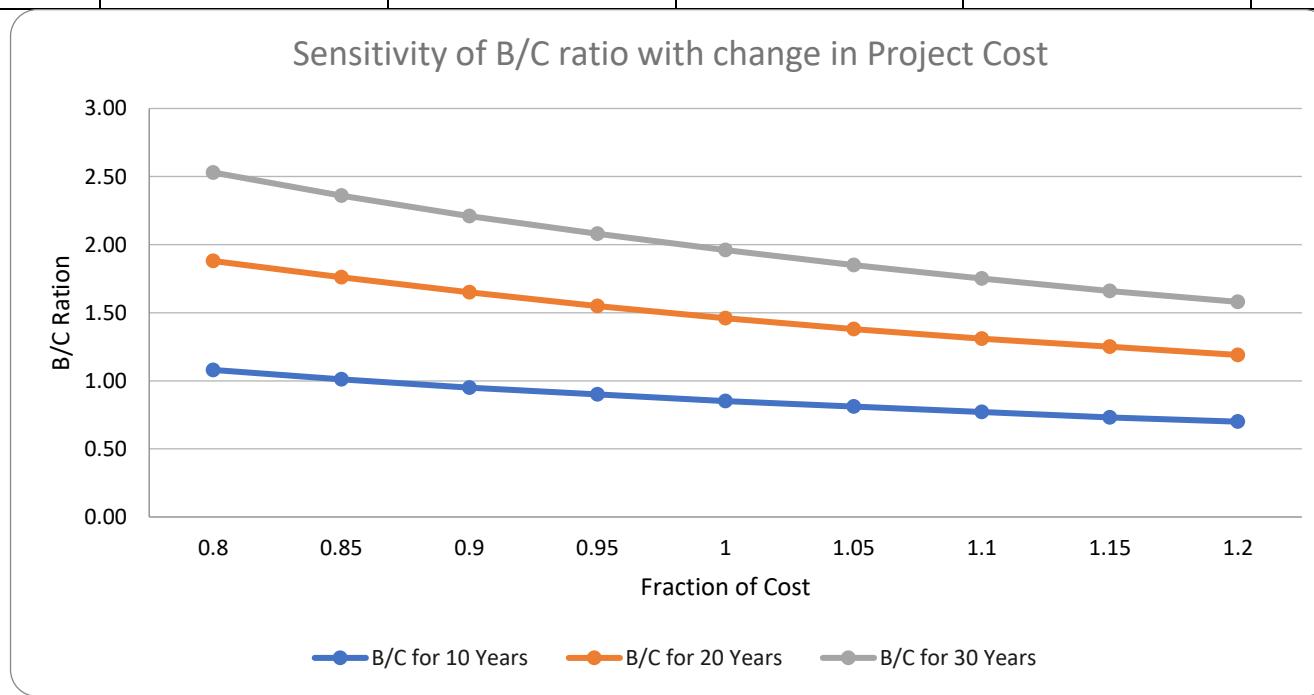
Sensitivity of IRR with Change in project Cost					
% Change of Project Cost	Project Cost	Fraction of Cost	IRR for 10 years	IRR for 20 years	IRR for 30 years
-0.2	4224124429	0.8	5.00%	15.01%	16.03%
-0.15	4488132206	0.85	3.00%	14.00%	16.00%
-0.1	4752139982	0.9	2.00%	13.07%	15.00%
-0.05	5016147759	0.95	1.00%	12.21%	14.00%
0	5280155536	1	0.00%	11.41%	13.00%
0.05	5544163313	1.05	-1.00%	10.66%	13.00%
0.1	5808171090	1.1	-2.00%	9.96%	12.00%
0.15	6072178866	1.15	-3.00%	9.30%	11.00%
0.2	6336186643	1.2	-4.00%	8.68%	11.00%



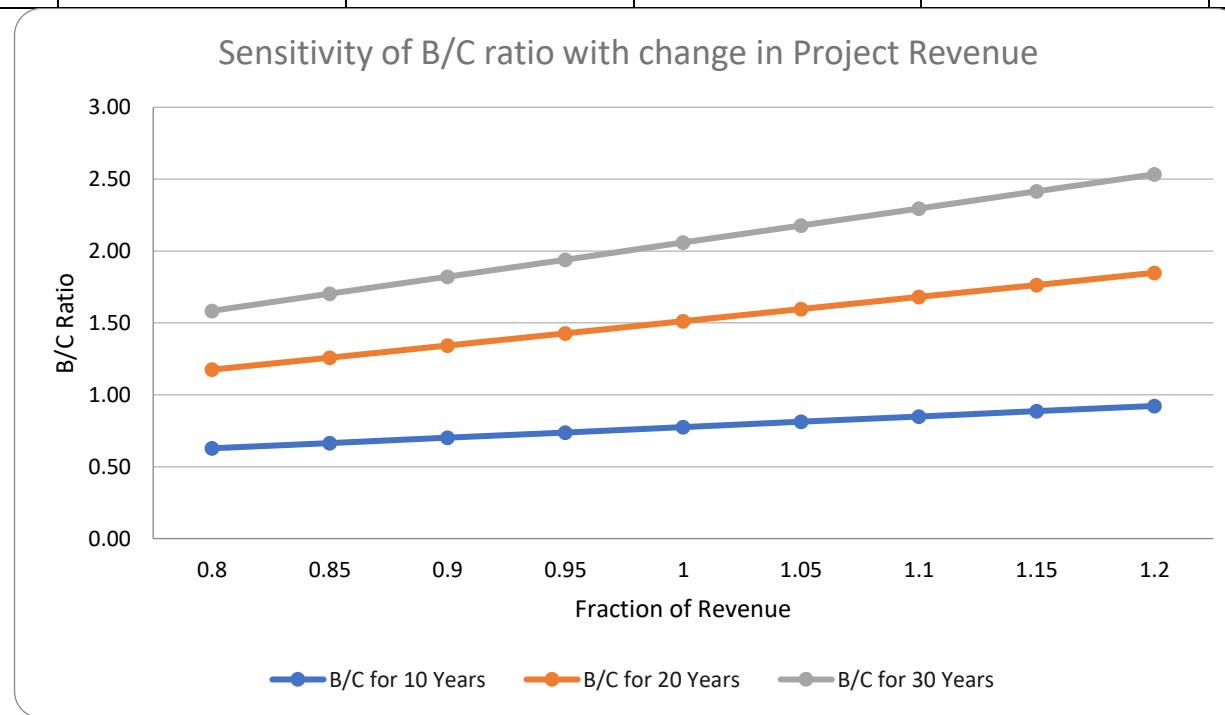
Sensitivity of IRR with change in revenue					
% Change of Revenue	Revenue	Fraction of revenue	IRR for 10 years	IRR for 20 Years	IRR for 30 years
-0.2	611996591.2	0.8	-5.00%	8.08%	10.00%
-0.15	650246378.2	0.85	-4.00%	8.97%	11.00%
-0.1	688496165.1	0.9	-3.00%	9.81%	12.00%
-0.05	726745952.1	0.95	-1.00%	10.63%	13.00%
0	764995739	1	0.00%	11.41%	13.00%
0.05	803245526	1.05	1.00%	12.17%	14.00%
0.1	841495312.9	1.1	2.00%	12.91%	15.00%
0.15	879745099.9	1.15	3.00%	13.63%	15.03%
0.2	917994886.8	1.2	4.00%	14.33%	16.01%



Sensitivity of B/C ratio with change in Project Cost					
% Change of Cost	Cost	Fraction of Cost	B/C for 10 Years	B/C for 20 Years	B/C for 30 Years
-0.2	4224124429	0.8	1.08	1.88	2.53
-0.15	4488132206	0.85	1.01	1.76	2.36
-0.1	4752139982	0.9	0.95	1.65	2.21
-0.05	5016147759	0.95	0.90	1.55	2.08
0	5280155536	1	0.85	1.46	1.96
0.05	5544163313	1.05	0.81	1.38	1.85
0.1	5808171090	1.1	0.77	1.31	1.75
0.15	6072178866	1.15	0.73	1.25	1.66
0.2	6336186643	1.2	0.70	1.19	1.58



Sensitivity of B/C ratio with change in Project Revenue					
% Change of Revenue	Revenue	Fraction of revenue	B/C for 10 Years	B/C for 20 Years	B/C for 30 Years
-0.2	611996591.2	0.8	0.63	1.18	1.58
-0.15	650246378.2	0.85	0.66	1.26	1.70
-0.1	688496165.1	0.9	0.70	1.34	1.82
-0.05	726745952.1	0.95	0.74	1.43	1.94
0	764995739	1	0.78	1.51	2.06
0.05	803245526	1.05	0.81	1.60	2.18
0.1	841495312.9	1.1	0.85	1.68	2.30
0.15	879745099.9	1.15	0.89	1.76	2.42
0.2	917994886.8	1.2	0.92	1.85	2.53



ANNEX H: DESIGN DRAWING