

APPENDIX I: ECONOMICS OF REMOVAL OF BOD₅

Table I.1 Cost estimation for removal of BOD₅ from discharge point A

Discharge point A

BOD₅ removal from wastewater (conventional treatment)

Plant size = 65,000 m³/d

1 acre land= US\$ 0.864 million

Land required=160 acres

BOD load = 83.02 tons/d

Level of treatment	BOD ₅ removed (%)	Actual BOD ₅ removed (tons/d)	Capital costs (civil) in US\$ million	Capital costs (M/E works) in US\$ million	Costs for land in US\$ million	Total Capital costs in US\$ million	Annualized Capital costs in US\$ million	Total annual O & M costs in US\$ million	Total Abatement Costs in US\$ million/year	Total Abatement Costs in US\$/day
Pretreatment (screening)	5.00	4.15	0.70	0.20	0.22	1.12	0.17	0.02	0.189	518.09
Primary plus pretreatment (Screening + primary clarifiers)	30.00	24.91	2.70	0.90	0.30	3.90	0.59	0.05	0.638	1750.26
Pretreatment plus Primary plus low efficiency secondary (Screening + primary clarifiers+ trickling filter)	80.00	66.42	5.70	1.80	0.40	7.90	1.19	1.17	2.362	6473.40
Pretreatment plus Primary plus high efficiency secondary (Screening + primary clarifiers+ trickling filter+ Biological Aerated Filter)	90.00	74.72	19.98	5.00	0.40	25.38	3.83	3.67	7.502	20553.49
Pretreatment plus Primary plus high efficiency secondary plus tertiary (Screening + primary clarifiers+ trickling filter+ Biological Aerated Filter+lagooning+ chlorination)	95.00	78.87	27.98	5.60	138.40	171.98	25.97	3.72	29.686	81333.08

Table I.2 Abatement cost function for Discharge point A

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.710443031
R Square	0.5047293
Adjusted R Square	0.339639066
Standard Error	27662.20663
Observations	5

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	2339433888	2.34E+09	3.057294	0.178693542
Residual	3	2295593026	7.65E+08		
Total	4	4635026915			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-6292.060905	20425.08196	-0.30806	0.77819	-71293.78753	58709.66571	-71293.8	58709.67
X Variable 1	8.431696882	4.822213317	1.748512	0.178694	-6.914738069	23.77813183	-6.91474	23.77813

Table I.3 Cost estimation for removal of BOD₅ from discharge point B

Discharge point B

BOD₅ removal from wastewater (Moving Bed Biological Reactor)

Plant size = 25,000 m³/d

1 acre land= US\$ 0.864 million

Land required=2.5 acres

BOD load = 71.01 tons/d

Level of treatment	BOD ₅ removed (%)	Actual BOD ₅ removed (tons/d)	Capital costs (civil) in US\$ million	Capital costs (M/E works) in US\$ million	Costs for land in US\$ million	Total Capital costs in US\$ million	Annualized Capital costs in US\$ million	Total annual O & M costs in US\$ million	Total Abatement Costs in US\$ million/year	Total Abatement Costs in US\$/day
Pretreatment (screening)	5.00	3.55	0.50	0.15	0.10	0.75	0.11	0.02	0.133	365.04
Primary plus pretreatment (Screening + primary clarifiers)	30.00	21.30	2.10	0.80	0.20	3.10	0.47	0.05	0.518	1419.33
Pretreatment plus Primary plus low efficiency secondary (Screening + primary clarifiers+ activated sludge process)	70.00	49.71	4.80	1.70	0.26	6.76	1.02	1.15	2.171	5947.03
Pretreatment plus Primary plus high efficiency secondary (Screening + primary clarifiers+ activated sludge process+ Moving Bed Biological Reactor)	90.00	63.91	8.35	5.30	2.16	15.81	2.39	2.05	4.437	12156.41
Pretreatment plus Primary plus high efficiency secondary plus tertiary (Screening + primary clarifiers+ activated sludge process+ Moving Bed Biological Reactor+ sand filtration + chlorination)	95.00	67.46	10.55	5.90	2.30	18.75	2.83	3.02	5.851	16030.10

Table I.4 Abatement cost function for Discharge point B

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.981759956
R Square	0.963852612
Adjusted R Square	0.951803483
Standard Error	1489.935687
Observations	5

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	177578345.7	177578345.7	79.99355	0.002949041
Residual	3	6659725.05	2219908.35		
Total	4	184238070.8			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-314.735496	1070.909882	-0.293895407	0.787998	-3722.84869	3093.378	-3722.848693	3093.378
X Variable 1	3.239754724	0.362230196	8.94391124	0.002949	2.086976575	4.392533	2.086976575	4.392533

Table I.5 Cost estimation for removal of BOD₅ from discharge point C

Discharge point C
 BOD₅ removal from wastewater (existing-PSTP)

Plant size = 120,000 m³/d
 1 acre land= US\$ 0.864 million
 Land required=236 acres

BOD load = 32 tons/d

Level of treatment	BOD ₅ removed (%)	Actual BOD ₅ removed (tons/d)	Capital costs (civil) in US\$ million	Capital costs (M/E works) in US\$ million	Costs for land in US\$ million	Total Capital costs in US\$ million	Annualized Capital costs in US\$ million	Total annual O & M costs in US\$ million	Total Abatement Costs in US\$ million/year	Total Abatement Costs in US\$/day
Pretreatment (screening)	5.00	1.60	0.70	0.20	0.10	1.00	0.15	0.70	0.851	2331.47
Primary plus pretreatment (Screening + primary clarifiers)	30.00	9.60	1.80	0.80	0.20	2.80	0.42	1.30	1.722	4719.89
Pretreatment plus Primary plus low efficiency secondary (Screening + primary clarifiers+ trickling filter)	80.00	25.60	8.50	2.50	0.26	11.26	1.70	2.10	3.801	10411.24
Pretreatment plus Primary plus low efficiency secondary plus tertiary (Screening + primary clarifiers+ trickling filter + lagooning + chlorination)	95.00	30.40	11.10	5.50	204.56	221.16	33.39	2.80	36.192	99156.34

Table I.6 Abatement cost function for Discharge point C

SUMMARY OUTPUT

<i>Regression Statistics</i>	
Multiple R	0.8037367
R Square	0.645992683
Adjusted R Square	0.468989024
Standard Error	34096.57461
Observations	4

ANOVA

	<i>df</i>	<i>SS</i>	<i>MS</i>	<i>F</i>	<i>Significance F</i>
Regression	1	4.24E+09	4242939682	3.649600733	0.1962633
Residual	2	2.33E+09	1162576400		
Total	3	6.57E+09			

	<i>Coefficients</i>	<i>Standard Error</i>	<i>t Stat</i>	<i>P-value</i>	<i>Lower 95%</i>	<i>Upper 95%</i>	<i>Lower 95.0%</i>	<i>Upper 95.0%</i>
Intercept	-6301.101738	25201.14	-0.250032455	0.82590043	-114732.8355	102130.6	-114733	102130.632
X Variable 1	84.70909039	44.34119	1.910392822	0.1962633	-106.0756502	275.4938	-106.076	275.493831