Appendix E Mechanical Surface Aeration Capacity

Reference Small and Decentralized Wastewater Management Systems, Crites and Tchobanoglous, Metcalf & Eddy, McGraw- Hill, 1998 Section 8-5 Partial-Mix Aerated Lagoons

					Kandahar Region				**Kunduz Region**				**Kabul Region**					
Design Loadings					**Design Population (see lagoons)**				**Design Population (see lagoons)**				**Design Population (see lagoons)**					
				120	155	340	680	120	155	340	680	120	155	340	680			
BOD loading	lb/day based on 0.2 lb/d-capita			24	31	68	136	24	31	68	136	24	31	68	136			
	kg/day (for carbonaceous demand)			11	14	31	62	11	14	31	62	11	14	31	62			
Hydraulic loading	cu m/day			27	35	78	155	27	35	78	155	27	35	78	155			
Mechanical aerator air transfer calc																		
Oxygen demand	lb/day based on organic loading times factor			36	47	102	204	36	47	102	204	36	47	102	204			
	kg/day (AOTR)			16	21	46	93	16	21	46	93	16	21	46	93			
factor =	1.5	from ref. p 544																
SOTR	kg/day			38	49	108	217	35	45	98	197	45	57	126	252			
	lb/day			84	109	239	478	76	99	217	433	98	127	278	556			
Assumed aerator ransfer =		1.3	kg O_2/kwh-h															
Total Aerator Power (to divide into units) =			hp	1.7	2.2	4.8	9.7	1.6	2.0	4.4	8.8	2.0	2.6	5.6	11.3			
SOTR/(O2 transfer aerators * 24 hour/day)			kw	1.3	1.6	3.6	7.2	1.2	1.5	3.3	6.6	1.5	1.9	4.2	8.4			
1st cell total lagoon capacity, cubic meters				504	651	1,429	2,857	591	764	1,675	3,350	646	834	1,830	3,660			
Energy used for mixing, kW/1,000 cu meters				2.5	2.5	2.5	2.5	2.0	2.0	2.0	2.0	2.3	2.3	2.3	2.3			
Should range between 2 to 4 kW/1,000 cu meters per ref, p 463																		
For complete suspension of solids, 10 times this energy input is needed, i.e. 20 kW/1,000 cubic meters, ref, p 544																		

Calculation of actual air transfer rate under field conditions for aerators

						Example from ref p 544				**Kandahar**	**Kunduz**	**Kabul**						
SOTR=AOTR/((beta*CsTH-Cl)/Cs20)*(1.024^(T-20))*alpha				units of kg/day=		calc check		SOTR, kg O2/h per										
SOTR, kg O2/h=	32.73	std O2 transfer rate, 20C		**785**	◄——►	**783**		kg O2 /h AOTR, ratio =		2.34	2.12	2.73						
AOTR, kg O2/h=	19.0	actual transfer @ field conditon		**455**		455		AOTR, kg O2/h= 1		1	1	1						
beta=	0.95	salinity-surface tension correction factor						beta=		0.95	0.95	0.95						
CsTH, mg/L	8.46	average dissolved O2 at T and H						CsTH, mg/L		5.65	6.2	5.7						
Cl, mg/L	2	operating oxygen concentration						Cl, mg/L		2	2	2						
Cs20, mg/L	9.08	O2 concentration at 20 C/1 atm						Cs20, mg/L		9.08	9.08	9.08						
T, deg C	23.6	operating temperature						T, deg C		41	39	34						
alpha, unitless	0.8	oxygen correction transfer for waste						alpha, unitless		0.7	0.7	0.7						

Calculation example of atmospheric pressure at project site at specific temperature

pb=pa*(exp(-(g*M*(zb-za)/(gc*R*T))=			pb=	14.0	psi	725	mm_Hg	**Field condition**		**Kandahar**	**Kunduz**	**Kabul**						
g=	32.2		pa=	14.7	psi	760	mm_Hg		elevation, m	1010	432	1790						
gc=	32.2		za=	0	ft				elevation, ft	3314	1417	5876						
M=	28.97		zb=	1417	ft	432	m	summer high, o C		41	39	34						
R=	1545							summer high, o F		106	102	93						
T, air temp:								summer temp, Rankine		566	562	553						
C=	41							air pressure psi		13.2	14.0	12.0						
F=	105.8	T=degreesR=460+F		565.8	n for air	0.283		air pressure mm Hg		681	725	623						
specific weight of air at field operating temperature and pressure								Dissolved O2 mg/l		5.65	6.2	5.7						
gamma_a=pb*(144)/R*T=		**0.067**	lb/ft^3															
R=	53.3	ft.lb/(lb air).degreesR																
T=	565.8	degrees R																

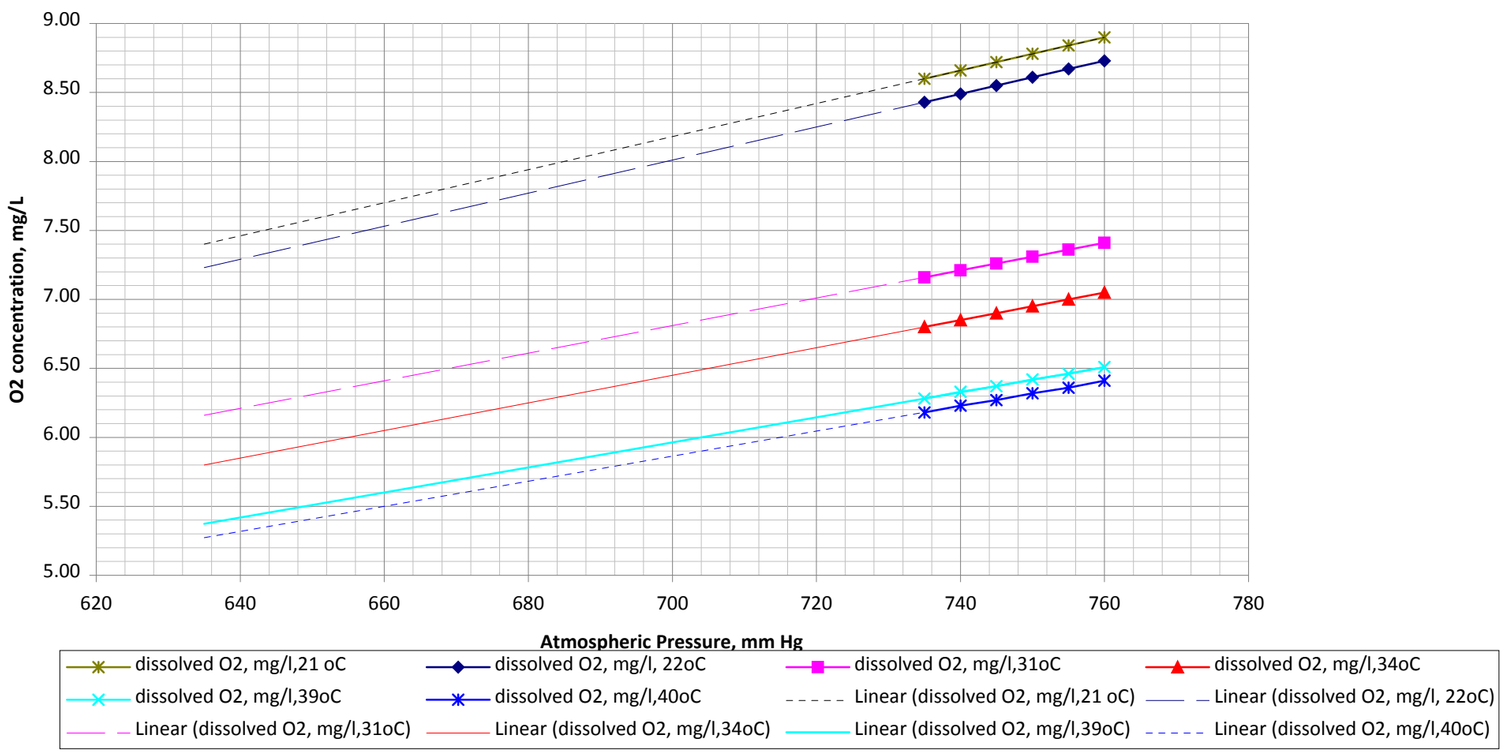
Table 10 Partial Mix Aerated Lagoon Aeration Requirements (680 capita)

Field condition	**Kandahar**	**Kunduz**	**Kabul**
elevation, m	1010	432	1790
elevation, ft	3314	1417	5876
summer high, o C	41	39	34
summer high, o F	106	102	93
air pressure mm Hg	681	725	623
Dissolved O2 mg/l	5.65	6.20	5.70
AOTR, kg O_2 /day	93	93	93
SOTR, kg O2/day	217	197	252
total aerator power, kw	7.2	6.6	8.4
Energy used for mixing, kW/1,000 cu meters	2.5	2.0	2.3

Air properties

specific weight at std conditions	0.075	lb/ft^3
ratio at 5,000 feet	0.832	
specific weight at 20o C & 5,000 ft	0.062	lb/ft^3
fraction of O_2 in air	0.232	

Chart of Dissolved Oxygen for Temperature and Pressure

Based on Appendix E in Reference

pressure mb_Hg	dissolved O_2, mg/l,21 oC	dissolved O_2, mg/l, 22oC	dissolved O_2, mg/l,31oC	dissolved O_2, mg/l,34oC	dissolved O_2, mg/l,39oC	dissolved O_2, mg/l,40oC
735	8.60	8.43	7.16	6.80	6.28	6.18
740	8.66	8.49	7.21	6.85	6.33	6.23
745	8.72	8.55	7.26	6.90	6.37	6.27
750	8.78	8.61	7.31	6.95	6.42	6.32
755	8.84	8.67	7.36	7.00	6.46	6.36
760	8.90	8.73	7.41	7.05	6.51	6.41