Table V.2.43 Cash flow and P/L calculation for Alternative I

Project expenditure estimation (Unit : S/.000)

Fiscal Year	Total(99-25)	1999FY	2000FY	2001FY	2002FY	2003FY	2004FY	2005FY	2006FY	2007FY	2008FY	2009FY	2010FY	2011FY	2012FY	2013FY	2014FY	2015FY	2016FY	2017FY	2018FY	2019FY	2020FY	2021FY	2022FY	2023FY	2024FY	2025FY
Land Acquisition	0																											
Proposed project administration expense	601		22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Construction work (a)	59,984		2,586	18,268	2,586							9,022	1,447	1,447	1,447	1,447	1,447	1,447	1,375	6,465	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
Contingency (15%) (b)=(a) x 0.15	8,998		388	2,740	388							1,353	217	217	217	217	217	217	206	970	206	206	206	206	206	206	206	206
GST (18%) (c)=(a+b) x 0.18	12,417		535	3,781	535							1,868	300	300	300	300	300	300	285	1,338	285	285	285	285	285	285	285	285
Maintenance Equipment (d)	21,587		15		234	173	377					114	15		8,670	173	377				188	2,016	15		8,670	173	377	
Contingency (15%) (e)=(d) x 0.15	3,238		2		35	26	57					17	2		1,301	26	57				28	302	2		1,301	26	57	
GST (18%) (f) =(d+e) x 0.18	4,469		3		48	36	78					24	3		1,795	36	78				39	417	3		1,795	36	78	
Engineering Service (g)	5,999	1,406		938								1,062		708					1,131		754							
Contingency (15%) (h)=(g) x 0.15	900	211		141								159		106					170		113							
GST (18%) (i) =(g+h) x 0.18	1,242	291		194								220		147					234		156							
Maintenance (with GST)	28,646	317	335	354	550	574	599	623	659	696	735	778	1,096	1,135	1,174	1,215	1,255	1,297	1,338	1,379	1,418	1,464	1,507	1,547	1,588	1,629	1,670	1,713
Total	148,079	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	14,646	3,109	4,088	14,932	3,442	3,759	3,290	4,759	10,172	4,582	6,086	3,413	3,433	15,239	3,750	4,067	3,599

Donation, Loan & Local Fund

Donation up to S/.21,180 (DM12MIL)	21,180	1,908	3,509	15,763	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan available for construction work	50,245	0	0	5,245	2,974	0	0	0	0	0	0	10,375	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund of non-construction expense	76,655	317	378	5,431	1,425	831	1,133	645	681	718	757	4,270	1,445	2,424	13,268	1,778	2,095	1,626	3,177	2,737	3,001	4,504	1,832	1,852	13,658	2,168	2,486	2,018
Total	148,079	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	14,646	3,109	4,088	14,932	3,442	3,759	3,290	4,759	10,172	4,582	6,086	3,413	3,433	15,239	3,750	4,067	3,599

Loan transaction

Loan Receipt	50,245	0	0	5,245	2,974	0	0	0	0	0	0	10,375	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Loan Repayment	11,394	0	0	0	0	0	0	0	0	0	0	0	0	262	411	411	411	411	411	411	411	930	1,013	1,096	1,179	1,263	1,346	1,429
Loan Balance	38,850	0	0	5,245	8,219	8,219	8,219	8,219	8,219	8,219	8,219	18,594	20,258	21,660	22,913	24,166	25,419	26,672	27,843	34,867	36,037	36,688	37,257	37,742	38,144	38,463	38,698	38,850

Interest

Interest (5 %)	29,352	0	0	262	411	411	411	411	411	411	411	930	1,013	1,083	1,146	1,208	1,271	1,334	1,392	1,743	1,802	1,834	1,863	1,887	1,907	1,923	1,935	1,943

Cash Flow

Cash - In :																												
Donation	21,180	1,908	3,509	15,763	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan for Project Disbursement	50,245	0	0	5,245	2,974	0	0	0	0	0	0	10,375	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund for Project Disbursement	76,655	317	378	5,431	1,425	831	1,133	645	681	718	757	4,270	1,445	2,424	13,268	1,778	2,095	1,626	3,177	2,737	3,001	4,504	1,832	1,852	13,658	2,168	2,486	2,018
Local Fund for Loan Repayment	11,394	0	0	0	0	0	0	0	0	0	0	0	0	262	411	411	411	411	411	411	411	930	1,013	1,096	1,179	1,263	1,346	1,429
Revenue + F/A sold	171,559	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	52,208
Local Fund for Interest Payment	29,352	0	0	262	411	411	411	411	411	411	411	930	1,013	1,083	1,146	1,208	1,271	1,334	1,392	1,743	1,802	1,834	1,863	1,887	1,907	1,923	1,935	1,943
Cash - Out :																												
Project Disbursement	148,079	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	14,646	3,109	4,088	14,932	3,442	3,759	3,290	4,759	10,172	4,582	6,086	3,413	3,433	15,239	3,750	4,067	3,599
Loan Repayment	11,394	0	0	0	0	0	0	0	0	0	0	0	0	262	411	411	411	411	411	411	411	930	1,013	1,096	1,179	1,263	1,346	1,429
Interest Payment	29,352	0	0	262	411	411	411	411	411	411	411	930	1,013	1,083	1,146	1,208	1,271	1,334	1,392	1,743	1,802	1,834	1,863	1,887	1,907	1,923	1,935	1,943
EMSAPUNO existing expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Repayment of Local Fund	150,310	785	996	1,116	1,238	1,472	1,612	1,755	2,088	2,308	2,535	2,953	3,219	3,394	3,797	3,994	4,196	4,669	4,887	5,113	5,639	5,902	6,161	6,761	7,022	7,290	7,984	51,421
Balance of Cash Fund / -- Local Fund	32,909	468	618	-4,577	-598	230	69	699	996	1,179	1,367	-2,247	761	-375	-11,027	596	419	1,298	-93	221	426	-1,366	1,453	1,927	-9,722	1,936	2,217	46,032

P/L ESTIMATION

Revenue	128,420	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069
Expense: 1. Administration	22,577	787	809	809	1,127	809	809	809	809	809	809	971	816	816	816	816	816	816	807	807	1,062	807	807	807	807	807	807	807
2. Engineering service	8,141	1,908	0	1,273	0	0	0	0	0	0	0	1,441	0	961	0	0	0	0	1,535	0	1,023	0	0	0	0	0	0	0
3. Maintenance	28,646	317	335	354	550	574	599	623	659	696	735	778	1,096	1,135	1,174	1,215	1,255	1,297	1,338	1,379	1,418	1,464	1,507	1,547	1,588	1,629	1,670	1,713
4. Interest expense	29,352	0	0	262	411	411	411	411	411	411	411	930	1,013	1,083	1,146	1,208	1,271	1,334	1,392	1,743	1,802	1,834	1,863	1,887	1,907	1,923	1,935	1,943
5. Depreciation (proposed)	57,789	0	0	0	0	1,678	1,678	1,678	1,678	1,678	1,678	1,678	2,189	2,238	2,287	2,336	2,385	2,434	2,483	2,530	3,232	3,279	3,325	3,372	3,419	3,465	3,512	3,559
6. Depreciation (existing)	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362
Expense total	156,271	3,374	1,506	3,060	2,449	3,833	3,858	3,882	3,918	3,955	3,994	6,159	5,475	6,594	5,784	5,937	6,089	6,243	7,917	6,821	8,899	7,746	7,864	7,975	8,083	8,186	8,286	8,383
Profit / Loss	-27,851	-1,802	277	-1,157	-424	-1,574	-1,459	-1,340	-1,044	-860	-672	-2,418	-1,469	-2,413	-1,200	-1,156	-1,106	-787	-2,243	-921	-2,473	-1,057	-916	-427	-274	-109	485	686

Assumption

1. Revenue : The rate will be revised every 3 years and 5 % increase is expected.
   Fee collection rate will be increased by 1% annually.

2. Depreciation (construction) civil work will be depreciated for 40 years (every year 2.5 % of acquisition cost is depreciated.)
   mechanical/electrical will be depreciated for 10 years.

3. Depreciation (equipment) items will be depreciated for 10 years (every year 10 % of acquisition cost is depreciated.)

4. Depreciation (EMSAPUNO) Existing fixed asset is for water and sewerage business. According to the 1998 FY detail expense information, 66% of depreciation was for water business, 34% of depreciation was for sewerage business.

5. Local Fund : Non-construction expense loan principal payment & interest payment are funded by Peru/Puno government without interest.

(Unit : S/.000)

Depreciation of proposed fixed asset		1999F/Y	2000F/Y	2001F/Y	2002F/Y	2003F/Y	2004F/Y	2005F/Y	2006F/Y	2007F/Y	2008F/Y	2009F/Y	2010F/Y	2011F/Y	2012F/Y	2013F/Y	2014F/Y	2015F/Y	2016F/Y	2017F/Y	2018F/Y	2019F/Y	2020F/Y	2021F/Y	2022F/Y	2023F/Y	2024F/Y	2025F/Y
sewer civil work (2000-2FY)	6,054					263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
sewer civil work (2009-15FY)	4,468												49	98	147	196	246	295	344	344	344	344	344	344	344	344	344	344	344
sewer civil work (2016-25FY)	2,099																			47	93	140	187	233	280	327	373	420
pump civil work (2001FY)	2,772					1	1	1	1	1	1	1	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173	173
plant civil work (2001FY)	5,445					237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237
plant civil work (2009FY)	268												17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
plant civil work (2017FY)	94																				12	12	12	12	12	12	12	12	12
pump mechanical (2001FY. 2017FY)	3,366					25	25	25	25	25	25	25	187	187	187	187	187	187	187	187	212	212	212	212	212	212	212	212	212
plant mechanical (2001FY)	26,496					1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
plant mechanical (2009FY)	1,774												111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
plant mechanical (2017FY)	4,953																				619	619	619	619	619	619	619	619	619
total depreciation of proposed F/A	57,789					1,678	1,678	1,678	1,678	1,678	1,678	1,678	2,189	2,238	2,287	2,336	2,385	2,434	2,483	2,530	3,232	3,279	3,325	3,372	3,419	3,465	3,512	3,559

Depreciation for existing (EMSAPUNO) fixed asset																												
Building, Construction (S/.23449 +S/.12450) x 34	8,239	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305
Machine (S/. 874) x 34%	802	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Transportation equipment (S/. 236) x 34%	217	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Equipment (S/. 43) x 34%	39	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other (S/. 510) x 34%	468	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
total of depreciation of existing F/A	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362

REVENUE ESTIMATION

wastewater flow estimation (61.3 l/s in 98FY)		65.8	70.4	74.4	78.4	82.5	86.8	91.1	97.2	103.7	110.3	117.2	124.4	128.7	133.2	137.7	142.3	147.1	151.7	156.4	160.9	166.1	171.1	175.6	180.2	184.9	189.7	194.6
increase rate of wastewater (each year / 98FY)A		1.0734	1.1485	1.2137	1.2790	1.3458	1.4160	1.4861	1.5856	1.6917	1.7993	1.9119	2.0294	2.0995	2.1729	2.2463	2.3214	2.3997	2.4747	2.5514	2.6248	2.7096	2.7912	2.8646	2.9396	3.0163	3.0946	3.1746
increase rate of sewerage fee (each year / 98FY)B		1.00	1.05	1.05	1.05	1.10	1.10	1.10	1.16	1.16	1.16	1.22	1.22	1.22	1.28	1.28	1.28	1.34	1.34	1.34	1.41	1.41	1.41	1.48	1.48	1.48	1.55	1.55
increase of collection rate (annually 1 %) C		1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27
estimated revenue (S/. 1450 in 1998 x A x B x C)		1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069

Administration detail(without contingency and GST)																												
EMSAPUNO existing administration expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Proposed project administration expense	601	0	22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Proposed project maintenance equipment	727	0	0	0	318	0	0	0	0	0	0	155	0	0	0	0	0	0	0	0	255	0	0	0	0	0	0	0
total	22,577	787	809	809	1,127	809	809	809	809	809	809	971	816	816	816	816	816	816	807	807	1,062	807	807	807	807	807	807	807

IRR (Internal Rate of Return)

Cash Flow In (Donation + Revenue + F/A sold)	192,739	3,480	5,292	17,666	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	52,208
Cash Flow Out (Project dis + EMSAPUNO)	169,328	3,012	4,674	27,226	5,186	1,618	1,920	1,432	1,468	1,505	1,544	15,433	3,896	4,875	15,719	4,229	4,546	4,077	5,546	10,959	5,369	6,873	4,200	4,220	16,026	4,537	4,854	4,386
Balance	23,411	468	618	-9,560	-3,161	641	480	1,110	1,407	1,590	1,778	-11,692	110	-694	-11,135	551	437	1,379	129	-5,059	1,057	-183	2,747	3,328	-8,217	3,541	3,917	47,822

IRR	3.532
NPR(12%)	-8,367
NPR(10%)	-8,339
NPR(8%)	-7,666
NPR(6%)	-5,750
NPR(5%)	-4,018

Table V.2.44 Cash flow and P/L calculation for Alternative I-A

Project expenditure estimation

(Unit : S/.000)

Fiscal Year	Total(99-25)	1999FY	2000FY	2001FY	2002FY	2003FY	2004FY	2005FY	2006FY	2007FY	2008FY	2009FY	2010FY	2011FY	2012FY	2013FY	2014FY	2015FY	2016FY	2017FY	2018FY	2019FY	2020FY	2021FY	2022FY	2023FY	2024FY	2025FY
Land Acquisition	0																											
Proposed project administration expense	601		22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Construction work (a)	53,720		2,586	18,268	2,586							2,758	1,447	1,447	1,447	1,447	1,447	1,447	1,375	6,465	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
Contingency (15%) (b)=(a) x 0.15	8,058		388	2,740	388							414	217	217	217	217	217	217	206	970	206	206	206	206	206	206	206	206
GST (18%) (c)=(a+b) x 0.18	11,120		535	3,781	535							571	300	300	300	300	300	300	285	1,338	285	285	285	285	285	285	285	285
Maintenance Equipment (d)	20,389		15		234	173	377					114	15		8,670	173	377				188	817	15		8,670	173	377	
Contingency (15%) (e)=(d) x 0.15	3,058		2		35	26	57					17	2		1,301	26	57				28	123	2		1,301	26	57	
GST (18%) (f) =(d+e) x 0.18	4,221		3		48	36	78					24	3		1,795	36	78				39	169	3		1,795	36	78	
Engineering Service (g)	5,373	1,406		938								686		458					1,131		754							
Contingency (15%) (h)=(g) x 0.15	806	211		141								103		69					170		113							
GST (18%) (i) =(g+h) x 0.18	1,112	291		194								142		95					234		156							
Maintenance (with GST)	24,901	317	335	354	550	574	599	623	659	696	735	778	913	945	978	1,012	1,046	1,081	1,114	1,149	1,181	1,219	1,256	1,289	1,322	1,357	1,391	1,427
Total	133,359	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	5,635	2,925	3,559	14,736	3,240	3,551	3,074	4,535	9,942	4,345	4,214	3,162	3,175	14,973	3,478	3,789	3,313

Donation, Loan & Local Fund

Donation up to S/.21,180 (DM12MIL)	21,180	1,617	2,974	16,589	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan available for construction work	42,215	0	0	4,419	2,974	0	0	0	0	0	0	3,172	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund of non-construction expense	69,964	608	913	5,431	1,425	831	1,133	645	681	718	757	2,464	1,261	1,895	13,072	1,576	1,887	1,410	2,953	2,507	2,764	2,632	1,580	1,594	13,392	1,897	2,208	1,732
Total	133,359	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	5,635	2,925	3,559	14,736	3,240	3,551	3,074	4,535	9,942	4,345	4,214	3,162	3,175	14,973	3,478	3,789	3,313

Loan transaction

Loan Receipt	42,215	0	0	4,419	2,974	0	0	0	0	0	0	3,172	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Loan Repayment	8,253	0	0	0	0	0	0	0	0	0	0	0	0	221	370	370	370	370	370	370	370	528	611	695	778	861	944	1,027
Loan Balance	33,962	0	0	4,419	7,393	7,393	7,393	7,393	7,393	7,393	7,393	10,565	12,229	13,672	14,966	16,261	17,555	18,849	20,061	27,126	28,338	29,391	30,361	31,247	32,051	32,771	33,408	33,962

Interest

Interest (5 %)	22,949	0	0	221	370	370	370	370	370	370	370	528	611	684	748	813	878	942	1,003	1,356	1,417	1,470	1,518	1,562	1,603	1,639	1,670	1,698

Cash Flow

Cash - In :																												
Donation	21,180	1,617	2,974	16,589	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan for Project Disbursement	42,215	0	0	4,419	2,974	0	0	0	0	0	0	3,172	1,664	1,664	1,664	1,664	1,664	1,664	1,581	7,435	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund for Project Disbursement	69,964	608	913	5,431	1,425	831	1,133	645	681	718	757	2,464	1,261	1,895	13,072	1,576	1,887	1,410	2,953	2,507	2,764	2,632	1,580	1,594	13,392	1,897	2,208	1,732
Local Fund for Loan Repayment	8,253	0	0	0	0	0	0	0	0	0	0	0	0	221	370	370	370	370	370	370	370	528	611	695	778	861	944	1,027
Revenue + F/A sold	166,671	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	47,320
Local Fund for Interest Payment	22,949	0	0	221	370	370	370	370	370	370	370	528	611	684	748	813	878	942	1,003	1,356	1,417	1,470	1,518	1,562	1,603	1,639	1,670	1,698
Cash - Out :																												
Project Disbursement	133,359	2,225	3,887	26,439	4,399	831	1,133	645	681	718	757	5,635	2,925	3,559	14,736	3,240	3,551	3,074	4,535	9,942	4,345	4,214	3,162	3,175	14,973	3,478	3,789	3,313
Loan Repayment	8,253	0	0	0	0	0	0	0	0	0	0	0	0	221	370	370	370	370	370	370	370	528	611	695	778	861	944	1,027
Interest Payment	22,949	0	0	221	370	370	370	370	370	370	370	528	611	684	748	813	878	942	1,003	1,356	1,417	1,470	1,518	1,562	1,603	1,639	1,670	1,698
EMSAPUNO existing expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Repayment of Local Fund	145,422	785	996	1,116	1,238	1,472	1,612	1,755	2,088	2,308	2,535	2,953	3,219	3,394	3,797	3,994	4,196	4,669	4,887	5,113	5,639	5,902	6,161	6,761	7,022	7,290	7,984	46,533
Balance of Cash Fund / – Local Fund	44,255	177	84	-4,536	-556	271	110	740	1,037	1,220	1,409	-38	1,346	595	-10,392	1,235	1,062	1,947	561	879	1,089	1,272	2,451	2,911	-8,750	2,894	3,162	42,076

P/L ESTIMATION

Revenue	128,420	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069
Expense: 1. Administration	22,577	787	809	809	1,127	809	809	809	809	809	809	971	816	816	816	816	816	816	807	807	1,062	807	807	807	807	807	807	807
2. Engineering service	7,291	1,908	0	1,273	0	0	0	0	0	0	0	931	0	622	0	0	0	0	1,535	0	1,023	0	0	0	0	0	0	0
3. Maintenance	24,901	317	335	354	550	574	599	623	659	696	735	778	913	945	978	1,012	1,046	1,081	1,114	1,149	1,181	1,219	1,256	1,289	1,322	1,357	1,391	1,427
4. Interest expense	22,949	0	0	221	370	370	370	370	370	370	370	528	611	684	748	813	878	942	1,003	1,356	1,417	1,470	1,518	1,562	1,603	1,639	1,670	1,698
5. Depreciation (proposed)	52,437	0	0	0	0	1,678	1,678	1,678	1,678	1,678	1,678	1,678	1,854	1,903	1,952	2,002	2,051	2,100	2,149	2,196	2,898	2,944	2,991	3,038	3,084	3,131	3,178	3,224
6. Depreciation (existing)	9,771	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362
Expense total	139,926	3,374	1,506	3,019	2,408	3,792	3,817	3,841	3,877	3,914	3,953	5,247	4,557	5,331	4,857	5,005	5,152	5,301	6,970	5,870	7,943	6,802	6,934	7,058	7,178	7,295	7,408	7,518
Profit / Loss	-11,506	-1,802	277	-1,116	-383	-1,533	-1,417	-1,299	-1,003	-819	-631	-1,507	-551	-1,150	-273	-224	-169	154	-1,295	30	-1,516	-112	14	490	631	782	1,363	1,551

Assumption

1. Revenue : The rate will be revised every 3 years and 5 % increase is expected.
   Fee collection rate will be increased by 1% annually.

2. Depreciation (construction) civil work will be depreciated for 40 years (every year 2.5 % of acquisition cost is depreciated.)
   mechanical/electrical will be depreciated for 10 years.

3. Depreciation (equipment) items will be depreciated for 10 years (every year 10 % of acquisition cost is depreciated.)

4. Depreciation (EMSAPUNO) Existing fixed asset is for water and sewerage business. According
   to the 1998 FY detail expense information, 66% of depreciation was for water business, 34% of depreciation was for sewerage business.

5. Local Fund : Non-construction expense loan principal payment & interest payment are funded by
   Peru/Puno government without interest.

(Unit : S/.000)

Depreciation of proposed fixed asset		1999F/Y	2000F/Y	2001F/Y	2002F/Y	2003F/Y	2004F/Y	2005F/Y	2006F/Y	2007F/Y	2008F/Y	2009F/Y	2010F/Y	2011F/Y	2012F/Y	2013F/Y	2014F/Y	2015F/Y	2016F/Y	2017F/Y	2018F/Y	2019F/Y	2020F/Y	2021F/Y	2022F/Y	2023F/Y	2024F/Y	2025F/Y
sewer civil work (2000-2FY)	6,054					263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
sewer civil work (2009-15FY)	4,468												49	98	147	196	246	295	344	344	344	344	344	344	344	344	344	344
sewer civil work (2016-25FY)	2,099																			47	93	140	187	233	280	327	373	420
pump civil work (2001FY)	23					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
plant civil work (2001FY)	5,415					237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237	237
plant civil work (2009FY)	268												17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
plant civil work (2017FY)	94																				12	12	12	12	12	12	12	12
pump mechanical (2001FY. 2017FY)	763					25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	49	49	49	49	49	49	49	49
plant mechanical (2001FY)	26,496					1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152	1,152
plant mechanical (2009FY)	1,774												111	111	111	111	111	111	111	111	111	111	111	111	111	111	111	111
plant mechanical (2017FY)	4,953																				619	619	619	619	619	619	619	619
total depreciation of proposed F/A	52,437					1,678	1,678	1,678	1,678	1,678	1,678	1,678	1,854	1,903	1,952	2,002	2,051	2,100	2,149	2,196	2,898	2,944	2,991	3,038	3,084	3,131	3,178	3,224
Depreciation for existing (EMSAPUNO) fixed asset																												
Building, Construction (S/.23449 +S/.12450) x 3-	8,239	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305
Machine (S/. 874) x 34 %	808	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Transportation equipment (S/. 236) x 34%	216	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Equipment (S/. 43) x 34%	39	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other (S/. 510) x 34%	468	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
total depreciation of proposed F/A	9,771	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362

REVENUE ESTIMATION

wastewater flow estimation (61.3 l/s in 98FY)	65.8	70.4	74.4	78.4	82.5	86.8	91.1	97.2	103.7	110.3	117.2	124.4	128.7	133.2	137.7	142.3	147.1	151.7	156.4	160.9	166.1	171.1	175.6	180.2	184.9	189.7	194.6
increase rate of wastewater (each year / 98FY)A	1.0734	1.1485	1.2137	1.2790	1.3458	1.4160	1.4861	1.5856	1.6917	1.7993	1.9119	2.0294	2.0995	2.1729	2.2463	2.3214	2.3997	2.4747	2.5514	2.6248	2.7096	2.7912	2.8646	2.9396	3.0163	3.0946	3.1746
increase rate of sewerage fee (each year / 98FY)B	1.00	1.05	1.05	1.05	1.10	1.10	1.10	1.16	1.16	1.16	1.22	1.22	1.22	1.28	1.28	1.28	1.34	1.34	1.34	1.41	1.41	1.41	1.48	1.48	1.48	1.55	1.55
increase of collection rate (annually 1 %) C	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27
estimated revenue (S/. 1450 in 1998 x A x B x C)	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069

Administration detail(without contingency and GST)

EMSAPUNO existing administration expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Proposed project administration expense	601	0	22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Proposed project maintenance equipment	727	0	0	0	318	0	0	0	0	0	0	155	0	0	0	0	0	0	0	0	255	0	0	0	0	0	0	0
total	22,577	787	809	809	1,127	809	809	809	809	809	809	971	816	816	816	816	816	816	807	807	1,062	807	807	807	807	807	807	807

IRR (Internal Rate of Return)

Cash Flow In (Donation + Revenue + F/A sold)	187,851	3,189	4,757	18,492	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	47,320
Cash Flow Out (Project dis + EMSAPUNO)	154,608	3,012	4,674	27,226	5,186	1,618	1,920	1,432	1,468	1,505	1,544	6,422	3,712	4,346	15,523	4,027	4,338	3,861	5,322	10,729	5,132	5,001	3,949	3,962	15,760	4,265	4,576	4,100
Balance	33,243	177	84	-8,734	-3,161	641	479	1,110	1,407	1,590	1,778	-2,682	294	-165	-10,939	754	646	1,595	353	-4,829	1,294	1,689	2,999	3,586	-7,951	3,812	4,195	43,220

IRR	5.883
NPR(12%)	-5,438
NPR(10%)	-4,717
NPR(8%)	-3,191
NPR(6%)	-236
NPR(5%)	2,094

Table V.2.45 Cash flow and P/L calculation for Alternative II

Project expenditure estimation

(Unit : S/.000)

Fiscal Year	Total(99-25)	1999FY	2000FY	2001FY	2002FY	2003FY	2004FY	2005FY	2006FY	2007FY	2008FY	2009FY	2010FY	2011FY	2012FY	2013FY	2014FY	2015FY	2016FY	2017FY	2018FY	2019FY	2020FY	2021FY	2022FY	2023FY	2024FY	2025FY
Land Acquisition	167		100																67									
Proposed project administration expense	396		22	22	22	22	22	22	22	22	22	14	14	14	14	14	14	14	10	10	10	10	10	10	10	10	10	10
Construction work (a)	56,541		2,586	20,168	2,586							1,447	1,447	1,447	1,447	1,447	1,447	1,447	8,697	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375	1,375
Contingency (15%) (b)=(a) x 0.15	8,481	0	388	3,025	388	0	0	0	0	0	0	217	217	217	217	217	217	217	1,305	206	206	206	206	206	206	206	206	206
GST (18%) (c)=(a+b) x 0.18	11,704	0	535	4,175	535	0	0	0	0	0	0	300	300	300	300	300	300	300	1,800	285	285	285	285	285	285	285	285	285
Maintenance Equipment (d)	10,039		15	206		173	377					101	15		3,931	173	377		175				15		3,931	173	377	
Contingency (15%) (e)=(d) x 0.15	1,506	0	2	31	0	26	57	0	0	0	0	15	2	0	590	26	57	0	26	0	0	0	2	0	590	26	57	0
GST (18%) (f) =(d+e) x 0.18	2,078	0	3	43	0	36	78	0	0	0	0	21	3	0	814	36	78	0	36	0	0	0	3	0	814	36	78	0
Engineering Service (g)	5,615	1,507		1,005								608		405					1,254		836							
Contingency (15%) (h)=(g) x 0.15	842	226		151								91		61					188		125							
GST (18%) (I) =(g+h) x 0.18	1,162	312		208								126		84					260		173							
Maintenance (with GST)	41,605	317	335	354	1,013	1,057	1,102	1,147	1,213	1,281	1,352	1,432	1,515	1,569	1,623	1,679	1,736	1,793	1,849	1,906	1,961	2,024	2,084	2,139	2,195	2,251	2,309	2,368
Total	140,136	2,362	3,987	29,388	4,544	1,314	1,636	1,169	1,235	1,303	1,374	4,372	3,513	4,096	8,935	3,891	4,225	3,771	15,667	3,782	4,971	3,900	3,980	4,015	9,405	4,362	4,696	4,244

Donation, Loan & Local Fund

Donation up to S/.21,180 (DM12MIL)	21,180	2,362	3,509	15,309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan available for construction work	46,739	0	0	7,884	2,974	0	0	0	0	0	0	1,664	1,664	1,664	1,664	1,664	1,664	1,664	10,002	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund of non-construction expense	72,217	0	478	6,195	1,570	1,314	1,636	1,169	1,235	1,303	1,374	2,708	1,849	2,432	7,271	2,227	2,561	2,107	5,665	2,201	3,390	2,319	2,399	2,434	7,824	2,780	3,115	2,663
Total	140,136	2,362	3,987	29,388	4,544	1,314	1,636	1,169	1,235	1,303	1,374	4,372	3,513	4,096	8,935	3,891	4,225	3,771	15,667	3,782	4,971	3,900	3,980	4,015	9,405	4,362	4,696	4,244

Loan transaction

Loan Receipt	46,739	0	0	7,884	2,974	0	0	0	0	0	0	1,664	1,664	1,664	1,664	1,664	1,664	1,664	10,002	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Loan Repayment	10,324	0	0	0	0	0	0	0	0	0	0	0	0	394	543	543	543	543	543	543	543	626	709	793	876	959	1,042	1,125
Loan Balance	36,415	0	0	7,884	10,858	10,858	10,858	10,858	10,858	10,858	10,858	12,522	14,186	15,456	16,577	17,698	18,819	19,940	29,399	30,437	31,476	32,431	33,303	34,092	34,797	35,420	35,959	36,415

Interest

Interest (5 %)	26,641	0	0	394	543	543	543	543	543	543	543	626	709	773	829	885	941	997	1,470	1,522	1,574	1,622	1,665	1,705	1,740	1,771	1,798	1,821

Cash Flow

Cash - In :																												
Donation	21,180	2,362	3,509	15,309	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan for Project Disbursement	46,739	0	0	7,884	2,974	0	0	0	0	0	0	1,664	1,664	1,664	1,664	1,664	1,664	1,664	10,002	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581	1,581
Local Fund for Project Disbursement	72,217	0	478	6,195	1,570	1,314	1,636	1,169	1,235	1,303	1,374	2,708	1,849	2,432	7,271	2,227	2,561	2,107	5,665	2,201	3,390	2,319	2,399	2,434	7,824	2,780	3,115	2,663
Local Fund for Loan Repayment	10,324	0	0	0	0	0	0	0	0	0	0	0	0	394	543	543	543	543	543	543	543	626	709	793	876	959	1,042	1,125
Revenue + F/A sold	170,599	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	51,248
Local Fund for Interest Payment	26,641	0	0	394	543	543	543	543	543	543	543	626	709	773	829	885	941	997	1,470	1,522	1,574	1,622	1,665	1,705	1,740	1,771	1,798	1,821
Cash - Out :																												
Project Disbursement	140,136	2,362	3,987	29,388	4,544	1,314	1,636	1,169	1,235	1,303	1,374	4,372	3,513	4,096	8,935	3,891	4,225	3,771	15,667	3,782	4,971	3,900	3,980	4,015	9,405	4,362	4,696	4,244
Loan Repayment	10,324	0	0	0	0	0	0	0	0	0	0	0	0	394	543	543	543	543	543	543	543	626	709	793	876	959	1,042	1,125
Interest Payment	26,641	0	0	394	543	543	543	543	543	543	543	626	709	773	829	885	941	997	1,470	1,522	1,574	1,622	1,665	1,705	1,740	1,771	1,798	1,821
EMSAPUNO existing expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Repayment of Local Fund	149,350	785	996	1,116	1,238	1,472	1,612	1,755	2,088	2,308	2,535	2,953	3,219	3,394	3,797	3,994	4,196	4,669	4,887	5,113	5,639	5,902	6,161	6,761	7,022	7,290	7,984	50,461
Balance of Cash Fund / – Local Fund	40,167	785	519	-5,473	-875	-385	-566	43	310	462	618	-380	661	-205	-4,845	339	151	1,022	-2,791	847	133	1,336	1,387	1,831	-3,418	1,780	2,029	44,852

P/L ESTIMATION

Revenue	128,420	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069
Expense: 1. Administration	22,299	787	809	1,089	809	809	809	809	809	809	809	938	801	801	801	801	801	801	1,034	797	797	797	797	797	797	797	797	797
2. Engineering service	7,620	2,045	0	1,364	0	0	0	0	0	0	0	825	0	550	0	0	0	0	1,702	0	1,134	0	0	0	0	0	0	0
3. Maintenance	41,605	317	335	354	1,013	1,057	1,102	1,147	1,213	1,281	1,352	1,432	1,515	1,569	1,623	1,679	1,736	1,793	1,849	1,906	1,961	2,024	2,084	2,139	2,195	2,251	2,309	2,368
4. Interest expense	26,641	0	0	394	543	543	543	543	543	543	543	626	709	773	829	885	941	997	1,470	1,522	1,574	1,622	1,665	1,705	1,740	1,771	1,798	1,821
5. Depreciation (proposed)	38,405	0	0	0	0	1,260	1,260	1,260	1,260	1,260	1,260	1,260	1,309	1,358	1,407	1,456	1,505	1,554	1,603	1,968	2,015	2,062	2,108	2,155	2,202	2,248	2,295	2,342
6. Depreciation (existing)	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362
Expense total	146,335	3,511	1,506	3,563	2,727	4,030	4,075	4,120	4,186	4,254	4,325	5,443	4,696	5,412	5,022	5,183	5,345	5,507	8,020	6,555	7,843	6,866	7,016	7,157	7,295	7,429	7,561	7,689
Profit / Loss	-17,915	-1,939	277	-1,659	-701	-1,771	-1,676	-1,578	-1,312	-1,159	-1,003	-1,702	-690	-1,231	-437	-402	-362	-51	-2,346	-655	-1,416	-176	-68	391	514	648	1,210	1,380

Assumption

1. Revenue : The rate will be revised every 3 years and 5 % increase is expected.
   Fee collection rate will be increased by 1% annually.

2. Depreciation (construction) civil work will be depreciated for 40 years (every year 2.5 % of acquisition cost is depreciated.)
   mechanical/electrical will be depreciated for 10 years.

3. Depreciation (equipment) items will be depreciated for 10 years (every year 10 % of acquisition cost is depreciated.)

4. Depreciation (EMSAPUNO) Existing fixed asset is for water and sewerage business. According to the 1998 FY detail expense information, 66% of depreciation was for water business, 34% of depreciation was for sewerage business.

5. Local Fund : Non-construction expense loan principal payment & interest payment are funded by Peru/Puno government without interest.

(Unit : S/.000)

Depreciation of proposed fixed asset		1999F/Y	2000F/Y	2001F/Y	2002F/Y	2003F/Y	2004F/Y	2005F/Y	2006F/Y	2007F/Y	2008F/Y	2009F/Y	2010F/Y	2011F/Y	2012F/Y	2013F/Y	2014F/Y	2015F/Y	2016F/Y	2017F/Y	2018F/Y	2019F/Y	2020F/Y	2021F/Y	2022F/Y	2023F/Y	2024F/Y	2025F/Y
sewer civil work (2000-2FY)	6,054					263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
sewer civil work (2009-15FY)	4,468												49	98	147	196	246	295	344	344	344	344	344	344	344	344	344	344	344
sewer civil work (2016-25FY)	2,099																			47	93	140	187	233	280	327	373	420
pump civil work (2001FY)	1,408					61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61
plant civil work (2001FY)	9,243					402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402	402
plant civil work (2009FY)	0																											
plant civil work (2017FY)	2,026																			225	225	225	225	225	225	225	225	225
pump mechanical (2001FY、2017FY)	13,107					533	533	533	533	533	533	533	533	533	533	533	533	533	533	627	627	627	627	627	627	627	627	627
plant mechanical (2001FY)	0																											
plant mechanical (2009FY)	0																											
plant mechanical (2017FY)	0																											
total depreciation of proposed F/A	38,405					1,260	1,260	1,260	1,260	1,260	1,260	1,260	1,309	1,358	1,407	1,456	1,505	1,554	1,603	1,968	2,015	2,062	2,108	2,155	2,202	2,248	2,295	2,342
Depreciation for existing (EMSAPUNO) fixed asset																												
Building, Construction (23449 +12450)	8,239	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305
Machine (S/. 874)	802	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Transportation equipment (S/. 236)	217	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Equipment (S/. 43)	39	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other (S/. 510)	468	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
total depreciation of proposed F/A	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362

REVENUE ESTIMATION

wastewater flow estimation (61.3 l/s in 98FY)		65.8	70.4	74.4	78.4	82.5	86.8	91.1	97.2	103.7	110.3	117.2	124.4	128.7	133.2	137.7	142.3	147.1	151.7	156.4	160.9	166.1	171.1	175.6	180.2	184.9	189.7	194.6
increase rate of wastewater (each year / 98FY)A		1.0734	1.1485	1.2137	1.2790	1.3458	1.4160	1.4861	1.5856	1.6917	1.7993	1.9119	2.0294	2.0995	2.1729	2.2463	2.3214	2.3997	2.4747	2.5514	2.6248	2.7096	2.7912	2.8646	2.9396	3.0163	3.0946	3.1746
increase rate of sewerage fee (each year / 98FY)B		1.00	1.05	1.05	1.05	1.10	1.10	1.10	1.16	1.16	1.16	1.22	1.22	1.22	1.28	1.28	1.28	1.34	1.34	1.34	1.41	1.41	1.41	1.48	1.48	1.48	1.55	1.55
increase of collection rate (annually 1 %) C		1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27
estimated revenue (S/. 1450 in 1998 x A x B x C)		1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069

Administration detail(without contingency and GST)

EMSAPUNO existing administration expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Proposed project administration expense	396	0	22	22	22	22	22	22	22	22	22	14	14	14	14	14	14	14	10	10	10	10	10	10	10	10	10	10
Proposed project maintenance equipment	654	0	0	280	0	0	0	0	0	0	0	137	0	0	0	0	0	0	237	0	0	0	0	0	0	0	0	0
total	22,299	787	809	1,089	809	809	809	809	809	809	809	938	801	801	801	801	801	801	1,034	797	797	797	797	797	797	797	797	797

IRR (Internal Rate of Return)

Cash Flow In (Donation + Revenue + F/A sold)	191,779	3,934	5,293	17,212	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	51,248
Cash Flow Out (Project dis + EMSAPUNO)	161,385	3,149	4,774	30,175	5,331	2,101	2,423	1,956	2,022	2,090	2,161	5,159	4,300	4,883	9,722	4,678	5,012	4,558	16,454	4,569	5,758	4,687	4,767	4,802	10,192	5,149	5,483	5,031
Balance	30,394	785	519	-12,963	-3,306	158	-23	586	853	1,005	1,161	-1,418	-294	-702	-5,138	102	-29	898	-10,780	1,331	668	2,003	2,180	2,746	-2,383	2,929	3,288	46,217

IRR	4.428
NPR(12%)	-8,594
NPR(10%)	-8,095
NPR(8%)	-6,775
NPR(6%)	-3,975
NPR(5%)	-1,683

Table V.2.46 Cash flow and P/L calculation for Alternative III

Project expenditure estimation (Unit : S/.000)

Fiscal Year	Total(99-25)	1999FY	2000FY	2001FY	2002FY	2003FY	2004FY	2005FY	2006FY	2007FY	2008FY	2009FY	2010FY	2011FY	2012FY	2013FY	2014FY	2015FY	2016FY	2017FY	2018FY	2019FY	2020FY	2021FY	2022FY	2023FY	2024FY	2025FY
Land Acquisition	0																											
Proposed project administration expense	601		22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Construction work (a)	83,426		2,586	37,281	2,586							1,447	1,447	9,010	1,447	1,447	1,447	1,447	1,375	3,303	8,978	1,375	1,375	1,375	1,375	1,375	1,375	1,375
Contingency (15%) (b)=(a) x 0.15	12,514	0	388	5,592	388	0	0	0	0	0	0	217	217	1,352	217	217	217	217	206	495	1,347	206	206	206	206	206	206	206
GST (18%) (c)=(a+b) x 0.18	17,269	0	535	7,717	535	0	0	0	0	0	0	300	300	1,865	300	300	300	300	285	684	1,858	285	285	285	285	285	285	285
Maintenance Equipment (d)	53,926				425										23,945						233			5,555	23,768			
Contingency (15%) (e)=(d) x 0.15	8,089	0	0	0	64	0	0	0	0	0	0	0	0	0	3,592	0	0	0	0	0	35	0	0	833	3,565	0	0	0
GST (18%) (f) =(d+e) x 0.18	11,163	0	0	0	88	0	0	0	0	0	0	0	0	0	4,957	0	0	0	0	0	48	0	0	1,150	4,920	0	0	0
Engineering Service (g)	8,342	2,547		1,698								1,061		708					1,397		931							
Contingency (15%) (h)=(g) x 0.15	1,251	382		255								159		106					210		140							
GST (18%) (I) =(g+h) x 0.18	1,727	527		351								220		147					289		193							
Maintenance (with GST)	32,330	317	335	354	781	815	850	885	936	988	1,043	1,105	1,169	1,211	1,253	1,295	1,339	1,384	1,427	1,471	1,513	1,561	1,608	1,650	1,693	1,737	1,782	1,827
Total	230,638	3,773	3,867	53,271	4,889	837	872	907	958	1,010	1,065	4,537	3,162	14,427	35,739	3,288	3,332	3,377	5,209	5,973	15,296	3,447	3,494	11,074	35,832	3,623	3,668	3,713

Donation, Loan & Local Fund

Donation up to S/.21,180 (DM12MIL)	21,180	3,773	3,509	13,898	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan available for construction work	95,802	0	0	36,693	3,509	0	0	0	0	0	0	1,964	1,964	12,227	1,964	1,964	1,964	1,964	1,866	4,482	12,183	1,866	1,866	1,866	1,866	1,866	1,866	1,866
Local Fund of non-construction expense	113,655	0	357	2,681	1,380	837	872	907	958	1,010	1,065	2,574	1,198	2,201	33,775	1,324	1,368	1,413	3,343	1,491	3,113	1,581	1,628	9,208	33,966	1,757	1,802	1,847
Total	230,638	3,773	3,867	53,271	4,889	837	872	907	958	1,010	1,065	4,537	3,162	14,427	35,739	3,288	3,332	3,377	5,209	5,973	15,296	3,447	3,494	11,074	35,832	3,623	3,668	3,713

Loan transaction

Loan Receipt	95,802	0	0	36,693	3,509	0	0	0	0	0	0	1,964	1,964	12,227	1,964	1,964	1,964	1,964	1,866	4,482	12,183	1,866	1,866	1,866	1,866	1,866	1,866	1,866
Loan Repayment	35,291	0	0	0	0	0	0	0	0	0	0	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,818	2,916	3,014	3,112	3,211
Loan Balance	60,512	0	0	36,693	40,202	40,202	40,202	40,202	40,202	40,202	40,202	42,166	44,129	54,521	54,475	54,428	54,382	54,335	54,191	56,663	66,836	66,593	66,253	65,301	64,251	63,103	61,856	60,512

Interest

Interest (5 %)	65,105	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,726	2,724	2,721	2,719	2,717	2,710	2,833	3,342	3,330	3,313	3,265	3,213	3,155	3,093	3,026

Cash Flow

Cash - In :																												
Donation	21,180	3,773	3,509	13,898	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Loan for Project Disbursement	95,802	0	0	36,693	3,509	0	0	0	0	0	0	1,964	1,964	12,227	1,964	1,964	1,964	1,964	1,866	4,482	12,183	1,866	1,866	1,866	1,866	1,866	1,866	1,866
Local Fund for Project Disbursement	113,655	0	357	2,681	1,380	837	872	907	958	1,010	1,065	2,574	1,198	2,201	33,775	1,324	1,368	1,413	3,343	1,491	3,113	1,581	1,628	9,208	33,966	1,757	1,802	1,847
Local Fund for Loan Repayment	35,291	0	0	0	0	0	0	0	0	0	0	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,818	2,916	3,014	3,112	3,211
Revenue + F/A sold	128,420	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	70,967
Local Fund for Interest Payment	65,105	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,726	2,724	2,721	2,719	2,717	2,710	2,833	3,342	3,330	3,313	3,265	3,213	3,155	3,093	3,026
Cash - Out :																												
Project Disbursement	230,638	3,773	3,867	53,271	4,889	837	872	907	958	1,010	1,065	4,537	3,162	14,427	35,739	3,288	3,332	3,377	5,209	5,973	15,296	3,447	3,494	11,074	35,832	3,623	3,668	3,713
Loan Repayment	35,291	0	0	0	0	0	0	0	0	0	0	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,818	2,916	3,014	3,112	3,211
Interest Payment	65,105	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,726	2,724	2,721	2,719	2,717	2,710	2,833	3,342	3,330	3,313	3,265	3,213	3,155	3,093	3,026
EMSAPUNO existing expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Repayment of Local Fund	169,069	785	996	1,116	1,238	1,472	1,612	1,755	2,088	2,308	2,535	2,953	3,219	3,394	3,797	3,994	4,196	4,669	4,887	5,113	5,639	5,902	6,161	6,761	7,022	7,290	7,984	70,180
Balance of Cash Fund / - Local Fund	-44,982	785	639	-3,399	-2,152	-1,375	-1,270	-1,162	-881	-712	-540	-1,729	-186	-3,367	-34,712	-2,062	-1,901	-1,471	-3,175	-1,222	-2,825	-1,117	-986	-8,530	-33,073	-636	-23	62,097

P/L ESTIMATION

Revenue	128,420	1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069
Expense: 1. Administration	22,983	787	809	809	1,386	809	809	809	809	809	809	816	816	816	1,056	816	816	816	807	807	1,123	807	807	807	807	807	807	807
2. Engineering service	11,320	3,456	0	2,304	0	0	0	0	0	0	0	1,440	0	961	0	0	0	0	1,896	0	1,263	0	0	0	0	0	0	0
3. Maintenance	32,330	317	335	354	781	815	850	885	936	988	1,043	1,105	1,169	1,211	1,253	1,295	1,339	1,384	1,427	1,471	1,513	1,561	1,608	1,650	1,693	1,737	1,782	1,827
4. Interest expense	65,105	0	0	1,835	2,010	2,010	2,010	2,010	2,010	2,010	2,010	2,108	2,206	2,726	2,724	2,721	2,719	2,717	2,710	2,833	3,342	3,330	3,313	3,265	3,213	3,155	3,093	3,026
5. Depreciation (proposed)	114,724	0	0	0	0	3,859	3,859	3,859	3,859	3,859	3,859	3,859	3,908	3,957	4,828	4,877	4,926	4,976	5,025	5,071	5,202	6,280	6,327	6,373	6,420	6,467	6,513	6,560
6. Depreciation (existing)	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362
Expense total	256,228	4,922	1,506	5,664	4,539	7,855	7,890	7,925	7,976	8,028	8,083	9,690	8,461	10,033	10,223	10,071	10,162	10,254	12,226	10,544	12,805	12,339	12,416	12,457	12,494	12,528	12,557	12,581
Profit / Loss	-127,808	-3,350	277	-3,761	-2,513	-5,596	-5,490	-5,383	-5,101	-4,933	-4,760	-5,949	-4,455	-5,851	-5,639	-5,291	-5,179	-4,798	-6,551	-4,644	-6,378	-5,650	-5,468	-4,909	-4,685	-4,450	-3,786	-3,512

Assumption

1. Revenue : The rate will be revised every 3 years and 5 % increase is expected.
   Fee collection rate will be increased by 1% annually.

2. Depreciation (construction) civil work will be depreciated for 40 years (every year 2.5 % of acquisition cost is depreciated.)
   mechanical/electrical will be depreciated for 10 years.

3. Depreciation (equipment) items will be depreciated for 10 years (every year 10 % of acquisition cost is depreciated.)

4. Depreciation (EMSAPUNO) Existing fixed asset is for water and sewerage business. According to the 1998 FY detail expense information, 66% of depreciation was for water business, 34% of depreciation was for sewerage business.

5. Local Fund : Non-construction expense loan principal payment & interest payment are funded by Peru/Puno government without interest.

(Unit : S/.000)

Depreciation of proposed fixed asset		1999F/Y	2000F/Y	2001F/Y	2002F/Y	2003F/Y	2004F/Y	2005F/Y	2006F/Y	2007F/Y	2008F/Y	2009F/Y	2010F/Y	2011F/Y	2012F/Y	2013F/Y	2014F/Y	2015F/Y	2016F/Y	2017F/Y	2018F/Y	2019F/Y	2020F/Y	2021F/Y	2022F/Y	2023F/Y	2024F/Y	2025F/Y
sewer civil work (2000-2FY)	6,053					263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263	263
sewer civil work (2009-15FY)	4,467												49	98	147	196	245	295	344	344	344	344	344	344	344	344	344	344
sewer civil work (2016-25FY)	2,099																			47	93	140	187	233	280	327	373	420
pump civil work (2001FY)	23					1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
pump civil work (2011FY)	954														68	68	68	68	68	68	68	68	68	68	68	68	68	68
plant civil work (2001FY)	8,500					370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370	370
plant civil work (2017FY)	474																				59	59	59	59	59	59	59	59
pump mechanical (2001FY)	565					25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
pump mechanical (2011FY)	10,553														754	754	754	754	754	754	754	754	754	754	754	754	754	754
pump mechanical (2017FY)	196																				25	25	25	25	25	25	25	25
plant mechanical (2001FY)	73,617					3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201	3,201
plant mechanical (2009FY)																												
plant mechanical (2018FY)																						1,032	1,032	1,032	1,032	1,032	1,032	1,032
total depreciation of proposed F/A	114,724					3,859	3,859	3,859	3,859	3,859	3,859	3,859	3,908	3,957	4,828	4,877	4,926	4,976	5,025	5,071	5,202	6,280	6,327	6,373	6,420	6,467	6,513	6,560

Depreciation for existing (EMSAPUNO) fixed asset

Building, Construction (S/. 23,449 +S/. 12,450)	8,239	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305	305
Machine (S/. 874)	802	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
Transportation equipment (S/. 236)	217	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Equipment (S/. 43)	39	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Other (S/. 510)	468	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17	17
total depreciation of proposed F/A	9,765	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362	362

REVENUE ESTIMATION

wastewater flow estimation (61.3 l/s in 98FY)		65.8	70.4	74.4	78.4	82.5	86.8	91.1	97.2	103.7	110.3	117.2	124.4	128.7	133.2	137.7	142.3	147.1	151.7	156.4	160.9	166.1	171.1	175.6	180.2	184.9	189.7	194.6
increase rate of wastewater (each year / 98FY)A		1.0734	1.1485	1.2137	1.2790	1.3458	1.4160	1.4861	1.5856	1.6917	1.7993	1.9119	2.0294	2.0995	2.1729	2.2463	2.3214	2.3997	2.4747	2.5514	2.6248	2.7096	2.7912	2.8646	2.9396	3.0163	3.0946	3.1746
increase rate of sewerage fee (each year / 98FY)B		1.00	1.05	1.05	1.05	1.10	1.10	1.10	1.16	1.16	1.16	1.22	1.22	1.22	1.28	1.28	1.28	1.34	1.34	1.34	1.41	1.41	1.41	1.48	1.48	1.48	1.55	1.55
increase of collection rate (annually 1 %) C		1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.17	1.18	1.19	1.20	1.21	1.22	1.23	1.24	1.25	1.26	1.27
estimated revenue (S/. 1450 in 1998 x A x B x C)		1,572	1,783	1,903	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	9,069

Administration detail(without contingency and GST)

EMSAPUNO existing administration expense	21,249	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787	787
Proposed project administration expense	601		22	22	22	22	22	22	22	22	22	29	29	29	29	29	29	29	20	20	20	20	20	20	20	20	20	20
Proposed project maintenance equipment	1,133				577										240						316							
total	22,983	787	809	809	1,386	809	809	809	809	809	809	816	816	816	1,056	816	816	816	807	807	1,123	807	807	807	807	807	807	807

IRR (Internal Rate of Return)

Cash Flow In (Donation + Revenue + F/A sold)	211,498	5,345	5,293	15,801	2,025	2,259	2,399	2,542	2,875	3,095	3,322	3,740	4,006	4,181	4,584	4,781	4,983	5,456	5,674	5,900	6,426	6,689	6,948	7,548	7,809	8,077	8,771	70,967
Cash Flow Out (Project dis + EMSAPUNO)	251,887	4,560	4,654	54,058	5,676	1,624	1,659	1,694	1,745	1,797	1,852	5,324	3,949	15,214	36,526	4,075	4,119	4,164	5,996	6,760	16,083	4,234	4,281	11,861	36,619	4,410	4,455	4,500
Balance	-40,389	785	639	-38,257	-3,651	635	740	848	1,130	1,298	1,470	-1,584	57	-11,033	-31,942	706	865	1,292	-321	-861	-9,656	2,456	2,667	-4,313	-28,810	3,667	4,316	66,467

IRR	-3.462
NPR(12%)	-34,222
NPR(10%)	-37,245
NPR(8%)	-40,419
NPR(6%)	-43,440
NPR(5%)	-44,703

Table V.2.47 Internal Return Rate (IRR) and Net Present Value (NPV)

	IRR (%)	NPV (5%) (1,000 soles)
Alternative I	3.5	- 4,018
Alternative I-A	6.0	2,277
Alternative II	4.4	- 1,183
Alternative III	- 3.5	- 34,222

Summary of financial evaluation

From the above financial analysis, only alternative I-A is regarded as financially feasible unless additional financial resources are available for the project.

(4) Overall evaluation

Four alternative plans are evaluated from environmental, technical and financial aspects. Environmental evaluation indicates that although Alternative I and II have maximized pollution reduction for Puno inner bay, those may rise concern over the environment to which treated water is finally discharged. Especially, Alternative I discharges treated water to the Puno outer bay. Its discharge point is not so far from the drinking water intake. This drinking water source is most important for the residents of Puno City and should be protected at all cost. Failure for this may result in increased treatment cost for water supply.

Technical evaluation shows all four alternative plans are feasible for the Puno city although staff training is required for the all the alternatives, especially for Alternative III.

Financial evaluation shows that only alternative I-A, which costs minimum among the alternatives, is financially feasible. Other alternatives required substantial rise in sewerage rates or subsidies from the municipality or the government.

From the above evaluation, the study team concludes that Alternative I-A is feasible for the Puno city, especially from the financial point of view. Alternative I-A is further analyzed for optimum performance. An appropriate plan is proposed in section 2.4.

Advantages and disadvantages of alternative plans are summarized in *Table V.2.48*.

Table V.2.48 Advantages and disadvantages for alternative plans

Alternative	Advantages	Disadvantages
I I-A	- high flexibility for changing load - low O & M cost - low skill requirement - low vulnerability for power failure - low construction cost (for I-A)	- low compatibility with land use plans - high land requirement - possibility for lake contamination (medium nutrient removal efficiency) - possibility for drinking water source contamination (for I) - eyesore for tourists and residents
II	- maximum contaminant reduction to Titicaca lake - compatibility with land use plans (possible use of the surrounding area of the existing Espinar stabilization for tourism development) - water reuse for forestation	- susceptible for disasters (power failure etc.) (contaminant release to Titicaca lake) - high land requirement (outside the catchment area of the interior bay of Puno) - possibility for ground water contamination - odor release - eyesore for tourists
III	- high contaminant removal - low land requirements - high compatibility with land use plans(possible use of the existing Espinar stabilization lagoon and surrounding area for tourism development) - water reuse for landscaping/wet-land restoration and enhancement	- high construction cost - high skill requirement for O & M - susceptible for power failure (reduction in treatment efficiency)

2.4 PROPOSED PLANS

2.4.1 STRUCTURAL MEASURES

(1) On-site system

On-site wastewater treatment/disposal is important, not only for small rural communities, but also for urban/semi-urban households which are not served by the public sewerage system. The study of on-site treatment/disposal was undertaken to offer alternatives from the viewpoints of low-cost sanitation and technical aspects, corresponding to the differences among the locations such as a cluster of households, apartments and individual households. The study also looked into technical options as an intermediate countermeasure for those unsewered households situated in the transitional areas for on-site treatment.

As on-site wastewater treatment/disposal, Pit Latrine, by standard design for sanitary toilet will be adopted. Sludge will be collected by Small Pit Emptying Machine. Collected sludge will be transferred by dump truck and will be disposed to the forest area.

a) Proposed on-site wastewater treatment/disposal system

Pit Latrine

- Pit Capacity : 0.7 W×0.7 L×1.5 H = 0.74 m3
- Sludge Collection : Every 3 years
- Installation: Each house

Small Pit Emptying Machines

- Capacity : 500 L/unit
- Performance : 4.2 pits/day×250days/year = 1,050 pits/year
- Economic Life : 4 years

Trucks for Sludge Transfer

- Loading Capacity : 2 ton
- Economic Life : 8 years

Required number of small pit emptying machine and trucks are shown in *Table V.2.49*.

b) Sludge collection cost for on-site system

Total operation cost for sludge collection is calculated as shown in *Table V.2.50.* Average cost per collection is 78 soles. Since the above cost calculation does not include administration cost and interests on capital cost, actual tariff may be set slightly higher.

TableV.2.49 Number of Small Pit Emptying Machines and Trucks

Small Pit Emptying Machine
Capacity 1,050 houses/year
Economic Life 4 years

Pit Latrine
Sludge Collection Interval 3 years/pit

Sludge Transfer (2t)
Economic Life 8 years

Year	Total Population	Served Population	Average Number of Family Member	Number of Served Family	Small Pit Emptying Machine				Sludge Amount		Truck 2 ton			
					Required Number	Purchase Number		Scrap	0.05 m3/p/year		Required Number	Purchase Number		Scrap
						Yearly	Phase Total					Yearly	Phase Total	
	(pop)	(pop)	(pop/HH)	(HH)	(unit)	(unit)	(unit)	(unit)	(m3/year)	(m3/day)	(unit)	(unit)	(unit)	(unit)
1998	108,457	58,350	4.15	14,060			Phase 1		2,917	8.0			Phase 1	
1999	111,518	57,320	4.13	13,896					2,866	7.9				
2000	114,579	56,144	4.10	13,694					2,807	7.7				
2001	117,641	54,821	4.08	13,450	5	5		0	2,741	7.5	4	4		0
2002	120,703	53,351	4.05	13,166	5	0		0	2,668	7.3	4	0		0
2003	123,764	51,734	4.03	12,843	5	0		0	2,587	7.1	4	0		0
2004	126,826	49,970	4.00	12,480	4	0		0	2,498	6.8	4	0		0
2005	129,888	48,059	3.98	12,075	4	4		5	2,403	6.6	4	0		0
2006	132,951	46,001	3.96	11,628	4	0		0	2,300	6.3	4	0		0
2007	136,013	43,796	3.93	11,138	4	0		0	2,190	6.0	3	0		0
2008	139,076	41,445	3.91	10,605	4	0	9	0	2,072	5.7	3	0	4	0
2009	142,138	38,946	3.88	10,027	4	3	Phase 2	4	1,947	5.3	3	3	Phase 2	4
2010	145,201	36,300	3.86	9,404	3	0		0	1,815	5.0	3	0		0
2011	148,262	36,077	3.84	9,400	3	0		0	1,804	4.9	3	0		0
2012	151,324	35,813	3.82	9,385	3	0		0	1,791	4.9	3	0		0
2013	154,385	35,509	3.79	9,359	3	3		3	1,775	4.9	3	0		0
2014	157,447	35,163	3.77	9,322	3	0		0	1,758	4.8	3	0		0
2015	160,508	34,777	3.75	9,274	3	0	6	0	1,739	4.8	3	0	3	0
2016	163,264	34,285	3.73	9,197	3	0	Phase 3	0	1,714	4.7	3	0	Phase 3	0
2017	166,020	33,757	3.71	9,109	3	3		3	1,688	4.6	3	3		3
2018	168,775	33,192	3.68	9,010	3	0		0	1,660	4.5	3	0		0
2019	171,531	32,591	3.66	8,900	3	0		0	1,630	4.5	3	0		0
2020	174,287	31,953	3.64	8,778	3	0		0	1,598	4.4	3	0		0
2021	176,430	31,169	3.62	8,615	3	3		3	1,558	4.3	3	0		0
2022	178,574	30,358	3.60	8,442	3	0		0	1,518	4.2	3	0		0
2023	180,717	29,517	3.57	8,259	3	0		0	1,476	4.0	3	0		0
2024	182,861	28,648	3.55	8,065	3	0		0	1,432	3.9	2	0		0
2025	185,004	27,751	3.53	7,861	3	3	9	3	1,388	3.8	2	2	5	2
Total						24						12		

TableV.2.50 Pit Emptying Operation Cost Calculation

Small Pit Emptying Machine		Sludge Transfer (truck)	
Capacity	1,050 houses/year	Capacity	2 ton
Economic Life	4 years	Economic Life	8 years
Price	22,000 soles	Price	60,000 soles
Fuel (petrol)	858 l/year	Fuel (diesel)	3587 l/year
Fuel cost	1,587 soles/year	Fuel cost	4,735 soles/year
Maintenance	2,200 soles/year	Maintenance	3,000 soles/year
Labor cost (2 person/machine)	36,000 soles/year	Labor cost (1 person/truck)	18,000 soles/year

Year	Small Pit Emptying Machine								Truck								Tariff Calculation		
	Required Number	Purchase			Operation and Maintenance				Required Number	Purchase			Operation and Maintenance				Total cost	Family served per year	Cost per collection
		Yearly	Cost	Depreciation	Fuel	Labour	Maintenance	Sub-total		Yearly	Cost	Depreciation	Fuel	Labour	Maintenance	Sub-total			
	(unit)	(unit)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(unit)	(unit)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)	(1,000 soles)		(soles)
1998	0	0	0		0	0	0	0	0	0	0		0	0	0	0	0	4687	0
1999	0	0	0		0	0	0	0	0	0	0		0	0	0	0	0	4632	0
2000	0	0	0		0	0	0	0	0	0	0		0	0	0	0	0	4565	0
2001	5	5	110	27.5	6.8	180	11	198	4	4	240	30	17.8	72	12	102	357	4483	80
2002	5	0	0	27.5	6.6	180	11	198	4	0	0	30	17.3	72	12	101	356	4389	81
2003	5	0	0	27.5	6.5	180	11	197	4	0	0	30	16.8	72	12	101	356	4281	83
2004	4	0	0	27.5	6.3	144	8.8	159	4	0	0	30	16.2	72	12	100	317	4160	76
2005	4	4	88	22	6.1	144	8.8	159	4	0	0	30	15.6	72	12	100	310	4025	77
2006	4	0	0	22	5.9	144	8.8	159	4	0	0	30	14.9	72	12	99	310	3876	80
2007	4	0	0	22	5.6	144	8.8	158	3	0	0	30	14.2	54	9	77	288	3713	77
2008	4	0	0	22	5.3	144	8.8	158	3	0	0	30	13.4	54	9	76	287	3535	81
2009	4	3	66	16.5	5.1	144	8.8	158	3	3	180	22.5	12.6	54	9	76	272	3342	82
2010	3	0	0	16.5	4.7	108	6.6	119	3	0	0	22.5	11.8	54	9	75	233	3135	74
2011	3	0	0	16.5	4.7	108	6.6	119	3	0	0	22.5	11.7	54	9	75	233	3133	74
2012	3	0	0	16.5	4.7	108	6.6	119	3	0	0	22.5	11.6	54	9	75	233	3128	74
2013	3	3	66	16.5	4.7	108	6.6	119	3	0	0	22.5	11.5	54	9	75	233	3120	75
2014	3	0	0	16.5	4.7	108	6.6	119	3	0	0	22.5	11.4	54	9	74	233	3107	75
2015	3	0	0	16.5	4.7	108	6.6	119	3	0	0	22.5	11.3	54	9	74	233	3091	75
2016	3	0	0	16.5	4.6	108	6.6	119	3	0	0	22.5	11.1	54	9	74	232	3066	76
2017	3	3	66	16.5	4.6	108	6.6	119	3	3	180	22.5	10.9	54	9	74	232	3036	76
2018	3	0	0	16.5	4.5	108	6.6	119	3	0	0	22.5	10.8	54	9	74	232	3003	77
2019	3	0	0	16.5	4.5	108	6.6	119	3	0	0	22.5	10.6	54	9	74	232	2967	78
2020	3	0	0	16.5	4.4	108	6.6	119	3	0	0	22.5	10.4	54	9	73	231	2926	79
2021	3	3	66	16.5	4.3	108	6.6	119	3	0	0	22.5	10.1	54	9	73	231	2872	80
2022	3	0	0	16.5	4.3	108	6.6	119	3	0	0	22.5	9.8	54	9	73	231	2814	82
2023	3	0	0	16.5	4.2	108	6.6	119	3	0	0	22.5	9.6	54	9	73	230	2753	84
2024	3	0	0	16.5	4.1	108	6.6	119	2	0	0	22.5	9.3	36	6	51	209	2688	78
2025	3	3	66	16.5	4.0	108	6.6	119	2	2	120	15	9.0	36	6	51	201	2620	77
Total		24	528	478.5	125.8	3132	191.4	3449		12	720		309.7	1422	237	1969		Average	78

(2) Off-site system

General layout of proposed sewerage system in Puno City is shown in *Figure V.2.18*.

1. Wastewater collection system

a) Sanitary sewer system: **Separate system**

b) Piping Materials

Diameter of 150 mm :	RC (service connection)
Diameter of 150 to 400mm:	PVC
Diameter of more than 450 mm:	RC

c) Wastewater collection facilities

The sewer and a pump station, which will be implemented in future plan, are as follows.

1) Sewer

Sewer pipes have already been installed by EMSAPUNO. Although, a large part of the study area is already sewered, additional pipes shall be installed in future to cover the non-served population. *Table V.2.52* shows the breakdown of pipes by several categories, namely areas, existing sewers and future plan. In future plan, new installation length and replacement length are tabulated by phases.

2) Pump Station

Table V.2.51 Summary of Pump Station Plan

Name	Specification
E.B. EL PUERTO	Submersible pump, 5.25 l/s, 8.6 m, 1.2 kW, 1 set(+1)

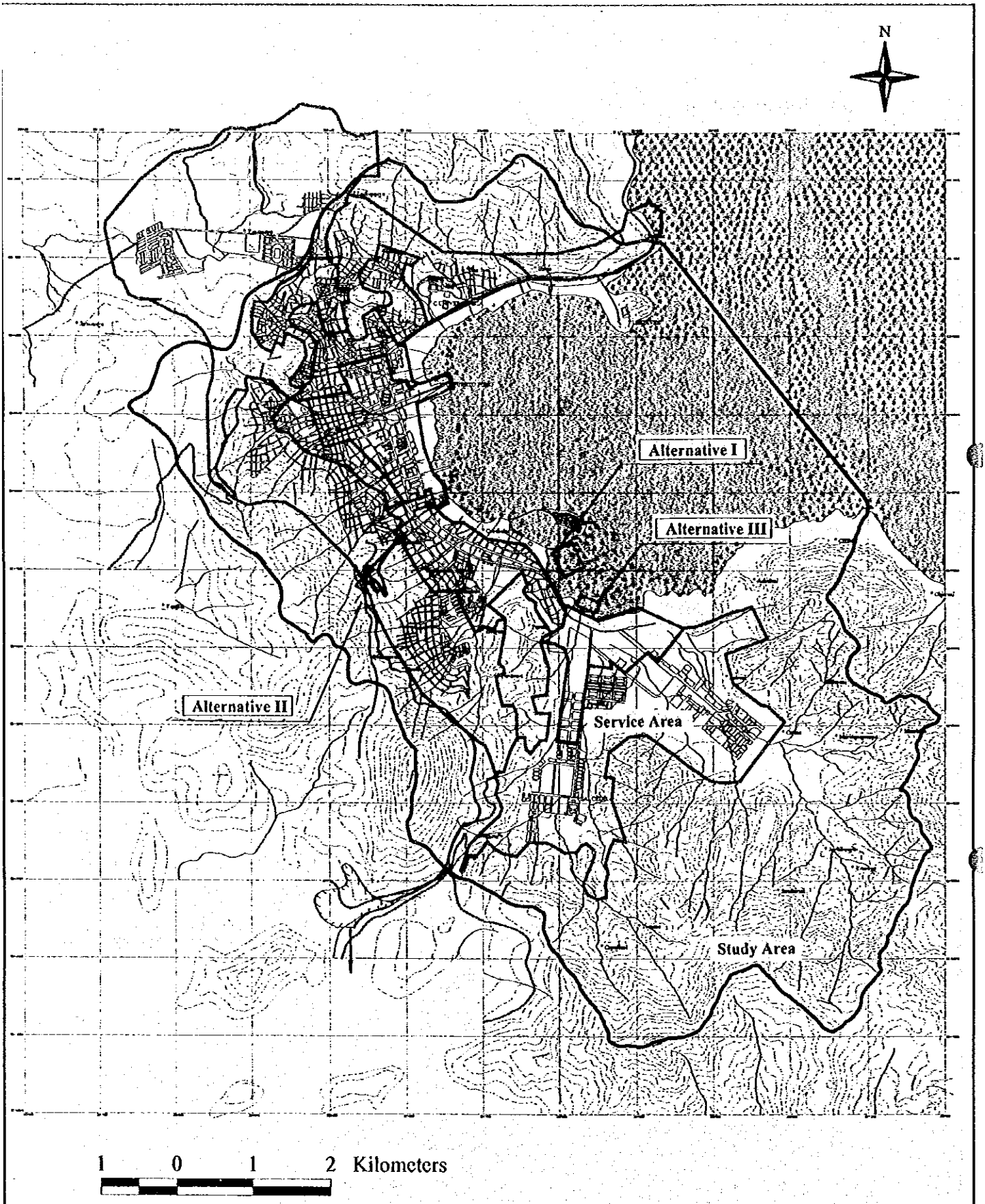

Figure V.2.18 General Layout of Master Plan

Table V.2.52 Summary of Sewer Plan

Area No.	Existing *1)		Future Plan							Total Length
			2008		2015		2025		Total	
	Area (ha)	Length (m)	Length (m)	Service Ratio *2)	Length (m)	Service Ratio *2)	Length (m)	Service Ratio *2)		
①	155.0	29,081	4,691	100.0%		100.0%		100.0%	4,691	33,772
②	57.0	11,252		100.0%		100.0%		100.0%	0	11,252
③	87.0	13,800		100.0%		100.0%		100.0%	0	13,800
④	123.7	23,856	10,857	100.0%		100.0%		100.0%	10,857	34,713
⑤	69.6	8,850		27.2%	14,039	70.3%		70.3%	14,039	22,889
⑥	120.7	14,536		47.5%	5,335	65.0%		65.0%	5,335	19,871
⑦	44.6	7,710	7,848	100.0%		100.0%		100.0%	7,848	15,557
⑧	27.3	7,673		47.9%	6,380	87.7%		87.7%	6,380	14,053
⑨	42.0	3,634		21.5%		21.5%	10,383	83.1%	10,383	14,017
⑩	116.9	21,243		19.8%		19.8%	55,624	71.8%	55,624	76,867
⑪	27.4	1,040		3.8%	12,240	48.1%		48.1%	12,240	13,280
⑫	25.9	3,505		25.9%	5,968	70.0%		70.0%	5,968	9,474
⑭	0.0	0		0.0%	2,870	59.3%		59.3%	2,870	2,870
Subtotal	897	146,179	23,396		46,832		66,007		136,234	282,413
Replacement	-	-	1,827		-		-		1,827	1,827
Total	897	146,179	25,223		46,832		66,007		138,062	284,241

*1) Existing : Service area, *2) Service Ratio : Area ratio

2. Wastewater treatment plant

Alternative I-A is further evaluated for its nutrient removal to propose optimum plan.

a) Mass balance of the wastewater treatment plant

The mass balance of the treatment plant (Alternative I-A) is estimated for organic matter (BOD_5), suspended solids (SS), nitrogen (T-N) and phosphorus (T-P). For the performance of the facultative lagoons, the following figures are used.

Table V.2.53 Pollutants removal by facultative lagoons by various standards

Source	BOD	T-N	T-P
	Removal (%)	Removal (%)	Removal (%)
ASCE/WEF (1998)		40 – 90 %	< 40 %
MOC, Japan (1993)	70 %		
Mara and Pearson (1998)	70 – 80 %	47 %*1	< 45 %
Proposed value*2	**70 %**	**45 %**	**40 %**

*1 water temperature = 10 °C, pH = 8.2

*2 values used for the mass balance calculations

The results are shown in *Table V.2.54, 2.55, 2.56* and *2.57.* The serious accumulation of solids is expected in the first facultative lagoon after the installation of aerated lagoons as substantial amount of suspended solids flows into the lagoon. Accumulated solids should be removed to maintain treatment capacity of facultative lagoons. Phosphorus is further removed by coagulant addition from year 2010. The target effluent concentration of T-P is less than 3 mg/l.

b) Possible improvement for Alternative I-A

Sedimentation lagoons

As required removal of accumulated solids from the facultative lagoons is quite difficult while continuous operation is required, installation of sedimentation lagoons is proposed. Two lagoons are to be constructed at Phase 2, which operate alternatively as a sedimentation lagoon and a sludge pond. Another lagoon is constructed at the start of Phase 3. At year 2025, each sedimentation lagoon has 12-hour retention time and 2 lagoons operate simultaneously while one is used as a sludge pond. Accumulated sludge in the aerated lagoons will be pumped to the sedimentation pond while it is used as a sludge pond. Suspended solid and sludge generation projection is shown in *Table V.2.55.*

Inlets for facultative lagoons

Inlets for the facultative lagoons are modified as shown in *Figure V.2.20b* to maximize the average retention time of the lagoons.

Outlet facility for the second facultative lagoons

At present, a large amount algae is observed in the effluent of facultative lagoons. In order to minimize the release of algae into the effluent, outlet structure such as *Figure V.2.19* is to be installed.

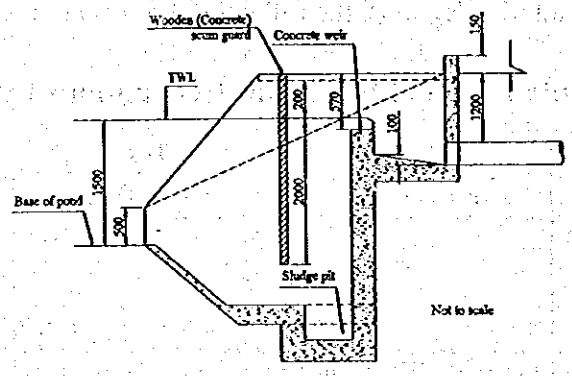

Figure V.2.19 Proposed outlet weir structure

* Source: Mara and Pearson, 1998

Table V.2.54 BOD_5 projection for the proposed plan (Aerated lagoons + Sedimentation ponds + Facultative lagoons + Constructed wetlands)

Year	Total population	Service ratio	Served population	Average daily flow	Influent		Aerated lagoons (Water temp.= 10.7)						Facultative lagoons (70% BOD removal) (Water temp.= 10)						BOD removal (Aer.+Fac.)	Constructed wetland				
					BOD load	BOD conc.	Volume	Effluent soluble BOD conc.	Effluent solid BOD conc.	Effluent BOD total	Effluent soluble BOD load	Effluent total BOD load	Minimum area (Peru)	Required area(Mara)	Area	Retention time	Effluent BOD conc.	Effluent BOD load		Area	Flow velocity	Retention time	Effluent BOD conc.	Effluent BOD load
		(%)		(l/s)	(kg/d)	(mg/l)	(m^3)	(mg/l)	(mg/l)	(mg/l)	(kg/d)	(kg/d)	(ha)	(ha)	(ha)	(day)	(mg/l)	(kg/d)	(%)	(ha)	(m/d)	(day)	(mg/l)	(kg/d)
1995	100,802	39.0	39,313	64.3	1,769	319	32,928	40	144	184	223	1,022	1.5	2.2	21.5	58.2	12.0	67	96	17.2	0.032	6.4	5.4	30
1996	103,656	41.4	42,914	68.2	1,931	328	32,928	43	148	192	256	1,130	1.7	2.6	21.5	54.8	13.0	77	96	17.2	0.034	6.0	5.7	34
1997	106,591	43.8	46,687	72.3	2,101	337	32,928	47	152	199	293	1,245	1.9	2.9	21.5	51.7	14.1	88	96	17.2	0.036	5.6	6.0	38
1998	108,457	46.2	50,107	77.2	2,255	338	32,928	50	153	203	333	1,354	2.2	3.3	21.5	48.4	15.0	100	96	17.2	0.039	5.3	6.3	42
1999	111,518	48.6	54,198	81.7	2,439	346	32,928	53	156	210	377	1,481	2.5	3.8	21.5	45.8	16.0	113	95	17.2	0.041	5.0	6.7	47
2000	114,579	51.0	58,435	86.3	2,630	353	32,928	57	159	217	426	1,615	2.8	4.3	21.5	43.3	17.1	128	95	17.2	0.043	4.7	7.1	53
2001	117,641	53.4	62,820	91.5	2,827	358	32,928	61	161	222	481	1,756	3.1	4.8	21.5	40.9	18.3	144	95	17.2	0.046	4.5	7.4	59
2002	120,703	55.8	67,352	96.7	3,031	363	32,928	65	163	228	540	1,902	3.5	5.4	21.5	38.7	19.4	162	95	17.2	0.049	4.2	7.8	65
2003	123,764	58.2	72,031	100.8	3,241	372	32,928	69	167	235	597	2,050	3.9	6.0	21.5	37.1	20.6	179	94	17.2	0.051	4.0	8.2	71
2004	126,826	60.6	76,857	105.0	3,459	381	32,928	73	170	243	659	2,204	4.3	6.6	21.5	35.6	21.8	198	94	17.2	0.053	3.9	8.6	78
2005	129,888	63.0	81,829	109.3	3,682	390	32,928	77	174	250	725	2,364	4.7	7.2	21.5	34.2	23.0	217	94	17.2	0.055	3.7	9.0	85
2006	132,951	65.4	86,950	115.5	3,913	392	32,928	81	174	254	805	2,536	5.2	8.0	21.5	32.4	24.2	241	94	17.2	0.058	3.5	9.4	94
2007	136,013	67.8	92,217	121.9	4,150	394	32,928	85	173	258	890	2,716	5.8	8.9	21.5	30.7	25.4	267	94	17.2	0.061	3.3	9.8	103
2008	139,076	70.2	97,631	128.6	4,393	396	32,928	88	173	261	983	2,902	6.4	9.8	21.5	29.1	26.5	295	93	17.2	0.065	3.2	10.2	113
2009	142,138	72.6	103,192	136.1	4,644	395	32,928	92	171	263	1,086	3,098	7.1	10.8	21.5	27.5	27.7	326	93	17.2	0.068	3.0	10.5	124
2010	145,201	75.0	108,901	143.9	4,901	394	32,928	96	169	265	1,195	3,301	7.8	11.9	21.5	26.0	28.8	359	93	17.2	0.072	2.8	10.9	136
2011	148,262	75.7	112,185	149.0	5,048	392	32,928	98	168	266	1,264	3,420	8.2	12.6	21.5	25.1	29.5	379	92	17.2	0.075	2.7	11.1	143
2012	151,324	76.3	115,511	154.1	5,198	390	32,928	100	166	266	1,334	3,541	8.7	13.3	21.5	24.3	30.1	400	92	17.2	0.077	2.6	11.3	151
2013	154,385	77.0	118,877	159.3	5,349	389	32,928	102	164	266	1,407	3,665	9.2	14.1	21.5	23.5	30.7	422	92	17.2	0.080	2.6	11.5	159
2014	157,447	77.7	122,284	164.6	5,503	387	32,928	104	162	267	1,483	3,790	9.7	14.8	21.5	22.7	31.3	445	92	17.2	0.083	2.5	11.7	167
2015	160,508	78.3	125,731	170.0	5,658	385	32,928	106	160	267	1,561	3,918	10.2	15.6	21.5	22.0	31.9	468	92	17.2	0.085	2.4	11.9	175
2016	163,264	79.0	128,978	175.3	5,804	383	32,928	108	159	267	1,637	4,039	10.7	16.3	21.5	21.3	32.4	491	92	17.2	0.088	2.3	12.1	183
2017	166,020	79.7	132,262	180.6	5,952	381	32,928	110	157	267	1,715	4,162	11.2	17.1	21.5	20.7	33.0	515	91	17.2	0.091	2.3	12.3	192
2018	168,775	80.3	135,583	185.8	6,101	380	49,392	83	167	249	1,326	4,004	8.6	13.2	21.5	20.1	24.8	398	93	17.2	0.093	2.2	9.6	154
2019	171,531	81.0	138,940	191.7	6,252	378	49,392	84	165	249	1,392	4,126	9.1	13.9	21.5	19.5	25.2	418	93	17.2	0.096	2.1	9.7	161
2020	174,287	81.7	142,334	197.4	6,405	376	49,392	86	164	249	1,459	4,248	9.5	14.6	21.5	18.9	25.7	438	93	17.2	0.099	2.1	9.9	168
2021	176,430	82.3	145,261	202.5	6,537	374	49,392	87	162	249	1,519	4,355	9.9	15.2	21.5	18.5	26.0	456	93	17.2	0.102	2.0	10.0	175
2022	178,574	83.0	148,216	207.8	6,670	372	49,392	88	161	249	1,580	4,463	10.3	15.8	21.5	18.0	26.4	474	93	17.2	0.104	2.0	10.1	182
2023	180,717	83.7	151,200	213.1	6,804	369	49,392	89	159	248	1,643	4,573	10.7	16.4	21.5	17.5	26.8	493	93	17.2	0.107	1.9	10.2	188
2024	182,861	84.3	154,212	218.6	6,940	367	49,392	90	158	248	1,708	4,684	11.1	17.1	21.5	17.1	27.1	513	93	17.2	0.110	1.9	10.4	196
2025	185,004	85.0	157,253	224.1	7,076	365	49,392	92	156	248	1,775	4,796	11.6	17.7	21.5	16.7	27.5	533	92	17.2	0.113	1.8	10.5	203

BOD removal by aerated lagoons

$C/C_i = 1/(1+k*RT)$

C: effluent BOD_5 concentration (mg/l)
C_i: influent BOD_5 concentration (mg/l)
RT: retention time (day)
k_t: overall first-order BOD_5 removal rate constant (1/day)
$k_{20} = 2.5$ (Metcalf & Eddy, Inc.,1990)
$k_t = k_{20} \times 1.085^{(T-20)}$

T: lagoon water temperature (°C)

Cell concentration in aerated lagoons

$X = Y (C_i-C)/(1+b_t*RT)$

X: cell concentration (mg/l)
Y: yield coefficient (0.6 - 0.7)
b_t: autolysis rate (1/day)
$k_{20} = 0.07$ (Metcalf & Eddy, Inc.,1990)
$k_t = k_{20} \times 1.085^{(T-20)}$

Effluent solid BOD_5 from cell

$BOD_5 = 0.95*X$

Minimum area for facultative lagoons (Peru)

$A_{min} = L_i / (250 * 1.05^{(t-20)})$

A_{min}: Minimum area (ha)
L: Incoming BOD_5 load (kg)

Required area for facultative lagoons (Mara, 1998)

$A_{req} = L_i / (350 * (1.107 - 0.002T)^{(T-20)})$

A_{req}: Required area (ha)
L: Incoming BOD_5 load (kg)

* Solid BOD is to be removed by sedimentation ponds and facultative lagoons

BOD_5 removal by sub-surface constructed wetland

$C = 0.33C_i+1.4$ (NADB)

C: effluent BOD_5 concentration (mg/l)
C_i: influent BOD_5 concentration (mg/l)

Table V.2.55 SS projection for the proposed plan (Aerated lagoons + Sedimentation ponds + Facultative lagoons + Constructed wetlands)

Year	Total population	Service ratio (%)	Served population	Average daily flow (l/s)	Influent		Aerated lagoons						Water temp.= 10.7	Sedimentation ponds				
					SS load (kg/d)	SS conc. (mg/l)	Volume (m^3)	Effluent non-biodegradable SS (40% inf.) (mg/l)	Effluent biosolid conc. (mg/l)	Effluent SS total (mg/l)	Effluent non-biodegradable SS load (kg/d)	Effluent total SS load (kg/d)	Required volume (1day RT) (m^3)	Effluent SS (mg/l)	SS removed (kg/d)	SS accumulated per year (t)	Sludge generation (40%solid) (m^3)	Proposed volume* (m^3)
1995	100,802	39.0	39,313	64.3	3,184	574	32,928	229	152	381	1,274	2,115	5,552	100	1,560	491	1,228	
1996	103,656	41.4	42,914	68.2	3,476	590	32,928	236	156	392	1,390	2,311	5,896	100	1,721	538	1,344	
1997	106,591	43.8	46,687	72.3	3,782	606	32,928	242	161	403	1,513	2,515	6,243	100	1,890	587	1,466	
1998	108,457	46.2	50,107	77.2	4,059	609	32,928	243	161	405	1,623	2,699	6,668	100	2,032	630	1,575	
1999	111,518	48.6	54,198	81.7	4,390	622	32,928	249	165	414	1,756	2,918	7,057	100	2,213	683	1,707	
2000	114,579	51.0	58,435	86.3	4,733	635	32,928	254	168	422	1,893	3,144	7,454	100	2,399	737	1,843	
2001	117,641	53.4	62,820	91.5	5,088	644	32,928	258	170	427	2,035	3,377	7,904	100	2,587	793	1,983	
2002	120,703	55.8	67,352	96.7	5,456	653	32,928	261	172	433	2,182	3,616	8,352	100	2,781	851	2,128	
2003	123,764	58.2	72,031	100.8	5,835	670	32,928	268	176	444	2,334	3,863	8,707	100	2,992	912	2,280	
2004	126,826	60.6	76,857	105.0	6,225	686	32,928	274	179	454	2,490	4,116	9,074	100	3,209	975	2,436	
2005	129,888	63.0	81,829	109.3	6,628	702	32,928	281	183	463	2,651	4,377	9,444	100	3,432	1,039	2,597	
2006	132,951	65.4	86,950	115.5	7,043	706	32,928	282	183	465	2,817	4,640	9,978	100	3,643	1,104	2,759	
2007	136,013	67.8	92,217	121.9	7,470	709	32,928	284	182	466	2,988	4,909	10,532	100	3,856	1,170	2,924	
2008	139,076	70.2	97,631	128.6	7,908	712	32,928	285	182	467	3,163	5,184	11,107	100	4,073	1,238	3,094	
2009	142,138	72.6	103,192	136.1	8,359	711	32,928	284	180	464	3,343	5,462	11,761	100	4,286	1,306	3,266	
2010	145,201	75.0	108,901	143.9	8,821	709	32,928	284	178	462	3,528	5,744	12,436	100	4,501	1,377	3,441	14,522
2011	148,262	75.7	112,185	149.0	9,087	706	32,928	282	176	459	3,635	5,905	12,870	100	4,618	1,416	3,541	14,522
2012	151,324	76.3	115,511	154.1	9,356	703	32,928	281	175	456	3,743	6,066	13,312	100	4,734	1,457	3,641	14,522
2013	154,385	77.0	118,877	159.3	9,629	700	32,928	280	173	453	3,852	6,228	13,762	100	4,851	1,497	3,743	14,522
2014	157,447	77.7	122,284	164.6	9,905	697	32,928	279	171	449	3,962	6,391	14,221	100	4,968	1,538	3,845	14,522
2015	160,508	78.3	125,731	170.0	10,184	693	32,928	277	169	446	4,074	6,554	14,688	100	5,086	1,579	3,948	14,522
2016	163,264	79.0	128,978	175.3	10,447	690	32,928	276	167	443	4,179	6,707	15,143	100	5,193	1,618	4,045	14,522
2017	166,020	79.7	132,262	180.6	10,713	686	32,928	275	165	440	4,285	6,861	15,607	100	5,300	1,657	4,142	14,522
2018	168,775	80.3	135,583	185.8	10,982	684	49,392	274	176	449	4,393	7,213	16,050	100	5,608	1,714	4,286	19,362
2019	171,531	81.0	138,940	191.7	11,254	680	49,392	272	174	446	4,502	7,380	16,561	100	5,723	1,755	4,386	19,362
2020	174,287	81.7	142,334	197.4	11,529	676	49,392	270	172	443	4,612	7,548	17,052	100	5,843	1,796	4,489	19,362
2021	176,430	82.3	145,261	202.5	11,766	672	49,392	269	171	440	4,706	7,692	17,498	100	5,942	1,831	4,577	19,362
2022	178,574	83.0	148,216	207.8	12,006	669	49,392	267	169	437	4,802	7,837	17,952	100	6,042	1,866	4,665	19,362
2023	180,717	83.7	151,200	213.1	12,247	665	49,392	266	167	433	4,899	7,982	18,414	100	6,141	1,901	4,754	19,362
2024	182,861	84.3	154,212	218.6	12,491	661	49,392	265	166	430	4,996	8,128	18,884	100	6,240	1,937	4,843	19,362
2025	185,004	85.0	157,253	224.1	12,738	658	49,392	263	164	427	5,095	8,275	19,362	100	6,339	1,973	4,933	19,362

BOD removal by aerated lagoons

$C/C_i = 1/(1+k*RT)$

C: effluent BOD_5 concentration (mg/l)
C_i: influent BOD_5 concentration (mg/l)
RT: retention time (day)
k_t: overall first-order BOD_5 removal rate constant (1/day)
$k_{20} = 2.5$ (Metcalf & Eddy, Inc., 1990)
$k_t = k_{20} \times 1.085^{(T-20)}$
T: lagoon water temperature (℃)

Cell concentration (effluent biosolid) in aerated lagoons

$X = Y (C_i-C)/(1+b_t*RT)$

X: cell concentration (mg/l)
Y: yield coefficient (0.6 - 0.7)
b_t: autolysis rate (1/day)
$k_{20} = 0.07$ (Metcalf & Eddy, Inc., 1990)
$k_t = k_{20} \times 1.085^{(T-20)}$

40% of SS is non-biodegradable and carried over to sedimentation ponds

Sedimentation ponds operation (1 day retention time)

Year 2010 - 2017:

2 sedimentation ponds with 9,681m^3 capacity each are proposed (operation cycle: 1 year operation - 6 month rest(sludge drying))

Year 2018 - 2025:

3 sedimentation ponds with 9,681m^3 capacity each are proposed (operation cycle: 1 year operation - 6 month rest(sludge drying))

75% of accumulated biosolid degraded within one year

Table V.2.56 T-N projection for the proposed plan (Aerated lagoons + Sedimentation ponds + Facultative lagoons + Constructed wetlands)

Year	Total population	Service ratio (%)	Served population	Average daily flow (l/s)	Influent		Facultative lagoons (45% T-N removal)				Constructed wetland					Temp.(℃)= 10
					T-N load (kg/d)	T-N conc. (mg/l)	Area (ha)	Retention time (day)	Effluent T-N conc. (mg/l)	Effluent T-N load (kg/d)	Area (ha)	Flow velocity (m/d)	Retention time (day)	Background T-N (mg/l)	Effluent T-N conc. (mg/l)	Effluent T-N load (kg/d)
1995	100,802	39.0	39,313	64.3	432	77.9	21.5	58.2	42.8	238	17.2	0.032	6.4	1.50	11.6	65
1996	103,656	41.4	42,914	68.2	472	80.1	21.5	54.8	44.0	260	17.2	0.034	6.0	1.50	12.8	76
1997	106,591	43.8	46,687	72.3	514	82.3	21.5	51.7	45.2	282	17.2	0.036	5.6	1.50	14.0	88
1998	108,457	46.2	50,107	77.2	551	82.7	21.5	48.4	45.5	303	17.2	0.039	5.3	1.50	15.1	101
1999	111,518	48.6	54,198	81.7	596	84.5	21.5	45.8	46.5	328	17.2	0.041	5.0	1.50	16.4	115
2000	114,579	51.0	58,435	86.3	643	86.2	21.5	43.3	47.4	354	17.2	0.043	4.7	1.50	17.6	131
2001	117,641	53.4	62,820	91.5	691	87.4	21.5	40.9	48.1	380	17.2	0.046	4.5	1.50	18.8	149
2002	120,703	55.8	67,352	96.7	741	88.7	21.5	38.7	48.8	407	17.2	0.049	4.2	1.50	20.1	168
2003	123,764	58.2	72,031	100.8	792	91.0	21.5	37.1	50.0	436	17.2	0.051	4.0	1.50	21.3	185
2004	126,826	60.6	76,857	105.0	845	93.2	21.5	35.6	51.2	465	17.2	0.053	3.9	1.50	22.5	204
2005	129,888	63.0	81,829	109.3	900	95.3	21.5	34.2	52.4	495	17.2	0.055	3.7	1.50	23.8	224
2006	132,951	65.4	86,950	115.5	956	95.9	21.5	32.4	52.7	526	17.2	0.058	3.5	1.50	24.9	249
2007	136,013	67.8	92,217	121.9	1014	96.3	21.5	30.7	53.0	558	17.2	0.061	3.3	1.50	26.0	274
2008	139,076	70.2	97,631	128.6	1074	96.7	21.5	29.1	53.2	591	17.2	0.065	3.2	1.50	27.1	301
2009	142,138	72.6	103,192	136.1	1135	96.5	21.5	27.5	53.1	624	17.2	0.068	3.0	1.50	28.1	330
2010	145,201	75.0	108,901	143.9	1198	96.3	21.5	26.0	53.0	659	17.2	0.072	2.8	1.50	29.0	360
2011	148,262	75.7	112,185	149.0	1234	95.9	21.5	25.1	52.7	679	17.2	0.075	2.7	1.50	29.4	379
2012	151,324	76.3	115,511	154.1	1271	95.5	21.5	24.3	52.5	699	17.2	0.077	2.6	1.50	29.9	397
2013	154,385	77.0	118,877	159.3	1308	95.0	21.5	23.5	52.3	719	17.2	0.080	2.6	1.50	30.3	417
2014	157,447	77.7	122,284	164.6	1345	94.6	21.5	22.7	52.0	740	17.2	0.083	2.5	1.50	30.7	436
2015	160,508	78.3	125,731	170.0	1383	94.2	21.5	22.0	51.8	761	17.2	0.085	2.4	1.50	31.0	456
2016	163,264	79.0	128,978	175.3	1419	93.7	21.5	21.3	51.5	780	17.2	0.088	2.3	1.50	31.4	475
2017	166,020	79.7	132,262	180.6	1455	93.2	21.5	20.7	51.3	800	17.2	0.091	2.3	1.50	31.7	494
2018	168,775	80.3	135,583	185.8	1491	92.9	21.5	20.1	51.1	820	17.2	0.093	2.2	1.50	32.0	513
2019	171,531	81.0	138,940	191.7	1528	92.3	21.5	19.5	50.8	841	17.2	0.096	2.1	1.50	32.2	534
2020	174,287	81.7	142,334	197.4	1566	91.8	21.5	18.9	50.5	861	17.2	0.099	2.1	1.50	32.5	554
2021	176,430	82.3	145,261	202.5	1598	91.3	21.5	18.5	50.2	879	17.2	0.102	2.0	1.50	32.7	572
2022	178,574	83.0	148,216	207.8	1630	90.8	21.5	18.0	49.9	897	17.2	0.104	2.0	1.50	32.9	590
2023	180,717	83.7	151,200	213.1	1663	90.3	21.5	17.5	49.7	915	17.2	0.107	1.9	1.50	33.0	608
2024	182,861	84.3	154,212	218.6	1696	89.8	21.5	17.1	49.4	933	17.2	0.110	1.9	1.50	33.2	627
2025	185,004	85.0	157,253	224.1	1730	89.3	21.5	16.7	49.1	951	17.2	0.113	1.8	1.50	33.3	645

T-N removal by constructed wetlands (Subsurface flow)

$$C = C_b + (C_i - C_b)e^{(-k/q)}$$

C: effluent T-N concentration (mg/l)
C_i: influent T-N concentration (mg/l)
C_b: background T-N concentration (1.5 mg/l)
k_t: areal rate constant at t ℃ (k_{20} = 27 m/year)

$k_t = k_{20} \times 1.05^{(T-20)}$

T: Temperature (℃)

q: hydraulic loading (m/day)

Table V.2.57 T-P projection for the proposed plan (Aerated lagoons + Sedimentation ponds + Facultative lagoons + Constructed wetlands)

Year	Total population	Service ratio (%)	Served population	Average daily flow (l/s)	Influent		Facultative lagoons (40% T-P removal)				T-P removal (Aer.+Fac.) (%)	Constructed wetland					
					T-P load (kg/d)	T-P conc. (mg/l)	Area (ha)	Retention time (day)	Effluent T-P conc. (mg/l)	Effluent T-P load (kg/d)		Area (ha)	Flow velocity (m/d)	Retention time (day)	Backgroun d T-P conc. (mg/l)	Effluent T-P conc. (mg/l)	Effluent T-P load (kg/d)
1995	100,802	39.0	39,313	64.3	49	8.9	21.5	58.2	5.3	29	40	17.2	0.032	6.4	0.02	1.9	11
1996	103,656	41.4	42,914	68.2	54	9.1	21.5	54.8	5.5	32	40	17.2	0.034	6.0	0.02	2.1	12
1997	106,591	43.8	46,687	72.3	58	9.3	21.5	51.7	5.6	35	40	17.2	0.036	5.6	0.02	2.3	14
1998	108,457	46.2	50,107	77.2	63	9.4	21.5	48.4	5.6	38	40	17.2	0.039	5.3	0.02	2.4	16
1999	111,518	48.6	54,198	81.7	68	9.6	21.5	45.8	5.8	41	40	17.2	0.041	5.0	0.02	2.6	18
2000	114,579	51.0	58,435	86.3	73	9.8	21.5	43.3	5.9	44	40	17.2	0.043	4.7	0.02	2.8	21
2001	117,641	53.4	62,820	91.5	79	9.9	21.5	40.9	6.0	47	40	17.2	0.046	4.5	0.02	2.9	23
2002	120,703	55.8	67,352	96.7	84	10.1	21.5	38.7	6.0	51	40	17.2	0.049	4.2	0.02	3.1	26
2003	123,764	58.2	72,031	100.8	90	10.3	21.5	37.1	6.2	54	40	17.2	0.051	4.0	0.02	3.3	28
2004	126,826	60.6	76,857	105.0	96	10.6	21.5	35.6	6.4	58	40	17.2	0.053	3.9	0.02	3.4	31
2005	129,888	63.0	81,829	109.3	102	10.8	21.5	34.2	6.5	61	40	17.2	0.055	3.7	0.02	3.6	34
2006	132,951	65.4	86,950	115.5	109	10.9	21.5	32.4	6.5	65	40	17.2	0.058	3.5	0.02	3.7	37
2007	136,013	67.8	92,217	121.9	115	10.9	21.5	30.7	6.6	69	40	17.2	0.061	3.3	0.02	3.8	41
2008	139,076	70.2	97,631	128.6	122	11.0	21.5	29.1	6.6	73	40	17.2	0.065	3.2	0.02	4.0	44
2009	142,138	72.6	103,192	136.1	129	11.0	21.5	27.5	6.6	77	40	17.2	0.068	3.0	0.02	4.1	48
2010	145,201	75.0	108,901	143.9	136	10.9	21.5	26.0	6.6	82	40	17.2	0.072	2.8	0.02	4.2	52
2011	148,262	75.7	112,185	149.0	140	10.9	21.5	25.1	6.5	84	40	17.2	0.075	2.7	0.02	4.2	54
2012	151,324	76.3	115,511	154.1	144	10.8	21.5	24.3	6.5	87	40	17.2	0.077	2.6	0.02	4.3	57
2013	154,385	77.0	118,877	159.3	149	10.8	21.5	23.5	6.5	89	40	17.2	0.080	2.6	0.02	4.3	59
2014	157,447	77.7	122,284	164.6	153	10.7	21.5	22.7	6.4	92	40	17.2	0.083	2.5	0.02	4.3	62
2015	160,508	78.3	125,731	170.0	157	10.7	21.5	22.0	6.4	94	40	17.2	0.085	2.4	0.02	4.4	64
2016	163,264	79.0	128,978	175.3	161	10.6	21.5	21.3	6.4	97	40	17.2	0.088	2.3	0.02	4.4	67
2017	166,020	79.7	132,262	180.6	165	10.6	21.5	20.7	6.4	99	40	17.2	0.091	2.3	0.02	4.4	69
2018	168,775	80.3	135,583	185.8	169	10.6	21.5	20.1	6.3	102	40	17.2	0.093	2.2	0.02	4.5	72
2019	171,531	81.0	138,940	191.7	174	10.5	21.5	19.5	6.3	104	40	17.2	0.096	2.1	0.02	4.5	74
2020	174,287	81.7	142,334	197.4	178	10.4	21.5	18.9	6.3	107	40	17.2	0.099	2.1	0.02	4.5	77
2021	176,430	82.3	145,261	202.5	182	10.4	21.5	18.5	6.2	109	40	17.2	0.102	2.0	0.02	4.5	79
2022	178,574	83.0	148,216	207.8	185	10.3	21.5	18.0	6.2	111	40	17.2	0.104	2.0	0.02	4.5	81
2023	180,717	83.7	151,200	213.1	189	10.3	21.5	17.5	6.2	113	40	17.2	0.107	1.9	0.02	4.5	84
2024	182,861	84.3	154,212	218.6	193	10.2	21.5	17.1	6.1	116	40	17.2	0.110	1.9	0.02	4.5	86
2025	185,004	85.0	157,253	224.1	197	10.2	21.5	16.7	6.1	118	40	17.2	0.113	1.8	0.02	4.6	88

T-P removal by constructed wetlands (Subsurface flow)

$$C = C_b + (C_i - C_b)e^{(-k_t/q)}$$

C: effluent T-P concentration (mg/l)
C_i: influent T-P concentration (mg/l)
C_b: background T-P concentration (0.02 mg/l)
k_t: areal rate constant at t ℃ (k_{20} = 12 m/year)
$k_t = k_{20} \times 1.0^{(T-20)}$
T: Temperature (℃)
q: hydraulic loading (m/day)

*T-P concentration will be further reduced to 3 mg/l at the outlet of the constructed wetlands with coagulant addition from 2010
*Coagulant can be added at outlet of aerated lagoons

Alternative for constructed wetland

Use of the existing natural wetland for the treatment of facultative lagoon is evaluated. Recommended minimum pretreatment levels to natural wetland discharge are shown in *Table V.2.58.* Those levels are much lower than the expected nutrient level of the facultative lagoon effluent. At least, solid removal facilities such as rock filters are required before discharge to the natural wetland as large amount of algae is expected in the facultative lagoon effluent. This option is not included in the proposed plan since further study of totora culture and careful examination of flow in the wetland are required for the use of natural wetland.

Table V.2.58 Recommended minimum wastewater pretreatment levels prior to natural wetland discharge

Constituent	Suggested Pretreatment Level	Potential Harmful Effect
BOD_5	Minimum of secondary (20-30 mg/L)	Oxygen depletion; odor; mosquito production
TSS	Minimum of secondary (30-50 mg/L); mineral solids should be reduced to < 10 mg/L	Oxygen depletion; smothering of plant roots and elimination of woody plant species
NH_4-N	Nitrification is highly desirable; maximum of 5 mg/L	Oxygen depletion; un-ionized ammonia toxicity
Total N	Less than 20 mg/L	Eutrophication; selection of fast-growing species
Total P	Less than 1.0 mg/L	Eutrophication; selection of fast-growing species
TDS	Site specific; dependent on available natural wetland type	Toxic to unadapted plant and animal species
Metals and other toxins	Below chronic toxicity levels	Accumulation to toxic concentrations; food chain biomagnification for a few constituents

* Source: Kadlec and Knight, 1995

Treated water irrigation for the inner bay area

The relatively large amount of Nitrogen (T-N) will be discharged to the inner bay. Further Nitrogen removal is difficult with the proposed treatment system. Biological Nitrogen removal is possible with the treatment system like Alternative III. Nitrogen level may decrease when treated water is used for agricultural and forest irrigation. Treated water reuse for the outside of catchment area required a large capital investment, such as Alternative II, irrigation for the inner Puno bay can be considered.

c) **Proposed wastewater treatment plant**

Schematic of the proposed wastewater treatment plant is shown in *Figure V.2.20a.*

Layout for the proposed wastewater treatment plant is shown in *Figure V.2.20b.*

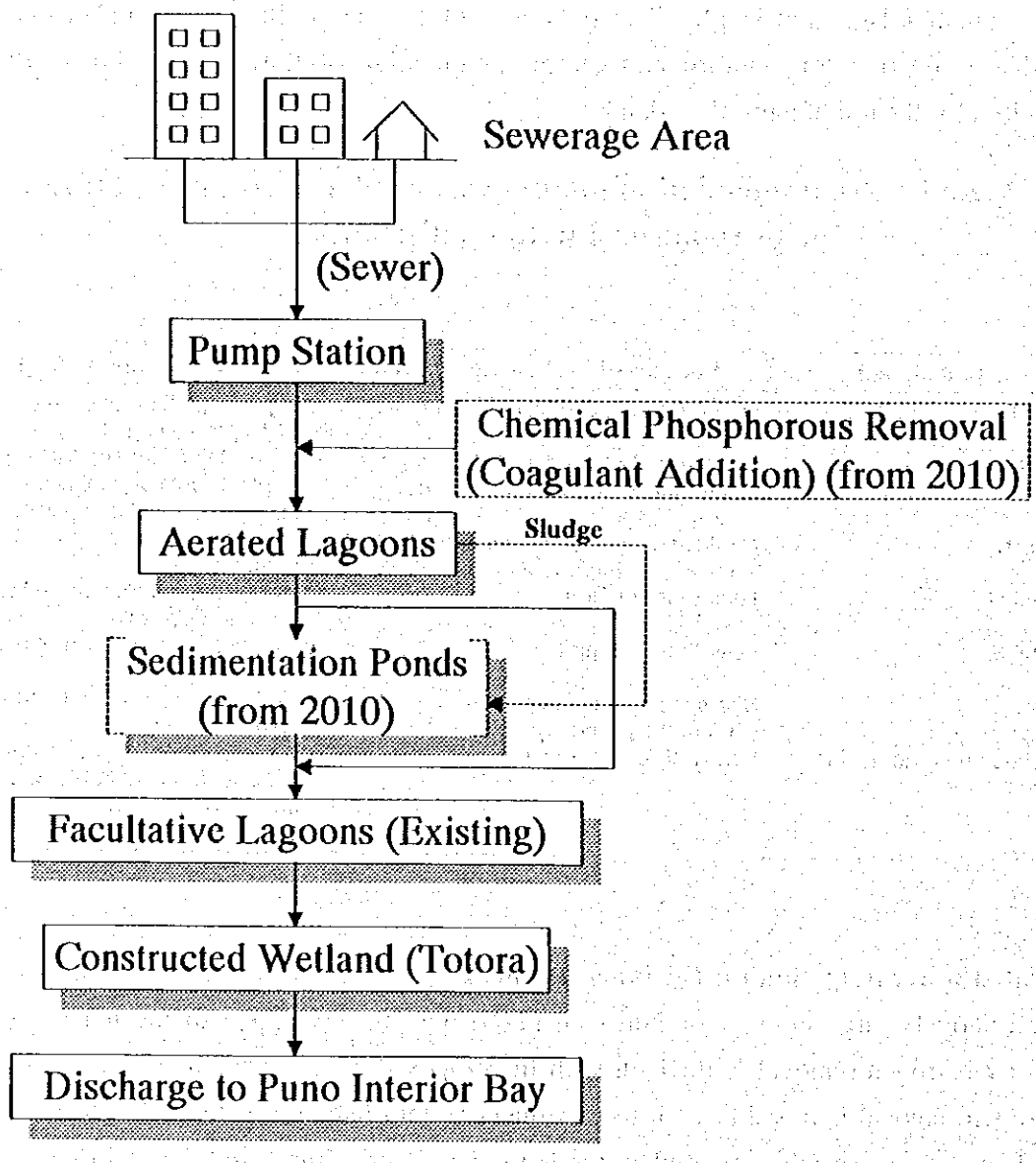

Figure V.2.20a Schematic of proposed wastewater treatment process

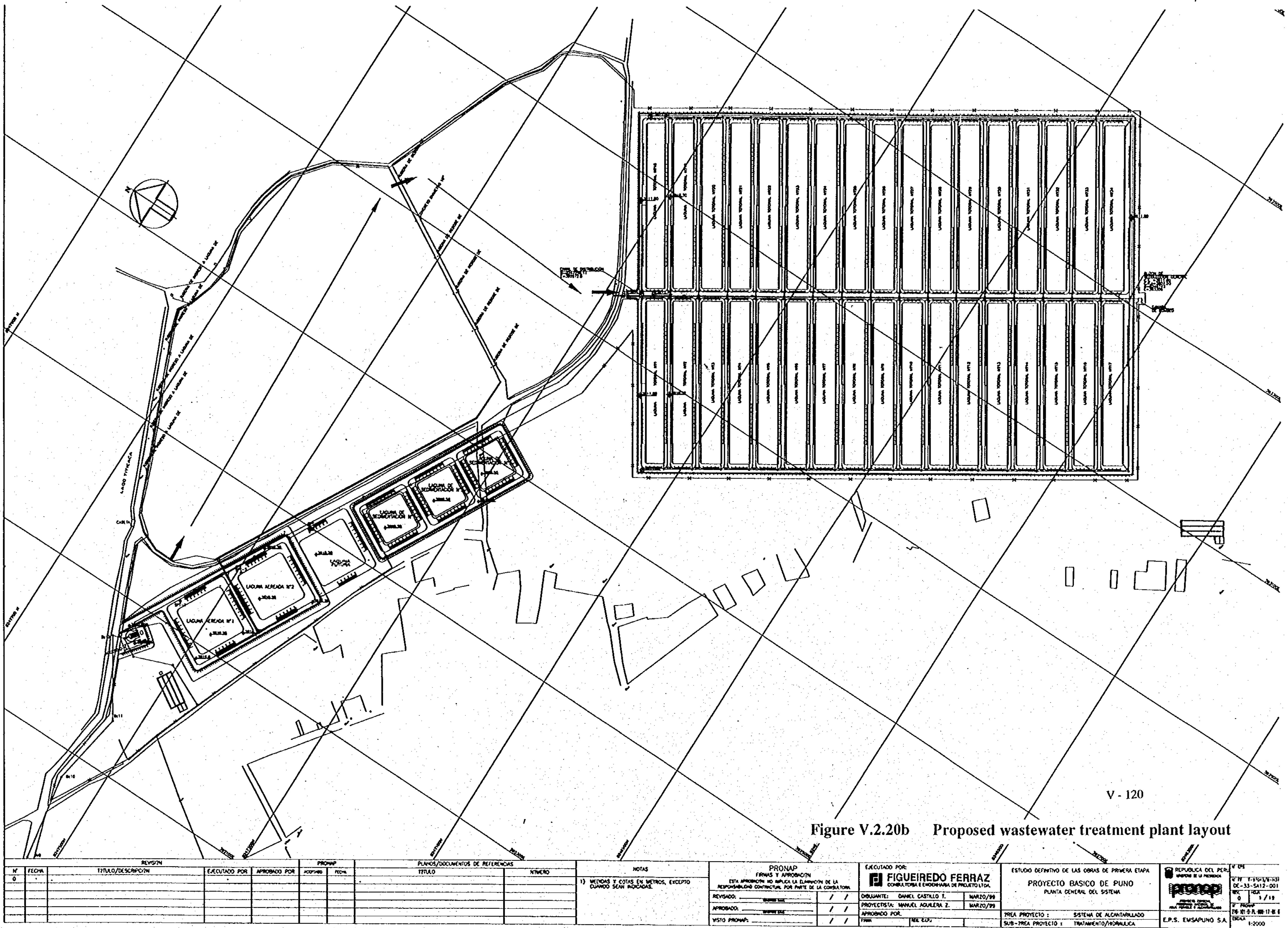

Figure V.2.20b Proposed wastewater treatment plant layout

d) Specifications for wastewater treatment facilities

Specifications for major wastewater treatment facilities are as follows:

Table V.2.59 Specifications of proposed wastewater treatment plant

Facilities	Specifications
1.Pump Station	
EB Puno	Submersible Pump, 200 l/s, 8.6 m, 30 kW, 2 sets(+1)
2. Aerated Lagoon	3 basins
Type	Rectangular Type
Dimension	64.0 m W x 80.0 m L x 4.0 m D
Aeration Power Level	22.35 kW (4 per Basin)
Retention Time	2.43 days
3. Existing Primary Lagoon	1 basins
Type	Facultative lagoon
Area	13.4 ha
Depth Average	1.5 m
Volume	204,600 m3
4. Existing Secondary Lagoon	1 basins
Type	Facultative lagoon
Area	7.9 ha
Depth Average	1.5 m
Volume	118,350 m3
5. Constructed Wetland	34 basins
Type	Sub-surface flow
Dimension	23.0 m W x 203.0 m L
Depth Average	0.3 - 0.5 m
6. Sedimentation ponds	3 basins
Type	Rectangular Type
Dimension	63.0 m W x 63.0 m L x 4.0 m D
Retention Time	2 days in year 2025

2.4.2 NON-STRUCTURAL MEASURES

(1) Institutional and operative capacity strengthening of EMSAPUNO

The on-going "Program MIO" of EMSAPUNO, scheduled to complete in year 2001, shall be further extended towards the future to effectively implement the proposed Master Plan. In addition to the above program, staff training program shall be established to provide the existing and future staff to upgrade their knowledge and skills for organization management, operation & maintenance of the facilities.

Training program may include:

- on the job training at various facilities by experienced personnel of EMSAPUNO or other organizations
- training at other water companies, such as SEDAPAL for familiarizing with new management practices and technologies.

Requirement of operation and maintenance staff will be discussed in Section 2.7.

(2) Sanitation promotion

In order to achieve improvement of public health, sanitation promotion among the residents of Puno City is essential. Possible strategies of sanitation promotion are as follows:

- Community management: Community members played a key role in managing the project.
- Involvement of women: The active participation of women in each stage of the project was ensured.
- Latrine construction: Household latrines were constructed by family or community personnel.
- Community contribution towards investment costs: This facilitated local ownership of the program although the program may need state subsidies.
- Hygiene and sanitation education and training: This key activity ensured the effective and sustained use of services. Training materials, such as *Figure V.2.21*, shall be developed for teachers and health workers.

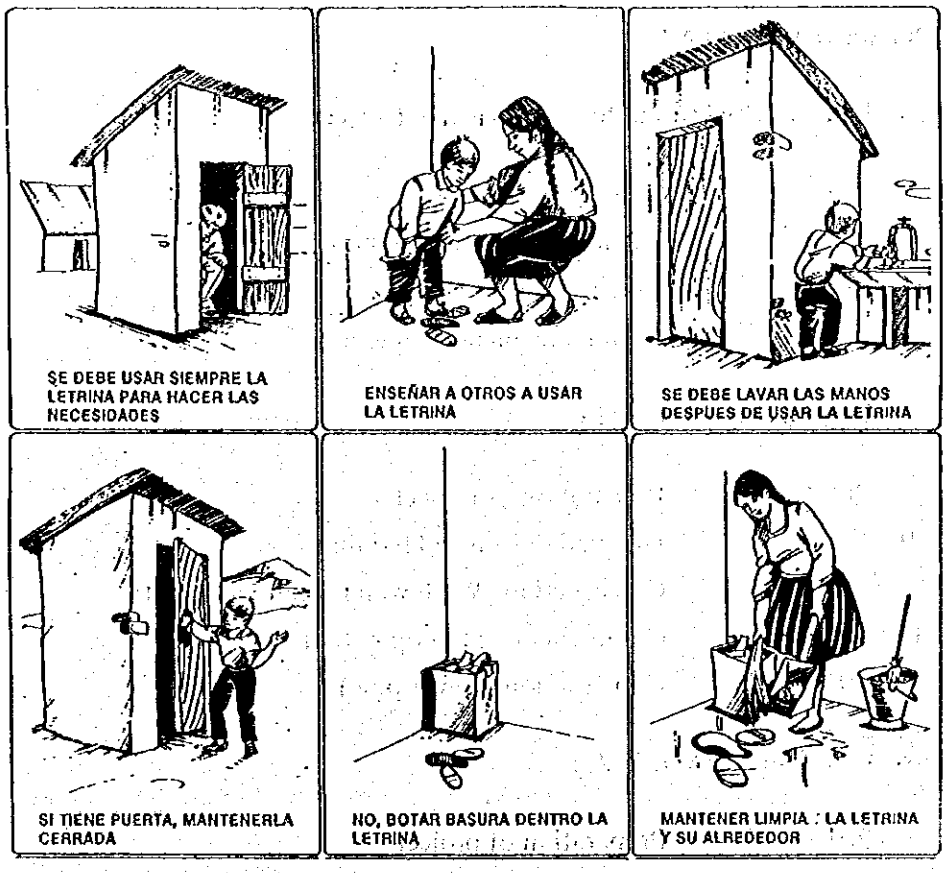

Figure V.2.21 Rules for correctly using a latrine – Reglas para buen uso de letrinas

Source: WHO (1998)

(3) Control of sewerage system use

Sewerage systems are often damaged through public misuse. This results from a public misconception that a sewerage system can be used to carry away any unwanted object. Adequate regulations setting forth proper uses of the system and public cooperation are required to properly maintain and control the sewerage system.

Regulations shall prohibit:

- discharge of explosive or flammable substances into the sanitary sewer
- discharge of corrosive or abrasive wastes
- roof drain connections to the sanitary sewer

Appropriate regulations shall be adopted and enforced by Puno Provincial Municipality, EMSAPUNO and communities.

2.5 IMPLEMENTATION PLAN

Phase 1 (Year 1998 to 2008) - Priority Project

-1997	Preparation of project
1998 - 2000	Detailed design and bidding
2000 - 2002	Construction
2004 -	Commencement of operation

Phase 2 (Year 2009 to 2015)

- 2008	Preparation of project
2009	Detailed design and bidding
	Construction (Wastewater treatment plant)
2010	Commencement of operation
- 2015	Construction (Sewer pipe)

Phase 3 (Year 2016 to 2025)

- 2015	Preparation of project
2016	Detailed design and bidding
2016 – 2017	Construction (Wastewater treatment plant, Pump station)
2018	Commencement of operation
- 2025	Construction (Sewer pipe)

Construction works according to the phases are as follows:

Facilities	Sewer Pipe	Pump Station	Wastewater Treatment Plant
Year	2000-2002	2000-2002	2000-2002
Phase 1	ϕ 150-900, L =25,223m	EB EL PUERTO	EB Puno Aerated Lagoon×2 Constructed Wetland×34
Phase 2	ϕ 150-300, L = 46,832m	-	<2009> Sedimentation Ponds×2
Phase 3	ϕ 150-300, L = 66,007m	<2017> EB EL PUERTO (Pump equipment renewal)	<2016-2017> EB Puno (Pump equipment renewal) Aerated Lagoon×1 Sedimentation Pond×1

2.6 COST ESTIMATE

Construction cost for the proposed project is estimated following the same procedure explained in section 2.3.3.

Table V.2.60 Construction cost for proposed project

Unit: Thousand S/.

	Phase 1 (1998-2008)		Phase 2 (2009-2015)		Phase 3 (2016-2025)	
(1) Construction Cost		23,431		11,172		18,950
(2) Procurement of Maintenance Equipment		234		112		189
(3) Engineering Cost						
1) Detailed Design	1,406		670		1,137	
2) Construction Supervision	937		447		758	
Sub-Total		2,343		1,117		1,895
(4) Common Expenses						
1) General/Administration Expenses	200		200		200	
2) Land Acquisition	0		0		0	
Sub-Total		200		200		200
(5) Contingency		3,901		1,860		3,155
(6) GST 18%		5,384		2,567		4,354
Total		35,494		17,028		28,743
				Grand Total		81,265

2.7 ORGANIZATION FOR OPERATION AND MAINTENANCE

2.7.1 GENERAL

The appropriate operation and maintenance (O & M) of the sewerage facilities is vital not only to maintain the performance of the system, but also to prolong its service life. The minimum requirements to attain satisfactory levels of O & M practice are described and the further development of O & M activities will be subject to the progress of human resource development in this particular field.