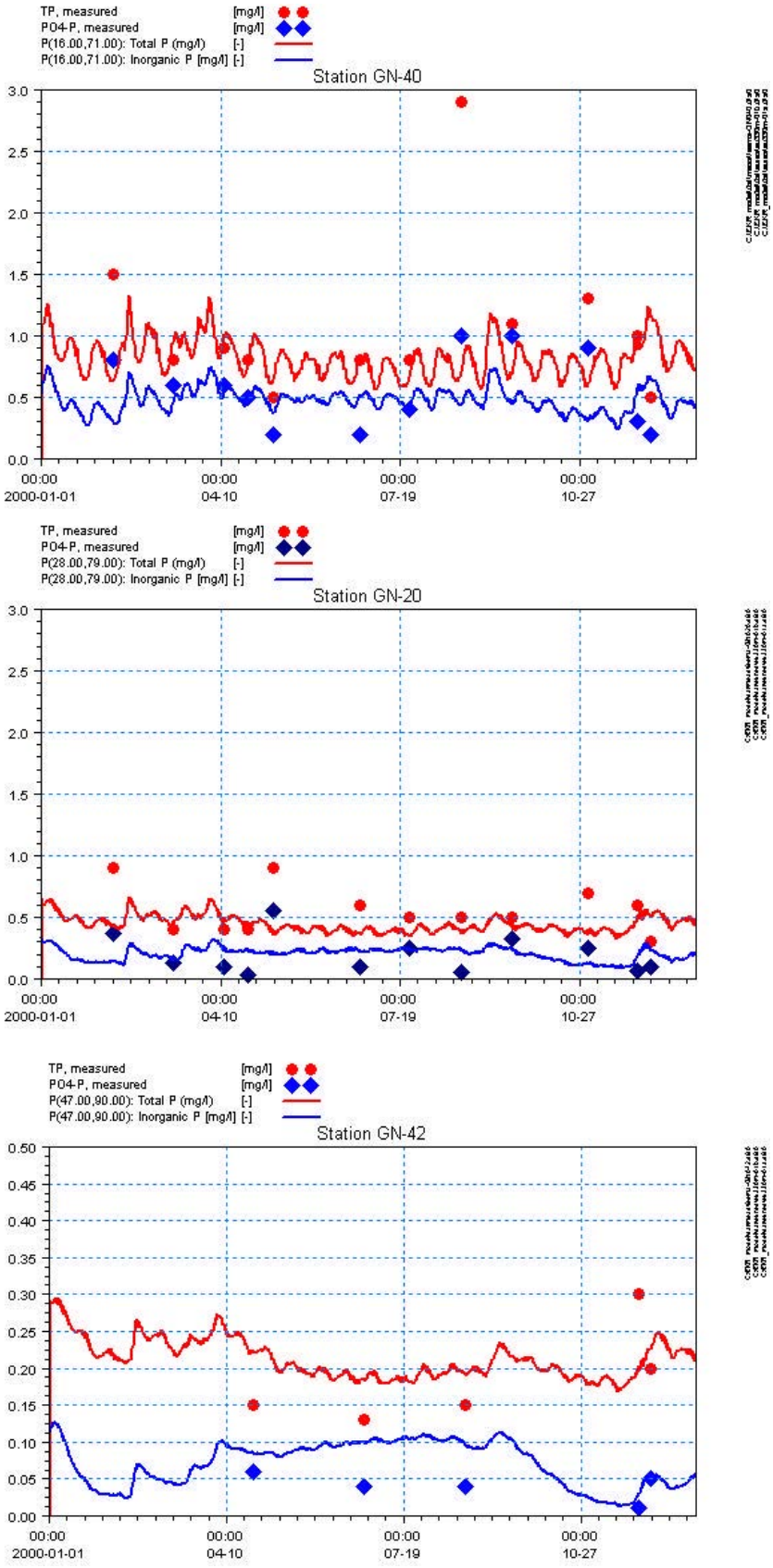

Figure 22 Total P and phosphate at 3 stations making a gradient from Rio S.J.Meriti north of Ilha do Governador

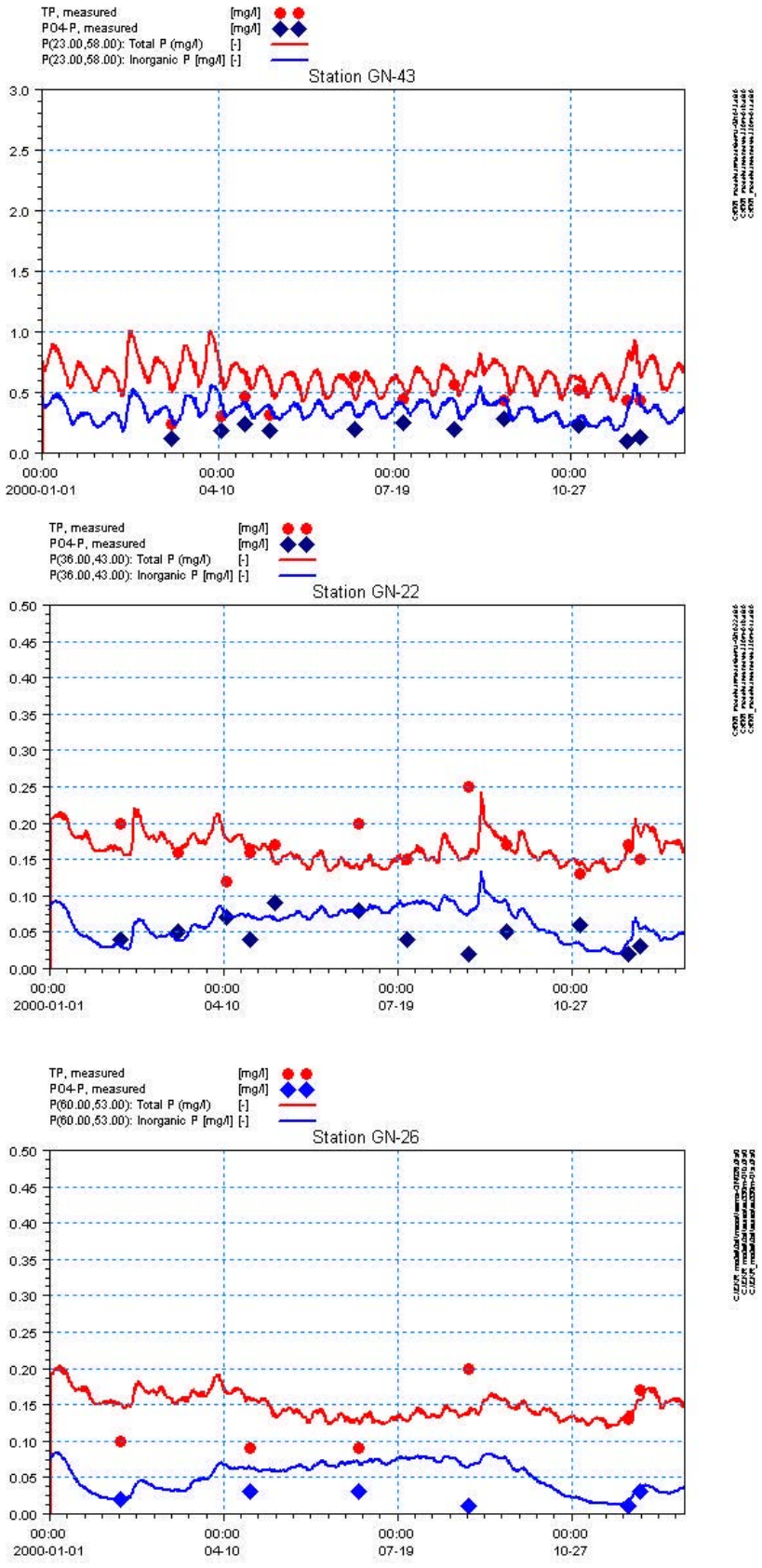

Figure 23 Total P and phosphate N at 3 stations making a gradient south of Ilha do Governador

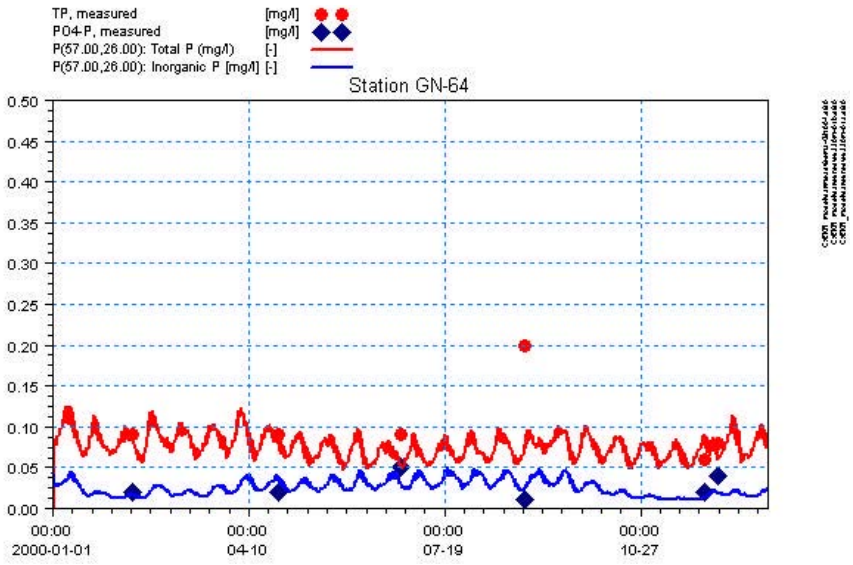

Figure 24 Total P and phosphate at 3 at the entrance to the Bay

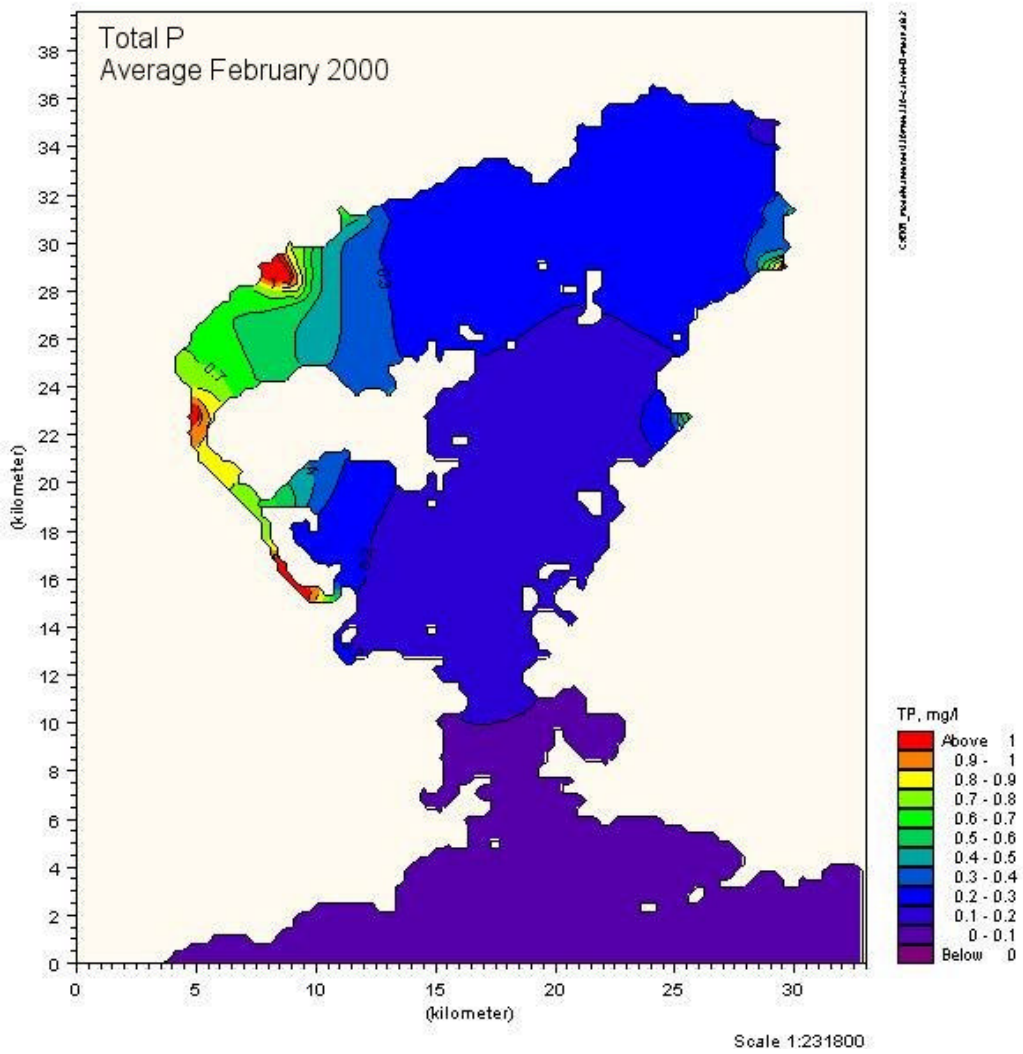

Figure 25 Simulated average total P concentrations in February 2000

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SUPPORTING 7 PLANNING BASIS

(2000, 2005, 2010, 2015 AND 2020)

The population distribution to each of the sewer systems has been estimated for the years 2000, 2005, 2010 and 2020 based upon the 2000 population census data. This appendix describes the procedures to estimate the sewer service population for sewer systems, and attaches tables for the calculation bases of population estimates.

1. POPULATION IN SEWER SYSTEMS

The 2000 population census has been conducted for the administrative units of municipality, district, sub-district and bairro in the Study Area. Out of the units, the boundaries of the units that can be identified from the available digital maps are to the district levels of municipalities and Rio de Janeiro, whereas such smaller units as sub-districts or bairros are hardly recognizable.

The sewer system area is determined in principle by topographic conditions to effectively collect and transport the wastewater to WWTP(s), thus may include two or more municipalities

In view of these, the service population of sewer system is estimated by the following procedures:

- Estimate the ratios of each administrative boundary area that topographically located within the watershed to sewer system is estimated;
- Each municipality population is distributed to sewer systems by the distribution ratios;
- The service population of a sewer system can be calculated by adding the population distributed to the sewer system; and
- The future population distribution can also be estimated by the same method.

The results of the above calculations are shown in the following tables:

Table 1	Population forecast for municipalities
Table 2	Population distribution ratio to sewer systems
Tables 3 to 7	Population distributions (2000, 2005, 2010, 2015, 2020)
Table 8	Population distribution ratio to sewer systems of Rio de Janeiro
Table 9	Population distribution of Rio de Janeiro in 2000
Table 10	Population of Acari Sewer District in Pavuna-Meriti Sewer System
Table 11(1/7) to (7/7)	Census 2000 IBGE

The small differences in the estimated population figures for municipalities between *Table 1* and *Table 10* are that *Table 1* is calculated based on those by the provisional result of the census while *Table 10* is the final census result.

The population predictions for Brazil, Rio de Janeiro, etc. are made based on the provisional results in *Table 1.* The differences between the provisional and the final results are minor and negligible for sewered population estimates, and that these are adopted in the sewer systems plan.

Tables 12 through 16 show wastewater flow rates in each sewer system in 2000, 2005, 2010, 2015 and 2020, respectively.

Table 1 Population Forecast for Municipalities

Municipalities	1980	1991	2000	2005	2010	2015	2020
Brazil	119,002,706	146,825,475	170,143,121	181,341,499	192,040,996	201,517,470	209,705,328
RJ State	11,291,520	12,807,706	14,367,083	15,058,809	15,716,858	16,290,907	16,785,058
Rio de Janairo	5,090,700	5,480,768	5,851,914	5,951,178	6,057,637	6,159,998	6,247,174
Belford Roxo	282,428	360,714	433,120	472,084	510,595	539,061	563,739
Duque de Caxias	575,814	667,821	770,865	826,136	885,994	944,541	1,001,288
Guapimirim	23,188	28,001	37,940	42,748	48,983	54,156	58,107
Itaborai	95,723	139,493	187,127	216,657	242,144	261,936	278,985
Magé	143,414	163,733	205,699	233,706	262,149	282,588	300,205
Nilópolis	151,588	158,092	153,572	153,874	156,146	157,600	159,479
Niterói	397,123	436,155	458,465	467,108	479,926	493,038	505,381
Nova Iguaçu	536,550	630,384	750,487	810,564	860,565	902,732	936,191
Mesquita	125,239	142,058	164,879	173,438	182,238	190,520	198,224
São Gonçalo	615,352	779,832	889,828	951,897	1,012,976	1,069,642	1,122,453
São João de Meriti	398,826	425,772	449,229	451,929	453,746	455,240	456,704
Tanguá	18,817	23,249	26,001	26,998	28,007	30,109	30,938
Cachoeiras de Macacu	35,867	40,208	48,460	50,319	54,518	58,673	62,748
Rio Bonito	40,036	45,161	49,599	52,619	54,585	57,546	59,130
Petrópolis			286,348	295,095	303,804	311,226	317,334
Total	8,530,665	9,521,441	10,763,533	11,176,350	11,594,013	11,968,606	12,298,080

(Unit: person)

Table 2 Population Distribution Ratio to Sewer Systems

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito
To Alegria From Ipanema	0.019														
Alegria	0.213														
Penha	0.103														
Pavuna-Meriti	0.181		0.2				0.4					0.4			
Sarapuí		0.4	0.2				0.6			1.0		0.6			
Bangu	0.065														
Bota		0.6							1.0						
Iguaçu			0.3												
Estrela			0.3			0.5									
Rancador				0.9		0.5									
Macacu				0.1	0.9						0.1		1.0		
Guaxindiba					0.1						0.2				
Alcântara								0.1			0.4				
Imboassu											0.3				
Norte-Niteroi								0.4							
Sul-Niteroi								0.4							
Ilha do Governador	0.036														
Paquetá	0.001														
Others (Non Sewerage)														1.0	1.0
Out of Study Area	0.382							0.1							

Table 3 Population Distribution (2000)

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito	Total
To Alegria From Ipanema	109,176															109,200
Alegria	1,250,306															1,250,300
Penha	605,314															605,300
Pavuna-Meriti	1,060,353		154,173				61,429					179,692				1,455,600
Sarapuí		173,248	154,173				92,143			164,879		269,537				854,000
Bangu	378,453															378,500
Bota		259,872							750,487							1,010,400
Iguaçu			231,260													231,300
Estrela			231,260			102,850										334,100
Rancador				34,146		102,850										137,000
Macacu				3,794	168,414						88,983		26,001			287,200
Guaxindiba					18,713						177,966					196,700
Alcântara								45,847			355,931					401,800
Imboassu											266,948					266,900
Norte-Niteroi								183,386								183,400
Sul-Niteroi								183,386								183,400
Ilha do Governador	211,469															211,500
Paquetá	3,421															3,400
Others														48,460	49,599	98,100
Out of Study Area	2,239,412							45,847								2,285,300
Study Area	3,618,492	433,120	770,865	37,940	187,127	205,699	153,572	412,618	750,487	164,879	889,828	449,229	26,001	48,460	49,599	8,198,100
Total	5,857,904	433,120	770,865	37,940	187,127	205,699	153,572	458,465	750,487	164,879	889,828	449,229	26,001	48,460	49,599	10,483,400

(Unit: person)

Table 4 Population Distribution (2005)

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito	Total
To Alegria From Ipanema					21,700						190,400					212,100
Alegria								46,700			380,800					427,500
Penha											285,600					285,600
Pavuna-Meriti								186,800								186,800
Sarapuí								186,800								186,800
Bangu	214,800															214,800
Bota	3,600															3,600
Iguaçu														50,300	52,600	102,900
Estrela	2,275,100							46,700								2,321,800
Rancador	3,675,500	472,100	826,000	42,800	216,700	233,800	153,800	420,300	810,600	173,400	952,000	452,000	27,000	50,300	52,600	8,558,900
Macacu	5,951,178	472,084	826,136	42,748	216,657	233,706	153,874	467,108	810,564	173,438	951,897	451,929	26,998	50,319	52,619	10,881,255
Guaxindiba					21,700						190,400					212,100
Alcântara								46,700			380,800					427,500
Imboassu											285,600					285,600
Norte-Niteroi								186,800								186,800
Sul-Niteroi								186,800								186,800
Ilha do Governador	214,800															214,800
Paquetá	3,600															3,600
Others														50,300	52,600	102,900
Out of Study Area	2,275,100							46,700								2,321,800
Study Area	3,675,500	472,100	826,000	42,800	216,700	233,800	153,800	420,300	810,600	173,400	952,000	452,000	27,000	50,300	52,600	8,558,900
Total	5,951,178	472,084	826,136	42,748	216,657	233,706	153,874	467,108	810,564	173,438	951,897	451,929	26,998	50,319	52,619	10,881,255

(Unit: person)

Table 5 Population Distribution (2010)

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito	Total
To Alegria From Ipanema	112,700															112,700
Alegria	1,292,700															1,292,700
Penha	625,800															625,800
Pavuna-Meriti	1,096,400		177,200				62,500					181,500				1,517,600
Sarapuí		204,200	177,200				93,700			182,200		272,200				929,500
Bangu	391,300															391,300
Bota		306,400							860,600							1,167,000
Iguaçu			265,800													265,800
Estrela			265,800			131,100										396,900
Rancador				44,100		131,100										175,200
Macacu				4,900	217,900						101,300		28,000			352,100
Guaxindiba					24,200						202,600					226,800
Alcântara								48,000			405,200					453,200
Imboassu											303,900					303,900
Norte-Niteroi								192,000								192,000
Sul-Niteroi								192,000								192,000
Ilha do Governador	218,700															218,700
Paquetá	3,600															3,600
Others														54,500	54,600	109,100
Out of Study Area	2,315,800							48,000								2,363,800
Study Area	3,741,200	510,600	886,000	49,000	242,100	262,200	156,200	432,000	860,600	182,200	1,013,000	453,700	28,000	54,500	54,600	8,925,900
Total	6,057,637	510,595	885,994	48,983	242,144	262,149	156,146	479,926	860,565	182,238	1,012,976	453,746	28,007	54,518	54,585	11,290,209

(Unit: person)

Table 6 Population Distribution (2015)

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito	Total
To Alegria From Ipanema	114,600															114,600
Alegria	1,314,500															1,314,500
Penha	636,300															636,300
Pavuna-Meriti	1,115,000		188,900				63,000					182,100				1,549,000
Sarapuí		215,600	188,900				94,600			190,500		273,100				962,700
Bangu	397,900															397,900
Bota		323,400							902,700							1,226,100
Iguaçu			283,400													283,400
Estrela			283,400			141,300										424,700
Rancador				48,700		141,300										190,000
Macacu				5,400	235,700						107,000		30,100			378,200
Guaxindiba					26,200						213,900					240,100
Alcântara								49,300			427,900					477,200
Imboassu											320,900					320,900
Norte-Niteroi								197,200								197,200
Sul-Niteroi								197,200								197,200
Ilha do Governador	222,400															222,400
Paquetá	3,700															3,700
Others														58,700	57,500	116,200
Out of Study Area	2,355,000							49,300								2,404,300
Study Area	3,804,400	539,000	944,600	54,100	261,900	282,600	157,600	443,700	902,700	190,500	1,069,700	455,200	30,100	58,700	57,500	9,252,300
Total	6,159,998	539,061	944,541	54,156	261,936	282,588	157,600	493,038	902,732	190,520	1,069,642	455,240	30,109	58,673	57,546	11,657,380

(Unit: person)

Table 7 Population Distribution (2020)

Sewer System	Rio de Janairo	Belford Roxo	Duque de Caxias	Guapimirim	Itaborai	Magé	Nilópolis	Niterói	Nova Iguaçu	Mesquita	São Gonçalo	São João de Meriti	Tanguá	Cachoeiras de Macacu	Rio Bonito	Total
To Alegria From Ipanema	109,176															109,200
Alegria	1,250,306															1,250,300
Penha	605,314															605,300
Pavuna-Meriti	1,060,353		154,173				61,429					179,692				1,455,600
Sarapuí		173,248	154,173				92,143			164,879		269,537				854,000
Bangu	378,453															378,500
Bota		259,872							750,487							1,010,400
Iguaçu			231,260													231,300
Estrela			231,260			102,850										334,100
Rancador				34,146		102,850										137,000
Macacu				3,794	168,414						88,983		26,001			287,200
Guaxindiba					18,713						177,966					196,700
Alcântara								45,847			355,931					401,800
Imboassu											266,948					266,900
Norte-Niteroi								183,386								183,400
Sul-Niteroi								183,386								183,400
Ilha do Governador	211,469															211,500
Paquetá	3,421															3,400
Others														48,460	49,599	98,100
Out of Study Area	2,239,412							45,847								2,285,300
Study Area	3,618,492	433,120	770,865	37,940	187,127	205,699	153,572	412,618	750,487	164,879	889,828	449,229	26,001	48,460	49,599	8,198,100
Total	5,857,904	433,120	770,865	37,940	187,127	205,699	153,572	458,465	750,487	164,879	889,828	449,229	26,001	48,460	49,599	10,483,400

(Unit: person)

Table 8 Population Distribution Ratio to Sewer Systems of Rio de Janeiro

Sub-District	Alegria	Penha	Pavuna -Meriti	Bangú	To Alegria From Ipanema	Ilha do Governador	Ilha de Paquetá	Others
Anchieta			1.0					
Bangu			0.1	0.9				
Barra da Tijuca								1.0
Botafogo								1.0
Campo Grande								1.0
Centro					0.7			0.3
Cidade de Deus								1.0
Complexo do Alemão	0.9	0.1						
Copacabana								1.0
Guaratiba								1.0
Ilha de Paquetá							1.0	
Ilha do Governador						1.0		
Inhaúma	1.0							
Irajá		0.6	0.4					
Jacarepaguá			0.1					0.9
Jacarezinho								1.0
Lagoa								1.0
Madureira	0.2		0.8					
Maré	0.4	0.6						
Méier	1.0							
Pavuna			1.0					
Penha		1.0						
Portuária					1.0			
Ramos	0.4	0.6						
Realengo			1.0					
Rio Comprido	0.6				0.4			
Rocinha								1.0
Santa Cruz								1.0
Santa Teresa					0.3			0.7
São Cristovão	1.0							
Tijuca	1.0							
Vila Isabel	1.0							

Table 9 Population Distribution of Rio de Janeiro in 2000

Sub-District	Alegria	Penha	Pavuna -Meriti	Bangú	To Alegria From Ipanema	Ilha do Governador	Ilha de Paquetá	Others	Total
Anchieta			154,608						154,608
Bangu			42,050	378,453					420,503
Barra da Tijuca								174,353	174,353
Botafogo								238,895	238,895
Campo Grande								484,362	484,362
Centro					27,395			11,741	39,135
Cidade de Deus								38,016	38,016
Complexo do Alemão	58,523	6,503							65,026
Copacabana								161,178	161,178
Guaratiba								101,205	101,205
Ilha de Paquetá							3,421		3,421
Ilha do Governador						211,469			211,469
Inhaúma	130,635								130,635
Irajá		121,780	81,187						202,967
Jacarepaguá			46,968					422,714	469,682
Jacarezinho								36,459	36,459
Lagoa								174,062	174,062
Madureira	74,831		299,326						374,157
Maré	45,523	68,284							113,807
Méier	398,486								398,486
Pavuna			197,068						197,068
Penha		318,505							318,505
Portuária					39,973				39,973
Ramos	60,161	90,242							150,403
Realengo			239,146						239,146
Rio Comprido	44,197				29,464				73,661
Rocinha								56,338	56,338
Santa Cruz								311,289	311,289
Santa Teresa					12,344			28,802	41,145
São Cristovão	70,945								70,945
Tijuca	180,992								180,992
Vila Isabel	186,013								186,013
Total	1,250,306	605,314	1,060,353	378,453	109,176	211,469	3,421	2,239,414	5,857,904
Study Area									3,618,490

Table 10 Population of Acari Sewer District in Pavuna-Meriti Sewer System

Sub-District	All Population	Ratio	Population of Acari
Bangu	420,503	0.1	42,100
Madureira	374,157	0.3	112,200
Realengo	239,146	1.0	239,100
Total	1,033,806		393,400

Table 11(1/7) Census 2000-IBGE

Mesorregiões, Microrregiões, Municípios, Distritos, Subdistritos e Bairros	Total	Urbana	Rural
Total	**14 391 282**	**13 821 466**	**569 816**
Belford Roxo	434 474	434 474	-
Belford Roxo	434 474	434 474	-
Areia Branca	112 441	112 441	-
Jardim Redentor	83 242	83 242	-
Lote XV	89 747	89 747	-
Nova Aurora	81 032	81 032	-
Parque São José	68 012	68 012	-
Bairros			
Andrade Araujo	11 678	11 678	-
Areia Branca	16 725	16 725	-
Barro Vermelho	4 283	4 283	-
Bom Pastor	18 941	18 941	-
Centro	20 368	20 368	-
Das Graças	8 600	8 600	-
Glaucia	12 648	12 648	-
Heliópolis	24 467	24 467	-
Itaipu	6 514	6 514	-
Lote XV	12 217	12 217	-
Maringá	16 486	16 486	-
Nova Aurora	14 393	14 393	-
Nova Piam	10 383	10 383	-
Parque dos Ferreiras	13 896	13 896	-
Pauline	29 307	29 307	-
Piam	13 624	13 624	-
Recantus	7 128	7 128	-
Redentor	9 247	9 247	-
Santa Amélia	12 864	12 864	-
Santa Maria	7 661	7 661	-
Santa Tereza	22 128	22 128	-
Santo Antônio da Prata	15 196	15 196	-
São Bernardo	3 195	3 195	-
São Francisco de Assis	16 612	16 612	-
São José	19 340	19 340	-
São Vicente	17 152	17 152	-
Shangri-lá	20 119	20 119	-
Vale do Ipê	20 653	20 653	-
Wona	12 383	12 383	-
Xavantes	16 266	16 266	-
Sem especificação	-	-	-
Cachoeiras de Macacu	48 543	41 117	7 426
Cachoeiras de Macacu	19 183	18 384	799
Japuíba	22 883	20 443	2 440
Subaio	6 477	2 290	4 187
Duque de Caxias	775 456	772 327	3 129
Campos Elyseos	243 767	243 767	-
Duque de Caxias	338 542	338 542	-
Imbariê	140 246	139 908	338
Xerém	52 901	50 110	2 791
Bairros			
Amapá	4 586	4 586	-
Bar dos Cavalheiros	41 636	41 636	-
Barro Branco	13 736	13 736	-
Campos Elíseos	18 558	18 558	-
Cângulo	6 263	6 263	-
Capivari	1 443	1 443	-
Centenário	21 735	21 735	-
Centro	25 025	25 025	-
Chácaras Arcampo	10 432	10 432	-
Chacaras Rio-Petrópolis	11 983	11 983	-
Cidade dos Meninos	1 464	1 464	-
Cidade Parque Paulista	27 991	27 991	-
Doutor Laureano	45 148	45 148	-
Figueira	14 436	14 436	-
Gramacho	55 460	55 460	-
Imbariê	30 482	30 482	-
Jardim Anhangá	9 061	9 061	-

Table 11(2/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Jardim Primavera	35 935	35 935	-
Lamarão	180	180	-
Mantiquira	8 281	8 281	-
Meio da Serra	2 525	2 525	-
Olavo Bilac	33 951	33 951	-
Parada Angélica	14 445	14 445	-
Parada Morabi	2 497	2 497	-
Parque Duque	44 449	44 449	-
Parque Eldorado	7 180	7 180	-
Parque Fluminense	33 001	33 001	-
Parque Sarapuí	463	463	-
Periquitos	23 674	23 674	-
Pilar	24 934	24 934	-
Santa Cruz da Serra	18 704	18 704	-
Santa Lúcia	16 070	16 070	-
Santo Antônio	9 904	9 904	-
São Bento	16 550	16 550	-
Saracuruna	38 523	38 523	-
Taquara	9 568	9 568	-
Vila São José	25 786	25 786	-
Vila São Luís	31 257	31 257	-
Vinte e Cinco de Agosto	15 744	15 744	-
Xerém	19 267	19 267	-
Sem especificação	3 129	-	3 129
Guapimirim	37 952	25 593	12 359
Guapimirim	37 952	25 593	12 359
Iguaba Grande	15 089	15 089	-
Iguaba Grande	15 089	15 089	-
Itaboraí	187 479	177 260	10 219
Cabuçu	7 732	903	6 829
Itaboraí	97 960	96 454	1 506
Itambi	71 294	71 294	-
Porto das Caixas	5 553	5 244	309
Sambaetiba	4 940	3 365	1 575
Magé	205 830	193 851	11 979
Guia de Pacobaíba	19 859	19 405	454
Inhomirim	101 574	96 254	5 320
Magé	54 843	52 580	2 263
Santo Aleixo	12 109	11 801	308
Suruí	17 445	13 811	3 634
Nilópolis	153 712	153 712	-
Nilópolis	99 705	99 705	-
Olinda	54 007	54 007	-
Niterói	459 451	459 451	-
Itaipu	57 778	57 778	-
Niterói	401 673	401 673	-
Bairros			
Badu	5 289	5 289	-
Baldeador	5 107	5 107	-
Barreto	15 953	15 953	-
Boa Viagem	2 104	2 104	-
Cachoeira	3 149	3 149	-
Cafubá	3 593	3 593	-
Camboinhas	2 863	2 863	-
Cantagalo	7 829	7 829	-
Caramujo	13 186	13 186	-
Centro	18 487	18 487	-
Charitas	6 353	6 353	-
Cubango	10 643	10 643	-
Engenho do Mato	12 219	12 219	-
Engenhoca	22 193	22 193	-
Fátima	3 767	3 767	-
Fonseca	54 984	54 984	-
Gragoatá	220	220	-
Icaraí	75 127	75 127	-
Ilha da Conceição	6 438	6 438	-
Ingá	16 592	16 592	-
Itacoatiara	1 334	1 334	-
Itaipu	17 330	17 330	-

Table 11(3/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Ititioca	7 642	7 642	-
Jacaré	4 154	4 154	-
Jurujuba	2 960	2 960	-
Largo da Batalha	9 043	9 043	-
Maceió	4 142	4 142	-
Maria Paula	6 049	6 049	-
Matapaca	834	834	-
Morro do Estado	3 811	3 811	-
Muriqui	989	989	-
Pé Pequeno	3 841	3 841	-
Piratininga	14 297	14 297	-
Ponta D'Areia	7 162	7 162	-
Rio do Ouro	3 579	3 579	-
Santa Bárbara	5 891	5 891	-
Santa Rosa	27 038	27 038	-
Santana	8 813	8 813	-
São Domingos	4 619	4 619	-
São Francisco	9 654	9 654	-
São Lourenço	8 209	8 209	-
Sapê	4 861	4 861	-
Tenente Jardim	2 208	2 208	-
Várzea das Moças	2 002	2 002	-
Viçoso Jardim	3 371	3 371	-
Vila Progresso	2 942	2 942	-
Viradouro	3 516	3 516	-
Vital Brasil	3 064	3 064	-
Sem especificação	-	-	-
Nova Iguaçu	920 599	920 599	-
Nova Iguaçu	920 599	920 599	-
U.R.G. de Tinguá,Adrianópolis,Rio D'Ouro e Jaceruba-URG XII	13 328	13 328	-
Unidade Regional de Governo Centro - URG I	175 562	175 562	-
Unidade Regional de Governo da Chatuba - URG VI	34 988	34 988	-
Unidade Regional de Governo da Posse - URG II	117 834	117 834	-
Unidade Regional de Governo de Austim - URG IX	96 199	96 199	-
Unidade Regional de Governo de Banco de Areia - URG V	45 360	45 360	-
Unidade Regional de Governo de Cabuçu - URG VII	76 350	76 350	-
Unidade Regional de Governo de Comendador Soares - URG III	108 614	108 614	-
Unidade Regional de Governo de Km 32 - URG VIII	57 467	57 467	-
Unidade Regional de Governo de Mesquita - URG IV	80 990	80 990	-
Unidade Regional de Governo de Miguel Couto - URG XI	50 872	50 872	-
Unidade Regional de Governo de Vila de Cava - URG X	63 035	63 035	-
Bairros			
Adrianópolis	3 893	3 893	-
Ambaí	5 824	5 824	-
Austin	25 445	25 445	-
Banco de Areia	15 788	15 788	-
Boa Esperança	5 207	5 207	-
Botafogo	3 984	3 984	-
Cabuçu	21 476	21 476	-
Cacuia	7 670	7 670	-
Califórnia	6 692	6 692	-
Campo Alegre	6 422	6 422	-
Caonze	6 151	6 151	-
Carlos Sampaio	5 935	5 935	-
Carmary	17 888	17 888	-
Centro	28 867	28 867	-
Chacrinha	5 017	5 017	-
Chatuba	34 944	34 944	-

Table 11(4/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Comendador Soares	29 428	29 428	-
Corumbá	12 902	12 902	-
Cosmorama	9 564	9 564	-
Da Cerâmica	21 664	21 664	-
Da Luz	23 005	23 005	-
Da Palhada	11 684	11 684	-
Da Posse	12 900	12 900	-
Da Prata	6 801	6 801	-
Da Viga	11 158	11 158	-
Danon	6 157	6 157	-
Edson Passos	4 787	4 787	-
Engenho Pequeno	13 114	13 114	-
Figueiras	2 397	2 397	-
Geneciano	7 423	7 423	-
Grama	9 299	9 299	-
Iguaçu Velho	5 988	5 988	-
Inconfidência	4 978	4 978	-
Ipiranga	8 132	8 132	-
Jaceruba	860	860	-
Jacutinga	11 605	11 605	-
Jardim Alvorada	12 185	12 185	-
Jardim Guandu	16 135	16 135	-
Jardim Iguaçu	9 500	9 500	-
Jardim Nova Era	12 132	12 132	-
Jardim Palmares	14 311	14 311	-
Jardim Pernambuco	9 178	9 178	-
Jardim Tropical	9 604	9 604	-
Juscelino	7 848	7 848	-
Kennedy	15 371	15 371	-
Km - 32	15 316	15 316	-
Lagoinha	7 546	7 546	-
Marapicu	12 026	12 026	-
Mesquita	37 372	37 372	-
Miguel Couto	18 626	18 626	-
Montevidéu	3 876	3 876	-
Moquetá	8 318	8 318	-
Nova América	14 941	14 941	-
Ouro Verde	9 875	9 875	-
Paraíso	16 349	16 349	-
Parque Ambaí	10 317	10 317	-
Parque Flora	7 772	7 772	-
Ponto Chic	14 473	14 473	-
Prados Verdes	9 666	9 666	-
Rancho Fundo	6 003	6 003	-
Rancho Novo	6 962	6 962	-
Riachão	11 204	11 204	-
Rio D'Ouro	845	845	-
Rocha Sobrinho	8 746	8 746	-
Rodilândia	14 098	14 098	-
Rosa dos Ventos	15 348	15 348	-
Santa Eugênia	13 447	13 447	-
Santa Rita	22 587	22 587	-
Santa Terezinha	20 942	20 942	-
Santo Elias	9 221	9 221	-
Tinguá	3 803	3 803	-
Tinguazinho	10 336	10 336	-
Três Corações	3 017	3 017	-
Valverde	9 055	9 055	-
Vila de Cava	13 158	13 158	-
Vila Emil	8 229	8 229	-
Vila Guimarães	16 533	16 533	-
Vila Nova	8 091	8 091	-
Vila Operária	10 966	10 966	-
Sem especificação	222	222	-
Rio Bonito	49 691	32 450	17 241
Boa Esperança	8 576	3 550	5 026
Rio Bonito	41 115	28 900	12 215
Rio de Janeiro	5 857 904	5 857 904	-
Rio de Janeiro	5 857 904	5 857 904	-
Anchieta	154 608	154 608	-

Table 11(5/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Bangu	420 503	420 503	-
Barra da Tijuca	174 353	174 353	-
Botafogo	238 895	238 895	-
Campo Grande	484 362	484 362	-
Centro	39 135	39 135	-
Cidade de Deus	38 016	38 016	-
Complexo do Alemão	65 026	65 026	-
Copacabana	161 178	161 178	-
Guaratiba	101 205	101 205	-
Ilha de Paquetá	3 421	3 421	-
Ilha do Governador	211 469	211 469	-
Inhaúma	130 635	130 635	-
Irajá	202 967	202 967	-
Jacarepaguá	469 682	469 682	-
Jacarezinho	36 459	36 459	-
Lagoa	174 062	174 062	-
Madureira	374 157	374 157	-
Maré	113 807	113 807	-
Méier	398 486	398 486	-
Pavuna	197 068	197 068	-
Penha	318 505	318 505	-
Portuária	39 973	39 973	-
Ramos	150 403	150 403	-
Realengo	239 146	239 146	-
Rio Comprido	73 661	73 661	-
Rocinha	56 338	56 338	-
Santa Cruz	311 289	311 289	-
Santa Teresa	41 145	41 145	-
São Cristovão	70 945	70 945	-
Tijuca	180 992	180 992	-
Vila Isabel	186 013	186 013	-
Bairros			
Abolição	12 346	12 346	-
Acari	24 650	24 650	-
Água Santa	7 243	7 243	-
Alto da Boa Vista	8 254	8 254	-
Anchieta	53 808	53 808	-
Andaraí	38 540	38 540	-
Anil	21 551	21 551	-
Bancários	12 126	12 126	-
Bangu	244 518	244 518	-
Barra da Tijuca	92 233	92 233	-
Barra de Guaratiba	4 380	4 380	-
Barros Filho	15 223	15 223	-
Benfica	19 017	19 017	-
Bento Ribeiro	46 507	46 507	-
Bonsucesso	19 298	19 298	-
Botafogo	78 259	78 259	-
Brás de Pina	59 389	59 389	-
Cachambi	41 334	41 334	-
Cacuia	9 952	9 952	-
Caju	17 679	17 679	-
Camorim	786	786	-
Campinho	9 407	9 407	-
Campo dos Afonsos	1 515	1 515	-
Campo Grande	297 494	297 494	-
Cascadura	33 526	33 526	-
Catete	21 724	21 724	-
Catumbi	12 914	12 914	-
Cavalcanti	15 773	15 773	-
Centro	39 135	39 135	-
Cidade de Deus	38 016	38 016	-
Cidade Nova	5 282	5 282	-
Cidade Universitária	1 736	1 736	-
Cocotá	4 910	4 910	-
Coelho Neto	32 052	32 052	-
Colégio	26 488	26 488	-
Complexo do Alemão	65 026	65 026	-
Copacabana	147 021	147 021	-
Cordovil	46 533	46 533	-

Table 11(6/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Cosme Velho	7 229	7 229	-
Cosmos	65 961	65 961	-
Costa Barros	25 922	25 922	-
Curicica	24 839	24 839	-
Del Castilho	14 246	14 246	-
Deodoro	11 593	11 593	-
Encantado	15 412	15 412	-
Engenheiro Leal	6 196	6 196	-
Engenho da Rainha	27 311	27 311	-
Engenho de Dentro	46 834	46 834	-
Engenho Novo	44 472	44 472	-
Estácio	20 632	20 632	-
Flamengo	53 268	53 268	-
Freguesia (Ilha do Governador)	18 371	18 371	-
Freguesia (Jacarepaguá)	54 010	54 010	-
Galeão	21 633	21 633	-
Gamboa	10 490	10 490	-
Gardênia Azul	19 268	19 268	-
Gávea	17 475	17 475	-
Glória	10 098	10 098	-
Grajaú	38 296	38 296	-
Grumari	136	136	-
Guadalupe	46 325	46 325	-
Guaratiba	87 132	87 132	-
Higienópolis	16 587	16 587	-
Honório Gurgel	22 010	22 010	-
Humaitá	15 186	15 186	-
Inhaúma	42 722	42 722	-
Inhoaíba	59 536	59 536	-
Ipanema	46 808	46 808	-
Irajá	101 859	101 859	-
Itanhangá	21 813	21 813	-
Jacaré	7 392	7 392	-
Jacarepaguá	100 822	100 822	-
Jacarezinho	36 459	36 459	-
Jardim América	25 946	25 946	-
Jardim Botânico	19 560	19 560	-
Jardim Carioca	25 202	25 202	-
Jardim Guanabara	29 886	29 886	-
Jardim Sulacap	11 221	11 221	-
Joá	971	971	-
Lagoa	18 675	18 675	-
Laranjeiras	46 381	46 381	-
Leblon	46 670	46 670	-
Leme	14 157	14 157	-
Lins de Vasconcelos	35 171	35 171	-
Madureira	51 410	51 410	-
Magalhães Bastos	24 849	24 849	-
Mangueira	13 594	13 594	-
Manguinhos	31 059	31 059	-
Maracanã	27 319	27 319	-
Maré	113 807	113 807	-
Marechal Hermes	49 186	49 186	-
Maria da Graça	8 189	8 189	-
Méier	51 344	51 344	-
Moneró	6 180	6 180	-
Olaria	62 509	62 509	-
Oswaldo Cruz	35 901	35 901	-
Paciência	83 561	83 561	-
Padre Miguel	64 754	64 754	-
Paquetá	3 421	3 421	-
Parada de Lucas	23 269	23 269	-
Parque Anchieta	27 092	27 092	-
Parque Columbia	9 194	9 194	-
Pavuna	90 027	90 027	-
Pechincha	31 615	31 615	-
Pedra de Guaratiba	9 693	9 693	-
Penha	72 692	72 692	-
Penha Circular	51 113	51 113	-
Piedade	44 111	44 111	-

Table 11(7/7) Census 2000-IBGE

Subdistritos e Bairros	Total	Urbana	Rural
Pilares	28 956	28 956	-
Pitangueiras	11 605	11 605	-
Portuguesa	24 733	24 733	-
Praça da Bandeira	9 102	9 102	-
Praça Seca	59 657	59 657	-
Praia da Bandeira	6 587	6 587	-
Quintino Bocaiúva	34 757	34 757	-
Ramos	37 537	37 537	-
Realengo	176 277	176 277	-
Recreio dos Bandeirantes	37 572	37 572	-
Riachuelo	13 107	13 107	-
Ribeira	3 323	3 323	-
Ricardo de Albuquerque	27 383	27 383	-
Rio Comprido	34 833	34 833	-
Rocha	9 542	9 542	-
Rocha Miranda	41 253	41 253	-
Rocinha	56 338	56 338	-
Sampaio	10 508	10 508	-
Santa Cruz	191 836	191 836	-
Santa Teresa	41 145	41 145	-
Santíssimo	34 086	34 086	-
Santo Cristo	9 618	9 618	-
São Conrado	11 155	11 155	-
São Cristóvão	38 334	38 334	-
São Francisco Xavier	7 787	7 787	-
Saúde	2 186	2 186	-
Senador Camará	111 231	111 231	-
Senador Vasconcelos	27 285	27 285	-
Sepetiba	35 892	35 892	-
Tanque	32 462	32 462	-
Taquara	93 741	93 741	-
Tauá	33 184	33 184	-
Tijuca	163 636	163 636	-
Todos os Santos	22 927	22 927	-
Tomás Coelho	21 580	21 580	-
Turiaçu	16 054	16 054	-
Urca	6 750	6 750	-
Vargem Grande	9 306	9 306	-
Vargem Pequena	11 536	11 536	-
Vaz Lobo	12 177	12 177	-
Vicente de Carvalho	24 310	24 310	-
Vidigal	13 719	13 719	-
Vigário Geral	39 563	39 563	-
Vila da Penha	24 290	24 290	-
Vila Isabel	81 858	81 858	-
Vila Kosmos	17 673	17 673	-
Vila Militar	13 691	13 691	-
Vila Valqueire	31 717	31 717	-
Vista Alegre	8 347	8 347	-
Zumbi	2 041	2 041	-
Sem especificação	-	-	-
São Gonçalo	891 119	891 119	-
Ipiiba	159 812	159 812	-
Monjolo	176 716	176 716	-
Neves	156 751	156 751	-
São Gonçalo	320 754	320 754	-
Sete Pontes	77 086	77 086	-
São João de Meriti	449 476	449 476	-
Coelho da Rocha	162 418	162 418	-
São João de Meriti	230 518	230 518	-
São Mateus	56 540	56 540	-
Tanguá	26 057	22 448	3 609
Tanguá	26 057	22 448	3 609

2. WASTEWATER FLOW RATES IN SEWER DISTRICT

Wastewater flow rates in sewer districts are calculated by multiplying Population and Per Capita Flow in each sewer districts.

Table 12 Wastewater Flow Rates (2000)

Sewer System	WWTP	Population (person)	Sewerd Ratio	Sewered -Pop (person)	Average Daily Wastewater		Max.Daily Wastewater		Max.Hourly Wastewater	
					Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)
Alegria	Alegria	1,359,500	0.173	235,200	300	817	356	969	524	1,426
Penha	Penha	605,300	0.90	544,800	235	1,482	278	1,753	407	2,566
Pavuna	Pavuna	1,055,600	0.40	422,200	240	1,173	284	1,388	416	2,033
-Meriti	Acari	400,000	0.19	76,000	240	211	284	250	416	366
	Sub-Total	1,455,600		498,200		1,384		1,638		2,399
Sarapuí	Gramacho	65,300	0.90	58,800	235	160	278	189	407	277
	Sarapuí	788,700	0.45	354,900	240	986	284	1,167	416	1,709
	Sub-Total	854,000		413,700		1,146		1,356		1,986
Bangu	Bangu	378,500	0.00	-	240	0	284	0	416	0
Bota	Iguaçu 02	111,000	0.00	-	240	0	284	0	416	0
	Madame	10,100	0.00	-	240	0	284	0	416	0
	Velhos	31,400	0.00	-	250	0	296	0	434	0
	Bota	706,100	0.00	-	255	0	302	0	443	0
	Joinville	104,900	0.00	-	220	0	260	0	380	0
	Others	46,900	0.00	-						
	Sub-Total	1,010,400		-		0		0		0
Iguaçu	Xerém	9,000	0.00	-	220	0	260	0	380	0
	Campos eliseos	203,000	0.00	-	220	0	260	0	380	0
	Others	19,300	0.00	-						
	Sub-Total	231,300		-		0		0		0
Estrela	1	73,000	0.00	-	245	0	290	0	425	0
	2	111,300	0.00	-	250	0	296	0	434	0
	3	89,300	0.00	-	250	0	296	0	434	0
	4	34,800	0.00	-	245	0	290	0	425	0
	Others	25,800	0.00	-						
	Sub-Total	334,100		-		0		0		0
Roncador	1	13,500	0.00	-	220	0	260	0	380	0
	2	54,700	0.00	-	225	0	266	0	389	0
	3	15,100	0.00	-	220	0	260	0	380	0
	Others	53,700	0.00	-						
	Sub-Total	137,000		-		0		0		0
Macacu	1	64,200	0.00	-	225	0	266	0	389	0
	2	48,700	0.00	-	225	0	266	0	389	0
	3	24,700	0.00	-	225	0	266	0	389	0
	4	20,900	0.00	-	225	0	266	0	389	0
	5	28,700	0.00	-	225	0	266	0	389	0
	6	35,200	0.00	-	225	0	266	0	389	0
	7	15,200	0.00	-	225	0	266	0	389	0
	8	21,200	0.00	-	225	0	266	0	389	0
	Others	28,300	0.00	-						
	Sub-Total	287,200		-		0		0		0
Guaxindiba	1	140,700	0.00	-	225	0	266	0	389	0
	2	32,900	0.00	-	225	0	266	0	389	0
	3	10,900	0.00	-	220	0	260	0	380	0
	Others	12,100	0.00	-						
	Sub-Total	196,700		-		0		0		0
Alcântara	Trindade	140,200	0.00	-	220	0	260	0	380	0
	Alcântara	81,600	0.00	-	220	0	260	0	380	0
	Jardim Nazaré	102,500	0.00	-	220	0	260	0	380	0
	Others	77,500	0.00	-						
	Sub-Total	401,800		-		0		0		0
Imboassu	Sao Gonçalo	207,000	0.18	37,300	280	121	332	143	488	211
	Bomba	35,400	0.00	-	230	0	272	0	398	0
	Others	24,500	0.00	-						
	Sub-Total	266,900		37,300		121		143		211
Niteroi	Toque Toque	183,400	0.00	-	250	0	296	0	434	0
	Icaraí	183,400	0.90	165,100	255	487	302	577	443	847
	Sub-Total	366,800		165,100		487		577		847
Ilha do Governador	Ilha do Governador	211,500	0.90	190,400	220	485	260	573	380	837
Paquetá	Paquetá	3,400	0.90	3,100	705	25	842	30	1,253	45
Others		98,100	0.00	-						
Total		8,198,100		2,087,800		5,947		7,039		10,317

Table 13 Wastewater Flow Rates (2005)

Sewer System	WWTP	Population (person)	Sewerd Ratio	Sewered Population (person)	Average Daily Wastewater		Max.Daily Wastewater		Max.Hourly Wastewater	
					Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)
Alegria	Alegria	1,380,700	0.90	1,242,600	300	4,315	356	5,120	524	7,536
Penha	Penha	614,800	0.90	553,300	235	1,505	278	1,780	407	2,606
Pavuna	Pavuna	1,076,700	0.50	538,400	240	1,496	284	1,770	416	2,592
-Meriti	Acari	408,000	0.19	77,500	240	215	284	255	416	373
	Sub-Total	1,484,700		615,900		1,711		2,025		2,965
Sarapuí	Gramacho	68,100	0.90	61,300	235	167	278	197	407	289
	Sarapuí	822,800	0.65	534,800	240	1,486	284	1,758	416	2,575
	Sub-Total	890,900		596,100		1,653		1,955		2,864
Bangu	Bangu	384,400	0.00	-	240	0	284	0	416	0
Bota	Iguaçu 02	120,100	0.00	-	240	0	284	0	416	0
	Madame	10,900	0.00	-	240	0	284	0	416	0
	Velhos	34,000	0.00	-	250	0	296	0	434	0
	Bota	764,400	0.00	-	255	0	302	0	443	0
	Joinville	113,500	0.00	-	220	0	260	0	380	0
	Others	51,000	0.00	-						
	Sub-Total	1,093,900		-		0		0		0
Iguaçu	Xerém	9,700	0.00	-	220	0	260	0	380	0
	Campos eliseos	217,400	0.00	-	220	0	260	0	380	0
	Others	20,700	0.00	-						
	Sub-Total	247,800		-		0		0		0
Estrela	1	79,600	0.00	-	245	0	290	0	425	0
	2	121,500	0.00	-	250	0	296	0	434	0
	3	97,500	0.00	-	250	0	296	0	434	0
	4	37,900	0.00	-	245	0	290	0	425	0
	Others	28,200	0.00	-						
	Sub-Total	364,700		-		0		0		0
Roncador	1	15,300	0.00	-	220	0	260	0	380	0
	2	62,100	0.00	-	225	0	266	0	389	0
	3	17,100	0.00	-	220	0	260	0	380	0
	Others	60,900	0.00	-						
	Sub-Total	155,400		-		0		0		0
Macacu	1	71,900	0.00	-	225	0	266	0	389	0
	2	54,500	0.00	-	225	0	266	0	389	0
	3	27,700	0.00	-	225	0	266	0	389	0
	4	23,400	0.00	-	225	0	266	0	389	0
	5	32,100	0.00	-	225	0	266	0	389	0
	6	39,400	0.00	-	225	0	266	0	389	0
	7	17,000	0.00	-	225	0	266	0	389	0
	8	23,700	0.00	-	225	0	266	0	389	0
	Others	31,700	0.00	-						
	Sub-Total	321,500		-		0		0		0
Guaxindiba	1	151,700	0.00	-	225	0	266	0	389	0
	2	35,500	0.00	-	225	0	266	0	389	0
	3	11,800	0.00	-	220	0	260	0	380	0
	Others	13,100	0.00	-						
	Sub-Total	212,100		-		0		0		0
Alcântara	Trindade	149,200	0.00	-	220	0	260	0	380	0
	Alcântara	86,900	0.00	-	220	0	260	0	380	0
	Jardim Nazaré	109,000	0.00	-	220	0	260	0	380	0
	Others	82,400	0.00	-						
	Sub-Total	427,500		-		0		0		0
Imboassu	Sao Gonçalo	221,500	0.90	199,400	280	646	332	766	488	1,126
	Bomba	37,900	0.00	-	230	0	272	0	398	0
	Others	26,200	0.00	-						
	Sub-Total	285,600		199,400		646		766		1,126
Niteroi	Toque Toque	186,800	0.00	-	250	0	296	0	434	0
	Icaraí	186,800	0.90	168,100	255	496	302	588	443	862
	Sub-Total	373,600		168,100		496		588		862
Ilha do Governador	Ilha do Governador	214,800	0.90	193,300	280	626	332	743	488	1,092
Paquetá	Paquetá	3,600	0.90	3,200	705	26	842	31	1,253	46
Others		102,900	0.00	-						
Total		8,558,900		3,571,900		10,978		13,008		19,097

Table 14 Wastewater Flow Rates (2010)

Sewer System	WWTP	Population (person)	Sewerd Ratio	Sewered Population (person)	Average Daily Wastewater		Max.Daily Wastewater		Max.Hourly Wastewater	
					Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)
Alegria	Alegria	1,405,400	0.90	1,264,900	300	4,392	356	5,212	524	7,671
Penha	Penha	625,800	0.90	563,200	235	1,532	278	1,812	407	2,653
Pavuna	Pavuna	1,100,600	0.90	990,500	240	2,751	284	3,256	416	4,769
-Meriti	Acari	417,000	0.90	375,300	240	1,043	284	1,234	416	1,807
	Sub-Total	1,517,600		1,365,800		3,794		4,490		6,576
Sarapuí	Gramacho	71,100	0.90	64,000	235	174	278	206	407	301
	Sarapuí	858,400	0.90	772,600	240	2,146	284	2,540	416	3,720
	Sub-Total	929,500		836,600		2,320		2,746		4,021
Bangu	Bangu	391,300	0.90	352,200	240	978	284	1,158	416	1,696
Bota	Iguaçu 02	128,200	0.00	-	240	0	284	0	416	0
	Madame	11,700	0.00	-	240	0	284	0	416	0
	Velhos	36,200	0.00	-	250	0	296	0	434	0
	Bota	815,500	0.00	-	255	0	302	0	443	0
	Joinville	121,100	0.30	36,300	220	92	260	109	380	160
	Others	54,300	0.00	-						
	Sub-Total	1,167,000		36,300		92		109		160
Iguaçu	Xerém	10,400	0.00	-	220	0	260	0	380	0
	Campos eliseos	233,200	0.00	-	220	0	260	0	380	0
	Others	22,200	0.00	-						
	Sub-Total	265,800		-		0		0		0
Estrela	1	86,700	0.00	-	245	0	290	0	425	0
	2	132,200	0.00	-	250	0	296	0	434	0
	3	106,100	0.00	-	250	0	296	0	434	0
	4	41,300	0.00	-	245	0	290	0	425	0
	Others	30,700	0.00	-						
	Sub-Total	396,900		-		0		0		0
Roncador	1	17,300	0.00	-	220	0	260	0	380	0
	2	70,000	0.00	-	225	0	266	0	389	0
	3	19,300	0.00	-	220	0	260	0	380	0
	Others	68,600	0.00	-						
	Sub-Total	175,200		-		0		0		0
Macacu	1	78,800	0.00	-	225	0	266	0	389	0
	2	59,700	0.00	-	225	0	266	0	389	0
	3	30,300	0.00	-	225	0	266	0	389	0
	4	25,600	0.00	-	225	0	266	0	389	0
	5	35,200	0.00	-	225	0	266	0	389	0
	6	43,200	0.00	-	225	0	266	0	389	0
	7	18,600	0.00	-	225	0	266	0	389	0
	8	26,000	0.00	-	225	0	266	0	389	0
	Others	34,700	0.00	-						
	Sub-Total	352,100		-		0		0		0
Guaxindiba	1	162,300	0.00	-	225	0	266	0	389	0
	2	38,000	0.00	-	225	0	266	0	389	0
	3	12,600	0.00	-	220	0	260	0	380	0
	Others	14,000	0.00	-						
	Sub-Total	226,800		-		0		0		0
Alcântara	Trindade	158,100	0.00	-	220	0	260	0	380	0
	Alcântara	92,100	0.00	-	220	0	260	0	380	0
	Jardim Nazaré	115,600	0.00	-	220	0	260	0	380	0
	Others	87,400	0.00	-						
	Sub-Total	453,200		-		0		0		0
Imboassu	Sao Gonçalo	235,700	0.90	212,100	280	687	332	815	488	1,198
	Bomba	40,300	0.00	-	230	0	272	0	398	0
	Others	27,900	0.00	-						
	Sub-Total	303,900		212,100		687		815		1,198
Niteroi	Toque Toque	192,000	0.00	-	250	0	296	0	434	0
	Icaraí	192,000	0.90	172,800	255	510	302	604	443	886
	Sub-Total	384,000		172,800		510		604		886
Ilha do Governador	Ilha do Governador	218,700	0.90	196,800	280	638	332	756	488	1,112
Paquetá	Paquetá	3,600	0.90	3,200	705	26	842	31	1,253	46
Others		109,100	0.00	-						
Total		8,925,900		5,003,900		14,969		17,733		26,019

Table 15 Wastewater Flow Rates (2015)

Sewer System	WWTP	Population (person)	Sewerd Ratio	Sewered Population (person)	Average Daily Wastewater		Max.Daily Wastewater		Max.Hourly Wastewater	
					Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)
Alegria	Alegria	1,429,100	0.90	1,286,200	300	4,466	356	5,300	524	7,801
Penha	Penha	636,300	0.90	572,700	235	1,558	278	1,843	407	2,698
Pavuna	Pavuna	1,123,300	0.90	1,011,000	240	2,808	284	3,323	416	4,868
-Meriti	Acari	425,700	0.90	383,100	240	1,064	284	1,259	416	1,845
	Sub-Total	1,549,000		1,394,100		3,872		4,582		6,713
Sarapuí	Gramacho	73,600	0.90	66,200	235	180	278	213	407	312
	Sarapuí	889,100	0.90	800,200	240	2,223	284	2,630	416	3,853
	Sub-Total	962,700		866,400		2,403		2,843		4,165
Bangu	Bangu	397,900	0.90	358,100	240	995	284	1,177	416	1,724
Bota	Iguaçu 02	134,700	0.00	-	240	0	284	0	416	0
	Madame	12,300	0.00	-	240	0	284	0	416	0
	Velhos	38,100	0.00	-	250	0	296	0	434	0
	Bota	856,800	0.00	-	255	0	302	0	443	0
	Joinville	127,300	0.30	38,200	220	97	260	115	380	168
	Others	56,900	0.00	-						
	Sub-Total	1,226,100		38,200		97		115		168
Iguaçu	Xerém	11,000	0.00	-	220	0	260	0	380	0
	Campos eliseos	248,700	0.00	-	220	0	260	0	380	0
	Others	23,700	0.00	-						
	Sub-Total	283,400		-		0		0		0
Estrela	1	92,700	0.00	-	245	0	290	0	425	0
	2	141,500	0.00	-	250	0	296	0	434	0
	3	113,500	0.00	-	250	0	296	0	434	0
	4	44,200	0.00	-	245	0	290	0	425	0
	Others	32,800	0.00	-						
	Sub-Total	424,700		-		0		0		0
Roncador	1	18,700	0.00	-	220	0	260	0	380	0
	2	75,900	0.00	-	225	0	266	0	389	0
	3	20,900	0.00	-	220	0	260	0	380	0
	Others	74,400	0.00	-						
	Sub-Total	190,000		-		0		0		0
Macacu	1	84,600	0.00	-	225	0	266	0	389	0
	2	64,200	0.00	-	225	0	266	0	389	0
	3	32,600	0.00	-	225	0	266	0	389	0
	4	27,500	0.00	-	225	0	266	0	389	0
	5	37,800	0.00	-	225	0	266	0	389	0
	6	46,300	0.00	-	225	0	266	0	389	0
	7	20,000	0.00	-	225	0	266	0	389	0
	8	27,900	0.00	-	225	0	266	0	389	0
	Others	37,300	0.00	-						
	Sub-Total	378,200		-		0		0		0
Guaxindiba	1	171,800	0.00	-	225	0	266	0	389	0
	2	40,200	0.00	-	225	0	266	0	389	0
	3	13,300	0.00	-	220	0	260	0	380	0
	Others	14,800	0.00	-						
	Sub-Total	240,100		-		0		0		0
Alcântara	Trindade	166,500	0.00	-	220	0	260	0	380	0
	Alcântara	97,000	0.00	-	220	0	260	0	380	0
	Jardim Nazaré	121,700	0.00	-	220	0	260	0	380	0
	Others	92,000	0.00	-						
	Sub-Total	477,200		-		0		0		0
Imboassu	Sao Gonçalo	248,800	0.90	223,900	280	726	332	860	488	1,265
	Bomba	42,600	0.00	-	230	0	272	0	398	0
	Others	29,500	0.00	-						
	Sub-Total	320,900		223,900		726		860		1,265
Niteroi	Toque Toque	197,200	0.00	-	250	0	296	0	434	0
	Icaraí	197,200	0.90	177,500	255	524	302	620	443	910
	Sub-Total	394,400		177,500		524		620		910
Ilha do Governador	Ilha do Governador	222,400	0.90	200,200	280	649	332	769	488	1,131
Paquetá	Paquetá	3,700	0.90	3,300	705	27	842	32	1,253	48
Others		116,200	0.00	-						
Total		9,252,300		5,120,600		15,317		18,141		26,623

Table 16 Wastewater Flow Rates (2020)

Sewer System	WWTP	Population (person)	Sewerd Ratio	Sewered Population (person)	Average Daily Wastewater		Max.Daily Wastewater		Max.Hourly Wastewater	
					Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)	Per Capita Flow (Lcd)	Wastewater Flow Rate (L/s)
Alegria	Alegria	1,449,300	0.9	1,304,400	300	4,529	356	5,375	524	7,911
Penha	Penha	645,300	0.9	580,800	235	1,580	278	1,869	407	2,736
Pavuna-Meriti	Pavuna	1,144,000	0.9	1,029,600	240	2,860	284	3,384	416	4,957
	Acari	433,500	0.9	390,200	240	1,084	284	1,283	416	1,879
	Sub-Total	1,577,500		1,419,800		3,944		4,667		6,836
Sarapuí	Gramacho	76,000	0.9	68,400	235	186	278	220	407	322
	Sarapuí	917,700	0.9	825,900	240	2,294	284	2,715	416	3,977
	Sub-Total	993,700		894,300		2,480		2,935		4,299
Bangu	Bangu	403,600	0.9	363,200	240	1,009	284	1,194	416	1,749
Bota	Iguaçu 02	140,000	0.9	126,000	240	350	284	414	416	607
	Madame	12,700	0.9	11,400	240	32	284	37	416	55
	Velhos	39,600	0.9	35,600	250	103	296	122	434	179
	Bota	890,600	0.9	801,500	255	2,366	302	2,802	443	4,110
	Joinville	132,300	0.9	119,100	220	303	260	358	380	524
	Others	59,200	0.0	-						
	Sub-Total	1,274,400		1,093,600		3,154		3,733		5,475
Iguaçu	Xerém	11,700	0.9	10,500	220	27	260	32	380	46
	Campos eliseos	263,600	0.9	237,200	220	604	260	714	380	1,043
	Others	25,100	0.0	-						
	Sub-Total	300,400		247,700		631		746		1,089
Estrela	1	98,400	0.0	-	245	0	290	0	425	0
	2	150,100	0.0	-	250	0	296	0	434	0
	3	120,400	0.0	-	250	0	296	0	434	0
	4	46,900	0.0	-	245	0	290	0	425	0
	Others	34,800	0.0	-						
	Sub-Total	450,500		-		0		0		0
Roncador	1	19,900	0.0	-	220	0	260	0	380	0
	2	80,900	0.0	-	225	0	266	0	389	0
	3	22,300	0.0	-	220	0	260	0	380	0
	Others	79,300	0.0	-						
	Sub-Total	202,400		-		0		0		0
Macacu	1	89,500	0.0	-	225	0	266	0	389	0
	2	67,900	0.0	-	225	0	266	0	389	0
	3	34,500	0.0	-	225	0	266	0	389	0
	4	29,100	0.0	-	225	0	266	0	389	0
	5	40,000	0.0	-	225	0	266	0	389	0
	6	49,000	0.0	-	225	0	266	0	389	0
	7	21,100	0.0	-	225	0	266	0	389	0
	8	29,500	0.0	-	225	0	266	0	389	0
	Others	39,400	0.0	-						
	Sub-Total	400,000		-		0		0		0
Guaxindiba	1	180,600	0.0	-	225	0	266	0	389	0
	2	42,200	0.0	-	225	0	266	0	389	0
	3	14,000	0.0	-	220	0	260	0	380	0
	Others	15,500	0.0	-						
	Sub-Total	252,400		-		0		0		0
Alcântara	Trindade	174,300	0.9	156,900	220	400	260	472	380	690
	Alcântara	101,500	0.9	91,400	220	233	260	275	380	402
	Jardim Nazaré	127,400	0.9	114,700	220	292	260	345	380	504
	Others	96,300	0.0	-						
	Sub-Total	499,500		363,000		925		1,092		1,596
Imboassu	Sao Gonçalo	261,100	0.9	235,000	280	762	332	903	488	1,327
	Bomba	44,700	0.9	40,200	230	107	272	127	398	185
	Others	30,900	0.0	-						
	Sub-Total	336,700		275,200		869		1,030		1,512
Niteroi	Toque Toque	202,200	0.0	-	250	0	296	0	434	0
	Icaraí	202,200	0.9	182,000	255	537	302	636	443	933
	Sub-Total	404,400		182,000		537		636		933
Ilha do Governador	Ilha do Governador	225,500	0.9	203,000	280	658	332	780	488	1,147
Paquetá	Paquetá	3,700	0.9	3,300	705	27	842	32	1,253	48
Others		121,800	0.0	-						
Total		9,541,100		6,930,300		20,343		24,089		35,331

SUPPORTING 8

FACILITY PLANNING AND DESIGN

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SUPPORTING 8 FACILITY PLANNING AND DESIGN

1. TRUNK SEWER HYDRAULIC CALCULATION

1.1 PAVUNA SEWER DISTRICT

Trunk Sewer Hydraulic Calculation of Pavuna Sewer District is shown in *Table 1 (1/15 - 15/15).*

Table 1 (1/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 1 Notes: entrance flow (l/s):
1				37.09	37.09			13.00	11.00	2.00	11.21	0.44	0.69			
	o	82.506	110.00	-	-	400	0.0025	-	-	-		-	-	2.34	5.99	37.094
2				47.78	47.78			13.00	10.72	2.28	10.93	0.51	0.73			47.782
2				37.09	37.09			13.00	10.72	2.28	10.93	0.44	0.69			
	o		110.00	-	-	400	0.0025	-	-	-		-	-	2.34	5.99	
3				47.78	47.78			13.00	10.44	2.56	10.65	0.51	0.73			
3				37.09	83.22			13.00	10.34	2.66	10.58	0.41	1.09			
	j		110.00	-	-	500	0.0051	-	-	-		-	-	5.55	6.52	
4				47.78	107.20			13.00	9.78	3.22	10.02	0.47	1.16			
4				83.22	83.22			13.00	9.78	3.22	10.02	0.41	1.09			
	j		70.00	-	-	500	0.0051	-	-	-		-	-	5.59	6.52	
5				107.20	107.20			12.00	9.42	2.58	9.66	0.47	1.16			
5				83.22	83.22			12.00	9.42	2.58	9.66	0.41	1.08			
	j		150.00	-	-	500	0.0051	-	-	-		-	-	5.53	6.53	
6				107.20	107.20			12.00	8.66	3.34	8.90	0.47	1.16			
6				83.22	83.22			12.00	8.66	3.34	8.90	0.41	1.08			
	j		150.00	-	-	500	0.0051	-	-	-		-	-	5.53	6.53	
7				107.20	107.20			12.00	7.90	4.10	8.14	0.47	1.16			
7				140.32	140.32			12.00	7.90	4.10	8.23	0.56	1.25			
	j	127.000	70.00	-	-	500	0.0051	-	-	-		-	-	6.87	7.16	57.098
8				180.75	180.75			11.00	7.54	3.46	7.87	0.66	1.32			73.549
8				140.32	140.32			11.00	7.54	3.46	7.87	0.56	1.24			
	j		110.00	-	-	500	0.0051	-	-	-		-	-	6.81	7.17	
9				180.75	180.75			9.00	6.98	2.02	7.31	0.67	1.32			
9				140.32	140.32			9.00	6.98	2.02	7.34	0.61	1.13			
	o		150.00	-	-	500	0.0040	-	-	-		-	-	5.59	7.27	
10				180.75	180.75			9.00	6.38	2.62	6.74	0.73	1.19			
10				140.32	140.32			9.00	6.38	2.62	6.74	0.61	1.13			
	j		150.00	-	-	500	0.0040	-	-	-		-	-	5.59	7.27	
11				180.75	180.75			9.00	5.78	3.22	6.14	0.73	1.19			
11				140.32	140.32			9.00	5.78	3.22	6.14	0.61	1.13			
	j		150.00	-	-	500	0.0040	-	-	-		-	-	5.59	7.27	
12				180.75	180.75			8.00	5.18	2.82	5.54	0.73	1.19			
12				140.32	140.32			8.00	5.18	2.82	5.54	0.61	1.13			
	o		150.00	-	-	500	0.0040	-	-	-		-	-	5.59	7.27	
13				180.75	180.75			7.00	4.58	2.42	4.94	0.73	1.19			
13				153.63	153.63			7.00	4.58	2.42	4.95	0.62	1.21			
	j	29.596	140.00	-	-	500	0.0045	-	-	-		-	-	6.35	7.29	13.306
14				197.89	197.89			7.00	3.95	3.05	4.32	0.74	1.27			17.140
14				153.63	153.63			7.00	3.55	3.45	4.05	0.47	0.52			
	j		150.00	-	-	900	0.0005	-	-	-		-	-	1.00	9.18	
15				197.89	197.89			7.00	3.48	3.52	3.98	0.55	0.55			
15				153.63	153.63			7.00	3.48	3.52	3.98	0.47	0.52			
	j		150.00	-	-	900	0.0005	-	-	-		-	-	1.00	9.18	
16				197.89	197.89			9.00	3.41	5.59	3.91	0.55	0.55			

Table 1 (2/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 2 Notes: entrance flow (l/s):
16				189.75	189.75			9.00	3.11	5.89	3.59	0.35	0.54			
	j	80.331	150.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	36.117
17				244.41	244.41			8.00	3.04	4.96	3.52	0.40	0.57			46.522
17				189.75	189.75			8.00	3.04	4.96	3.52	0.35	0.54			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
18				244.41	244.41			8.00	2.98	5.02	3.46	0.40	0.57			
18				189.75	189.75			8.00	2.98	5.02	3.46	0.35	0.54			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
19				244.41	244.41			8.00	2.91	5.09	3.39	0.40	0.57			
19				189.75	189.75			8.00	2.91	5.09	3.39	0.35	0.54			
	j		80.00	-	-	1200	0.0005	-	-	-		-	-	1.05	9.53	
20				244.41	244.41			8.00	2.87	5.13	3.35	0.40	0.57			
20				189.75	189.75			8.00	2.87	5.13	3.35	0.35	0.54			
	j		130.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
21				244.41	244.41			8.00	2.81	5.19	3.29	0.40	0.57			
21				189.75	189.75			8.00	2.81	5.19	3.29	0.35	0.54			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
22				244.41	244.41			8.00	2.75	5.26	3.22	0.40	0.57			
22				189.75	189.75			8.00	2.75	5.26	3.22	0.35	0.54			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
23				244.41	244.41			9.00	2.68	6.32	3.16	0.40	0.57			
23				189.75	189.75			9.00	2.68	6.32	3.16	0.35	0.54			
	j		110.00	-	-	1200	0.0005	-	-	-		-	-	1.06	9.52	
24				244.41	244.41			9.00	2.63	6.37	3.11	0.40	0.57			
24				189.75	268.74			9.00	2.63	6.37	3.25	0.45	0.54			
	j		50.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.43	
25				244.41	346.16			9.00	2.61	6.39	3.24	0.52	0.58			
25				268.74	268.74			9.00	2.61	6.39	3.24	0.45	0.54			
	j		100.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.43	
26				346.16	346.16			9.00	2.57	6.43	3.20	0.52	0.58			
26				268.74	268.74			9.00	2.57	6.43	3.20	0.45	0.54			
	j		100.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.43	
27				346.16	346.16			9.00	2.54	6.46	3.16	0.52	0.58			
27				268.74	268.74			9.00	2.54	6.46	3.16	0.45	0.54			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.43	
28				346.16	346.16			9.00	2.48	6.52	3.11	0.52	0.58			
28				268.74	268.74			9.00	2.48	6.52	3.11	0.45	0.54			
	j		130.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.44	
29				346.16	346.16			9.00	2.44	6.56	3.07	0.52	0.58			
29				268.74	268.74			9.00	2.44	6.56	3.06	0.45	0.54			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.00	10.44	
30				346.16	346.16			9.00	2.38	6.62	3.01	0.52	0.58			
30				303.53	303.53			9.00	2.38	6.62	3.07	0.48	0.55			
	j	77.398	150.00	-	-	1200	0.0004	-	-	-		-	-	1.04	10.70	34.798
31				390.98	390.98			9.00	2.33	6.67	3.01	0.57	0.59			44.823
31				303.53	303.53			9.00	2.33	6.67	3.01	0.48	0.55			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.04	10.70	
32				390.98	390.98			8.00	2.28	5.72	2.96	0.57	0.59			

Table 1 (3/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 3 Notes: entrance flow (l/s):
32				303.53	303.53			8.00	2.28	5.72	2.96	0.48	0.55			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.04	10.70	
33				390.98	390.98			8.00	2.22	5.78	2.91	0.57	0.59			
33				303.53	303.53			8.00	2.22	5.78	2.89	0.47	0.57			
	j		130.00	-	-	1200	0.0004	-	-	-		-	-	1.09	10.63	
34				390.98	390.98			8.00	2.18	5.83	2.84	0.56	0.61			
34				354.90	354.90			8.00	2.18	5.83	2.93	0.53	0.58			
	j	114.261	150.00	-	-	1200	0.0004	-	-	-		-	-	1.10	10.99	51.371
35				457.15	457.15			9.00	2.12	6.88	2.88	0.63	0.61			66.172
35				354.90	354.90			9.00	2.12	6.88	2.88	0.53	0.58			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.10	10.99	
36				457.15	457.15			9.00	2.07	6.93	2.83	0.63	0.61			
36				354.90	354.90			9.00	2.07	6.93	2.83	0.53	0.58			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.10	10.99	
37				457.15	457.15			9.00	2.02	6.98	2.78	0.63	0.61			
37				354.90	354.90			9.00	2.02	6.98	2.78	0.53	0.58			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.10	10.99	
38				457.15	457.15			7.00	1.96	5.04	2.72	0.63	0.61			
38				354.90	354.90			7.00	1.96	5.04	2.72	0.54	0.57			
	j		80.00	-	-	1200	0.0004	-	-	-		-	-	1.10	10.99	
39				457.15	457.15			7.00	1.94	5.07	2.70	0.63	0.61			
39				354.90	354.90			7.00	1.94	5.07	2.69	0.53	0.58			
	j		70.00	-	-	1200	0.0004	-	-	-		-	-	1.11	10.98	
40				457.15	457.15			7.00	1.91	5.09	2.67	0.63	0.62			
40				393.92	393.92			7.00	1.91	5.09	2.72	0.57	0.60			
	j	86.786	50.00	-	-	1200	0.0004	-	-	-		-	-	1.17	11.14	39.019
41				507.41	507.41			7.00	1.89	5.11	2.70	0.68	0.63			50.260
41				440.23	440.23			7.00	1.89	5.11	2.78	0.61	0.61			
	j	102.998	70.00	-	-	1200	0.0004	-	-	-		-	-	1.20	11.28	46.307
TC 116				567.06	567.06			5.93	1.87	4.07	2.75	0.74	0.64			59.649
TOTAL			5,120.00						-0.946	4.07						

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1-1 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
3.1				46.13	46.13			13.00	11.00	2.00	11.26	0.54	0.66			
	o	102.604	140.00	-	-	400	0.0020	-	-	-		-	-	2.10	6.37	46.130
3.2				59.42	59.42			13.00	10.72	2.28	10.98	0.64	0.70			59.421
3.2				46.13	46.13			13.00	10.72	2.28	10.98	0.54	0.66			
	o		140.00	-	-	400	0.0020	-	-	-		-	-	2.10	6.37	
3 (No. 1 TS)				59.42	59.42			13.00	10.44	2.56	10.70	0.64	0.70			
TOTAL			280.00							2.56						

Table 1 (4/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1-2 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 4 Notes: entrance flow (l/s):
24.1				41.22	41.22			17.00	14.80	2.20	15.04	0.50	0.64			
	o	91.690	150.00	-	-	400	0.0020	-	-	-		-	-	2.01	6.25	41.224
24.2				53.10	53.10			18.00	14.50	3.50	14.74	0.59	0.69			53.098
24.2				41.22	41.22			18.00	14.50	3.50	14.62	0.26	1.61			
	o		100.00	-	-	400	0.0250	-	-	-		-	-	14.95	4.84	
24.3				53.10	53.10			14.00	12.00	2.00	12.12	0.29	1.73			
24.3				41.22	41.22			14.00	12.00	2.00	12.16	0.35	1.09			
	o		150.00	-	-	400	0.0082	-	-	-		-	-	6.28	5.45	
24.4				53.10	53.10			13.00	10.77	2.23	10.93	0.39	1.16			
24.4				41.22	41.22			13.00	10.77	2.23	10.93	0.35	1.09			
	o		100.00	-	-	400	0.0082	-	-	-		-	-	6.28	5.45	
24.5				53.10	53.10			12.00	9.95	2.05	10.11	0.39	1.16			
24.5				41.22	41.22			12.00	9.95	2.05	10.11	0.35	1.09			
	o		130.00	-	-	400	0.0082	-	-	-		-	-	6.25	5.45	
24.6				53.10	53.10			11.00	8.89	2.11	9.05	0.39	1.16			
24.6				41.22	41.22			11.00	8.89	2.11	9.05	0.35	1.09			
	o		110.00	-	-	400	0.0082	-	-	-		-	-	6.27	5.45	
24.7				53.10	53.10			10.00	7.99	2.01	8.15	0.39	1.16			
24.7				78.99	78.99			10.00	7.99	2.01	8.22	0.49	1.29			
	o	84.000	150.00	-	-	400	0.0082	-	-	-		-	-	8.07	6.19	37.766
24.8				101.74	101.74			9.00	6.76	2.24	6.99	0.57	1.37			48.644
24.8				78.99	78.99			9.00	6.76	2.24	6.99	0.49	1.28			
	o		70.00	-	-	400	0.0081	-	-	-		-	-	8.02	6.19	
24.9				101.74	101.74			9.00	6.19	2.81	6.42	0.57	1.37			
24.9				78.99	78.99			9.00	6.19	2.81	6.42	0.49	1.29			
	o		100.00	-	-	400	0.0082	-	-	-		-	-	8.07	6.19	
24(No. 1 TS)				101.74	101.74			9.00	5.37	3.63	5.60	0.57	1.37			
TOTAL			1,060.00							3.63						

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 2 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
1				61.18	61.18			18.00	15.50	2.50	16.29	0.61	0.49			
	j	136.071	80.00	-	-	500	0.0070	-	-	-		-	-	1.05	7.28	61.177
2				78.80	78.80			20.00	15.44	4.56	16.17	0.73	0.52			78.802
2				61.18	61.18			20.00	15.44	4.56	16.17	0.64	0.47			
	j		150.00	-	-	500	0.0070	-	-	-		-	-	1.01	7.31	
3				78.80	78.80			18.00	15.34	2.66	15.95	0.76	0.49			

Table 1 (5/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 5 Notes: entrance flow (l/s):
3				61.18	61.18			18.00	15.34	2.66	15.83	0.55	0.55			
	o		40.00	-	-	500	0.0010	-	-	-		-	-	1.33	7.15	
4				78.80	78.80			17.80	15.30	2.50	15.47	0.66	0.58			
4				61.18	61.18			17.80	15.30	2.50	15.47	0.30	1.22			
	o		90.00	-	-	500	0.0090	-	-	-		-	-	7.63	5.82	
5				78.80	78.80			17.00	14.49	2.51	14.66	0.35	1.33			
5				61.18	61.18			17.00	14.49	2.51	14.66	0.30	1.22			
	o		90.00	-	-	500	0.0090	-	-	-		-	-	7.63	5.82	
6				78.80	78.80			16.30	13.68	2.62	13.85	0.35	1.33			
6				61.18	61.18			16.30	13.68	2.62	13.95	0.47	0.68			
	j		80.00	-	-	500	0.0018	-	-	-		-	-	2.09	6.82	
7				78.80	78.80			19.00	13.54	5.46	13.81	0.54	0.72			
7				61.18	61.18			19.00	13.54	5.46	13.81	0.46	0.68			
	j		90.00	-	-	500	0.0018	-	-	-		-	-	2.11	6.81	
8				78.80	78.80			18.50	13.38	5.12	13.65	0.54	0.73			
8				61.18	61.18			18.50	13.38	5.12	13.65	0.46	0.68			
	j		130.00	-	-	500	0.0018	-	-	-		-	-	2.10	6.81	
9				78.80	78.80			17.20	13.15	4.05	13.42	0.54	0.72			
9				61.18	61.18			17.20	13.15	4.05	13.42	0.46	0.69			
	j		120.00	-	-	500	0.0018	-	-	-		-	-	2.17	6.79	
10				78.80	78.80			15.80	12.93	2.87	13.20	0.54	0.73			
10				99.77	99.77			15.80	12.93	2.87	13.30	0.61	0.80			
	j	85.846	10.00	-	-	500	0.0020	-	-	-		-	-	2.80	7.28	38.596
EE-1				128.52	128.52			18.80	12.91	5.89	13.28	0.73	0.84			49.716
TOTAL			880.00							5.89						
11				12.58	112.35			19.00	16.90	2.10	17.18	0.36	0.93			
	o	27.976	110.00	-	-	700	0.0027	-	-	-		-	-	3.74	7.30	12.578
12				16.20	144.72			19.00	16.60	2.40	16.88	0.40	0.99			16.202
12				112.35	112.35			19.00	16.60	2.40	16.88	0.36	0.92			
	o		90.00	-	-	700	0.0027	-	-	-		-	-	3.67	7.31	
13				144.72	144.72			19.00	16.36	2.64	16.64	0.41	0.98			
13				112.35	112.35			19.00	16.36	2.64	16.64	0.35	0.93			
	o		50.00	-	-	700	0.0028	-	-	-		-	-	3.82	7.28	
14				144.72	144.72			19.00	16.22	2.78	16.50	0.40	1.00			
14				112.35	112.35			19.00	16.22	2.78	16.50	0.36	0.92			
	o		120.00	-	-	700	0.0027	-	-	-		-	-	3.67	7.31	
15				144.72	144.72			18.00	15.90	2.10	16.18	0.41	0.98			
15				112.35	112.35			18.00	15.90	2.10	16.18	0.36	0.92			
	o		60.00	-	-	700	0.0027	-	-	-		-	-	3.67	7.31	
16				144.72	144.72			18.00	15.74	2.26	16.02	0.41	0.98			
16				112.35	112.35			18.00	15.74	2.26	16.02	0.36	0.92			
	o		60.00	-	-	700	0.0027	-	-	-		-	-	3.67	7.31	
17				144.72	144.72			18.00	15.58	2.42	15.86	0.41	0.98			
17				112.35	112.35			18.00	15.58	2.42	15.86	0.36	0.92			
	o		140.00	-	-	700	0.0027	-	-	-		-	-	3.72	7.30	
18				144.72	144.72			19.00	15.20	3.80	15.48	0.40	0.98			

Table 1 (6/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 6 Notes: entrance flow (l/s):
18				136.00	136.00			19.00	15.20	3.80	15.52	0.39	0.96			
	o	52.606	150.00	-	-	700	0.0027	-	-	-		-	-	3.94	7.59	23.651
19				175.19	175.19			17.80	14.80	3.00	15.12	0.45	1.03			30.465
19				136.00	136.00			17.80	14.80	3.00	15.00	0.26	1.73			
	o		150.00	-	-	700	0.0137	-	-	-		-	-	14.32	6.40	
20				175.19	175.19			15.00	12.75	2.25	12.95	0.29	1.86			
20				136.00	136.00			15.00	12.75	2.25	12.95	0.26	1.73			
	o		150.00	-	-	700	0.0137	-	-	-		-	-	14.32	6.40	
21				175.19	175.19			12.80	10.70	2.10	10.90	0.29	1.86			
21				160.43	160.43			12.80	10.70	2.10	11.14	0.53	0.78			
	o	54.333	150.00	-	-	700	0.0013	-	-	-		-	-	2.41	8.36	24.428
22				206.65	206.65			12.80	10.50	2.30	10.94	0.62	0.83			31.466
22				160.43	160.43			12.80	10.50	2.30	10.94	0.54	0.76			
	o		150.00	-	-	700	0.0013	-	-	-		-	-	2.31	8.40	
23				206.65	206.65			12.80	10.31	2.49	10.75	0.64	0.81			
23				160.43	160.43			12.80	10.31	2.49	10.75	0.54	0.76			
	o		150.00	-	-	700	0.0013	-	-	-		-	-	2.31	8.40	
24				206.65	206.65			12.80	10.12	2.68	10.56	0.64	0.81			
24				160.43	160.43			12.80	10.12	2.68	10.57	0.54	0.76			
	o		40.00	-	-	700	0.0013	-	-	-		-	-	2.29	8.41	
25				206.65	206.65			12.80	10.07	2.73	10.52	0.64	0.81			
25				160.43	160.43			12.80	10.07	2.73	10.51	0.53	0.77			
	o		100.00	-	-	700	0.0013	-	-	-		-	-	2.36	8.38	
26				206.65	206.65			12.80	9.94	2.86	10.38	0.63	0.82			
26				194.07	194.07			12.80	9.94	2.86	10.45	0.61	0.80			
	o	74.818	150.00	-	-	700	0.0013	-	-	-		-	-	2.48	8.61	33.638
27				249.98	249.98			12.80	9.75	3.05	10.26	0.73	0.84			43.329
27				194.07	194.07			12.80	9.75	3.05	10.03	0.35	1.62			
	o		150.00	-	-	700	0.0084	-	-	-		-	-	11.45	7.27	
28				249.98	249.98			11.00	8.49	2.51	8.77	0.40	1.72			
28				194.07	194.07			11.00	8.49	2.51	8.77	0.35	1.62			
	o		70.00	-	-	700	0.0084	-	-	-		-	-	11.48	7.27	
29				249.98	249.98			10.00	7.90	2.10	8.18	0.40	1.73			
29				194.07	194.07			10.00	7.68	2.32	7.98	0.28	1.28			
	o		140.00	-	-	900	0.0048	-	-	-		-	-	7.02	7.68	
30				249.98	249.98			10.00	7.01	2.99	7.31	0.33	1.40			
30				194.07	194.07			10.00	7.01	2.99	7.31	0.28	1.28			
	o		100.00	-	-	900	0.0048	-	-	-		-	-	7.04	7.68	
31				249.98	249.98			9.50	6.53	2.97	6.83	0.33	1.40			
31				194.07	194.07			9.50	6.53	2.97	6.83	0.28	1.28			
	o		100.00	-	-	900	0.0048	-	-	-		-	-	7.04	7.68	
32				249.98	249.98			9.00	6.05	2.95	6.35	0.33	1.40			
32				194.07	194.07			9.00	6.05	2.95	6.35	0.28	1.30			
	o		150.00	-	-	900	0.0050	-	-	-		-	-	7.27	7.65	
33				249.98	249.98			8.00	5.30	2.70	5.60	0.33	1.42			
33				194.07	194.07			8.00	5.30	2.70	5.65	0.35	1.01			
	o		80.00	-	-	900	0.0024	-	-	-		-	-	4.10	8.19	
34				249.98	249.98			8.00	5.11	2.89	5.46	0.39	1.07			

Table 1 (7/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 7 Notes: entrance flow (l/s):
34				245.54	245.54			8.00	5.11	2.89	5.51	0.39	1.07			
	j	114.484	50.00	-	-	900	0.0024	-	-	-		-	-	4.51	8.56	51.471
35				316.28	316.28			8.00	4.99	3.01	5.39	0.44	1.15			66.301
35				245.54	245.54			8.00	4.99	3.01	5.39	0.39	1.08			
	j		90.00	-	-	900	0.0024	-	-	-		-	-	4.58	8.55	
36				316.28	316.28			8.00	4.77	3.23	5.17	0.44	1.15			
36				245.54	245.54			8.00	4.77	3.23	5.17	0.39	1.08			
	j		90.00	-	-	900	0.0024	-	-	-		-	-	4.58	8.55	
37				316.28	316.28			8.00	4.55	3.45	4.95	0.44	1.15			
37				275.46	275.46			8.00	4.55	3.45	4.97	0.41	1.11			
	j	66.555	90.00	-	-	900	0.0024	-	-	-		-	-	4.79	8.75	29.922
38				354.83	354.83			8.30	4.33	3.97	4.75	0.47	1.19			38.544
38				275.46	275.46			8.30	4.33	3.97	4.76	0.41	1.10			
	j		100.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
39				354.83	354.83			9.00	4.09	4.91	4.52	0.47	1.18			
39				275.46	275.46			9.00	4.09	4.91	4.52	0.41	1.10			
	j		100.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
40				354.83	354.83			9.00	3.85	5.15	4.28	0.47	1.18			
40				275.46	275.46			9.00	3.85	5.15	4.28	0.41	1.10			
	j		150.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
41				354.83	354.83			9.00	3.49	5.51	3.92	0.47	1.18			
41				275.46	275.46			9.00	3.49	5.51	3.92	0.41	1.10			
	j		150.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
42				354.83	354.83			9.00	3.13	5.87	3.56	0.47	1.18			
42				275.46	275.46			9.00	3.13	5.87	3.56	0.41	1.10			
	j		150.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
43				354.83	354.83			9.00	2.77	6.23	3.20	0.47	1.18			
43				275.46	275.46			9.00	2.77	6.23	3.20	0.41	1.10			
	j		150.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
44				354.83	354.83			9.00	2.41	6.59	2.84	0.47	1.18			
44				275.46	275.46			9.00	2.41	6.59	2.84	0.41	1.10			
	j		150.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
45				354.83	354.83			9.00	2.05	6.95	2.48	0.47	1.18			
45				275.46	275.46			9.00	2.05	6.95	2.48	0.41	1.10			
	j		50.00	-	-	900	0.0024	-	-	-		-	-	4.72	8.76	
46				354.83	354.83			9.00	1.93	7.07	2.36	0.47	1.18			
46				302.87	302.87			9.00	1.93	7.07	2.38	0.43	1.13			
	j	60.971	100.00	-	-	900	0.0024	-	-	-		-	-	4.90	8.93	27.412
47				390.14	390.14			8.00	1.69	6.31	2.14	0.50	1.21			35.310
47				302.87	302.87			8.00	1.69	6.31	2.14	0.43	1.13			
	j		100.00	-	-	900	0.0024	-	-	-		-	-	4.90	8.93	
48				390.14	390.14			8.00	1.45	6.55	1.90	0.50	1.21			
48				348.71	348.71			8.00	1.30	6.70	1.97	0.62	0.85			
	j	101.954	100.00	-	-	900	0.0010	-	-	-		-	-	2.54	9.79	45.838
50 (No.3 TS)				449.18	449.18			8.00	1.20	6.80	1.87	0.75	0.88			59.044
TOTAL			4,230.00							6.80						

Table 1 (8/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 3 TRUNK SEWER																
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 8 Notes: entrance flow (l/s):
1				412.16	412.16			17.50	11.00	6.50	11.50	0.43	1.26			EXISTING
	-	916.733	50.00	-	-	1000	0.0026	-	-	-		-	-	5.87	9.39	412.158
2				530.91	530.91			16.80	10.87	5.93	11.37	0.50	1.35			530.905
2				412.16	412.16			16.80	10.87	5.93	11.37	0.43	1.26			EXISTING
	-		120.00	-	-	1000	0.0026	-	-	-		-	-	5.84	9.39	
3				530.91	530.91			16.50	10.56	5.94	11.06	0.50	1.34			
3				412.16	412.16			16.50	10.56	5.94	11.06	0.43	1.25			EXISTING
	-		140.00	-	-	1000	0.0026	-	-	-		-	-	5.81	9.40	
4				530.91	530.91			16.20	10.20	6.00	10.70	0.50	1.34			
4				412.16	412.16			16.20	10.20	6.00	10.69	0.43	1.27			EXISTING
	-		30.00	-	-	1000	0.0027	-	-	-		-	-	5.99	9.36	
5				530.91	530.91			16.20	10.12	6.08	10.61	0.49	1.36			
5				412.16	412.16			16.20	10.12	6.08	10.62	0.43	1.26			EXISTING
	-		150.00	-	-	1000	0.0026	-	-	-		-	-	5.87	9.39	
6				530.91	530.91			16.00	9.73	6.27	10.23	0.50	1.35			
6				412.16	412.16			16.00	9.73	6.27	10.23	0.43	1.26			EXISTING
	-		150.00	-	-	1000	0.0026	-	-	-		-	-	5.87	9.39	
7				530.91	530.91			16.00	9.34	6.66	9.84	0.50	1.35			
7				412.16	412.16			16.00	9.34	6.66	9.84	0.43	1.26			EXISTING
	-		150.00	-	-	1000	0.0026	-	-	-		-	-	5.87	9.39	
8				530.91	530.91			15.80	8.95	6.85	9.45	0.50	1.35			
8				412.16	412.16			15.80	8.95	6.85	9.45	0.43	1.26			EXISTING
	-		150.00	-	-	1000	0.0026	-	-	-		-	-	5.87	9.39	
9				530.91	530.91			15.40	8.56	6.84	9.06	0.50	1.35			
9				412.16	412.16			15.40	8.56	6.84	9.06	0.43	1.27			EXISTING
	-		110.00	-	-	1000	0.0026	-	-	-		-	-	5.93	9.37	
10				530.91	530.91			14.70	8.27	6.43	8.77	0.50	1.35			
10				412.16	412.16			14.70	8.27	6.43	8.76	0.42	1.29			EXISTING
	-		40.00	-	-	1000	0.0027	-	-	-		-	-	6.14	9.34	
11				530.91	530.91			14.80	8.16	6.64	8.65	0.49	1.38			
11				412.16	412.16			14.80	8.16	6.64	8.70	0.46	1.14			EXISTING
	-		60.00	-	-	1000	0.0020	-	-	-		-	-	4.75	9.63	
12				530.91	530.91			14.40	8.04	6.36	8.58	0.54	1.22			
12				482.56	482.56			14.40	7.84	6.56	8.66	0.57	0.73			
	j	40.106	150.00	-	-	1200	0.0005	-	-	-		-	-	1.73	11.15	70.403
13				621.59	621.59			13.20	7.76	5.44	8.58	0.68	0.77			90.686
13				482.56	482.56			13.20	7.76	5.44	8.60	0.58	0.71			
	j		80.00	-	-	1200	0.0005	-	-	-		-	-	1.64	11.19	
14				621.59	621.59			13.10	7.72	5.38	8.56	0.70	0.75			
14				482.56	614.36			13.10	7.72	5.38	8.36	0.45	1.21			
	j		100.00	-	-	1200	0.0018	-	-	-		-	-	5.07	10.48	
15				621.59	791.36			13.10	7.54	5.56	8.18	0.53	1.30			
15				614.36	614.36			13.10	7.54	5.56	8.18	0.46	1.20			
	j		80.00	-	-	1200	0.0018	-	-	-		-	-	4.95	10.51	
16				791.36	791.36			12.80	7.40	5.40	8.04	0.53	1.28			

Table 1 (9/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 9 Notes: entrance flow (l/s):
16				614.36	614.36			12.80	7.40	5.40	8.04	0.46	1.21			
	j		90.00	-	-	1200	0.0018	-	-	-		-	-	5.01	10.49	
17				791.36	791.36			13.40	7.24	6.16	7.88	0.53	1.29			
17				632.39	632.39			13.40	7.24	6.16	7.88	0.46	1.24			
	j		130.00	-	-	1200	0.0018	-	-	-		-	-	5.23	10.51	18.032
18				814.59	814.59			12.90	7.00	5.90	7.64	0.54	1.32			23.227
18				632.39	632.39			12.90	7.00	5.90	7.65	0.46	1.22			
	j		100.00	-	-	1200	0.0018	-	-	-		-	-	5.12	10.54	
19				814.59	814.59			12.70	6.82	5.88	7.47	0.54	1.31			
19				632.39	632.39			12.70	6.82	5.88	7.47	0.46	1.22			
	j		100.00	-	-	1200	0.0018	-	-	-		-	-	5.12	10.54	
20				814.59	814.59			12.40	6.64	5.76	7.29	0.54	1.31			
20				632.39	632.39			12.40	6.64	5.76	7.29	0.46	1.22			
	j		100.00	-	-	1200	0.0018	-	-	-		-	-	5.12	10.54	
21				814.59	814.59			12.20	6.46	5.74	7.11	0.54	1.31			
21				632.39	632.39			12.20	6.46	5.74	7.10	0.46	1.23			
	j		60.00	-	-	1200	0.0018	-	-	-		-	-	5.20	10.52	
22				814.59	814.59			11.90	6.35	5.55	6.99	0.54	1.32			
22				632.39	632.39			11.90	6.35	5.55	7.00	0.46	1.22			
	j		150.00	-	-	1200	0.0018	-	-	-		-	-	5.12	10.54	
23				814.59	814.59			11.70	6.08	5.62	6.73	0.54	1.31			
23				632.39	632.39			11.70	6.08	5.62	6.73	0.46	1.22			
	j		150.00	-	-	1200	0.0018	-	-	-		-	-	5.12	10.54	
24				814.59	814.59			11.00	5.81	5.19	6.46	0.54	1.31			
24				654.81	654.81			11.00	5.81	5.19	6.47	0.47	1.24			
	j	49.851	150.00	-	-	1200	0.0018	-	-	-		-	-	5.20	10.61	22.413
25				843.46	843.46			10.50	5.54	4.96	6.20	0.55	1.32			28.870
25				654.81	654.81			10.50	5.54	4.96	6.20	0.47	1.24			
	j		60.00	-	-	1200	0.0018	-	-	-		-	-	5.27	10.59	
26				843.46	843.46			10.10	5.43	4.67	6.09	0.55	1.33			
26				654.81	654.81			10.10	5.43	4.67	6.09	0.47	1.24			
	j		120.00	-	-	1200	0.0018	-	-	-		-	-	5.27	10.59	
27				843.46	843.46			10.50	5.21	5.29	5.87	0.55	1.33			
27				654.81	654.81			10.50	5.21	5.29	5.87	0.47	1.24			
	j		150.00	-	-	1200	0.0018	-	-	-		-	-	5.20	10.61	
28				843.46	843.46			11.00	4.94	6.06	5.60	0.55	1.32			
28				654.81	654.81			11.00	4.94	6.06	5.60	0.47	1.25			
	j		130.00	-	-	1200	0.0018	-	-	-		-	-	5.30	10.58	
29				843.46	843.46			9.80	4.70	5.10	5.36	0.55	1.33			
29				654.81	654.81			9.80	4.70	5.10	5.34	0.46	1.28			
	j		150.00	-	-	1200	0.0020	-	-	-		-	-	5.65	10.50	
30				843.46	843.46			8.00	4.40	3.60	5.04	0.53	1.37			
30				654.81	654.81			8.00	4.40	3.60	5.21	0.57	0.99			
	j		150.00	-	-	1200	0.0010	-	-	-		-	-	3.23	11.14	
31				843.46	843.46			8.00	4.25	3.75	5.06	0.68	1.05			
31				654.81	654.81			8.00	4.25	3.75	5.06	0.57	0.99			
	j		150.00	-	-	1200	0.0010	-	-	-		-	-	3.23	11.14	
32				843.46	843.46			9.00	4.10	4.90	4.91	0.68	1.05			

Table 1 (10/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 10 Notes: entrance flow (l/s):
32				672.48	672.48			9.00	4.10	4.90	4.93	0.58	0.99			
	j	39.311	80.00	-	-	1200	0.0010	-	-	-		-	-	3.23	11.18	17.674
33				866.23	866.23			9.00	4.02	4.98	4.85	0.69	1.05			22.766
33				751.25	751.25			9.00	4.02	4.98	4.92	0.63	1.02			
	j	175.202	70.00	-	-	1200	0.0010	-	-	-		-	-	3.35	11.31	78.770
34				967.69	967.69			9.00	3.95	5.05	4.85	0.75	1.06			101.465
34				751.25	751.25			9.00	3.95	5.05	4.85	0.62	1.03			
	j		100.00	-	-	1200	0.0010	-	-	-		-	-	3.39	11.30	
35				967.69	967.69			9.00	3.85	5.15	4.75	0.75	1.07			
35				751.25	751.25			9.00	3.85	5.15	4.75	0.62	1.03			
	j		70.00	-	-	1200	0.0010	-	-	-		-	-	3.39	11.30	
36				967.69	967.69			9.00	3.78	5.22	4.68	0.75	1.07			
36				751.25	751.25			9.00	3.78	5.22	4.69	0.63	1.02			
	j		100.00	-	-	1200	0.0010	-	-	-		-	-	3.34	11.31	
37				967.69	967.69			9.00	3.68	5.32	4.59	0.75	1.06			
37				751.25	751.25			9.00	3.68	5.32	4.57	0.61	1.04			
	j		100.00	-	-	1200	0.0010	-	-	-		-	-	3.51	11.28	
38				967.69	967.69			9.00	3.58	5.42	4.46	0.74	1.09			
38				767.04	767.04			9.00	3.58	5.42	4.48	0.63	1.04			
	j	35.123	100.00	-	-	1200	0.0010	-	-	-		-	-	3.47	11.31	15.791
39				988.03	988.03			9.00	3.48	5.52	4.38	0.75	1.08			20.341
39				767.04	767.04			9.00	3.48	5.52	4.38	0.62	1.04			
	j		120.00	-	-	1200	0.0010	-	-	-		-	-	3.51	11.31	
40				988.03	988.03			9.00	3.35	5.65	4.25	0.75	1.09			
40				767.04	767.04			9.00	3.35	5.65	4.25	0.62	1.05			
	j		100.00	-	-	1200	0.0010	-	-	-		-	-	3.53	11.30	
41				988.03	988.03			9.00	3.25	5.75	4.15	0.75	1.09			
41				767.04	767.04			9.00	3.25	5.75	4.15	0.62	1.05			
	j		70.00	-	-	1200	0.0010	-	-	-		-	-	3.54	11.30	
42				988.03	988.03			9.00	3.18	5.82	4.07	0.75	1.09			
42				767.04	767.04			9.00	3.18	5.82	4.08	0.63	1.04			
	j		120.00	-	-	1200	0.0010	-	-	-		-	-	3.46	11.31	
43				988.03	988.03			9.00	3.06	5.95	3.96	0.75	1.08			
43				767.04	767.04			9.00	3.06	5.95	3.96	0.63	1.04			
	j		50.00	-	-	1200	0.0010	-	-	-		-	-	3.47	11.31	
44				988.03	988.03			9.00	3.00	6.00	3.91	0.75	1.08			
44				767.04	767.04			9.00	3.00	6.00	3.90	0.63	1.04			
	j		130.00	-	-	1200	0.0010	-	-	-		-	-	3.50	11.31	
45				988.03	988.03			9.00	2.87	6.13	3.77	0.75	1.09			
45				767.04	767.04			9.00	2.87	6.13	3.76	0.62	1.05			
	j		40.00	-	-	1200	0.0011	-	-	-		-	-	3.56	11.30	
46				988.03	988.03			9.00	2.83	6.17	3.72	0.75	1.10			
46				767.04	767.04			9.00	2.83	6.17	3.71	0.61	1.07			
	j		80.00	-	-	1200	0.0011	-	-	-		-	-	3.70	11.28	
47				988.03	988.03			8.00	2.74	5.26	3.62	0.73	1.12			
47				767.04	767.04			8.00	2.74	5.26	3.63	0.62	1.06			
	j		150.00	-	-	1200	0.0011	-	-	-		-	-	3.60	11.29	
48				988.03	988.03			8.00	2.58	5.42	3.47	0.74	1.10			

Table 1 (11/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 11 Notes: entrance flow (l/s):
48				767.04	767.04			8.00	2.58	5.42	3.47	0.62	1.05			
	j		150.00	-	-	1200	0.0011	-	-	-		-	-	3.57	11.30	
49				988.03	988.03			8.00	2.42	5.58	3.32	0.74	1.10			
49				767.04	767.04			8.00	2.12	5.88	2.86	0.42	1.06			
	j		150.00	-	-	1500	0.0011	-	-	-		-	-	3.63	11.45	
50				988.03	988.03			8.00	1.96	6.04	2.70	0.49	1.13			
50				767.04	1115.752			8.00	1.20	6.80	2.02	0.46	1.37			
	j		60.00	-	-	1500	0.0017	-	-	-		-	-	5.96	11.81	
51				988.03	1437.21			8.00	1.10	6.90	1.92	0.54	1.46			
51				1115.75	1115.75			8.00	1.10	6.90	2.15	0.59	1.04			
	j		50.00	-	-	1500	0.0008	-	-	-		-	-	3.29	12.53	
52				1437.21	1437.21			8.00	1.06	6.94	2.11	0.70	1.10			
52				1115.75	1115.75			8.00	1.06	6.94	2.13	0.59	1.03			
	j		130.00	-	-	1500	0.0008	-	-	-		-	-	3.19	12.56	
53				1437.21	1437.21			7.00	0.96	6.04	2.03	0.71	1.08			
53				1141.81	1141.81			7.00	0.96	6.04	2.01	0.58	1.07			
	j	57.951	130.00	-	-	1500	0.0008	-	-	-		-	-	3.48	12.52	26.055
54				1470.77	1470.77			7.00	0.85	6.15	1.90	0.70	1.13			33.561
54				1141.81	1141.81			7.00	0.85	6.15	1.93	0.60	1.04			
	j		90.00	-	-	1500	0.0008	-	-	-		-	-	3.24	12.58	
55				1470.77	1470.77			7.00	0.78	6.22	1.86	0.72	1.09			
55				1141.81	1141.81			7.00	0.78	6.22	1.83	0.59	1.07			
	j		60.00	-	-	1500	0.0008	-	-	-		-	-	3.43	12.53	
56				1470.77	1470.77			7.00	0.73	6.27	1.78	0.70	1.12			
56				1141.81	1141.81			7.00	0.73	6.27	1.80	0.60	1.05			
	j		100.00	-	-	1500	0.0008	-	-	-		-	-	3.32	12.56	
57				1470.77	1470.77			7.00	0.65	6.35	1.72	0.71	1.10			
57				1141.81	1141.81			7.00	0.65	6.35	1.73	0.60	1.03			
	j		70.00	-	-	1500	0.0008	-	-	-		-	-	3.22	12.58	
58				1470.77	1470.77			7.00	0.60	6.40	1.68	0.72	1.08			
58				1141.81	1141.81			7.00	0.60	6.40	1.68	0.60	1.03			
	j		60.00	-	-	1500	0.0008	-	-	-		-	-	3.20	12.59	
59				1470.77	1470.77			7.00	0.55	6.45	1.63	0.72	1.08			
59				1141.81	1141.81			7.00	0.55	6.45	1.63	0.60	1.04			
	j		70.00	-	-	1500	0.0008	-	-	-		-	-	3.27	12.57	
60				1470.77	1470.77			7.00	0.50	6.51	1.57	0.72	1.09			
60				1185.69	1185.69			7.00	0.50	6.51	1.60	0.62	1.05			
	j	97.604	50.00	-	-	1500	0.0008	-	-	-		-	-	3.29	12.62	43.882
61				1527.30	1527.30			7.00	0.46	6.54	1.56	0.74	1.10			56.525
61				1194.93	1194.93			7.00	0.46	6.54	1.58	0.63	1.04			
	j	20.562	100.00	-	-	1500	0.0008	-	-	-		-	-	3.23	12.64	9.245
62				1539.21	1539.21			7.00	0.38	6.62	1.51	0.75	1.08			11.908
62				1194.93	1194.93			7.00	0.38	6.62	1.48	0.61	1.06			
	j		100.00	-	-	1500	0.0008	-	-	-		-	-	3.37	12.62	
63				1539.21	1539.21			7.00	0.30	6.70	1.40	0.74	1.11			
63				1194.93	1194.93			7.00	0.30	6.70	1.40	0.61	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.37	12.62	
64				1539.21	1539.21			6.00	0.18	5.82	1.28	0.74	1.11			

Table 1 (12/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 12 Notes: entrance flow (l/s):
64				1194.93	1194.93			6.00	0.18	5.82	1.28	0.61	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.37	12.62	
65				1539.21	1539.21			6.00	0.06	5.94	1.16	0.74	1.11			
65				1205.29	1205.29			6.00	0.06	5.94	1.17	0.62	1.06			
	j	23.031	150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	10.355
66				1552.54	1552.54			6.00	-0.06	6.06	1.05	0.74	1.11			13.338
66				1205.29	1205.29			6.00	-0.06	6.06	1.05	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
67				1552.54	1552.54			6.00	-0.18	6.18	0.93	0.74	1.11			
67				1205.29	1205.29			6.00	-0.18	6.18	0.93	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
68				1552.54	1552.54			6.00	-0.30	6.30	0.81	0.74	1.11			
68				1205.29	1205.29			6.00	-0.30	6.30	0.82	0.62	1.05			
	j		140.00	-	-	1500	0.0008	-	-	-		-	-	3.33	12.64	
69				1552.54	1552.54			7.00	-0.41	7.41	0.71	0.75	1.10			
69				1205.29	1205.29			7.00	-0.41	7.41	0.70	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
70				1552.54	1552.54			4.00	-0.53	4.53	0.58	0.74	1.11			
70				1205.29	1205.29			4.00	-0.53	4.53	0.58	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
71				1552.54	1552.54			4.00	-0.65	4.65	0.46	0.74	1.11			
71				1205.29	1205.29			4.00	-0.65	4.65	0.46	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
72				1552.54	1552.54			4.00	-0.77	4.77	0.34	0.74	1.11			
72				1205.29	1205.29			4.00	-0.77	4.77	0.34	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
73				1552.54	1552.54			4.00	-0.89	4.89	0.22	0.74	1.11			
73				1205.29	1205.29			4.00	-0.89	4.89	0.22	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
74				1552.54	1552.54			4.00	-1.01	5.01	0.10	0.74	1.11			
74				1205.29	1205.29			4.00	-1.01	5.01	0.10	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
75				1552.54	1552.54			4.00	-1.13	5.13	-0.02	0.74	1.11			
75				1205.29	1205.29			4.00	-1.13	5.13	-0.03	0.61	1.07			
	j		110.00	-	-	1500	0.0008	-	-	-		-	-	3.44	12.61	
76				1552.54	1552.54			4.00	-1.22	5.22	-0.12	0.73	1.12			
76				1205.29	1205.29			4.00	-1.22	5.22	-0.11	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
77				1552.54	1552.54			4.00	-1.34	5.34	-0.23	0.74	1.11			
77				1205.29	1205.29			4.00	-1.34	5.34	-0.23	0.62	1.06			
	j		50.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
78				1552.54	1552.54			4.00	-1.38	5.38	-0.27	0.74	1.11			
78				1205.29	1205.29			4.00	-1.38	5.38	-0.27	0.62	1.06			
	j		80.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
79				1552.54	1552.54			4.00	-1.44	5.44	-0.33	0.74	1.11			
79				1205.29	1205.29			4.00	-1.44	5.44	-0.33	0.62	1.06			
	j		120.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
80				1552.54	1552.54			4.00	-1.54	5.54	-0.43	0.74	1.11			

Table 1 (13/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 13 Notes: entrance flow (l/s):
80				1205.29	1205.29			4.00	-1.54	5.54	-0.45	0.61	1.08			
	j		60.00	-	-	1500	0.0008	-	-	-		-	-	3.50	12.60	
81				1552.54	1552.54			4.00	-1.59	5.59	-0.50	0.73	1.13			
81				1205.29	1205.29			4.00	-1.59	5.59	-0.46	0.63	1.05			
	j		70.00	-	-	1500	0.0008	-	-	-		-	-	3.28	12.64	
82				1552.54	1552.54			4.00	-1.64	5.64	-0.52	0.75	1.09			
82				1205.29	1205.29			4.00	-1.64	5.64	-0.55	0.61	1.08			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.52	12.60	
83				1552.54	1552.54			4.00	-1.77	5.77	-0.68	0.73	1.13			
83				1205.29	1205.29			4.00	-1.77	5.77	-0.66	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
84				1552.54	1552.54			5.00	-1.89	6.89	-0.78	0.74	1.11			
84				1205.29	1205.29			5.00	-1.89	6.89	-0.78	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
85				1552.54	1552.54			4.00	-2.01	6.01	-0.90	0.74	1.11			
85				1205.29	1205.29			4.00	-2.01	6.01	-0.90	0.62	1.06			
	j		150.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
86				1552.54	1552.54			4.00	-2.13	6.13	-1.02	0.74	1.11			
86				1205.29	1205.29			4.00	-2.13	6.13	-1.01	0.62	1.05			
	j		140.00	-	-	1500	0.0008	-	-	-		-	-	3.33	12.64	
87				1552.54	1552.54			4.00	-2.24	6.24	-1.12	0.75	1.10			
87				1205.29	1205.29			4.00	-2.24	6.24	-1.15	0.61	1.08			
	j		120.00	-	-	1500	0.0008	-	-	-		-	-	3.50	12.60	
88				1552.54	1552.54			4.00	-2.34	6.34	-1.25	0.73	1.13			
88				1205.29	1205.29			4.00	-2.34	6.34	-1.25	0.61	1.08			
	j		120.00	-	-	1500	0.0008	-	-	-		-	-	3.50	12.60	
89				1552.54	1552.54			4.00	-2.44	6.44	-1.35	0.73	1.13			
89				1205.29	1205.29			4.00	-2.44	6.44	-1.33	0.62	1.06			
	j		50.00	-	-	1500	0.0008	-	-	-		-	-	3.38	12.63	
90				1552.54	1552.54			4.00	-2.48	6.48	-1.37	0.74	1.11			
90				1205.29	1205.29			4.00	-2.48	6.48	-1.36	0.62	1.05			
	j		90.00	-	-	1500	0.0008	-	-	-		-	-	3.30	12.64	
91				1552.54	1552.54			4.00	-2.55	6.55	-1.43	0.75	1.10			
91				1205.29	1205.29			4.00	-2.55	6.55	-1.46	0.61	1.08			
	j		12.00	-	-	1500	0.0008	-	-	-		-	-	3.50	12.60	
TC053 (PDBG1)				1552.54	1552.54			4.00	-2.56	6.56	-1.47	0.73	1.13			
TOTAL			9,912.00							6.56						

Table 1 (14/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

JICA	PAVUNA SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 3-1 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 14 Notes: entrance flow (l/s):
14.1				70.85	70.85			29.90	27.90	2.00	28.09	0.42	1.41			
	o	157.579	150.00	-	-	400	0.0113	-	-	-		-	-	10.02	5.87	70.847
14.2				91.26	91.26			28.20	26.20	2.00	26.39	0.48	1.51			91.258
14.2				70.85	70.85			28.20	26.20	2.00	26.39	0.42	1.41			
	o		150.00	-	-	400	0.0113	-	-	-		-	-	10.02	5.87	
14.3				91.26	91.26			26.50	24.50	2.00	24.69	0.48	1.51			
14.3				70.85	70.85			26.50	24.50	2.00	24.69	0.42	1.41			
	o		150.00	-	-	400	0.0113	-	-	-		-	-	10.02	5.87	
14.4				91.26	91.26			24.80	22.80	2.00	22.99	0.48	1.51			
14.4				70.85	70.85			24.80	22.80	2.00	22.99	0.42	1.41			
	o		150.00	-	-	400	0.0113	-	-	-		-	-	10.02	5.87	
14.5				91.26	91.26			23.10	21.10	2.00	21.29	0.48	1.51			
14.5				70.85	70.85			23.10	21.10	2.00	21.29	0.42	1.41			
	o		150.00	-	-	400	0.0113	-	-	-		-	-	10.02	5.87	
14.6				91.26	91.26			21.50	19.40	2.10	19.59	0.48	1.51			
14.6				70.85	70.85			21.50	19.40	2.10	19.62	0.46	1.24			
	o		150.00	-	-	400	0.0080	-	-	-		-	-	7.58	6.08	
14.7				91.26	91.26			20.60	18.20	2.40	18.42	0.54	1.32			
14.7				70.85	70.85			20.60	18.20	2.40	18.42	0.46	1.24			
	o		150.00	-	-	400	0.0080	-	-	-		-	-	7.58	6.08	
14.8				91.26	91.26			19.00	17.00	2.00	17.22	0.54	1.32			
14.8				70.85	70.85			19.00	17.00	2.00	17.22	0.46	1.24			
	o		150.00	-	-	400	0.0080	-	-	-		-	-	7.58	6.08	
14.9				91.26	91.26			18.70	15.80	2.90	16.02	0.54	1.32			
14.9				70.85	70.85			18.70	15.80	2.90	16.07	0.57	0.96			
	o		130.00	-	-	400	0.0040	-	-	-		-	-	4.33	6.44	
14.10				91.26	91.26			18.80	15.28	3.52	15.55	0.68	1.01			
14.10				70.85	70.85			18.80	15.28	3.52	15.55	0.57	0.96			
	o		20.00	-	-	400	0.0040	-	-	-		-	-	4.33	6.44	
14.11				91.26	91.26			17.30	15.20	2.10	15.47	0.68	1.01			
14.11				102.36	102.36			17.30	15.10	2.20	15.39	0.49	1.05			
	o	70.084	130.00	-	-	500	0.0040	-	-	-		-	-	4.96	6.95	31.510
14.12				131.85	131.85			16.80	14.58	2.22	14.87	0.58	1.12			40.588
14.12				102.36	102.36			16.80	14.58	2.22	14.87	0.49	1.05			
	o		130.00	-	-	500	0.0040	-	-	-		-	-	4.96	6.95	
14.13				131.85	131.85			16.50	14.06	2.44	14.35	0.58	1.12			
14.13				102.36	102.36			16.50	14.06	2.44	14.35	0.49	1.05			
	o		70.00	-	-	500	0.0040	-	-	-		-	-	4.96	6.95	
14.14				131.85	131.85			15.90	13.78	2.12	14.07	0.58	1.12			
14.14				102.36	102.36			15.90	13.78	2.12	14.07	0.49	1.05			
	o		140.00	-	-	500	0.0040	-	-	-		-	-	4.96	6.95	
14.15				131.85	131.85			16.10	13.22	2.88	13.51	0.58	1.12			
14.15				102.36	102.36			16.10	13.22	2.88	13.51	0.49	1.05			
	o		120.00	-	-	500	0.0040	-	-	-		-	-	4.96	6.95	
14.16				131.85	131.85			15.50	12.74	2.76	13.03	0.58	1.12			

Table 1 (15/15) Trunk Sewer Hydraulic Calculation of Pavuna Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 15 Notes: entrance flow (l/s):
14.16	o	65.488	150.00	131.80 - 169.77	131.80 - 169.77	500	0.0040	15.50 - 14.70	12.74 - 12.14	2.76 - 2.56	13.09 12.49	0.58 - 0.69	1.12 - 1.18	5.47	7.22	29.443 37.926
14.17	o		150.00	131.80 - 169.77	131.80 - 169.77	500	0.0040	14.70 - 13.80	12.14 - 11.54	2.56 - 2.26	12.49 11.89	0.58 - 0.69	1.12 - 1.18	5.47	7.22	
14.18	o		150.00	131.80 - 169.77	131.80 - 169.77	500	0.0040	13.80 - 13.30	11.54 - 10.94	2.26 - 2.36	11.89 11.29	0.58 - 0.69	1.12 - 1.18	5.47	7.22	
14.19	o		90.00	131.80 - 169.77	131.80 - 169.77	500	0.0040	13.30 - 13.10	10.94 - 10.58	2.36 - 2.52	11.29 10.93	0.58 - 0.69	1.12 - 1.18	5.47	7.22	
14 (No. 3 TS)																
TOTAL			2,480.00							2.52						

1.2 ACARI SEWER DISTRICT

Trunk Sewer Hydraulic Calculation of Acari Sewer District is shown in *Table 2 (1/18 - 18/18).*

Table 2 (1/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

JICA	ACARI SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1 TRUNK SEWER																
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 1 Notes: entrance flow (l/s):	
1				12.58	12.58			34.00	30.00	4.00	30.12	0.21	0.41				
	j	33.025	150.00	-	-	500	0.0015	-	-	-		-	-	0.94	5.02	12.575	
2				16.20	16.20			34.00	29.78	4.22	29.90	0.24	0.44			16.198	
2				12.58	12.58			34.00	29.78	4.22	29.90	0.21	0.42				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	0.97	5.00		
3				16.20	16.20			34.00	29.55	4.45	29.67	0.24	0.45				
3				12.58	12.58			34.00	29.55	4.45	29.67	0.21	0.41				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	0.94	5.02		
4				16.20	16.20			34.00	29.33	4.67	29.45	0.24	0.44				
4				12.58	12.58			34.00	29.33	4.67	29.45	0.21	0.42				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	0.97	5.00		
5				16.20	16.20			34.00	29.10	4.90	29.22	0.24	0.45				
5				12.58	12.58			34.00	29.10	4.90	29.22	0.21	0.42				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	0.97	5.00		
6				16.20	16.20			32.00	28.87	3.13	28.99	0.24	0.45				
6				12.58	12.58			32.00	28.87	3.13	28.99	0.21	0.41				
	j		100.00	-	-	500	0.0015	-	-	-		-	-	0.96	5.01		
7				16.20	16.20			32.00	28.72	3.28	28.84	0.24	0.44				
7				36.97	36.97			32.00	28.72	3.28	28.93	0.37	0.56				
	j	64.070	100.00	-	-	500	0.0015	-	-	-		-	-	1.51	6.27	24.395	
8				47.62	47.62			32.00	28.57	3.43	28.78	0.42	0.60			31.424	
8				36.97	36.97			32.00	28.57	3.43	28.78	0.37	0.56				
	j		100.00	-	-	500	0.0015	-	-	-		-	-	1.51	6.27		
9				47.62	47.62			32.00	28.42	3.58	28.63	0.42	0.60				
9				36.97	36.97			32.00	28.42	3.58	28.63	0.37	0.56				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.49	6.28		
10				47.62	47.62			32.00	28.20	3.80	28.41	0.42	0.59				
10				36.97	36.97			32.00	28.20	3.80	28.41	0.37	0.56				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.49	6.28		
11				47.62	47.62			31.40	27.98	3.42	28.19	0.42	0.59				
11				36.97	36.97			31.40	27.98	3.42	28.19	0.37	0.56				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.54	6.26		
12				47.62	47.62			31.00	27.75	3.25	27.96	0.42	0.60				
12				36.97	36.97			31.00	27.75	3.25	27.96	0.37	0.56				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.49	6.28		
13				47.62	47.62			31.00	27.53	3.47	27.74	0.42	0.59				
13				36.97	36.97			31.00	27.53	3.47	27.74	0.37	0.56				
	j		100.00	-	-	500	0.0015	-	-	-		-	-	1.51	6.27		
14				47.62	47.62			31.00	27.38	3.62	27.59	0.42	0.60				
14				60.22	60.22			31.00	27.38	3.62	27.66	0.48	0.64				
	j	61.067	140.00	-	-	500	0.0015	-	-	-		-	-	1.83	6.90	23.252	
15				77.57	77.57			31.00	27.17	3.83	27.45	0.57	0.68			29.951	
15				60.22	60.22			31.00	27.17	3.83	27.46	0.49	0.63				
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.80	6.91		
16				77.57	77.57			31.00	26.95	4.05	27.24	0.57	0.67				

Table 2 (2/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 2 Notes: entrance flow (l/s):
16				60.22	60.22			31.00	26.95	4.05	27.24	0.49	0.63			
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.80	6.91	
17				77.57	77.57			30.60	26.73	3.87	27.02	0.57	0.67			
17				60.22	60.22			30.60	26.73	3.87	27.01	0.48	0.64			
	j		150.00	-	-	500	0.0015	-	-	-		-	-	1.87	6.88	
18				77.57	77.57			30.40	26.50	3.90	26.78	0.56	0.68			
18				74.45	74.45			30.40	26.50	3.90	26.83	0.55	0.67			
	j	37.355	100.00	-	-	500	0.0015	-	-	-		-	-	1.99	7.15	14.223
19				95.89	95.89			30.00	26.35	3.65	26.68	0.66	0.71			18.321
19				74.45	74.45			30.00	26.35	3.65	26.68	0.55	0.67			
	j		100.00	-	-	500	0.0015	-	-	-		-	-	1.99	7.15	
20				95.89	95.89			28.80	26.20	2.60	26.53	0.66	0.71			
20				74.45	262.05			28.80	25.44	3.36	25.90	0.44	0.97			
	j	42.954	110.00	-	-	900	0.0017	-	-	-		-	-	3.55	8.96	
21				95.89	337.13			28.50	25.25	3.25	25.71	0.51	1.03			
21				262.05	262.05			28.50	25.25	3.25	25.71	0.44	0.96			
	j		130.00	-	-	900	0.0017	-	-	-		-	-	3.50	8.98	
22				337.13	337.13			28.20	25.03	3.17	25.49	0.51	1.02			
22				262.05	262.05			28.20	25.03	3.17	25.49	0.44	0.96			
	j		130.00	-	-	900	0.0017	-	-	-		-	-	3.50	8.98	
23				337.13	337.13			27.80	24.81	2.99	25.27	0.51	1.02			
23				262.05	262.05			27.80	24.81	2.99	25.27	0.44	0.96			
	o		130.00	-	-	900	0.0017	-	-	-		-	-	3.50	8.98	
24				337.13	337.13			27.50	24.59	2.91	25.05	0.51	1.02			
24				278.40	278.40			27.50	24.59	2.91	25.07	0.46	0.98			
	o		100.00	-	-	900	0.0017	-	-	-		-	-	3.59	9.08	16.355
25				358.19	358.19			27.15	24.42	2.73	24.90	0.53	1.04			21.067
25				278.40	278.40			27.15	24.42	2.73	24.81	0.38	1.23			
	o		100.00	-	-	900	0.0032	-	-	-		-	-	5.98	8.53	
26				358.19	358.19			26.80	24.10	2.70	24.49	0.44	1.32			
26				284.29	284.29			26.80	24.10	2.70	24.73	0.58	0.74			
	o	15.473	100.00	-	-	900	0.0008	-	-	-		-	-	1.97	9.70	5.892
27				365.78	365.78			27.00	24.02	2.98	24.65	0.70	0.78			7.589
27				284.29	284.29			27.00	24.02	2.98	24.65	0.58	0.74			
	o		100.00	-	-	900	0.0008	-	-	-		-	-	1.97	9.70	
28				365.78	365.78			27.00	23.94	3.06	24.57	0.70	0.78			
28				284.29	284.29			27.00	23.84	3.16	24.60	0.63	0.55			EXISTING
	-		104.00	-	-	1000	0.0004	-	-	-		-	-	1.04	10.33	
29				365.78	365.78			27.83	23.80	4.03	24.56	0.76	0.57			
29				300.54	300.54			27.83	23.80	4.03	24.57	0.64	0.58			EXISTING
	-	42.676	53.00	-	-	1000	0.0004	-	-	-		-	-	1.13	10.34	16.251
30				386.71	386.71			27.98	23.78	4.20	24.55	0.77	0.60			20.932
30				300.54	300.54			27.98	23.78	4.20	24.52	0.61	0.60			EXISTING
	-		100.00	-	-	1000	0.0004	-	-	-		-	-	1.24	10.30	
31				386.71	386.71			28.06	23.74	4.32	24.47	0.74	0.63			
31				300.54	300.54			28.06	23.74	4.32	24.32	0.49	0.78			EXISTING
	-		85.00	-	-	1000	0.0009	-	-	-		-	-	2.15	9.81	
32				386.71	386.71			28.02	23.66	4.36	24.24	0.58	0.83			

Table 2 (3/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 3 Notes: entrance flow (l/s):
32				300.54	300.54			28.02	23.66	4.36	24.46	0.67	0.55			EXISTING
	-		100.00	-	-	1000	0.0004	-	-	-		-	-	1.02	10.37	
33				386.71	386.71			28.16	23.63	4.53	24.43	0.80	0.56			
33				300.54	300.54			28.16	23.63	4.53	24.30	0.56	0.66			EXISTING
	-		74.00	-	-	1000	0.0006	-	-	-		-	-	1.52	10.15	
34				386.71	386.71			28.02	23.59	4.43	24.26	0.67	0.70			
34				300.54	300.54			28.02	23.59	4.43	23.87	0.25	1.94			EXISTING
	-		10.00	-	-	1000	0.0110	-	-	-		-	-	16.14	7.58	
35				386.71	386.71			28.11	23.48	4.63	23.76	0.28	2.08			
35				300.54	300.54			28.11	23.48	4.63	24.11	0.53	0.70			EXISTING
	-		73.00	-	-	1000	0.0007	-	-	-		-	-	1.75	10.03	
36				386.71	386.71			27.93	23.43	4.51	24.06	0.63	0.75			
36				312.54	312.54			27.93	23.43	4.51	24.20	0.65	0.59			EXISTING
	-	31.500	85.00	-	-	1000	0.0004	-	-	-		-	-	1.18	10.35	11.995
37				402.16	402.16			27.66	23.39	4.27	24.17	0.78	0.61			15.450
37				312.54	312.54			27.66	23.39	4.27	23.97	0.49	0.80			EXISTING
	-		95.00	-	-	1000	0.0009	-	-	-		-	-	2.32	9.81	
38				402.16	402.16			27.51	23.30	4.21	23.88	0.58	0.86			
38				312.54	312.54			27.51	23.30	4.21	23.85	0.47	0.86			EXISTING
	-		79.00	-	-	1000	0.0011	-	-	-		-	-	2.69	9.65	
39				402.16	402.16			27.14	23.21	3.93	23.76	0.54	0.92			
39				312.54	312.54			27.14	23.21	3.93	23.86	0.55	0.71			EXISTING
	-		85.00	-	-	1000	0.0007	-	-	-		-	-	1.77	10.09	
40				402.16	402.16			26.89	23.16	3.73	23.81	0.65	0.75			
40				312.54	312.54			26.89	23.16	3.73	24.00	0.70	0.54			EXISTING
	-		69.00	-	-	1000	0.0003	-	-	-		-	-	0.99	10.36	
41				402.16	402.16			26.80	23.13	3.67	23.98	0.84	0.55			
41				324.54	324.54			26.80	21.86	4.94	22.38	0.38	0.83			EXISTING
	-	31.512	67.00	-	-	1200	0.0010	-	-	-		-	-	2.46	9.79	11.999
42				417.62	417.62			26.86	21.80	5.06	22.31	0.43	0.88			15.456
42				324.54	324.54			26.86	21.80	5.06	22.44	0.46	0.63			EXISTING
	-		59.00	-	-	1200	0.0005	-	-	-		-	-	1.35	10.53	
43				417.62	417.62			26.95	21.77	5.18	22.42	0.54	0.67			
43				324.54	324.54			26.95	21.77	5.18	22.20	0.32	1.09			EXISTING
	-		59.00	-	-	1200	0.0021	-	-	-		-	-	4.48	9.13	
44				417.62	417.62			26.19	21.65	4.54	22.08	0.36	1.16			
44				324.54	324.54			26.19	21.65	4.54	22.33	0.49	0.59			EXISTING
	-		43.00	-	-	1200	0.0004	-	-	-		-	-	1.17	10.71	
45				417.62	417.62			26.14	21.63	4.51	22.32	0.57	0.63			
45				324.54	842.02			26.14	21.63	4.51	23.07	0.98	0.62			EXISTING
	-		79.00	-	-	1200	0.0004	-	-	-		-	-	1.26	#NUM!	
46				417.62	1084.19			25.63	21.60	4.03	23.04	1.20	#NUM!			
46				842.02	842.02			25.63	21.60	4.03	22.87	0.86	0.77			EXISTING
	-		79.00	-	-	1200	0.0005	-	-	-		-	-	1.88	#NUM!	
47				1084.19	1084.19			25.47	21.56	3.91	22.83	1.06	#NUM!			
47				842.02	842.02			25.47	21.56	3.91	22.33	0.54	1.35			EXISTING
	-		79.00	-	-	1200	0.0019	-	-	-		-	-	6.05	11.01	
48				1084.19	1084.19			24.81	21.41	3.40	22.18	0.64	1.43			

Table 2 (4/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 4 Notes: entrance flow (l/s):
48				842.02	842.02			24.81	21.41	3.40	21.88	0.35	2.46			EXISTING
	-		20.00	-	-	1200	0.0097	-	-	-		-	-	22.23	9.45	
49				1084.19	1084.19			25.01	21.21	3.80	21.68	0.39	2.62			
49				842.02	842.02			25.01	21.21	3.80	21.93	0.41	1.21			EXISTING
	-		63.00	-	-	1500	0.0015	-	-	-		-	-	4.79	11.32	
50				1084.19	1084.19			24.52	21.12	3.40	21.83	0.48	1.30			
50				842.02	842.02			24.52	21.12	3.40	21.56	0.26	2.33			EXISTING
	-		69.00	-	-	1500	0.0089	-	-	-		-	-	20.06	9.38	
51				1084.19	1084.19			23.95	20.51	3.44	20.94	0.29	2.49			
51				842.02	842.02			23.95	20.51	3.44	21.17	0.39	1.32			EXISTING
	-		123.00	-	-	1500	0.0018	-	-	-		-	-	5.75	11.07	
52				1084.19	1084.19			23.97	20.28	3.69	20.95	0.44	1.41			
52				842.02	842.02			23.97	20.28	3.69	20.84	0.33	1.68			EXISTING
	-		74.00	-	-	1500	0.0035	-	-	-		-	-	9.71	10.40	
53				1084.19	1084.19			23.59	20.03	3.56	20.59	0.38	1.78			
53				842.02	842.02			23.59	20.03	3.56	20.63	0.35	1.52			EXISTING
	-		107.00	-	-	1500	0.0027	-	-	-		-	-	7.80	10.67	
54				1084.19	1084.19			22.93	19.74	3.19	20.34	0.40	1.62			
54				842.02	842.02			22.93	19.74	3.19	20.05	0.18	3.79			EXISTING
	-		4.00	-	-	1500	0.0347	-	-	-		-	-	58.61	8.15	
55				1084.19	1084.19			22.49	19.60	2.89	19.91	0.21	4.08			
55				842.02	842.02			22.49	19.60	2.89	20.29	0.40	1.27			EXISTING
	-		48.00	-	-	1500	0.0016	-	-	-		-	-	5.28	11.18	
56				1084.19	1084.19			23.17	19.52	3.65	20.21	0.46	1.35			
56				842.02	842.02			23.17	19.52	3.65	20.04	0.30	1.86			EXISTING
	-		78.00	-	-	1500	0.0048	-	-	-		-	-	12.28	10.09	
57				1084.19	1084.19			22.98	19.15	3.83	19.67	0.35	2.02			
57				842.02	842.02			22.98	19.15	3.83	19.76	0.36	1.49			EXISTING
	-		82.00	-	-	1500	0.0025	-	-	-		-	-	7.53	10.71	
58				1084.19	1084.19			22.72	18.94	3.78	19.55	0.41	1.59			
58				842.02	842.02			22.72	18.94	3.78	19.50	0.33	1.70			EXISTING
	-		81.00	-	-	1500	0.0036	-	-	-		-	-	9.99	10.37	
59				1084.19	1084.19			22.52	18.65	3.87	19.20	0.37	1.81			
59				842.02	842.02			22.52	18.65	3.87	19.33	0.40	1.28			EXISTING
	-		75.00	-	-	1500	0.0017	-	-	-		-	-	5.37	11.16	
60				1084.19	1084.19			22.40	18.52	3.88	19.20	0.46	1.36			
60				842.02	842.02			22.40	18.52	3.88	19.13	0.36	1.49			EXISTING
	-		81.00	-	-	1500	0.0026	-	-	-		-	-	7.54	10.71	
61				1084.19	1084.19			22.16	18.31	3.85	18.92	0.41	1.59			
61				842.02	842.02			22.16	18.31	3.85	18.90	0.34	1.59			EXISTING
	-		81.00	-	-	1500	0.0030	-	-	-		-	-	8.66	10.54	
62				1084.19	1084.19			21.87	18.07	3.80	18.65	0.39	1.70			
62				842.02	842.02			21.87	18.07	3.80	18.64	0.34	1.65			EXISTING
	-		81.00	-	-	1500	0.0033	-	-	-		-	-	9.39	10.44	
63				1084.19	1084.19			21.28	17.80	3.48	18.37	0.38	1.76			
63				842.02	842.02			21.28	17.39	3.89	18.00	0.36	1.48			EXISTING
	-		93.00	-	-	1500	0.0025	-	-	-		-	-	7.37	10.74	
64				1084.19	1084.19			21.29	17.16	4.13	17.77	0.41	1.58			

Table 2 (5/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 5 Notes: entrance flow (l/s):
64				842.02	842.02			21.29	17.16	4.13	17.77	0.36	1.48			EXISTING
	-		76.00	-	-	1500	0.0025	-	-	-		-	-	7.38	10.74	
65				1084.19	1084.19			21.21	16.97	4.24	17.58	0.41	1.58			
65				842.02	842.02			21.21	16.97	4.24	17.58	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
66				1084.19	1084.19			21.03	16.77	4.26	17.38	0.41	1.58			
66				842.02	842.02			21.03	16.77	4.26	17.38	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
67				1084.19	1084.19			20.78	16.57	4.21	17.18	0.41	1.58			
67				842.02	842.02			20.78	16.57	4.21	17.18	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.39	10.73	
68				1084.19	1084.19			20.63	16.36	4.27	16.98	0.41	1.58			
68				842.02	842.02			20.63	16.36	4.27	16.98	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.39	10.73	
69				1084.19	1084.19			20.44	16.16	4.28	16.77	0.41	1.58			
69				842.02	842.02			20.44	16.16	4.28	16.77	0.36	1.48			EXISTING
	-		76.00	-	-	1500	0.0025	-	-	-		-	-	7.38	10.74	
70				1084.19	1084.19			20.18	15.97	4.21	16.59	0.41	1.58			
70				842.02	842.02			20.18	15.97	4.21	16.58	0.36	1.48			EXISTING
	-		82.00	-	-	1500	0.0025	-	-	-		-	-	7.41	10.73	
71				1084.19	1084.19			19.91	15.77	4.15	16.38	0.41	1.58			
71				842.02	842.02			19.91	15.77	4.15	16.38	0.36	1.48			EXISTING
	-		80.00	-	-	1500	0.0025	-	-	-		-	-	7.38	10.74	
72				1084.19	1084.19			19.72	15.57	4.15	16.18	0.41	1.58			
72				842.02	842.02			19.72	15.57	4.15	16.18	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
73				1084.19	1084.19			19.48	15.37	4.11	15.98	0.41	1.58			
73				842.02	842.02			19.48	15.37	4.11	15.98	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
74				1084.19	1084.19			19.38	15.16	4.21	15.77	0.41	1.58			
74				842.02	842.02			19.38	15.16	4.21	15.77	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
75				1084.19	1084.19			19.02	14.96	4.07	15.57	0.41	1.58			
75				842.02	842.02			19.02	14.96	4.07	15.57	0.36	1.48			EXISTING
	-		81.00	-	-	1500	0.0025	-	-	-		-	-	7.42	10.73	
76				1084.19	1084.19			18.91	14.76	4.15	15.37	0.41	1.58			
76				842.02	842.02			18.91	14.76	4.15	15.37	0.36	1.48			EXISTING
	-		72.00	-	-	1500	0.0025	-	-	-		-	-	7.41	10.73	
77				1084.19	1084.19			18.93	14.58	4.35	15.19	0.41	1.58			
77				842.02	842.02			18.93	14.58	4.35	15.19	0.36	1.48			EXISTING
	-		104.00	-	-	1500	0.0025	-	-	-		-	-	7.43	10.73	
78				1084.19	1084.19			18.53	14.32	4.22	14.93	0.41	1.58			
78				842.02	842.02			18.53	14.32	4.22	14.76	0.26	2.27			
	j		80.00	-	-	1500	0.0083	-	-	-		-	-	18.98	9.45	
79				1084.19	1084.19			18.15	13.65	4.50	14.09	0.29	2.43			
79				999.25	999.25			18.15	13.65	4.50	14.15	0.28	2.38			
	j	412.922	150.00	-	-	1500	0.0083	-	-	-		-	-	20.38	9.92	157.226
80				1286.71	1286.71			17.40	12.40	5.00	12.90	0.33	2.59			202.522

Table 2 (6/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 6 Notes: entrance flow (l/s):
80				999.25	999.25			17.40	12.40	5.00	12.90	0.28	2.38			
	j		90.00	-	-	1500	0.0083	-	-	-		-	-	20.38	9.92	
81				1286.71	1286.71			17.00	11.65	5.35	12.15	0.33	2.59			
81				999.25	1441.63			17.00	10.92	6.08	11.92	0.56	1.42			
	j		110.00	-	-	1500	0.0015	-	-	-		-	-	6.19	12.41	
82				1286.71	1856.55			16.30	10.75	5.55	11.75	0.66	1.51			
82				1441.63	1441.63			16.30	10.75	5.55	11.76	0.56	1.41			
	j		40.00	-	-	1500	0.0015	-	-	-		-	-	6.04	12.44	
83				1856.55	1856.55			16.10	10.69	5.41	11.70	0.67	1.49			
83				1458.62	1458.62			16.10	10.69	5.41	11.87	0.65	1.21			
	j	11.124	30.00	-	-	1500	0.0010	-	-	-		-	-	4.33	12.69	16.991
ETE				1878.44	1878.44			16.10	10.66	5.44	11.84	0.79	1.25			21.887
TOTAL			7,715.00							5.44						

JICA

ACARI SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 1-1 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
20.1				39.21	39.21			25.00	23.00	2.00	23.22	0.38	0.57			
	j	102.984	135.00	-	-	500	0.0015	-	-	-		-	-	1.53	6.35	39.212
20.2				50.44	50.44			28.00	22.80	5.20	23.02	0.44	0.60			50.439
20.2				39.21	39.21			28.00	22.80	5.20	23.02	0.38	0.57			
	j		135.00	-	-	500	0.0015	-	-	-		-	-	1.53	6.35	
20.3				50.44	50.44			27.00	22.60	4.40	22.82	0.44	0.60			
20.3				53.81	53.81			27.00	22.60	4.40	22.84	0.42	0.69			
	j	38.350	5.00	-	-	500	0.0020	-	-	-		-	-	2.21	6.56	14.602
EE-1				69.25	69.25			27.00	22.59	4.41	22.83	0.48	0.73			18.809
TOTAL			275.00							4.41						

RECALQUE: L=480m e D=100mm

20.4				4.31	58.12			32.00	30.00	2.00	30.17	0.28	1.25			
	j	11.315	150.00	-	-	500	0.0100	-	-	-		-	-	8.13	5.72	4.308
20.5				5.55	74.80			33.00	28.50	4.50	28.67	0.33	1.36			5.550
20.5				58.12	58.12			33.00	28.50	4.50	28.67	0.28	1.25			
	j		150.00	-	-	500	0.0100	-	-	-		-	-	8.13	5.72	
20.6				74.80	74.80			32.00	27.00	5.00	27.17	0.33	1.36			
20.6				99.18	99.18			32.00	27.00	5.00	27.22	0.38	1.46			
	j	107.836	50.00	-	-	500	0.0100	-	-	-		-	-	10.24	6.32	41.059
20.7				127.69	127.69			29.00	26.50	2.50	26.72	0.43	1.56			52.889
20.7				99.18	99.18			29.00	26.50	2.50	26.77	0.46	1.10			
	j		150.00	-	-	500	0.0047	-	-	-		-	-	5.55	6.81	
20.8				127.69	127.69			29.00	25.80	3.20	26.07	0.54	1.18			
20.8				99.18	99.18			29.00	25.80	3.20	26.07	0.46	1.11			
	j		150.00	-	-	500	0.0047	-	-	-		-	-	5.61	6.80	
20.9				127.69	127.69			28.00	25.09	2.91	25.36	0.54	1.18			

Table 2 (7/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 7 Notes: entrance flow (l/s):
20.9				99.18	99.18			28.00	25.09	2.91	25.36	0.46	1.10			
	j		100.00	-	-	500	0.0047	-	-	-		-	-	5.58	6.80	
20.10				127.69	127.69			28.00	24.62	3.38	24.89	0.54	1.18			
20.10				113.72	113.72			28.00	24.62	3.38	24.91	0.49	1.17			
	j	38.193	8.00	-	-	500	0.0050	-	-	-		-	-	6.19	6.94	14.542
EE-2				146.42	146.42			28.00	24.58	3.42	24.87	0.58	1.25			18.733
TOTAL			758.00							3.42						
RECALQUE: L=10m e D=150mm																
20.11				0.00	113.72			28.00	25.90	2.10	26.29	0.48	0.62			
	o		110.00	-	-	700	0.0009	-	-	-		-	-	1.55	8.14	
20.12				0.00	146.42			28.00	25.80	2.20	26.19	0.56	0.66			
20.12				113.72	113.72			28.00	25.80	2.20	26.20	0.49	0.61			
	o		60.00	-	-	700	0.0009	-	-	-		-	-	1.49	8.18	
20.13				146.42	146.42			28.00	25.75	2.25	26.15	0.57	0.65			
20.13				119.13	119.13			28.00	25.75	2.25	26.16	0.50	0.61			
	o	14.190	150.00	-	-	700	0.0009	-	-	-		-	-	1.50	8.26	5.403
20.14				153.38	153.38			29.40	25.62	3.78	26.03	0.59	0.65			6.959
20.14				187.60	187.60			29.40	25.62	3.78	26.17	0.66	0.71			
	o	179.124	95.00	-	-	700	0.0009	-	-	-		-	-	1.92	8.67	68.475
20.15				241.23	241.23			29.30	25.53	3.77	26.08	0.79	0.73			87.853
20.15				187.60	187.60			29.30	25.53	3.77	26.08	0.66	0.71			
	o		95.00	-	-	700	0.0009	-	-	-		-	-	1.92	8.67	
20 (No.1 TS)				241.23	241.23			28.80	25.44	3.36	25.99	0.79	0.73			
TOTAL			510.00							3.36						

JICA

ACARI SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 2 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
1				33.92	33.92			36.40	34.40	2.00	34.61	0.45	0.61			
	o	89.088	150.00	-	-	400	0.0020	-	-	-		-	-	1.86	6.03	33.921
2				43.69	43.69			36.80	34.10	2.70	34.31	0.52	0.65			43.694
2				33.92	33.92			36.80	34.10	2.70	34.31	0.45	0.61			
	j		130.00	-	-	400	0.0020	-	-	-		-	-	1.86	6.03	
3				43.69	43.69			37.00	33.84	3.16	34.05	0.52	0.65			
3				58.73	58.73			37.00	33.74	3.26	33.99	0.44	0.70			
	j	65.147	150.00	-	-	500	0.0020	-	-	-		-	-	2.28	6.68	24.805
4				75.65	75.65			37.30	33.44	3.86	33.69	0.51	0.75			31.952
4				58.73	58.73			37.30	33.44	3.86	33.69	0.44	0.70			
	j		150.00	-	-	500	0.0020	-	-	-		-	-	2.28	6.68	
5				75.65	75.65			37.00	33.14	3.86	33.39	0.51	0.75			
5				58.73	58.73			37.00	33.14	3.86	33.39	0.44	0.70			
	j		120.00	-	-	500	0.0020	-	-	-		-	-	2.28	6.68	
6				75.65	75.65			37.80	32.90	4.90	33.15	0.51	0.75			

Table 2 (8/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 8 Notes: entrance flow (l/s):
6				118.39	118.39			37.80	32.90	4.90	33.26	0.60	0.98			
	j	156.685	150.00	-	-	500	0.0030	-	-	-		-	-	4.15	7.25	59.659
7				152.49	152.49			36.60	32.45	4.15	32.81	0.71	1.03			76.847
7				118.39	118.39			36.60	32.45	4.15	32.81	0.60	0.98			
	j		130.00	-	-	500	0.0030	-	-	-		-	-	4.15	7.25	
8				152.49	152.49			36.30	32.06	4.24	32.42	0.71	1.03			
8				118.39	118.39			36.30	32.06	4.24	32.42	0.60	0.98			
	j		20.00	-	-	500	0.0030	-	-	-		-	-	4.15	7.25	
9				152.49	152.49			36.30	32.00	4.30	32.36	0.71	1.03			
9				118.39	118.39			36.30	32.00	4.30	32.36	0.60	0.98			
	j		110.00	-	-	500	0.0030	-	-	-		-	-	4.15	7.25	
10				152.49	152.49			36.00	31.67	4.33	32.03	0.71	1.03			
10				118.39	118.39			36.00	31.67	4.33	32.03	0.60	0.98			
	j		110.00	-	-	500	0.0030	-	-	-		-	-	4.15	7.25	
11				152.49	152.49			35.80	31.34	4.46	31.70	0.71	1.03			
11				118.39	218.86			35.80	30.94	4.86	31.39	0.43	0.82			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.58	8.92	
12				152.49	281.91			35.30	30.75	4.55	31.20	0.50	0.88			
12				218.86	218.86			35.30	30.75	4.55	31.20	0.43	0.83			
	j		130.00	-	-	900	0.0013	-	-	-		-	-	2.65	8.89	
13				281.91	281.91			35.00	30.58	4.42	31.03	0.50	0.89			
13				218.86	218.86			35.00	30.58	4.42	31.03	0.43	0.83			
	j		130.00	-	-	900	0.0013	-	-	-		-	-	2.65	8.89	
14				281.91	281.91			34.95	30.41	4.54	30.86	0.50	0.89			
14				235.36	235.36			34.95	30.41	4.54	30.88	0.45	0.84			
	j	43.328	150.00	-	-	900	0.0013	-	-	-		-	-	2.66	9.05	16.499
15				303.16	303.16			34.90	30.22	4.68	30.69	0.52	0.90			21.252
15				235.36	235.36			34.90	30.22	4.68	30.69	0.45	0.84			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.66	9.05	
16				303.16	303.16			34.85	30.03	4.82	30.50	0.52	0.90			
16				235.36	235.36			34.85	30.03	4.82	30.50	0.45	0.84			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.66	9.05	
17				303.16	303.16			34.80	29.84	4.96	30.31	0.52	0.90			
17				235.36	235.36			34.80	29.84	4.96	30.31	0.45	0.84			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.66	9.05	
18				303.16	303.16			34.40	29.65	4.75	30.12	0.52	0.90			
18				235.36	235.36			34.40	29.65	4.75	30.11	0.44	0.85			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.77	9.00	
19				303.16	303.16			33.80	29.45	4.35	29.91	0.52	0.91			
19				235.36	235.36			33.80	29.45	4.35	29.91	0.44	0.85			
	j		150.00	-	-	900	0.0013	-	-	-		-	-	2.77	9.00	
20				303.16	303.16			33.00	29.25	3.75	29.71	0.52	0.91			
20				261.22	261.22			33.00	27.30	5.70	27.71	0.40	1.11			
	j	67.918	40.00	-	-	900	0.0025	-	-	-		-	-	4.78	8.63	25.860
21				336.48	336.48			33.00	27.20	5.80	27.61	0.45	1.18			33.311
21				261.22	401.55			33.00	26.90	6.10	27.53	0.45	0.81			
	j		50.00	-	-	1200	0.0008	-	-	-		-	-	2.23	10.44	
22				336.48	517.24			32.90	26.86	6.04	27.49	0.52	0.86			

Table 2 (9/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 9 Notes: entrance flow (l/s):
22				401.55	401.55			32.90	26.86	6.04	27.48	0.45	0.81			
	j		110.00	-	-	1200	0.0008	-	-	-		-	-	2.27	10.42	
23				517.24	517.24			32.80	26.77	6.03	27.39	0.52	0.87			
23				401.55	401.55			32.80	26.77	6.03	27.39	0.45	0.81			
	j		110.00	-	-	1200	0.0008	-	-	-		-	-	2.27	10.42	
24				517.24	517.24			32.70	26.68	6.02	27.30	0.52	0.87			
24				408.94	408.94			32.70	26.68	6.02	27.32	0.45	0.81			
	j	19.404	150.00	-	-	1200	0.0008	-	-	-		-	-	2.25	10.48	7.388
25				526.76	526.76			32.50	26.56	5.94	27.20	0.53	0.87			9.517
25				408.94	408.94			32.50	26.56	5.94	27.20	0.45	0.81			
	j		150.00	-	-	1200	0.0008	-	-	-		-	-	2.25	10.48	
26				526.76	526.76			31.00	26.44	4.56	27.08	0.53	0.87			
26				408.94	408.94			31.00	26.44	4.56	26.83	0.27	1.62			
	j		150.00	-	-	1200	0.0054	-	-	-		-	-	10.22	8.75	
27				526.76	526.76			30.00	25.63	4.37	26.02	0.32	1.77			
27				417.99	498.95			30.00	25.63	4.37	26.05	0.31	1.74			
	j	23.761	80.00	-	-	1200	0.0054	-	-	-		-	-	11.46	9.06	9.048
28				538.41	642.70			29.00	25.20	3.80	25.62	0.35	1.85			11.654
28				498.95	498.95			29.00	25.20	3.80	25.62	0.31	1.74			
	j		150.00	-	-	1200	0.0053	-	-	-		-	-	11.38	9.06	
29				642.70	642.70			28.00	24.40	3.60	24.82	0.35	1.84			
29				498.95	498.95			28.00	24.40	3.60	24.82	0.31	1.74			
	j		110.00	-	-	1200	0.0054	-	-	-		-	-	11.44	9.06	
30				642.70	642.70			28.00	23.81	4.19	24.23	0.35	1.85			
30				511.15	511.15			28.00	23.81	4.19	24.23	0.32	1.76			
	j	32.030	70.00	-	-	1200	0.0054	-	-	-		-	-	11.64	9.09	12.196
31				658.41	658.41			28.00	23.43	4.57	23.85	0.35	1.86			15.709
31				511.15	511.15			28.00	23.43	4.57	23.86	0.32	1.74			
	j		100.00	-	-	1200	0.0053	-	-	-		-	-	11.41	9.11	
32				658.41	658.41			26.50	22.90	3.60	23.33	0.36	1.85			
32				517.49	517.49			26.50	22.90	3.60	23.36	0.34	1.57			
	j	16.642	150.00	-	-	1200	0.0040	-	-	-		-	-	9.07	9.37	6.336
33				666.57	666.57			26.30	22.30	4.00	22.76	0.38	1.67			8.162
33				517.49	517.49			26.30	22.30	4.00	22.76	0.34	1.57			
	j		120.00	-	-	1200	0.0040	-	-	-		-	-	9.07	9.37	
45 (No.1 TS)				666.57	666.57			26.14	21.82	4.32	22.28	0.38	1.67			
TOTAL			4,070.00						21.63	4.32						

Table 2 (10/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

JICA	ACARI SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 2-1 TRUNK SEWER																
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 10 Notes: entrance flow (l/s):	
11.1				18.11	18.11			45.00	40.50	4.50	40.64	0.25	0.46				
	j	47.574	110.00	-	-	500	0.0015	-	-	-		-	-	1.14	5.38	18.114	
11.2				23.33	23.33			44.00	40.33	3.67	40.47	0.29	0.49			23.333	
11.2				34.57	34.57			44.00	40.33	3.67	40.53	0.36	0.55				
	j	43.206	130.00	-	-	500	0.0015	-	-	-		-	-	1.45	6.20	16.451	
11.3				44.52	44.52			42.80	40.14	2.66	40.34	0.41	0.58			21.191	
11.3				34.57	34.57			42.80	40.14	2.66	40.34	0.36	0.55				
	j		80.00	-	-	500	0.0015	-	-	-		-	-	1.48	6.19		
11.4				44.52	44.52			43.00	40.02	2.98	40.22	0.41	0.59				
11.4				43.77	43.77			43.00	38.50	4.50	38.71	0.37	0.65				
	j	24.179	140.00	-	-	500	0.0020	-	-	-		-	-	2.04	6.30	9.206	
11.5				56.38	56.38			42.30	38.22	4.08	38.43	0.43	0.69			11.859	
11.5				43.77	43.77			42.30	38.22	4.08	38.43	0.37	0.65				
	j		150.00	-	-	500	0.0020	-	-	-		-	-	2.04	6.30		
11.6				56.38	56.38			42.00	37.92	4.08	38.13	0.43	0.69				
11.6				43.77	43.77			42.00	37.92	4.08	38.13	0.37	0.65				
	j		150.00	-	-	500	0.0020	-	-	-		-	-	2.04	6.30		
11.7				56.38	56.38			41.50	37.62	3.88	37.83	0.43	0.69				
11.7				43.77	43.77			41.50	37.62	3.88	37.83	0.37	0.65				
	j		150.00	-	-	500	0.0020	-	-	-		-	-	2.04	6.30		
11.8				56.38	56.38			41.00	37.32	3.68	37.53	0.43	0.69				
11.8				43.77	43.77			41.00	37.32	3.68	37.53	0.37	0.65				
	j		120.00	-	-	500	0.0020	-	-	-		-	-	2.04	6.30		
11.9				56.38	56.38			40.20	37.08	3.12	37.29	0.43	0.69				
11.9				95.36	95.36			40.20	36.88	3.32	37.13	0.32	0.96				
	o	135.496	30.00	-	-	700	0.0033	-	-	-		-	-	4.17	6.94	51.591	
11.10				122.84	122.84			40.00	36.78	3.22	37.03	0.35	1.02			66.456	
11.10				100.48	100.48			40.00	36.78	3.22	37.03	0.32	1.00				
	o	13.427	150.00	-	-	700	0.0036	-	-	-		-	-	4.53	6.96	5.113	
11.11				129.42	129.42			39.50	36.24	3.26	36.49	0.36	1.06			6.580	
11.11				100.48	100.48			39.50	36.24	3.26	36.49	0.32	1.00				
	o		150.00	-	-	700	0.0036	-	-	-		-	-	4.53	6.96		
11.12				129.42	129.42			39.00	35.70	3.30	35.95	0.36	1.06				
11.12				100.48	100.48			39.00	35.70	3.30	35.95	0.32	1.00				
	o		150.00	-	-	700	0.0036	-	-	-		-	-	4.53	6.96		
11.13				129.42	129.42			37.80	35.16	2.64	35.41	0.36	1.06				
11.13				100.48	100.48			37.80	35.16	2.64	35.41	0.32	1.00				
	o		150.00	-	-	700	0.0036	-	-	-		-	-	4.53	6.96		
11.14				129.42	129.42			37.30	34.62	2.68	34.87	0.36	1.06				
11.14				100.48	100.48			37.30	34.62	2.68	34.87	0.32	1.00				
	o		150.00	-	-	700	0.0036	-	-	-		-	-	4.53	6.96		
11.15				129.42	129.42			36.70	34.08	2.62	34.33	0.36	1.06				
11.15				100.48	100.48			36.70	34.08	2.62	34.32	0.29	1.04				
	o		90.00	-	-	700	0.0042	-	-	-		-	-	4.97	6.86		
11 (No.2 TS)				129.42	129.42			35.80	33.70	2.10	33.94	0.34	1.13				
TOTAL			1,900.00							2.10							

Table 2 (11/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

JICA	ACARI SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 2-2 TRUNK SEWER																
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 11 Notes: entrance flow (l/s):	
27.1				43.01	43.01			35.00	33.00	2.00	33.17	0.37	1.00				
	o	112.947	110.00	-	-	400	0.0064	-	-	-		-	-	5.19	5.63	43.005	
27.2				55.40	55.40			34.30	32.30	2.00	32.47	0.43	1.07			55.396	
27.2				56.64	56.64			34.30	32.30	2.00	32.50	0.43	1.08				
	o	35.810	90.00	-	-	400	0.0064	-	-	-		-	-	5.83	5.94	13.636	
27.3				72.96	72.96			33.90	31.72	2.18	31.92	0.50	1.15			17.564	
27.3				60.51	60.51			33.90	31.72	2.18	31.93	0.45	1.09				
	o	10.164	150.00	-	-	400	0.0064	-	-	-		-	-	5.95	6.02	3.870	
27.4				77.95	77.95			32.80	30.76	2.04	30.97	0.52	1.17			4.985	
27.4				60.51	60.51			32.80	30.76	2.04	30.97	0.45	1.09				
	o		150.00	-	-	400	0.0064	-	-	-		-	-	5.95	6.02		
27.5				77.95	77.95			31.80	29.80	2.00	30.01	0.52	1.17				
27.5				80.97	80.97			31.80	29.80	2.00	30.08	0.58	1.08				
	o	53.715	150.00	-	-	400	0.0050	-	-	-		-	-	5.46	6.46	20.454	
27.6				104.29	104.29			31.10	29.05	2.05	29.33	0.69	1.13			26.347	
27.6				80.97	80.97			31.10	29.05	2.05	29.33	0.58	1.08				
	o		120.00	-	-	400	0.0050	-	-	-		-	-	5.46	6.46		
27.7				104.29	104.29			31.00	28.45	2.55	28.73	0.69	1.13				
27.7				80.97	80.97			31.00	28.45	2.55	28.73	0.58	1.08				
	o		120.00	-	-	400	0.0050	-	-	-		-	-	5.46	6.46		
27 (No.2 TS)				104.29	104.29			30.00	27.85	2.15	28.13	0.69	1.13				
TOTAL			890.00							2.15							

JICA	ACARI SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 3 TRUNK SEWER																
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	cota NA final (m) inicial final	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):	
1				17.38	17.38			43.00	41.00	2.00	41.11	0.24	0.76				
	o	45.641	100.00	-	-	400	0.0060	-	-	-		-	-	3.37	4.69	17.378	
2				22.39	22.39			42.40	40.40	2.00	40.51	0.27	0.81			22.385	
2				17.38	17.38			42.40	40.40	2.00	40.51	0.24	0.76				
	o		80.00	-	-	400	0.0060	-	-	-		-	-	3.37	4.69		
3				22.39	22.39			42.00	39.92	2.08	40.03	0.27	0.81				
3				17.38	17.38			42.00	39.92	2.08	40.03	0.24	0.76				
	o		150.00	-	-	400	0.0060	-	-	-		-	-	3.37	4.69		
4				22.39	22.39			41.10	39.02	2.08	39.13	0.27	0.81				
4				17.38	17.38			41.10	39.02	2.08	39.13	0.24	0.76				
	o		150.00	-	-	400	0.0060	-	-	-		-	-	3.37	4.69		
5				22.39	22.39			40.30	38.12	2.18	38.23	0.27	0.81				
5				17.38	17.38			40.30	38.12	2.18	38.23	0.24	0.76				
	o		80.00	-	-	400	0.0060	-	-	-		-	-	3.37	4.69		
6				22.39	22.39			40.00	37.64	2.36	37.75	0.27	0.81				

Table 2 (12/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 12 Notes: entrance flow (l/s):
6	o	32.360	60.00	29.70 - 38.26	29.70 - 38.26	400	0.0060	40.00 - 39.30	37.64 - 37.28	2.36 - 2.02	37.78 - 37.42	0.32 - 0.36	0.90 - 0.95	4.34	5.28	12.322 15.871
7																
7	o		80.00	29.70 - 38.26	29.70 - 38.26	400	0.0125	39.30 - 38.30	37.28 - 36.28	2.02 - 2.02	37.40 - 36.40	0.26 - 0.29	1.15 - 1.23	7.53	4.86	
8																
8	o		150.00	29.70 - 38.26	29.70 - 38.26	400	0.0125	38.30 - 36.40	36.28 - 34.40	2.02 - 2.00	36.40 - 34.52	0.26 - 0.29	1.15 - 1.23	7.55	4.85	
9																
9	o		150.00	29.70 - 38.26	29.70 - 38.26	400	0.0125	36.40 - 35.50	34.40 - 32.53	2.00 - 2.97	34.52 - 32.65	0.26 - 0.29	1.14 - 1.23	7.52	4.86	
10																
10	j		150.00	29.70 - 38.26	29.70 - 38.26	500	0.0046	35.50 - 35.00	32.43 - 31.74	3.07 - 3.26	32.57 - 31.88	0.25 - 0.28	0.79 - 0.84	3.33	5.33	
11																
11	j		60.00	29.70 - 38.26	29.70 - 38.26	500	0.0046	35.00 - 34.50	31.74 - 31.47	3.26 - 3.03	31.88 - 31.61	0.25 - 0.28	0.78 - 0.84	3.30	5.33	
12																
12	j		130.00	29.70 - 38.26	29.70 - 38.26	500	0.0047	34.50 - 34.00	31.47 - 30.86	3.03 - 3.14	31.61 - 31.00	0.25 - 0.28	0.79 - 0.85	3.37	5.32	
13																
13	j	10.401	100.00	33.66 - 43.36	131.00 - 168.74	500	0.0047	34.00 - 33.60	29.86 - 29.39	4.14 - 4.21	30.19 - 29.72	0.55 - 0.65	1.19 - 1.26	6.22	7.14	3.960 5.101
14																
14	j		100.00	131.00 - 168.74	131.00 - 168.74	500	0.0047	33.60 - 33.40	29.39 - 28.92	4.21 - 4.48	29.72 - 29.25	0.55 - 0.65	1.19 - 1.26	6.22	7.14	
15																
15	j	24.509	90.00	140.33 - 180.76	140.33 - 180.76	500	0.0047	33.40 - 33.00	28.92 - 28.50	4.48 - 4.50	29.26 - 28.84	0.58 - 0.69	1.20 - 1.27	6.34	7.21	9.332 12.020
21 (No.2 TS)																
TOTAL			1,630.00							4.50						

JICA

ACARI SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 3-1 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
13.1	j	144.665	140.00	55.08 - 70.95	55.08 - 70.95	500	0.0047	39.20 - 38.00	35.20 - 34.54	4.00 - 3.46	35.39 - 34.73	0.34 - 0.38	0.95 - 1.01	4.47	6.06	55.082 70.952
13.2																
13.2	j		140.00	55.08 - 70.95	55.08 - 70.95	500	0.0047	38.00 - 37.00	34.54 - 33.88	3.46 - 3.12	34.73 - 34.07	0.34 - 0.38	0.95 - 1.01	4.47	6.06	
13.3																
13.3	j		50.00	55.08 - 70.95	55.08 - 70.95	500	0.0047	37.00 - 36.50	33.88 - 33.65	3.12 - 2.85	34.07 - 33.84	0.34 - 0.39	0.95 - 1.01	4.44	6.07	
13.4																

Table 2 (13/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 13 Notes: entrance flow (l/s):
13.4				55.08	55.08			36.50	33.65	2.85	33.84	0.34	0.95			
	o		110.00	-	-	500	0.0047	-	-	-		-	-	4.45	6.06	
13.5				70.95	70.95			36.00	33.13	2.87	33.32	0.39	1.01			
13.5				55.08	55.08			36.00	33.13	2.87	33.32	0.34	0.95			
	o		110.00	-	-	500	0.0047	-	-	-		-	-	4.48	6.06	
13.6				70.95	70.95			35.10	32.61	2.49	32.80	0.38	1.01			
13.6				70.77	70.77			35.10	32.61	2.49	32.83	0.38	1.01			
	o	41.193	40.00	-	-	500	0.0047	-	-	-		-	-	4.93	6.36	15.685
13.7				91.16	91.16			35.10	32.42	2.68	32.64	0.44	1.08			20.204
13.7				70.77	70.77			35.10	32.42	2.68	32.64	0.39	1.01			
	j		150.00	-	-	500	0.0047	-	-	-		-	-	4.86	6.37	
13.8				91.16	91.16			35.00	31.72	3.28	31.94	0.44	1.08			
13.8				70.77	70.77			35.00	31.72	3.28	31.94	0.39	1.01			
	j		90.00	-	-	500	0.0047	-	-	-		-	-	4.86	6.37	
13.9				91.16	91.16			34.50	31.30	3.20	31.52	0.44	1.08			
13.9				97.34	97.34			34.50	31.30	3.20	31.57	0.46	1.10			
	j	69.792	70.00	-	-	500	0.0047	-	-	-		-	-	5.55	6.78	26.574
13.10				125.39	125.39			34.00	30.97	3.03	31.24	0.53	1.18			34.230
13.10				97.34	97.34			34.00	30.00	4.00	30.27	0.46	1.10			
	j		30.00	-	-	500	0.0047	-	-	-		-	-	5.51	6.78	
13 (No.3 TS)				125.39	125.39			34.00	29.86	4.14	30.13	0.54	1.17			
TOTAL			930.00							4.14						

JICA

ACARI SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 4 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
1				47.18	47.18			43.00	41.00	2.00	41.26	0.55	0.67			
	o	123.919	150.00	-	-	400	0.0020	-	-	-		-	-	2.12	6.39	47.183
2				60.78	60.78			43.00	40.70	2.30	40.96	0.65	0.71			60.777
2				47.18	47.18			43.00	40.70	2.30	40.96	0.55	0.67			
	o		150.00	-	-	400	0.0020	-	-	-		-	-	2.12	6.39	
3				60.78	60.78			43.00	40.40	2.60	40.66	0.65	0.71			
3				47.18	47.18			43.00	40.40	2.60	40.66	0.55	0.67			
	o		130.00	-	-	400	0.0020	-	-	-		-	-	2.12	6.39	
4				60.78	60.78			43.00	40.14	2.86	40.40	0.65	0.71			
4				47.18	47.18			43.00	40.14	2.86	40.34	0.42	0.92			
	o		130.00	-	-	400	0.0048	-	-	-		-	-	4.26	5.91	
5				60.78	60.78			42.00	39.52	2.48	39.72	0.49	0.98			
5				47.18	47.18			42.00	39.52	2.48	39.72	0.42	0.92			
	o		150.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
6				60.78	60.78			41.20	38.80	2.40	39.00	0.49	0.99			
6				47.18	47.18			41.20	38.80	2.40	39.00	0.42	0.92			
	o		150.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
7				60.78	60.78			40.50	38.08	2.42	38.28	0.49	0.99			

Table 2 (14/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 14 Notes: entrance flow (l/s):
7				47.18	47.18			40.50	38.08	2.42	38.28	0.42	0.92			
	o		150.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
8				60.78	60.78			40.00	37.36	2.64	37.56	0.49	0.99			
8				47.18	47.18			40.00	37.36	2.64	37.56	0.42	0.92			
	o		150.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
9				60.78	60.78			39.00	36.64	2.36	36.84	0.49	0.99			
9				47.18	47.18			39.00	36.64	2.36	36.84	0.42	0.92			
	o		100.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
10				60.78	60.78			38.90	36.16	2.74	36.36	0.49	0.99			
10				47.18	47.18			38.90	36.16	2.74	36.36	0.42	0.92			
	o		150.00	-	-	400	0.0048	-	-	-		-	-	4.28	5.90	
11				60.78	60.78			39.00	35.44	3.56	35.64	0.49	0.99			
11				47.18	47.18			39.00	35.34	3.66	35.62	0.48	0.50			
	j		150.00	-	-	500	0.0009	-	-	-		-	-	1.14	6.89	
12				60.78	60.78			39.00	35.20	3.80	35.48	0.56	0.53			
12				47.18	47.18			39.00	35.20	3.80	35.49	0.49	0.49			
	j		150.00	-	-	500	0.0009	-	-	-		-	-	1.07	6.93	
13				60.78	60.78			40.00	35.07	4.93	35.36	0.58	0.52			
13				47.18	47.18			40.00	35.07	4.93	35.36	0.49	0.49			
	j		70.00	-	-	500	0.0009	-	-	-		-	-	1.06	6.94	
14				60.78	60.78			39.00	35.01	3.99	35.30	0.58	0.52			
14				72.24	72.24			39.00	35.01	3.99	35.16	0.27	1.71			
	j	65.800	150.00	-	-	500	0.0201	-	-	-		-	-	15.47	5.49	25.057
15				93.05	93.05			34.50	32.00	2.50	32.15	0.30	1.83			32.274
15				72.24	72.24			34.50	32.00	2.50	32.17	0.28	1.55			
	o		150.00	-	-	500	0.0153	-	-	-		-	-	12.49	5.72	
16				93.05	93.05			32.20	29.70	2.50	29.87	0.33	1.69			
16				72.24	72.24			32.20	29.70	2.50	29.87	0.28	1.55			
	o		150.00	-	-	500	0.0153	-	-	-		-	-	12.44	5.72	
17				93.05	93.05			30.00	27.41	2.59	27.58	0.33	1.69			
17				72.24	72.24			30.00	27.41	2.59	27.58	0.28	1.55			
	o		150.00	-	-	500	0.0153	-	-	-		-	-	12.49	5.72	
18				93.05	93.05			27.60	25.11	2.49	25.28	0.33	1.69			
18				72.24	72.24			27.60	25.11	2.49	25.28	0.28	1.55			
	o		100.00	-	-	500	0.0153	-	-	-		-	-	12.47	5.72	
19				93.05	93.05			26.10	23.58	2.52	23.75	0.33	1.69			
19				124.76	124.76			26.10	23.58	2.52	23.86	0.48	1.32			
	o	137.925	130.00	-	-	500	0.0065	-	-	-		-	-	7.89	6.89	52.516
20				160.70	160.70			25.30	22.74	2.56	23.02	0.57	1.41			67.647
20				124.76	124.76			25.30	22.74	2.56	23.02	0.48	1.32			
	o		150.00	-	-	500	0.0065	-	-	-		-	-	7.89	6.89	
21				160.70	160.70			24.30	21.77	2.53	22.05	0.57	1.41			
21				124.76	124.76			24.30	21.77	2.53	22.05	0.48	1.32			
	o		150.00	-	-	500	0.0065	-	-	-		-	-	7.89	6.89	
22				160.70	160.70			23.30	20.80	2.50	21.08	0.57	1.41			
22				166.24	166.24			23.30	20.80	2.50	21.14	0.58	1.42			
	o	108.939	80.00	-	-	500	0.0065	-	-	-		-	-	8.85	7.21	41.481
23				214.13	214.13			23.00	20.28	2.72	20.62	0.69	1.50			53.432

Table 2 (15/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 15 Notes: entrance flow (l/s):
23				166.24	166.24			23.00	20.28	2.72	20.62	0.58	1.42			
	o		100.00	-	-	500	0.0065	-	-	-		-	-	8.85	7.21	
24				214.13	214.13			22.50	19.63	2.87	19.97	0.69	1.50			
24				166.24	166.24			22.50	19.63	2.87	19.97	0.58	1.42			
	j		120.00	-	-	500	0.0065	-	-	-		-	-	8.85	7.21	
25				214.13	214.13			22.00	18.85	3.15	19.19	0.69	1.50			
25				166.24	166.24			22.00	18.85	3.15	19.20	0.58	1.42			
	j		150.00	-	-	500	0.0065	-	-	-		-	-	8.81	7.22	
26				214.13	214.13			21.30	17.88	3.42	18.23	0.69	1.50			
26				185.72	185.72			21.30	17.68	3.62	18.07	0.47	1.02			
	o	51.158	150.00	-	-	700	0.0025	-	-	-		-	-	4.28	8.11	19.479
27				239.22	239.22			20.60	17.30	3.30	17.69	0.55	1.09			25.091
27				185.72	185.72			20.60	17.30	3.30	17.69	0.47	1.02			
	o		100.00	-	-	700	0.0025	-	-	-		-	-	4.23	8.12	
28				239.22	239.22			20.00	17.05	2.95	17.44	0.56	1.09			
28				185.72	185.72			20.00	17.05	2.95	17.44	0.47	1.02			
	o		150.00	-	-	700	0.0025	-	-	-		-	-	4.28	8.11	
29				239.22	239.22			19.70	16.67	3.03	17.06	0.55	1.09			
29				192.24	192.24			19.70	16.67	3.03	17.07	0.49	1.02			
	o	17.120	130.00	-	-	700	0.0025	-	-	-		-	-	4.24	8.18	6.519
30				247.62	247.62			19.60	16.35	3.25	16.75	0.57	1.09			8.397
30				192.24	192.24			19.60	16.15	3.45	16.59	0.42	0.75			
	j		110.00	-	-	900	0.0011	-	-	-		-	-	2.17	8.82	
31				247.62	247.62			19.50	16.03	3.47	16.47	0.48	0.80			
31				192.24	192.24			19.50	16.03	3.47	16.47	0.42	0.75			
	j		130.00	-	-	900	0.0011	-	-	-		-	-	2.15	8.83	
32				247.62	247.62			19.50	15.89	3.61	16.33	0.49	0.80			
32				192.24	192.24			19.50	15.89	3.61	16.33	0.42	0.75			
	j		140.00	-	-	900	0.0011	-	-	-		-	-	2.14	8.84	
33				247.62	247.62			19.50	15.74	3.76	16.18	0.49	0.80			
33				192.24	192.24			19.50	15.74	3.76	16.17	0.42	0.76			
	j		90.00	-	-	900	0.0011	-	-	-		-	-	2.21	8.81	
34				247.62	247.62			19.00	15.64	3.36	16.07	0.48	0.81			
34				192.24	192.24			19.00	15.64	3.36	16.07	0.41	0.77			
	j		60.00	-	-	900	0.0012	-	-	-		-	-	2.29	8.76	
35				247.62	247.62			19.00	15.57	3.43	16.00	0.47	0.82			
35				192.24	192.24			19.00	15.57	3.43	16.00	0.42	0.75			
	j		100.00	-	-	900	0.0011	-	-	-		-	-	2.19	8.82	
36				247.62	247.62			19.00	15.46	3.54	15.89	0.48	0.81			
36				206.73	206.73			19.00	15.46	3.54	15.91	0.43	0.78			
	j	38.080	140.00	-	-	900	0.0011	-	-	-		-	-	2.32	8.91	14.499
37				266.30	266.30			18.00	15.30	2.70	15.75	0.50	0.83			18.677
37				206.73	206.73			18.00	15.30	2.70	15.57	0.27	1.51			
	o		140.00	-	-	900	0.0071	-	-	-		-	-	9.92	7.37	
38				266.30	266.30			17.00	14.30	2.70	14.57	0.30	1.62			
38				206.73	206.73			17.00	14.30	2.70	14.57	0.27	1.51			
	o		140.00	-	-	900	0.0071	-	-	-		-	-	9.92	7.37	
39				266.30	266.30			16.00	13.30	2.70	13.57	0.30	1.62			

Table 2 (16/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 16 Notes: entrance flow (l/s):
39				206.73	206.73			16.00	13.30	2.70	13.58	0.27	1.51			
	j		100.00	-	-	900	0.0071	-	-	-		-	-	9.87	7.51	
40				266.30	266.30			15.70	12.59	3.11	12.87	0.31	1.65			
40				236.43	236.43			15.70	12.59	3.11	13.01	0.41	0.96			
	j	78.003	40.00	-	-	900	0.0019	-	-	-		-	-	3.61	8.72	29.700
41				304.55	304.55			15.70	12.52	3.18	12.94	0.47	1.03			38.258
41				236.43	236.43			15.70	12.52	3.18	12.93	0.40	0.98			
	j		70.00	-	-	900	0.0019	-	-	-		-	-	3.75	8.68	
42				304.55	304.55			16.00	12.38	3.62	12.80	0.46	1.05			
42				236.43	236.43			16.00	12.38	3.62	12.80	0.40	0.98			
	j		110.00	-	-	900	0.0019	-	-	-		-	-	3.70	8.70	
43				304.55	304.55			16.20	12.17	4.03	12.59	0.46	1.04			
43				236.43	371.71			16.20	11.87	4.33	12.61	0.52	0.62			
	j		120.00	-	-	1200	0.0004	-	-	-		-	-	1.28	10.92	
44				304.55	478.80			16.30	11.82	4.48	12.56	0.62	0.66			
44				371.71	371.71			16.30	11.82	4.48	12.56	0.52	0.62			
	j		120.00	-	-	1200	0.0004	-	-	-		-	-	1.28	10.92	
45				478.80	478.80			16.70	11.77	4.93	12.51	0.62	0.66			
45				421.70	421.70			16.70	11.77	4.93	12.59	0.57	0.63			
	j	131.298	150.00	-	-	1200	0.0004	-	-	-		-	-	1.30	11.16	49.993
46				543.20	543.20			16.00	11.71	4.29	12.53	0.68	0.67			64.397
46				421.70	421.70			16.00	11.71	4.29	12.53	0.57	0.63			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.30	11.16	
47				543.20	543.20			16.60	11.65	4.95	12.47	0.68	0.67			
47				425.91	425.91			16.60	11.65	4.95	12.49	0.59	0.62			
	j	11.066	130.00	-	-	1200	0.0004	-	-	-		-	-	1.27	11.20	4.213
48				548.62	548.62			17.05	11.60	5.45	12.44	0.70	0.66			5.427
48				425.91	425.91			17.05	11.60	5.45	12.42	0.57	0.64			
	j		120.00	-	-	1200	0.0004	-	-	-		-	-	1.35	11.15	
49				548.62	548.62			17.50	11.55	5.95	12.37	0.68	0.68			
49				425.91	425.91			17.50	11.55	5.95	12.38	0.58	0.63			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.31	11.18	
50				548.62	548.62			17.30	11.49	5.81	12.32	0.69	0.67			
50				425.91	425.91			17.30	11.49	5.81	12.31	0.57	0.64			
	j		120.00	-	-	1200	0.0004	-	-	-		-	-	1.35	11.15	
51				548.62	548.62			17.05	11.44	5.61	12.26	0.68	0.68			
51				425.91	425.91			17.05	11.44	5.61	12.20	0.54	0.69			
	j		40.00	-	-	1200	0.0005	-	-	-		-	-	1.57	11.00	
52				548.62	548.62			17.05	11.42	5.63	12.18	0.64	0.73			
52				425.91	425.91			17.05	11.42	5.63	12.23	0.56	0.65			
	j		140.00	-	-	1200	0.0004	-	-	-		-	-	1.38	11.13	
53				548.62	548.62			16.80	11.36	5.44	12.17	0.67	0.69			
53				425.91	425.91			16.80	11.36	5.44	12.19	0.58	0.63			
	j		150.00	-	-	1200	0.0004	-	-	-		-	-	1.31	11.18	
54				548.62	548.62			16.80	11.30	5.50	12.13	0.69	0.67			
54				434.96	434.96			16.80	11.30	5.50	12.08	0.54	0.69			
	j	23.766	140.00	-	-	1200	0.0005	-	-	-		-	-	1.58	11.04	9.049
55				560.28	560.28			17.20	11.23	5.97	12.01	0.65	0.73			11.656

Table 2 (17/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 17 Notes: entrance flow (l/s):
55				434.96	434.96			17.20	11.23	5.97	11.98	0.53	0.71			
	j		110.00	-	-	1200	0.0005	-	-	-		-	-	1.70	10.96	
56				560.28	560.28			17.50	11.17	6.33	11.92	0.63	0.76			
56				434.96	434.96			17.50	11.17	6.33	11.96	0.56	0.67			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.49	11.09	
57				560.28	560.28			17.90	11.10	6.80	11.89	0.66	0.71			
57				434.96	434.96			17.90	11.10	6.80	11.89	0.56	0.67			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.49	11.09	
58				560.28	560.28			17.90	11.03	6.87	11.82	0.66	0.71			
58				434.96	434.96			17.90	11.03	6.87	11.79	0.53	0.71			
	j		150.00	-	-	1200	0.0005	-	-	-		-	-	1.66	10.98	
59				560.28	560.28			17.00	10.95	6.05	11.71	0.63	0.75			
59				442.38	442.38			17.00	10.95	6.05	11.69	0.52	0.74			
	j	19.481	50.00	-	-	1200	0.0006	-	-	-		-	-	1.84	10.91	7.417
81 (No. 1 TS)				569.84	569.84			17.00	10.92	6.08	11.66	0.61	0.79			9.555
TOTAL			7,400.00							6.08						

JICA

ACARI SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 4-1 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
43.1				59.53	59.53			12.50	7.50	5.00	7.78	0.48	0.63			
	j	156.332	60.00	-	-	500	0.0015	-	-	-		-	-	1.82	6.88	59.525
43.2				76.68	76.68			12.50	7.41	5.09	7.69	0.56	0.68			76.675
43.2				59.53	59.53			12.50	7.41	5.09	7.72	0.53	0.57			
	j		100.00	-	-	500	0.0011	-	-	-		-	-	1.42	7.07	
43.3				76.68	76.68			12.50	7.30	5.20	7.61	0.62	0.60			
43.3				59.53	59.53			12.50	7.30	5.20	7.61	0.53	0.56			
	j		120.00	-	-	500	0.0011	-	-	-		-	-	1.40	7.08	
43.4				76.68	76.68			12.70	7.17	5.53	7.48	0.63	0.60			
43.4				75.51	75.51			12.70	6.77	5.93	7.07	0.29	0.48			
	j	41.993	30.00	-	-	900	0.0007	-	-	-		-	-	1.00	7.74	15.989
43.5				97.27	97.27			12.70	6.75	5.95	7.05	0.34	0.53			20.596
43.5				75.51	75.51			12.70	6.75	5.95	7.05	0.28	0.51			
	j		40.00	-	-	900	0.0007	-	-	-		-	-	1.09	7.66	
43.6				97.27	97.27			12.90	6.72	6.18	7.02	0.33	0.55			
43.6				75.51	75.51			12.90	6.72	6.18	7.02	0.29	0.48			
	j		120.00	-	-	900	0.0007	-	-	-		-	-	1.00	7.74	
43.7				97.27	97.27			13.20	6.64	6.56	6.94	0.34	0.53			
43.7				75.51	75.51			13.20	6.64	6.56	6.94	0.29	0.48			
	j		150.00	-	-	900	0.0007	-	-	-		-	-	1.00	7.74	
43.8				97.27	97.27			13.60	6.54	7.06	6.84	0.34	0.53			

Table 2 (18/18) Trunk Sewer Hydraulic Calculation of Acari Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	cota NA final (m) inicial / final	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 18 Notes: entrance flow (l/s):
43.8				75.51	75.51			13.60	6.54	7.06	6.84	0.29	0.48			
	j		150.00	-	-	900	0.0007	-	-	-		-	-	1.00	7.74	
43.9				97.27	97.27			14.20	6.44	7.76	6.74	0.34	0.53			
43.9				121.34	121.34			14.20	6.44	7.76	6.82	0.37	0.57			
	j	120.364	110.00	-	-	900	0.0007	-	-	-		-	-	1.31	8.38	45.830
43.10				156.31	156.31			14.60	6.36	8.24	6.74	0.42	0.61			59.034
43.10				121.34	121.34			14.60	6.36	8.24	6.74	0.37	0.57			
	j		110.00	-	-	900	0.0007	-	-	-		-	-	1.31	8.38	
43.11				156.31	156.31			15.05	6.28	8.77	6.66	0.42	0.61			
43.11				121.34	121.34			15.05	6.28	8.77	6.66	0.37	0.57			
	j		110.00	-	-	900	0.0007	-	-	-		-	-	1.31	8.38	
43.12				156.31	156.31			15.50	6.20	9.30	6.58	0.42	0.61			
43.12				121.34	121.34			15.50	6.20	9.30	6.58	0.37	0.56			
	j		120.00	-	-	900	0.0007	-	-	-		-	-	1.22	8.46	
43.13				156.31	156.31			15.30	6.12	9.18	6.50	0.43	0.59			
43.13				121.34	121.34			15.30	6.12	9.18	6.50	0.37	0.57			
	j		100.00	-	-	900	0.0007	-	-	-		-	-	1.27	8.41	
43.14				156.31	156.31			15.00	6.05	8.95	6.43	0.42	0.60			
43.14				135.27	135.27			15.00	6.05	8.95	6.45	0.38	0.60			
	j	36.582	40.00	-	-	900	0.0008	-	-	-		-	-	1.40	8.54	13.929
43.15				174.25	174.25			15.00	6.02	8.98	6.42	0.44	0.64			17.942
43.15				135.27	135.27			15.00	6.02	8.98	6.33	0.29	0.85			
	j		5.00	-	-	900	0.0020	-	-	-		-	-	3.03	7.78	
EE-4				174.25	174.25			15.00	6.01	8.99	6.32	0.34	0.92			
TOTAL			1,365.00							8.99						

RECALQUE: L=120m e D=500mm

43.16				0.00	135.27			15.00	12.90	2.10	13.27	0.36	0.67			
	o		100.00	-	-	900	0.0010	-	-	-		-	-	1.77	8.30	
43.17				0.00	174.25			15.20	12.80	2.40	13.17	0.41	0.71			
43.17				135.27	135.27			15.20	12.80	2.40	13.17	0.36	0.67			
	j		70.00	-	-	900	0.0010	-	-	-		-	-	1.77	8.30	
43 (No. 4 TS)				174.25	174.25			16.20	12.73	3.47	13.10	0.41	0.71			
TOTAL			170.00							3.47						
				12.76	12.76											
EE-3	o	33.501														
				16.43	16.43											

RECALQUE: L=400m e D=150mm

1.3 SARAPUI SEWER DISTRICT

Trunk Sewer Hydraulic Calculation of Sarapui Sewer District is shown in *Table 3 (1/4 - 4/4).*

Table 3 (1/4) Trunk Sewer Hydraulic Calculation of Sarapui Sewer District

JICA	SARAPUÍ SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1 TRUNK SEWER														
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) Vinitial Vfinal	trative tension (Pa)	critical velocity Vc (m/s)	Page 1 Notes: entrance flow (l/s):
1				32.71	32.71			5.00	3.00	2.00	0.44	0.61			
	o	90.275	150.00	-	-	400	0.0020	-	-	-	-	-	1.83	6.07	32.707
2				45.29	45.29			5.00	2.70	2.30	0.54	0.66			45.288
2				32.71	32.71			5.00	2.70	2.30	0.44	0.61			
	o		150.00	-	-	400	0.0020	-	-	-	-	-	1.83	6.07	
3				45.29	45.29			5.00	2.40	2.60	0.54	0.66			
3				32.71	32.71			5.00	2.40	2.60	0.44	0.61			
	o		100.00	-	-	400	0.0020	-	-	-	-	-	1.83	6.07	
4				45.29	45.29			5.00	2.20	2.80	0.54	0.66			
4				32.71	32.71			5.00	2.20	2.80	0.44	0.61			
	o		100.00	-	-	400	0.0020	-	-	-	-	-	1.83	6.07	
5				45.29	45.29			5.00	2.00	3.00	0.54	0.66			
5				42.80	42.80			5.00	1.90	3.10	0.47	0.47			
	j	27.860	110.00	-	-	500	0.0008	-	-	-	-	-	1.00	6.93	10.094
6				59.25	59.25			5.00	1.81	3.19	0.58	0.51			13.958
6				42.80	42.80			5.00	1.81	3.19	0.47	0.47			
	j		150.00	-	-	500	0.0008	-	-	-	-	-	1.00	6.93	
7				59.25	59.25			5.00	1.68	3.32	0.58	0.51			
7				42.80	42.80			5.00	1.68	3.32	0.47	0.47			
	j		70.00	-	-	500	0.0008	-	-	-	-	-	1.01	6.92	
8				59.25	59.25			4.00	1.62	2.38	0.57	0.51			
8				103.89	103.89			4.00	1.22	2.78	0.36	0.50			
	o	168.608	150.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	61.087
9				143.72	143.72			4.00	1.14	2.86	0.43	0.54			84.472
9				103.89	103.89			4.00	1.14	2.86	0.36	0.50			
	o		150.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	
10				143.72	143.72			4.00	1.06	2.94	0.43	0.54			
10				103.89	103.89			4.00	1.06	2.94	0.36	0.50			
	j		150.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	
11				143.72	143.72			4.00	0.97	3.03	0.43	0.54			
11				103.89	103.89			4.00	0.97	3.03	0.36	0.50			
	j		140.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	
12				143.72	143.72			4.00	0.89	3.11	0.43	0.54			
12				103.89	103.89			4.00	0.89	3.11	0.36	0.50			
	j		130.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	
13				143.72	143.72			4.00	0.82	3.18	0.43	0.54			
13				103.89	103.89			4.00	0.82	3.18	0.36	0.50			
	o		120.00	-	-	900	0.0006	-	-	-	-	-	1.00	8.46	
14				143.72	143.72			4.00	0.75	3.25	0.43	0.54			
14				133.12	133.12			4.00	0.75	3.25	0.42	0.51			
	j	80.677	150.00	-	-	900	0.0005	-	-	-	-	-	1.01	8.99	29.227
15				184.14	184.14			5.00	0.68	4.32	0.51	0.56			40.420
15				133.12	133.12			5.00	0.68	4.32	0.42	0.51			
	j		150.00	-	-	900	0.0005	-	-	-	-	-	1.01	8.99	
16				184.14	184.14			5.00	0.60	4.40	0.51	0.56			

Table 3 (2/4) Trunk Sewer Hydraulic Calculation of Sarapui Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) Vinitial / Vfinal	trative tension (Pa)	critical velocity Vc (m/s)	Page 2 Notes: entrance flow (l/s):
16				133.12	133.12			5.00	0.60	4.40	0.42	0.51			
	j	80.331	130.00	-	-	900	0.0005	-	-	-	-	-	1.01	8.99	
17				184.14	184.14			4.00	0.54	3.46	0.51	0.56			
17				133.12	133.12			4.00	0.54	3.46	0.42	0.51			
	j		130.00	-	-	900	0.0005	-	-	-	-	-	1.01	8.99	
18				184.14	184.14			5.00	0.47	4.53	0.51	0.56			
18				155.60	155.60			5.00	0.47	4.53	0.48	0.52			
	j	62.078	70.00	-	-	900	0.0005	-	-	-	-	-	1.00	9.33	22.489
19				215.24	215.24			5.00	0.44	4.56	0.58	0.56			31.101
19				155.60	155.60			5.00	0.44	4.56	0.47	0.52			
	j		130.00	-	-	900	0.0005	-	-	-	-	-	1.00	9.32	
20				215.24	215.24			5.00	0.38	4.62	0.58	0.56			
20				155.60	155.60			5.00	0.38	4.62	0.48	0.52			
	j		120.00	-	-	900	0.0005	-	-	-	-	-	1.00	9.33	
21				215.24	215.24			5.00	0.33	4.67	0.58	0.56			
21				155.60	155.60			5.00	0.33	4.67	0.47	0.52			
	j		150.00	-	-	900	0.0005	-	-	-	-	-	1.00	9.33	
22				215.24	215.24			4.00	0.26	3.74	0.58	0.56			
22				155.60	155.60			4.00	0.26	3.74	0.24	1.34			
	j		150.00	-	-	900	0.0064	-	-	-	-	-	8.07	7.14	
23				215.24	215.24			2.00	-0.70	2.70	0.28	1.47			
23				155.60	257.04			2.00	-0.70	2.70	0.57	0.69			
	o		140.00	-	-	900	0.0007	-	-	-	-	-	1.73	9.73	
24				215.24	355.52			2.00	-0.80	2.80	0.71	0.74			
24				257.04	257.04			2.00	-0.80	2.80	0.57	0.69			
	o		140.00	-	-	900	0.0007	-	-	-	-	-	1.73	9.73	
25				355.52	355.52			2.00	-0.90	2.90	0.71	0.74			
25				278.47	278.47			2.00	-0.90	2.90	0.59	0.71			
	j	59.172	150.00	-	-	900	0.0007	-	-	-	-	-	1.82	9.79	21.436
26				385.16	385.16			2.00	-1.01	3.01	0.75	0.76			29.645
26				278.47	278.47			2.00	-1.01	3.01	0.59	0.71			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.82	9.79	
27				385.16	385.16			2.00	-1.12	3.12	0.75	0.76			
27				278.47	278.47			2.00	-1.12	3.12	0.59	0.71			
	j		60.00	-	-	900	0.0007	-	-	-	-	-	1.82	9.79	
28				385.16	385.16			2.00	-1.16	3.16	0.75	0.76			
28				313.25	313.25			2.00	-1.16	3.16	0.64	0.73			
	j	96.009	150.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	34.780
29				433.26	433.26			2.00	-1.27	3.27	0.82	0.76			48.100
29				313.25	313.25			2.00	-1.27	3.27	0.64	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	
30				433.26	433.26			2.00	-1.38	3.38	0.82	0.76			
30				313.25	313.25			2.00	-1.38	3.38	0.64	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	
31				433.26	433.26			2.00	-1.49	3.49	0.82	0.76			
31				313.25	313.25			2.00	-1.49	3.49	0.64	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	
32				433.26	433.26			2.00	-1.60	3.60	0.82	0.76			

Table 3 (3/4) Trunk Sewer Hydraulic Calculation of Sarapui Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) Vinitial / Vfinal	trative tension (Pa)	critical velocity Vc (m/s)	Page 3 Notes: entrance flow (l/s):
32				313.25	313.25			2.00	-1.60	3.60	0.64	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	
33				433.26	433.26			2.00	-1.71	3.71	0.82	0.76			
33				313.25	313.25			2.00	-1.71	3.71	0.64	0.74			
	j		70.00	-	-	900	0.0007	-	-	-	-	-	1.91	9.83	
34				433.26	433.26			2.00	-1.77	3.77	0.81	0.77			
34				313.25	313.25			2.00	-1.77	3.77	0.64	0.73			
	j		30.00	-	-	900	0.0007	-	-	-	-	-	1.89	9.83	
35				433.26	433.26			2.00	-1.79	3.79	0.82	0.76			
35				313.25	313.25			2.00	-1.79	3.79	0.65	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
36				433.26	433.26			2.00	-1.90	3.90	0.82	0.75			
36				313.25	313.25			2.00	-1.90	3.90	0.65	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
37				433.26	433.26			2.00	-2.00	4.00	0.82	0.75			
37				313.25	313.25			2.00	-2.00	4.00	0.65	0.73			
	j		150.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
38				433.26	433.26			2.00	-2.11	4.11	0.82	0.75			
38				313.25	313.25			2.00	-2.11	4.11	0.65	0.73			
	j		60.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
39				433.26	433.26			2.00	-2.16	4.16	0.82	0.75			
39				313.25	313.25			2.00	-2.16	4.16	0.65	0.73			
	j		110.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
40				433.26	433.26			2.00	-2.23	4.23	0.82	0.75			
40				313.25	313.25			2.00	-2.23	4.23	0.65	0.73			
	j		120.00	-	-	900	0.0007	-	-	-	-	-	1.86	9.83	
41				433.26	433.26			1.00	-2.32	3.32	0.82	0.75			
41				349.07	349.07			1.00	-2.70	3.70	0.64	0.82			COLETOR CC
	j		30.00	-	-	900	0.0009	-	-	-	-	-	2.40	9.83	35.820
42				484.53	484.53			1.00	-2.73	3.73	0.81	0.86			51.270
42				349.07	349.07			1.00	-2.73	3.73	0.64	0.82			
	j		150.00	-	-	900	0.0009	-	-	-	-	-	2.40	9.83	
43				484.53	484.53			1.00	-2.87	3.87	0.81	0.86			
43				349.07	349.07			1.00	-2.87	3.87	0.63	0.83			
	j		150.00	-	-	900	0.0009	-	-	-	-	-	2.43	9.83	
44				484.53	484.53			1.00	-3.01	4.01	0.81	0.87			
44				349.07	349.07			1.00	-3.01	4.01	0.64	0.82			WWTP efluent channel
	j		120.00	-	-	900	0.0009	-	-	-	-	-	2.40	9.83	
46 (interceptor)				484.53	484.53			0.95	-3.12	4.07	0.81	0.86			
TOTAL			5,530.00							4.07					

46 (interceptor)				1788.53	2137.60			0.95	-6.206	7.16	0.61	0.98			
PDBG	-		61.00	-	-	2100	0.00044	-	-	-	-	-	2.59	14.80	
ETE				3244.01	3728.53			0.95	-6.23	7.18	0.92	1.02			3244.010

Table 3 (4/4) Trunk Sewer Hydraulic Calculation of Sarapui Sewer District

JICA	SARAPUÍ SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1-1 TRUNK SEWER														
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) Vinitial Vfinal	trative tension (Pa)	critical velocity Vc (m/s)	Page 4 Notes: entrance flow (l/s):
23.1				82.31	82.31			4.00	2.00	2.00	0.54	0.77			PNB
	o	227.211	150.00	-	-	500	0.0020	-	-	-	-	-	2.61	7.17	82.311
23.2				113.83	113.83			4.00	1.70	2.30	0.67	0.83			113.834
23.2				82.31	82.31			4.00	1.70	2.30	0.54	0.77			
	o		150.00	-	-	500	0.0020	-	-	-	-	-	2.61	7.17	
23.3				113.83	113.83			4.00	1.40	2.60	0.67	0.83			
23.3				82.31	82.31			4.00	1.40	2.60	0.54	0.77			
	o		120.00	-	-	500	0.0020	-	-	-	-	-	2.61	7.17	
23.4				113.83	113.83			4.00	1.16	2.84	0.67	0.83			
23.4				101.43	101.43			4.00	0.96	3.04	0.51	0.51			
	o	52.783	150.00	-	-	700	0.0006	-	-	-	-	-	1.06	8.38	19.122
23.5				140.28	140.28			4.00	0.87	3.13	0.63	0.56			26.445
23.5				101.43	101.43			4.00	0.87	3.13	0.51	0.51			
	o		150.00	-	-	700	0.0006	-	-	-	-	-	1.06	8.38	
23.6				140.28	140.28			4.00	0.78	3.22	0.63	0.56			
23.6				101.43	101.43			4.00	0.78	3.22	0.51	0.51			
	o		150.00	-	-	700	0.0006	-	-	-	-	-	1.06	8.38	
23.7				140.28	140.28			4.00	0.69	3.31	0.63	0.56			
23.7				101.43	101.43			4.00	0.69	3.31	0.51	0.51			
	o		40.00	-	-	700	0.0006	-	-	-	-	-	1.06	8.38	
23.8				140.28	140.28			4.00	0.67	3.33	0.63	0.56			
23.8				101.43	101.43			4.00	0.17	3.83	0.34	0.53			
	j		30.00	-	-	900	0.0007	-	-	-	-	-	1.15	8.28	
23.9				140.28	140.28			4.00	0.15	3.85	0.40	0.58			
23.9				101.43	101.43			4.00	0.15	3.85	0.34	0.53			
	j		90.00	-	-	900	0.0007	-	-	-	-	-	1.15	8.28	
23.10				140.28	140.28			4.00	0.09	3.91	0.40	0.58			
23.10				101.43	101.43			4.00	0.09	3.91	0.19	1.27			
	j		90.00	-	-	900	0.0077	-	-	-	-	-	7.76	6.41	
23.11				140.28	140.28			2.00	-0.60	2.60	0.22	1.39			
23.11				101.43	101.43			2.00	-0.60	2.60	0.34	0.56			
	o		40.00	-	-	900	0.0007	-	-	-	-	-	1.26	8.18	
23.12				140.28	140.28			2.00	-0.63	2.63	0.39	0.60			
23.12				101.43	101.43			2.00	-0.63	2.63	0.34	0.53			
	o		60.00	-	-	900	0.0007	-	-	-	-	-	1.15	8.28	
23				140.28	140.28			2.00	-0.67	2.67	0.40	0.58			
TOTAL			1,220.00							2.67					

1.4 BANGU SEWER DISTRICT

Trunk Sewer Hydraulic Calculation of Bangu Sewer District is shown in *Table 4 (1/14 - 14/14).*

Table 4 (1/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 1 Notes: entrance flow (l/s):	
1				121.34	121.34			50.80	48.80	2.00	0.55	1.10				
	o	163.950	150.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13	121.339	
2				153.79	153.79			50.40	48.20	2.20	0.65	1.16			153.785	
2				121.34	121.34			50.40	48.20	2.20	0.55	1.10				
	o		110.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13		
3				153.79	153.79			50.00	47.76	2.24	0.65	1.16				
3				121.34	121.34			50.00	47.76	2.24	0.55	1.10				
	o		150.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13		
4				153.79	153.79			49.90	47.16	2.74	0.65	1.16				
4				121.34	121.34			49.90	47.16	2.74	0.55	1.10				
	j		150.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13		
5				153.79	153.79			49.80	46.56	3.24	0.65	1.16				
5				121.34	121.34			49.80	46.56	3.24	0.55	1.10				
	j		150.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13		
6				153.79	153.79			49.70	45.96	3.74	0.65	1.16				
6				121.34	121.34			49.70	45.96	3.74	0.55	1.10				
	j		130.00	-	-	500	0.0040	-	-	-	-	-	5.30	7.13		
7				153.79	153.79			49.65	45.44	4.21	0.65	1.16				
7				163.29	163.29			49.65	45.04	4.61	0.39	0.70				
	j	56.689	140.00	-	-	900	0.0010	-	-	-	-	-	1.90	8.59	41.955	
8				206.96	206.96			49.60	44.90	4.70	0.45	0.74			53.174	
8				181.41	181.41			49.60	44.90	4.70	0.42	0.72				
	j	24.480	150.00	-	-	900	0.0010	-	-	-	-	-	1.98	8.77	18.118	
9				229.92	229.92			49.55	44.75	4.80	0.48	0.76			22.962	
9				181.41	181.41			49.55	44.75	4.80	0.42	0.72				
	j		150.00	-	-	900	0.0010	-	-	-	-	-	1.98	8.77		
10				229.92	229.92			49.50	44.60	4.90	0.48	0.76				
10				181.41	181.41			49.50	44.60	4.90	0.42	0.72				
	j		100.00	-	-	900	0.0010	-	-	-	-	-	1.98	8.77		
11				229.92	229.92			49.46	44.50	4.96	0.48	0.76				
11				201.33	201.33			49.46	44.50	4.96	0.29	1.32				
	j	26.913	130.00	-	-	900	0.0050	-	-	-	-	-	7.38	7.68	19.918	
12				255.17	255.17			48.60	43.85	4.75	0.33	1.43			25.244	
12				201.33	201.33			48.60	43.85	4.75	0.29	1.32				
	j		130.00	-	-	900	0.0050	-	-	-	-	-	7.38	7.68		
13				255.17	255.17			47.74	43.20	4.54	0.33	1.43				
13				201.33	201.33			47.74	43.20	4.54	0.29	1.32				
	j		130.00	-	-	900	0.0050	-	-	-	-	-	7.38	7.68		
14				255.17	255.17			46.88	42.55	4.33	0.33	1.43				
14				201.33	201.33			46.88	42.55	4.33	0.29	1.32				
	j		130.00	-	-	900	0.0050	-	-	-	-	-	7.38	7.68		
15				255.17	255.17			46.00	41.90	4.10	0.33	1.43				
15				201.33	201.33			46.00	41.90	4.10	0.29	1.32				
	j		120.00	-	-	900	0.0050	-	-	-	-	-	7.38	7.68		
16				255.17	255.17			45.70	41.30	4.40	0.33	1.43				

Table 4 (2/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 2 Notes: entrance flow (l/s):
16				239.03	239.03			45.70	41.30	4.40	0.32	1.41			
	j	50.935	140.00	-	-	900	0.0050	-	-	-	-	-	8.17	7.92	37.697
17				302.94	302.94			44.00	40.60	3.40	0.36	1.49			47.777
17				239.03	262.29			44.00	40.48	3.52	0.38	1.16			
	j		135.00	-	-	900	0.0028	-	-	-	-	-	5.27	8.51	
18				302.94	332.43			44.00	40.10	3.90	0.44	1.23			
18				262.29	262.29			44.00	40.10	3.90	0.39	1.15			
	j		130.00	-	-	900	0.0028	-	-	-	-	-	5.20	8.53	
19				332.43	332.43			43.00	39.74	3.26	0.44	1.22			
19				262.29	262.29			43.00	39.74	3.26	0.39	1.15			
	j		90.00	-	-	900	0.0028	-	-	-	-	-	5.21	8.52	
20				332.43	332.43			43.00	39.49	3.51	0.44	1.22			
20				262.29	262.29			43.00	39.49	3.51	0.39	1.15			
	j		90.00	-	-	900	0.0028	-	-	-	-	-	5.21	8.52	
21				332.43	332.43			43.00	39.24	3.76	0.44	1.22			
21				265.03	265.03			43.00	39.24	3.76	0.39	1.16			
	j	3.696	110.00	-	-	900	0.0028	-	-	-	-	-	5.29	8.53	2.735
22				335.90	335.90			42.00	38.93	3.07	0.44	1.23			3.467
22				278.76	278.76			42.00	38.93	3.07	0.40	1.17			
	j	18.555	150.00	-	-	900	0.0028	-	-	-	-	-	5.37	8.62	13.733
23				353.30	353.30			42.00	38.51	3.49	0.45	1.25			17.405
23				278.76	278.76			42.00	38.51	3.49	0.40	1.17			
	j		150.00	-	-	900	0.0028	-	-	-	-	-	5.37	8.62	
24				353.30	353.30			42.00	38.09	3.91	0.45	1.25			
24				283.88	283.88			42.00	38.09	3.91	0.40	1.18			
	j	6.908	150.00	-	-	900	0.0028	-	-	-	-	-	5.41	8.65	5.113
25				359.78	359.78			42.00	37.67	4.33	0.46	1.25			6.480
25				283.88	283.88			42.00	37.67	4.33	0.40	1.16			
	j		70.00	-	-	900	0.0027	-	-	-	-	-	5.27	8.68	
26				359.78	359.78			42.00	37.48	4.52	0.46	1.24			
26				289.52	289.52			42.00	37.48	4.52	0.40	1.18			
	j	7.624	50.00	-	-	900	0.0028	-	-	-	-	-	5.45	8.69	5.642
27				366.93	366.93			41.00	37.34	3.66	0.46	1.26			7.151
27				289.52	289.52			41.00	37.34	3.66	0.40	1.19			
	j		120.00	-	-	900	0.0028	-	-	-	-	-	5.50	8.68	
28				366.93	366.93			41.00	37.00	4.00	0.46	1.27			
28				298.94	298.94			41.00	37.00	4.00	0.41	1.20			
	j	12.733	110.00	-	-	900	0.0028	-	-	-	-	-	5.54	8.74	9.424
29				378.88	378.88			40.00	36.69	3.31	0.47	1.27			11.944
29				298.94	298.94			40.00	36.69	3.31	0.37	1.69			
	j		130.00	-	-	900	0.0045	-	-	-	-	-	11.76	7.99	
30				378.88	378.88			40.00	36.11	3.89	0.41	1.79			
30				298.94	298.94			40.00	36.11	3.89	0.36	1.69			
	j		130.00	-	-	900	0.0045	-	-	-	-	-	11.76	7.99	
31				378.88	378.88			39.00	35.52	3.48	0.41	1.79			
31				303.83	303.83			39.00	35.52	3.48	0.37	1.71			
	j	6.600	70.00	-	-	900	0.0044	-	-	-	-	-	11.91	8.01	4.885
32				385.07	385.07			39.00	35.21	3.79	0.42	1.81			6.191

Table 4 (3/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 3 Notes: entrance flow (l/s):
32				310.83	310.83			39.00	35.21	3.79	0.37	1.71			
	j	9.463	110.00	-	-	900	0.0045	-	-	-	-	-	11.93	8.04	7.004
33				393.95	393.95			39.00	34.71	4.29	0.42	1.81			8.877
33				310.83	310.83			39.00	34.71	4.29	0.37	1.71			
	j		110.00	-	-	900	0.0045	-	-	-	-	-	11.93	8.04	
34				393.95	393.95			39.00	34.22	4.78	0.42	1.81			
34				310.83	310.83			39.00	34.22	4.78	0.37	1.72			
	j		110.00	-	-	900	0.0045	-	-	-	-	-	12.06	8.04	
35				393.95	393.95			38.00	33.72	4.28	0.42	1.82			
35				358.26	581.32			38.00	31.93	6.07	0.35	1.37			
	j	64.082	120.00	-	-	1200	0.0045	-	-	-	-	-	6.62	9.97	47.426
36				454.05	736.77			37.40	31.39	6.01	0.39	1.46			60.109
36				581.32	581.32			37.40	31.39	6.01	0.40	1.37			
	j		100.00	-	-	1200	0.0026	-	-	-	-	-	6.66	9.96	
37				736.77	736.77			37.00	31.13	5.87	0.45	1.46			
37				584.81	584.81			37.00	31.13	5.87	0.40	1.39			
	j	4.704	30.00	-	-	1200	0.0027	-	-		-	-	6.81	9.95	3.481
38				741.18	741.18			37.00	31.05	5.95	0.45	1.47			4.412
38				584.81	584.81			37.00	31.05	5.95	0.40	1.37			
	j		50.00	-	-	1200	0.0026	-	-	-	-	-	6.67	9.98	
39				741.18	741.18			36.70	30.92	5.78	0.45	1.46			
39				597.22	818.96			36.70	30.92	5.78	0.48	1.50			
	j	16.776	130.00	-	-	1200	0.0026	-	-	-	-	-	7.66	10.65	12.416
40				756.92	1037.95			35.80	30.58	5.22	0.56	1.60			15.736
40				818.96	818.96			35.80	30.58	5.22	0.48	1.50			
	j		130.00	-	-	1200	0.0026	-	-	-	-	-	7.66	10.65	
41				1037.95	1037.95			36.70	30.24	6.46	0.56	1.60			
41				818.96	818.96			36.70	30.24	6.46	0.48	1.50			
	j		120.00	-	-	1200	0.0026	-	-	-	-	-	7.59	10.66	
42				1037.95	1037.95			34.00	29.93	4.07	0.56	1.59			
42				829.55	829.55			34.00	29.93	4.07	0.49	1.51			
	j	14.311	150.00	-	-	1200	0.0026	-	-	-	-	-	7.66	10.68	10.591
43				1051.37	1051.37			34.00	29.54	4.46	0.57	1.60			13.423
43				829.55	829.55			34.00	29.54	4.46	0.49	1.51			
	j		150.00	-	-	1200	0.0026	-	-	-	-	-	7.66	10.68	
44				1051.37	1051.37			33.50	29.15	4.35	0.57	1.60			
44				829.55	829.55			33.50	29.15	4.35	0.49	1.51			
	j		150.00	-	-	1200	0.0026	-	-	-	-	-	7.66	10.68	
45				1051.37	1051.37			33.00	28.76	4.24	0.57	1.60			
45				850.00	850.00			33.00	28.76	4.24	0.49	1.52			
	j	27.621	150.00	-	-	1200	0.0026	-	-	-	-	-	7.74	10.73	20.443
46				1077.28	1077.28			32.00	28.37	3.63	0.57	1.61			25.909
46				850.00	850.00			32.00	28.37	3.63	0.59	1.22			
	j		150.00	-	-	1200	0.0015	-	-	-	-	-	4.86	11.21	
47				1077.28	1077.28			33.00	28.15	4.85	0.70	1.28			
47				850.00	850.00			33.00	28.15	4.85	0.59	1.24			
	j		150.00	-	-	1200	0.0015	-	-	-	-	-	5.04	11.18	
48				1077.28	1077.28			32.00	27.92	4.08	0.69	1.31			

Table 4 (4/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 4 Notes: entrance flow (l/s):
48				894.03	894.03			32.00	27.92	4.08	0.61	1.25			
	j	59.501	80.00	-	-	1200	0.0015	-	-	-	-	-	5.04	11.26	44.036
49				1133.09	1133.09			32.00	27.80	4.20	0.72	1.30			55.812
49				894.03	894.03			32.00	27.80	4.20	0.62	1.23			
	j		110.00	-	-	1200	0.0015	-	-	-	-	-	4.91	11.27	
50				1133.09	1133.09			34.00	27.64	6.36	0.73	1.29			
50				894.03	894.03			34.00	27.64	6.36	0.61	1.25			
	j		120.00	-	-	1200	0.0015	-	-	-	-	-	5.04	11.26	
51				1133.09	1133.09			32.00	27.46	4.54	0.72	1.30			
51				894.03	894.03			32.00	27.46	4.54	0.61	1.25			
	j		120.00	-	-	1200	0.0015	-	-	-	-	-	5.04	11.26	
52				1133.09	1133.09			31.00	27.28	3.72	0.72	1.30			
52				894.03	894.03			31.00	27.28	3.72	0.61	1.25			
	j		100.00	-	-	1200	0.0015	-	-	-	-	-	5.04	11.26	
53				1133.09	1133.09			31.00	27.13	3.87	0.72	1.30			
53				894.03	894.03			31.00	27.13	3.87	0.61	1.26			
	j		150.00	-	-	1200	0.0015	-	-	-	-	-	5.13	11.24	
54				1133.09	1133.09			31.00	26.90	4.10	0.72	1.32			
54				894.03	894.03			31.00	26.90	4.10	0.40	2.09			
	j		150.00	-	-	1200	0.0060	-	-	-	-	-	15.44	9.99	
55				1133.09	1133.09			31.00	26.00	5.00	0.46	2.22			
55				894.03	894.03			31.00	26.00	5.00	0.40	2.09			
	j		150.00	-	-	1200	0.0060	-	-	-	-	-	15.44	9.99	
56				1133.09	1133.09			29.00	25.10	3.90	0.46	2.22			
56				952.99	952.99			29.00	25.10	3.90	0.41	2.12			
	j	79.667	120.00	-	-	1200	0.0060	-	-	-	-	-	15.83	10.12	58.961
57				1207.82	1207.82			29.00	24.38	4.62	0.47	2.26			74.728
57				952.99	952.99			29.00	24.38	4.62	0.41	2.12			
	j		130.00	-	-	1200	0.0060	-	-	-	-	-	15.83	10.12	
58				1207.82	1207.82			28.00	23.60	4.40	0.47	2.26			
58				952.99	952.99			28.00	23.60	4.40	0.41	2.12			
	j		110.00	-	-	1200	0.0060	-	-	-	-	-	15.83	10.12	
59				1207.82	1207.82			27.00	22.94	4.06	0.47	2.26			
59				952.99	952.99			27.00	22.94	4.06	0.41	2.12			
	j		100.00	-	-	1200	0.0060	-	-	-	-	-	15.83	10.12	
60				1207.82	1207.82			26.00	22.34	3.66	0.47	2.26			
60				980.48	980.48			26.00	22.34	3.66	0.52	1.66			
	j	37.146	150.00	-	-	1200	0.0060	-	-	-	-	-	9.18	10.86	27.492
61				1242.67	1242.67			26.00	21.89	4.11	0.60	1.76			34.843
61				980.48	980.48			26.00	21.89	4.11	0.52	1.65			
	j		125.00	-	-	1200	0.0060	-	-	-	-	-	9.08	10.87	
62				1242.67	1242.67			26.00	21.52	4.48	0.61	1.75			
62				1007.46	1007.46			26.00	21.52	4.48	0.53	1.67			
	j	36.455	120.00	-	-	1200	0.0060	-	-	-	-	-	9.28	10.91	26.980
63				1276.86	1276.86			26.00	21.16	4.84	0.61	1.77			34.195
63				1007.46	1007.46			26.00	21.16	4.84	0.53	1.67			
	j		120.00	-	-	1200	0.0060	-	-	-	-	-	9.28	10.91	
64				1276.86	1276.86			26.00	20.80	5.20	0.61	1.77			

Table 4 (5/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 5 Notes: entrance flow (l/s):
64				1007.46	1007.46			26.00	20.80	5.20	0.53	1.67			
	j		120.00	-	-	1200	0.0060	-	-	-	-	-	9.28	10.91	
65				1276.86	1276.86			26.00	20.44	5.56	0.61	1.77			
65				1007.46	1007.46			26.00	18.40	7.60	0.53	1.67			
	j		50.00	-	-	1200	0.0030	-	-	-	-	-	9.28	10.91	
66				1276.86	1276.86			26.00	18.25	7.75	0.61	1.77			
66				1007.46	1007.46			26.00	18.25	7.75	0.53	1.67			
	j		50.00	-	-	1200	0.0030	-	-	-	-	-	9.28	10.91	
67				1276.86	1276.86			26.00	18.10	7.90	0.61	1.77			
67				1007.46	1379.93			26.00	18.10	7.90	0.65	1.80			
	j		10.00	-	-	1200	0.0030	-	-	-	-	-	10.36	11.33	
ETE				1276.86	1748.74			26.00	18.07	7.93	0.77	1.86			
TOTAL			7,940.00							7.93					

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1-1 TRUNK SEWER														
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
17.1				23.27	23.27			48.00	42.00	6.00	0.25	0.61			
	j	31.437	80.00	-	-	500	0.0027	-	-	-	-	-	2.00	5.32	23.267
17.2				29.49	29.49			47.00	41.78	5.22	0.28	0.65			29.488
17.2				23.27	23.27			47.00	41.78	5.22	0.25	0.60			
	j		150.00	-	-	500	0.0027	-	-	-	-	-	1.95	5.34	
17.3				29.49	29.49			46.00	41.38	4.62	0.28	0.64			
17.3				23.27	23.27			46.00	41.38	4.62	0.25	0.61			
	j		150.00	-	-	500	0.0027	-	-	-	-	-	1.99	5.33	
17.4				29.49	29.49			45.00	40.97	4.03	0.28	0.65			
17.4				23.27	23.27			45.00	40.97	4.03	0.25	0.61			
	j		110.00	-	-	500	0.0027	-	-	-	-	-	1.99	5.33	
17.5				29.49	29.49			44.50	40.67	3.83	0.28	0.65			
17.5				23.27	23.27			44.50	40.67	3.83	0.25	0.61			
	j		70.00	-	-	500	0.0027	-	-	-	-	-	1.98	5.33	
17				29.49	29.49			44.00	40.48	3.52	0.28	0.65			
TOTAL			560.00							3.52					

Table 4 (6/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 1-2 TRUNK SEWER														
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 6 Notes: entrance flow (l/s):
39.1				44.75	44.75			52.60	50.60	2.00	0.35	1.13			
	o	60.460	150.00	-	-	400	0.0087	-	-	-	-	-	6.77	5.49	44.747
39.2				56.71	56.71			52.60	49.30	3.30	0.40	1.20			56.712
39.2				44.75	44.75			52.60	49.30	3.30	0.36	1.12			
	o		65.00	-	-	400	0.0085	-	-	-	-	-	6.64	5.50	
39.3				56.71	56.71			52.60	48.75	3.85	0.40	1.19			
39.3				49.04	49.04			52.60	48.75	3.85	0.37	1.15			
	o	5.794	95.00	-	-	400	0.0084	-	-	-	-	-	6.84	5.61	4.288
39.4				62.15	62.15			51.00	47.95	3.05	0.42	1.22			5.435
39.4				49.04	49.04			51.00	47.95	3.05	0.37	1.15			
	o		95.00	-	-	400	0.0084	-	-	-	-	-	6.84	5.61	
39.5				62.15	62.15			51.00	47.15	3.85	0.42	1.22			
39.5				54.13	54.13			51.00	47.15	3.85	0.39	1.18			
	o	6.883	95.00	-	-	400	0.0084	-	-	-	-	-	7.10	5.72	5.094
39.6				68.60	68.60			50.00	46.35	3.65	0.45	1.25			6.457
39.6				81.82	81.82			50.00	46.25	3.75	0.36	1.30			
	j	37.412	95.00	-	-	500	0.0084	-	-	-	-	-	8.29	6.17	27.688
39.7				103.70	103.70			49.00	45.45	3.55	0.40	1.38			35.092
39.7				81.82	81.82			49.00	45.45	3.55	0.36	1.30			
	j		95.00	-	-	500	0.0084	-	-	-	-	-	8.29	6.17	
39.8				103.70	103.70			48.00	44.65	3.35	0.40	1.38			
39.8				113.92	113.92			48.00	44.00	4.00	0.47	1.25			
	j	43.375	25.00	-	-	500	0.0060	-	-	-	-	-	7.17	6.80	32.102
39.9				144.38	144.38			48.00	43.85	4.15	0.54	1.33			40.686
39.9				113.92	113.92			48.00	43.85	4.15	0.47	1.25			
	j		85.00	-	-	500	0.0060	-	-	-	-	-	7.17	6.80	
39.10				144.38	144.38			48.00	43.34	4.66	0.54	1.33			
39.10				145.39	145.39			48.00	43.34	4.66	0.54	1.34			
	j	42.518	90.00	-	-	500	0.0060	-	-	-	-	-	7.89	7.10	31.467
39.11				184.26	184.26			47.00	42.80	4.20	0.64	1.41			39.881
39.11				145.39	145.39			47.00	42.80	4.20	0.54	1.34			
	j		90.00	-	-	500	0.0061	-	-	-	-	-	8.01	7.09	
39.12				184.26	184.26			46.00	42.25	3.75	0.63	1.42			
39.12				174.61	174.61			46.00	42.25	3.75	0.61	1.40			
	j	39.486	140.00	-	-	500	0.0061	-	-	-	-	-	8.51	7.27	29.223
39.13				221.30	221.30			45.00	41.40	3.60	0.72	1.46			37.038
39.13				174.61	174.61			45.00	41.40	3.60	0.61	1.40			
	j		140.00	-	-	500	0.0061	-	-	-	-	-	8.51	7.27	
39.14				221.30	221.30			44.00	40.55	3.45	0.72	1.46			
39.14				191.92	191.92			44.00	40.15	3.85	0.44	1.17			
	o	23.392	140.00	-	-	700	0.0036	-	-	-	-	-	5.70	7.87	17.312
39.15				243.24	243.24			43.00	39.65	3.35	0.50	1.25			21.941
39.15				191.92	191.92			43.00	39.65	3.35	0.44	1.17			
	o		140.00	-	-	700	0.0036	-	-	-	-	-	5.70	7.87	
39.16				243.24	243.24			42.00	39.15	2.85	0.50	1.25			

Table 4 (7/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 7 Notes: entrance flow (l/s):
39.16				191.92	191.92			42.00	39.15	2.85	0.43	1.19			
	o		120.00	-	-	700	0.0037	-	-	-	-	-	5.93	7.83	
39.17				243.24	243.24			41.70	38.70	3.00	0.49	1.27			
39.17				191.92	191.92			41.70	38.70	3.00	0.43	1.19			
	o		120.00	-	-	700	0.0038	-	-	-	-	-	5.93	7.83	
39.18				243.24	243.24			41.00	38.25	2.75	0.49	1.27			
39.18				215.66	215.66			41.00	38.25	2.75	0.40	1.50			
	o	32.077	70.00	-	-	700	0.0064	-	-	-	-	-	9.58	7.60	23.741
39.19				273.33	273.33			41.00	37.80	3.20	0.45	1.60			30.089
39.19				215.66	215.66			41.00	37.80	3.20	0.28	1.47			
	j		40.00	-	-	900	0.0064	-	-	-	-	-	9.22	7.61	
39.20				273.33	273.33			41.00	37.55	3.46	0.32	1.60			
39.20				215.66	215.66			41.00	37.55	3.46	0.28	1.47			
	j		30.00	-	-	900	0.0064	-	-	-	-	-	9.28	7.61	
39.21				273.33	273.33			41.00	37.35	3.65	0.32	1.60			
39.21				215.66	215.66			41.00	37.35	3.65	0.28	1.47			
	j		150.00	-	-	900	0.0064	-	-	-	-	-	9.26	7.61	
39.22				273.33	273.33			41.00	36.39	4.61	0.32	1.60			
39.22				215.66	215.66			41.00	36.39	4.61	0.28	1.46			
	j		85.00	-	-	900	0.0064	-	-	-	-	-	9.19	7.61	
39.23				273.33	273.33			39.00	35.85	3.15	0.32	1.59			
39.23				215.66	215.66			39.00	35.85	3.15	0.28	1.47			
	j		85.00	-	-	900	0.0065	-	-	-	-	-	9.33	7.60	
39.24				273.33	273.33			38.00	35.30	2.70	0.32	1.60			
39.24				221.74	221.74			38.00	35.30	2.70	0.32	1.34			
	o	8.212	130.00	-	-	900	0.0046	-	-	-	-	-	7.46	7.87	6.078
39.25				281.03	281.03			37.50	34.70	2.80	0.35	1.42			7.703
39.25				221.74	221.74			37.50	34.70	2.80	0.32	1.34			
	o		120.00	-	-	900	0.0046	-	-	-	-	-	7.41	7.87	
39.26				281.03	281.03			37.00	34.15	2.85	0.35	1.41			
39.26				221.74	221.74			37.00	34.15	2.85	0.32	1.34			
	o		120.00	-	-	900	0.0046	-	-	-	-	-	7.41	7.87	
39				281.03	281.03			36.70	33.60	3.10	0.35	1.41			
TOTAL			2,610.00							3.10					

Table 4 (8/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 2 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 8 Notes: entrance flow (l/s):	
1				11.86	11.86			42.00	40.00	2.00	0.16	0.58				
	o	16.024	60.00	-	-	500	0.0042	-	-	-	-	-	2.08	4.42	11.859	
2				15.03	15.03			42.00	39.75	2.25	0.18	0.62			15.031	
2				55.73	55.73			42.00	39.75	2.25	0.42	0.69				
	o	59.276	50.00	-	-	500	0.0020	-	-	-	-	-	2.24	6.59	43.871	
3				70.63	70.63			42.00	39.65	2.35	0.49	0.74			55.601	
3				66.81	66.81			42.00	39.65	2.35	0.42	0.86				
	j	14.968	80.00	-	-	500	0.0031	-	-	-	-	-	3.44	6.53	11.078	
4				84.67	84.67			42.00	39.40	2.60	0.48	0.91			14.040	
4				66.81	66.81			42.00	39.40	2.60	0.43	0.81				
	o		110.00	-	-	500	0.0027	-	-	-	-	-	3.08	6.62		
5				84.67	84.67			42.00	39.10	2.90	0.50	0.87				
5				66.81	66.81			42.00	39.10	2.90	0.43	0.81				
	o		150.00	-	-	500	0.0027	-	-	-	-	-	3.03	6.64		
6				84.67	84.67			41.00	38.70	2.30	0.50	0.86				
6				122.15	122.15			41.00	38.70	2.30	0.59	1.02				
	j	74.772	150.00	-	-	500	0.0033	-	-	-	-	-	4.58	7.22	55.339	
7				154.81	154.81			41.80	38.20	3.60	0.69	1.08			70.136	
7				122.15	122.15			41.80	38.20	3.60	0.63	0.95				
	j		140.00	-	-	500	0.0027	-	-	-	-	-	3.86	7.30		
8				154.81	154.81			42.00	37.82	4.18	0.75	0.98				
8				124.87	124.87			42.00	37.82	4.18	0.62	0.99				
	j	3.678	150.00	-	-	500	0.0030	-	-	-	-	-	4.23	7.28	2.722	
9				158.26	158.26			41.50	37.37	4.13	0.73	1.03			3.450	
9				124.87	124.87			41.50	37.37	4.13	0.62	0.99				
	j		150.00	-	-	500	0.0030	-	-	-	-	-	4.23	7.28		
10				158.26	158.26			40.70	36.92	3.78	0.73	1.03				
10				124.87	124.87			40.70	36.92	3.78	0.62	0.99				
	j		100.00	-	-	500	0.0030	-	-	-	-	-	4.23	7.28		
11				158.26	158.26			40.50	36.62	3.88	0.73	1.03				
11				155.53	155.53			40.50	36.22	4.28	0.29	1.02				
	j	41.424	100.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68	30.658	
12				197.11	197.11			41.50	35.92	5.58	0.33	1.11			38.855	
12				155.53	155.53			41.50	35.92	5.58	0.29	1.02				
	j		100.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68		
13				197.11	197.11			41.00	35.62	5.38	0.33	1.11				
13				155.53	155.53			41.00	35.62	5.38	0.29	1.02				
	j		50.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68		
14				197.11	197.11			40.50	35.47	5.03	0.33	1.11				
14				155.53	155.53			40.50	35.47	5.03	0.29	1.02				
	j		100.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68		
15				197.11	197.11			39.75	35.17	4.58	0.33	1.11				
15				155.53	155.53			39.75	35.17	4.58	0.29	1.02				
	j		100.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68		
16				197.11	197.11			39.00	34.87	4.13	0.33	1.11				

Table 4 (9/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 9 Notes: entrance flow (l/s):
16				155.53	155.53			39.00	34.87	4.13	0.29	1.02			
	j		120.00	-	-	900	0.0030	-	-	-	-	-	4.43	7.68	
17				197.11	197.11			39.00	34.51	4.49	0.33	1.11			
17				155.53	155.53			39.00	34.51	4.49	0.29	1.01			
	j		115.00	-	-	900	0.0030	-	-	-	-	-	4.37	7.69	
18				197.11	197.11			39.00	34.17	4.83	0.33	1.10			
18				155.53	155.53			39.00	34.17	4.83	0.28	1.02			
	j		115.00	-	-	900	0.0030	-	-	-	-	-	4.48	7.67	
19				197.11	197.11			39.00	33.82	5.18	0.33	1.11			
19				155.53	155.53			39.00	33.82	5.18	0.28	1.04			
	j		30.00	-	-	900	0.0032	-	-	-	-	-	4.62	7.64	
20				197.11	197.11			39.00	33.73	5.28	0.33	1.13			
20				155.53	155.53			39.00	33.73	5.28	0.28	1.04			
	j		125.00	-	-	900	0.0032	-	-	-	-	-	4.61	7.64	
21				197.11	197.11			38.00	33.33	4.67	0.33	1.13			
21				155.53	155.53			38.00	33.33	4.67	0.28	1.04			
	j		125.00	-	-	900	0.0032	-	-	-	-	-	4.66	7.63	
22				197.11	197.11			37.00	32.93	4.07	0.33	1.13			
22				155.53	223.07			37.00	32.93	4.07	0.34	1.18			
	j		70.00	-	-	900	0.0033	-	-	-	-	-	5.63	8.13	
23				197.11	282.71			37.00	32.70	4.30	0.38	1.25			
23				223.07	223.07			37.00	32.30	4.70	0.33	1.24			
	j		40.00	-	-	900	0.0037	-	-	-	-	-	6.28	8.02	
24				282.71	282.71			37.00	32.15	4.85	0.37	1.31			
24				223.07	223.07			37.00	32.15	4.85	0.33	1.24			
	j		40.00	-	-	900	0.0037	-	-	-	-	-	6.28	8.02	
35 (N0.1 TS)				282.71	282.71			38.00	32.00	6.00	0.37	1.31			
TOTAL			2,370.00							6.00					

Table 4 (10/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 2-1 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 10 Notes: entrance flow (l/s):	
22.1				51.07	51.07			37.00	35.00	2.00	0.58	0.68				
	o	69.000	50.00	-	-	400	0.0020	-	-	-	-	-	2.18	6.44	51.067	
22.2				64.72	64.72			37.00	34.90	2.10	0.68	0.72			64.722	
22.2				51.07	51.07			37.00	34.90	2.10	0.53	0.76				
	o		150.00	-	-	400	0.0027	-	-	-	-	-	2.76	6.31		
22.3				64.72	64.72			37.00	34.50	2.50	0.62	0.80				
22.3				51.07	51.07			37.00	34.50	2.50	0.53	0.76				
	o		150.00	-	-	400	0.0027	-	-	-	-	-	2.76	6.31		
22.4				64.72	64.72			37.00	34.10	2.90	0.62	0.80				
22.4				67.54	67.54			37.00	34.10	2.90	0.63	0.82				
	o	22.260	140.00	-	-	400	0.0027	-	-	-	-	-	3.09	6.53	16.474	
22.5				85.60	85.60			37.00	33.72	3.28	0.75	0.85			20.879	
22.5				67.54	67.54			37.00	33.50	3.50	0.50	0.68				
	j		30.00	-	-	500	0.0017	-	-	-	-	-	2.09	6.95		
22.6				85.60	85.60			37.00	33.45	3.55	0.58	0.72				
22.6				67.54	67.54			37.00	33.45	3.55	0.50	0.69				
	j		110.00	-	-	500	0.0017	-	-	-	-	-	2.15	6.93		
22.7				85.60	85.60			37.00	33.26	3.74	0.58	0.73				
22.7				67.54	67.54			37.00	33.26	3.74	0.50	0.69				
	j		110.00	-	-	500	0.0017	-	-	-	-	-	2.15	6.93		
22				85.60	85.60			37.00	33.07	3.93	0.58	0.73				
TOTAL			740.00							3.93						

Table 4 (11/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 3 TRUNK SEWER															
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial final	downstream flow (l/s) initial final	diam. (mm)	slope (m/m)	ground level (m) upstream downstream	trunk sewer level (m) upstream downstream	trunk sewer depth (m) upstream downstream	h/d (m/m) inicial final	velocity (m/s) $V_{initial}$ V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 11 Notes: entrance flow (l/s):	
1				38.09	38.09			38.00	36.00	2.00	0.35	0.99				
	o	51.464	150.00	-	-	400	0.0067	-	-	-	-	-	5.15	5.46	38.089	
2				48.07	48.07			37.00	35.00	2.00	0.39	1.05			48.073	
2				38.09	38.09			37.00	35.00	2.00	0.35	0.99				
	o		150.00	-	-	400	0.0067	-	-	-	-	-	5.15	5.46		
3				48.07	48.07			36.00	34.00	2.00	0.39	1.05				
3				60.02	60.02			36.00	34.00	2.00	0.44	1.11				
	o	29.627	150.00	-	-	400	0.0067	-	-	-	-	-	6.13	5.97	21.927	
4				75.86	75.86			35.00	33.00	2.00	0.51	1.18			27.791	
4				60.02	60.02			35.00	33.00	2.00	0.44	1.11				
	o		110.00	-	-	400	0.0067	-	-	-	-	-	6.17	5.96		
5				75.86	75.86			34.50	32.26	2.24	0.51	1.18				
5				60.02	60.02			34.50	32.26	2.24	0.44	1.11				
	o		150.00	-	-	400	0.0067	-	-	-	-	-	6.18	5.96		
6				75.86	75.86			34.00	31.25	2.75	0.51	1.18				
6				60.02	60.02			34.00	31.25	2.75	0.44	1.11				
	o		50.00	-	-	400	0.0067	-	-	-	-	-	6.12	5.97		
7				75.86	75.86			34.00	30.92	3.08	0.51	1.18				
7				60.02	60.02			34.00	30.92	3.08	0.44	1.11				
	o		60.00	-	-	400	0.0067	-	-	-	-	-	6.12	5.97		
8				75.86	75.86			34.00	30.52	3.48	0.51	1.18				
8				123.48	123.48			34.00	30.42	3.58	0.43	1.53				
	j	85.745	70.00	-	-	500	0.0165	-	-	-	-	-	10.86	6.60	63.459	
9				156.29	156.29			34.00	29.74	4.26	0.49	1.62			80.428	
9				123.48	123.48			34.00	29.74	4.26	0.43	1.52				
	o		90.00	-	-	500	0.0165	-	-	-	-	-	10.85	6.60		
10				156.29	156.29			32.00	28.87	3.13	0.49	1.62				
10				123.48	123.48			32.00	28.87	3.13	0.43	1.52				
	o		90.00	-	-	500	0.0165	-	-	-	-	-	10.85	6.60		
11				156.29	156.29			31.00	28.00	3.00	0.49	1.62				
11				133.88	262.58			31.00	26.60	4.40	0.32	1.61				
	j	14.062	150.00	-	-	900	0.0067	-	-	-	-	-	10.72	7.84	10.408	
12				169.48	332.61			31.00	25.60	5.40	0.35	1.70			13.190	
12				262.58	262.58			31.00	25.60	5.40	0.39	1.13				
	j		150.00	-	-	900	0.0027	-	-	-	-	-	5.04	8.56		
13				332.61	332.61			28.00	25.20	2.80	0.44	1.21				
13				262.58	262.58			28.00	25.20	2.80	0.42	1.02				
	j		150.00	-	-	900	0.0020	-	-	-	-	-	4.00	8.81		
14				332.61	332.61			28.00	24.90	3.10	0.48	1.09				
14				262.58	262.58			28.00	24.90	3.10	0.42	1.02				
	j		110.00	-	-	900	0.0020	-	-	-	-	-	4.00	8.81		
15				332.61	332.61			28.00	24.68	3.32	0.48	1.09				
15				262.58	262.58			28.00	24.68	3.32	0.42	1.02				
	j		150.00	-	-	900	0.0020	-	-	-	-	-	4.00	8.81		
16				332.61	332.61			28.00	24.38	3.62	0.48	1.09				

Table 4 (12/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 12 Notes: entrance flow (l/s):
16				262.58	262.58			28.00	24.38	3.62	0.42	1.02			
	j		150.00	-	-	900	0.0020	-	-	-	-	-	4.00	8.81	
17				332.61	332.61			28.00	24.08	3.92	0.48	1.09			
17				262.58	262.58			28.00	24.08	3.92	0.42	1.02			
	j		130.00	-	-	900	0.0020	-	-	-	-	-	4.00	8.81	
18				332.61	332.61			27.00	23.82	3.18	0.48	1.09			
18				310.70	310.70			27.00	23.82	3.18	0.45	1.09			
	j	65.024	150.00	-	-	900	0.0021	-	-	-	-	-	4.50	9.05	48.124
19				393.60	393.60			26.50	23.50	3.00	0.52	1.16			60.992
19				310.70	310.70			26.50	23.50	3.00	0.46	1.07			
	o		150.00	-	-	900	0.0020	-	-	-	-	-	4.28	9.10	
20				393.60	393.60			26.00	23.20	2.80	0.54	1.13			
20				310.70	310.70			26.00	23.20	2.80	0.46	1.07			
	o		100.00	-	-	900	0.0020	-	-	-	-	-	4.28	9.10	
21				393.60	393.60			26.00	23.00	3.00	0.54	1.13			
21				322.56	372.46			26.00	23.00	3.00	0.52	1.12			
	o	16.021	100.00	-	-	900	0.0020	-	-	-	-	-	4.59	9.41	11.857
ETE-manhole				408.63	471.88			26.00	22.80	3.20	0.60	1.19			15.028
TOTAL			2,560.00							3.20					

JICA

BANGU SEWERAGE DISTRICT
TRUNK SEWER HYDRAULIC CONCEPT DESIGN
No. 3-1 TRUNK SEWER

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
11.1				51.59	51.59			38.00	35.50	2.50	0.36	1.26			
	o	69.705	120.00	-	-	400	0.0104	-	-	-	-	-	8.29	5.54	51.589
11.2				65.38	65.38			36.80	34.25	2.55	0.41	1.34			65.383
11.2				51.59	51.59			36.80	34.25	2.55	0.36	1.26			
	o		120.00	-	-	400	0.0104	-	-	-	-	-	8.29	5.54	
11.3				65.38	65.38			35.00	33.00	2.00	0.41	1.34			
11.3				51.59	51.59			35.00	33.00	2.00	0.36	1.26			
	o		130.00	-	-	400	0.0104	-	-	-	-	-	8.27	5.55	
11.4				65.38	65.38			34.00	31.65	2.35	0.41	1.34			
11.4				66.69	66.69			34.00	31.65	2.35	0.41	1.34			
	o	20.402	130.00	-	-	400	0.0104	-	-	-	-	-	9.12	5.84	15.100
11.5				84.52	84.52			33.00	30.30	2.70	0.47	1.43			19.137
11.5				66.69	66.69			33.00	30.30	2.70	0.41	1.34			
	o		140.00	-	-	400	0.0104	-	-	-	-	-	9.10	5.84	
11.6				84.52	84.52			31.80	28.85	2.95	0.47	1.43			
11.6				66.69	66.69			31.80	28.85	2.95	0.41	1.34			
	o		90.00	-	-	400	0.0104	-	-	-	-	-	9.10	5.84	
11.7				84.52	84.52			31.00	27.92	3.08	0.47	1.43			

Table 4 (13/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 13 Notes: entrance flow (l/s):
11.7	o	45.532	90.00	100.39 - 127.23	100.39 - 127.23	400	0.0104	31.00 - 31.00	27.92 - 26.98	3.08 - 4.02	0.53 - 0.61	1.50 - 1.59	10.75	6.30	33.698
11.8															42.708
11.8	j	38.250	30.00	128.70 - 163.13	128.70 - 163.13	500	0.0104	31.00 - 31.00	26.98 - 26.67	4.02 - 4.33	0.43 - 0.49	1.59 - 1.69	11.72	6.60	28.309
11															35.897
TOTAL			850.00							4.33					

JICA	BANGU SEWERAGE DISTRICT TRUNK SEWER HYDRAULIC CONCEPT DESIGN No. 3-2 TRUNK SEWER														
manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Notes: entrance flow (l/s):
21.1	o	27.530	100.00	20.38 - 25.82	20.38 - 25.82	400	0.0080	33.00 - 32.00	30.50 - 29.70	2.50 - 2.30	0.24 - 0.27	0.88 - 0.94	4.52	4.69	20.375
21.2															25.824
21.2	o		100.00	20.38 - 25.82	20.38 - 25.82	400	0.0080	32.00 - 31.00	29.70 - 28.90	2.30 - 2.10	0.24 - 0.27	0.88 - 0.94	4.52	4.69	
21.3															
21.3	o		150.00	20.38 - 25.82	20.38 - 25.82	400	0.0080	31.00 - 30.00	28.90 - 27.70	2.10 - 2.30	0.24 - 0.27	0.88 - 0.94	4.52	4.69	
21.4															
21.4	o		40.00	20.38 - 25.82	20.38 - 25.82	400	0.0080	30.00 - 29.50	27.70 - 27.38	2.30 - 2.12	0.24 - 0.27	0.88 - 0.94	4.52	4.69	
21.5															
21.5	o	31.811	100.00	43.92 - 55.66	43.92 - 55.66	400	0.0080	29.50 - 29.00	27.38 - 26.58	2.12 - 2.42	0.36 - 0.40	1.10 - 1.16	6.30	5.51	23.543
21.6															29.839
21.6	o		100.00	43.92 - 55.66	43.92 - 55.66	400	0.0080	29.00 - 28.00	26.58 - 25.78	2.42 - 2.22	0.36 - 0.40	1.10 - 1.16	6.30	5.51	
21.7															
21.7	o	3.428	100.00	46.46 - 58.88	46.46 - 58.88	400	0.0080	28.00 - 28.00	25.78 - 24.98	2.22 - 3.02	0.37 - 0.41	1.11 - 1.18	6.43	5.57	2.537
21.8															3.215
21.8	o		100.00	46.46 - 58.88	46.46 - 58.88	400	0.0033	28.00 - 27.00	24.98 - 24.65	3.02 - 2.35	0.47 - 0.54	0.80 - 0.85	3.15	6.08	
21.9															
21.9	o	4.659	50.00	49.90 - 63.25	49.90 - 63.25	400	0.0033	27.00 - 27.00	24.65 - 24.49	2.35 - 2.51	0.49 - 0.57	0.81 - 0.86	3.21	6.17	3.448
21.10															4.370
21.10	o		60.00	49.90 - 63.25	49.90 - 63.25	400	0.0033	27.00 - 27.00	24.49 - 24.29	2.51 - 2.71	0.49 - 0.57	0.81 - 0.86	3.23	6.17	
21.11															

Table 4 (14/14) Trunk Sewer Hydraulic Calculation of Bangu Sewer District

manhole	Construction Method o / j	Area (ha)	length (m)	upstream flow (l/s) initial / final	downstream flow (l/s) initial / final	diam. (mm)	slope (m/m)	ground level (m) upstream / downstream	trunk sewer level (m) upstream / downstream	trunk sewer depth (m) upstream / downstream	h/d (m/m) inicial / final	velocity (m/s) $V_{initial}$ / V_{final}	trative tension (Pa)	critical velocity Vc (m/s)	Page 14 Notes: entrance flow (l/s):
21.11	o		150.00	49.90 - 63.25	49.90 - 63.25	400	0.0033	27.00 - 26.00	24.29 - 23.80	2.71 - 2.20	0.49 - 0.57	0.81 - 0.86	3.22	6.17	
21															
TOTAL			1,050.00							2.20					

2. WWTP DESIGN CALCULATION

2.1 PAVUNA WWTP

2.1.1 LOCATION OF PAVUNA WWTP

Pavuna WWTP is located at;

Rua Bulhões Maciel, Vigário Geral, Rio de Janeiro, RJ

The treated effluent is discharged to;

Rio Pavuna

2.1.2 PRELIMINARY AND PRIMARY TREATMENT UNITS

(1) General

Preliminary and primary treatment units are shown below.

Raw Sewage Pumping Station; Grit chamber; Chemical Feed System; Primary Clarifier; Primary Sludge Pumping Station.

(2) Raw Sewage Pumping Station

The sewage flowing into the WWTP is conveyed up to the screen channel where the material with dimension larger than 5 cm is removed. The pumping station has the following characteristics:

Table 5 Specifications of Inlet Pumps

Facilities	Type	Number	Spec.
Inlet pumps	vertical centrifugal	2	Head: 17.3 m
Gates	slide	2 units/ bar screen	1,400 x 1,400 mm
Coarse bar screen	rack	1	depth: 11.2 m, bar spacing: 50 mm

(3) Grit Chambers

The grit removal system is performed by 3 (three) aerated and rectangular chambers with width 6 m, length 15 m and total depth 5.75 m. The material removed shall be washed and after this operation it shall be taken to the sanitary backfill. The grit chambers has the hereunder main characteristics:

Aeration system

type: 15 diffusers / tank coarse bubble, number of pumps:1, air flow requirement: 390 Nm^3/h per tank, blower: 390 Nm^3/h per tank, water depth: 4.81 m

Table 6 Specifications of Grit Chambers

Facilities	Type	Number	Spec.
Pump	Vortex pumps	1	flow: 0.96 m^3/min
Pump	Screw pumps	1	flow: 0.96 m^3/min
Grit concentrator and washer	inclined screw	number of screws: 1	flow: 0.96 m^3/min
Gates	slide, number of gates	2 units/bar screen	2,000 x 1,500 mm
Fine bar screen	rack	number of screens: 1	depth: 2.05 m, bar spacing: 13 mm

(4) Chemical Feed System

Ferric chloride (Fe Cl_3) will be used for the assisted chemical treatment. Application of ferric salts (Fe- Cl_3) as coagulant agent of the raw sewage can be made at 2 spots of the WWTP. A first application at the sewage inlet box, upstream the coarse racks and a second application at the fine racks channel.

Table 7 Specifications of Chemical Feed System

Facilities	Type	Number	Spec.
Tanks	Volume: 150,000 L/tank	1	material: fiber glass
Pumps	diaphragm pump	1	0.06 m^3/min

(5) Primary Clarifier

The settling system consists of 2 (two) circular primary clarifiers with 40 m diameter, 4m total depth and 3.5 m water depth next to the wall. The outflow distribution to the clarifiers shall be made from the distribution box.

Feeding of clarifiers is made from the center of the unit and the scrapers driving system is central type.

Sludge and scum scrapers

type: circular, water depth next to the wall (m): 3.5, driving gear: central

feeding: central, sludge withdrawal: scraper, bottom declivity (v:h)1:12

overflow rate ($m^3/m^2/d$): 52.0 for average daily

(6) Primary Sludge Pumping Station

The primary sludge pumping station consists of a building with the dimensions 16.8 m x 7.0 m in plan, with the scum chamber next to it, with 2.7 m x 2.7 m dimensions in plan.

Table 8 Specifications of Sludge Pumps

Facilities	Type	Number	Spec.
Pumps	piston pump	2	0.66 m^3/min

(7) Equipment

The list of main equipment of preliminary and primary units is shown below.

Table 9 List of Primary Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Pumping station	Inlet pump	6	4	2	59.00	320	N
	Coarse bar screen	4	3	1	96.00	2.2	N
	Slide gate	8	6	2	-	-	N
Grit chamber	Aeration system	3	2	1	-	-	N
	Vortex pump	3	2	1	0.96	10.5	N
	Screw pump	3	2	1	0.96	-	N
	Grit concentrator and washer	3	2	1	0.96	0.75	I
	Blower	3	2	1	-	11.2	I
	Fine bar screen	4	3	1	96.00	2.24	N
	Slide gate	8	6	2	-	-	N
Chemical feedingsystem($FeCl_3$)	Tank	3	2	1	-	-	N
	Diaphram pump	3	2	1	-	-	I
Primary clarifier	Sludge and scum scraper	4	2	2	72.00	1.12	I
Primary sludge pumping station	Pistom pump	5	3	2	0.66	7.5	I

2.1.3 SECONDARY TREATMENT UNITS

(1) General

The biological treatment is done through the activated sludge process. The primary effluent is conveyed to the aeration units and then to secondary clarifier.

The secondary treatment consists of the following main units:

Intermediate Pumping Station, Aeration Tanks, Blowers Platform, Secondary Clarifier, Sludge Pumping Station

(2) Intermediate Pumping Station

The function of the intermediate pumping station is to lift the primary effluent up to the adequate elevation so the secondary treatment occurs through gravity up to the receiving river Pavuna.

Table 10 Specifications of Intermediate Pumps

Facilities	Type	Number	Spec.
Screw pumps	Screw	1	0.96 m^3/min, head: 4.15 m screw diameter: 2,750 mm, inclination: 38°

(3) Blowers Platform

The blowers are installed adjacent to the aeration tanks, on concrete platforms, protected from bad weather. The platform has the dimensions of 49m x 10.5 m in plan. The blowers have the following features:

Table 11 Specifications of Blowers

Facilities	Type	Number	Spec.
Blowers	centrifuge	3	12,100 Nm^3/h

(4) Aeration Tanks

Primary effluent is conveyed directly to the aeration tanks. At the inlet of each six tanks with 24 m width, 48 m length and 6.2 m total depth, there is a distribution box which has the function to equally divide the outflow to each group of six aeration tanks.

From the total of 6 tanks, 4 have been constructed, and equipment was installed in just 3 tanks (PDBG-1). In this stage (F/S) the other 2 aeration tanks will be constructed and 3 more tanks will be equipped.

Diffuser system

type: flexible membrane, number of diffusers: 2,340 units per tank, type of bubble: fine, depth of the diffuser (m): 5.2 m, oxygen standard requirement (kg/h per tank):797 for average daily, air outflow (Nm^3/h per tank): 10,000 for average daily

Table 12 Specifications of Aeration Tanks

Facilities	Type	Number	Spec.
Tanks	-	2 (3)	water depth: 5.5 m volume: 6,340 m³ per tank

(5) Secondary Clarifiers

The mixed liquor is conveyed to the secondary clarifiers, where the biological solids will be separated. The settling system consists of 3 (three) circular secondary clarifiers with 46 m diameter, with circular concrete structures with central feed.

Sludge removal is done through a mechanical scraper system which will convey the sludge up to the clarifier center. The secondary sludge is withdrawn through centrifuge pumps located at the sludge pumping station.

Sludge and scum scrapers

type: circular, water depth next to the wall (m): 4.0, driving gear: central

feeding: central, sludge withdrawal: scraper, bottom declivity (v:h) 1:12

overflow rate ($m^3/m^2/d$): 27.0 for average daily

Excess sludge production (kg/d SST)

average daily: 15,800

(6) Sludge Pumping Station

Sludge pumps installed in sludge pumping station withdraw the sludges from the six secondary clarifiers. 2 pumping stations are installed for each set of 3 secondary clarifiers.

The withdrawn sludge is raised to an outfall box; from which it returns to aeration tanks by gravity through two ductile cast iron pipelines.

The excess sludge is withdrawn from the outfall box, located at the outflow of the reflux pumps of the sludge pumping station, through 2 progressive cavity pumps, conveying the sludge to the further the process.

Each pumping station consists of a 13 m x 5 m building in plan, with the scum well and the pumped sludge channel next to it.

Table 13 Specifications of Sludge Pumps

Facilities	Type	Number	Spec.
Return sludge pumps	vertical centrifuge	3	15 –30 m^3/min head (m): 7.5, speed: variable
Excess sludge pumps	progressive cavity	2	1.08 m^3/min, head (m): 26.0, speed: variable

(7) Equipment

The list of main equipment of secondary treatment units is shown below.

Table 14 List of Secondary Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Intermediate pumping station	Screw pump	4	3	1	96.00	112	N
Blower bldg.	Blowers	7	4	3	-	373	I
Aeration tank	Diffusers system	6	3	3	-	-	I
Secondary clarifier	Sludge and scum scraper	6	3	3	48.00	1.12	I
Return sludge pumping station	Vertical centrifuge pumps	7	4	3	30.00	37.3	N
Return sludge pumping station	Progressive cavity pumps	4	2	2	1.08	14.9	N

2.1.4 SLUDGE TREATMENT

(1) Sludge Treatment Building

The purpose of sludge treatment is to reduce and stabilize sludges by dewatering and chemical stabilization prior to the final disposal. The treatment is performed in the sludge treatment building, where sludge pumping equipment, sludge dewatering, polymer application pumps and the sludge alkaline stabilization equipment are located. The following units are used for sludge treatment.

Thickening, Dewatering, Lime stabilization, Thermal drying

The sludge treatment building consists of two floors with 37 m x 20 m dimensions in plan.

(2) Sludge Thickening and Dewatering

Thickening centrifuges

operation period: 7 days/week, 24h/d, number of centrifuges:	2
solids loading (kg/h/unit):	330 for average daily,
hydraulic loading (m^3/h/unit):	47.1 for average daily,
thickened sludge concentration (%):	5 to 7

Dewatering centrifuges

operation type: 7 days/week, 24h/d, number of centrifuges:	2+1
solids loading (kg/h/unit):	1,350 for average daily,
hydraulic loading (m^3/h/unit):	32.4 for average daily
dewatered sludge concentration (%):	24 to 27

Polymer shall be applied as conditioner for the sludge dewatering processes. These units shall apply the polymer with pre-settled dosing.

(3) Lime Stabilization of Sludge and Further Drying

The dewatered sludge will be chemically stabilized by mixing alkaline material. Stabilized sludge is then dried by thermal dryer using natural gas. The expected moisture contents of stabilized and dried sludges are 64% and 20%, respectively.

The alkaline material used is the calcium oxide (CaO). It is mixed with dewatered sludge to lift its pH higher than 12 at least two hours after the application.

The lime coming from the “lime silo” is dosed and mixed with dewatered sludge in screw mixers located at the second floor of the building.

The lime amended sludge is then dried by thermal dryer to the moisture content as low as 20%. The dried sludge is unloaded at the second floor, through a hopper, to trucks parked at the ground floor which will convey the dried sludge to final disposal at a sanitary landfill site.

Lime silo

diameter (m): 3.66 m, height (m) 8.1, available capacity (m^3):	65
lime: 92%, dosing (kg CaO/ton dry sludge):	200 on average
operation (7 days/week):	24 h/d

Lime dosing

capacity (kg/h): 60 – 1,200, operation (7 days/week):	24 h/d

Sludge and lime mixer

capacity (kg/h – dry basis): 4,100, operation (kg/h):	3,070 for average daily
detention time (s):	120

(4) Equipment

The list of main equipment of sludge treatment units is shown below.

Table 15 List of Sludge Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Sludge treatment bldg.	Thickening centrifuges	3	2	1	47.1	45	I
	Dewatering centrifuges	2	2	-	32.4	45	I
	Lime system	3	2	1	-	11.2	N
	Sludge and lime mixer	2	2	-	-	22	I
	Polymer system	2	1	1	-	-	N
Thermal dryer bldg.	Thermal dryer	2	1	1	-	215	I

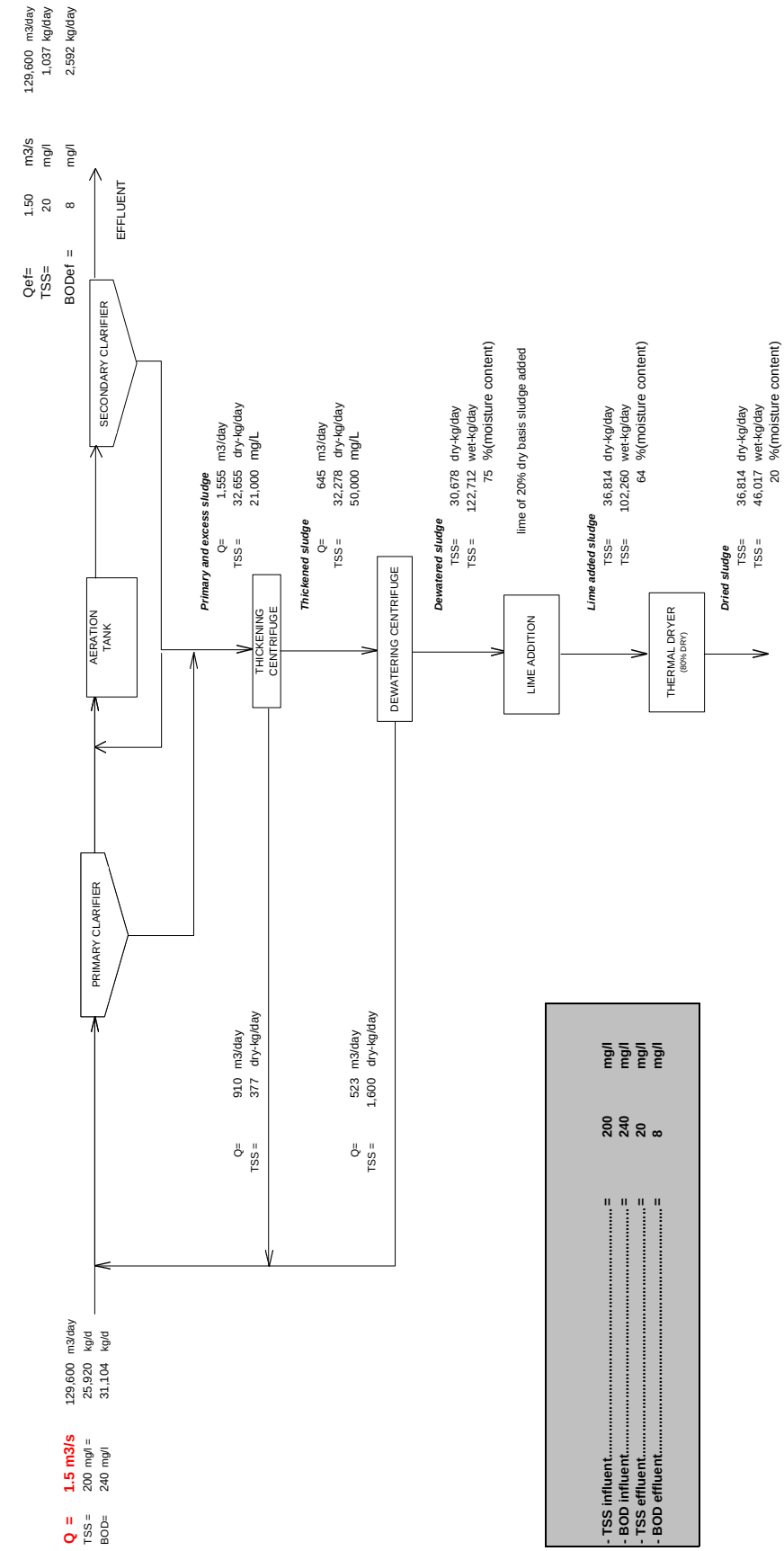

Figure 1 Mass Balance of Pavuna WWTP

2.2 ACARI SEWER DISTRICT

2.2.1 LOCATION OF ACARI WWTP

Acari WWTP is located at;

Rua Nazaré, Acari, Rio de Janeiro, RJ

The treated effluent is discharged to;

Rio Sapopemba

2.2.2 PRELIMINARY AND PRIMARY TREATMENT UNITS

(1) General

Major preliminary and primary treatment units are shown below.

Raw Sewerage Pumping Station;

Grit chambers;

Primary Clarifier;

(2) Raw Sewage Pumping Station

The sewage flowing into the WWTP is conveyed up to the coarse bar screen chute where the material with dimension larger than 8 cm is removed.

The coarse bar screen chute has 2 (two) parallel segments and insulated by upstream floodgates and downstream the screens, in order to allow its maintenance.

The pumping station has 4 motor-pump sets, one of them is spare. Each set discharges 660 l/s it being 3 (three) groups with variable speed. The estimated head is 10.5 mca.

The sewage is conveyed through a channel to the fine screen (1 cm) system, where the channel is subdivided into 3 (three) smaller channels directing the sewage to each screen. Each rack is insulated by a system of sliding floodgates, upstream and downstream. The racked material shall be cast on conveying mats and then taken to a compacter.

(3) Grit Chambers

The grit is removed by 2 (two) mechanized and square chambers with 10m side, which shall remove particles with diameter less than 0.2 mm. The material removed will be washed taken to the sanitary landfill.

Measuring of the flow to the WWTP is done through Parshall downstream the Grit Chamber.

(4) Primary Clarifiers

The settling system consists of 4 (four) circular primary clarifiers with 25 m diameter and 3.5m water depth. The flow distribution to the clarifiers shall be made from the distribution chamber.

Feeding of clarifiers is made from the center of the unit and the scrapers driving system is central type.

The sludge settled in the clarifiers is conveyed to the unit center from where it is withdrawn through helical pumps.

(5) Equipment

The list of main equipment of the preliminary and primary treatment units is shown below.

Table 16 List of Primary Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (kw/unit)	National (N) Imported (I)
Raw Sewerage Pumping Station	Coarse bar screen	59.4	2	2.0	N
Raw Sewerage Pumping Station	Slide gates	59.4	8	-	N
Raw Sewerage Pumping Station	Vertical Centrifuge Pump	39.6	4	100	N
Raw Sewerage Pumping Station	Fine bar screen	39.6	3	2.0	N
Grit Chamber	Bottom scraper	59.4	2	-	N
Grit Chamber	Screw for sand removal	-	2	-	N
Primary Clarifier	Sludge and Scum Scrapers	29.7	4	1	I
Primary Sludge Pumping Station	Progressive Cavity Pumps	-	5	-	N
Thickeners	Bottom Scrapers	0.75	4	0.37	N

2.2.3 SECONDARY TREATMENT UNITS

(1) General

The biological treatment is done through the activated sludge process. The primary effluent is conveyed to the aeration units and then to secondary clarifiers.

The secondary treatment consists of the following main units:

Aeration Tanks

Blowers

Secondary Clarifier

Sludge Return Pumping Station

(2) Aeration Tanks

Primary effluent is conveyed directly to the aeration tanks. At the inlet of each four tanks there is a chamber which has the function to equally divide the outflow to each group of four aeration tanks.

The liquid effluent to the chamber goes through a spiller, unloading individually into the aeration tank.

Inlet of the return sludge and the primary effluent into the aeration tank is controlled by two electrically driven floodgates.

The effluent of each group of four aeration tanks shall flow through a pipeline to two secondary clarifiers.

The process parameters are as follows:

Sludge age (days)	8
Retention time (hours)	6.6
Substratum / micro-organisms ratio F/M	0.35
Mixed liquor concentration (mg/l)	2,411 for average daily
Production of excess sludge (kg/d TSS)	11,795 for average daily
Excess sludge concentration (mg/l)	6,400 – 8,000
Demand of Oxygen (kg/h)	1,650

Main features of the aeration tanks are as hereunder:

Number of tanks	8
Width (m)	13
Length	50
Water depth (m)	5.0
Total depth (m)	6.0
Volume (m^3 per tank)	3,250

Air to the diffusers shall be supplied by a blowers system and distribution pipes (stainless steel for pipes that are not in contact with the sewage and glass fiber for internal pipeline to the aeration tanks). The air diffusion system has the following features:

Type of diffuser	Flexible membrane
Material	EPDM
Type of bubble	fine
Depth of the diffuser (m)	4.8
Oxygen requirement (kg/h per tank)	206 for average daily
Air outflow (Nm^3/h per tank)	4,980 for average daily

(3) Blowers Platform

The blowers shall be installed adjacent to the aeration tanks, in concrete platforms, protected from bad weather. These blowers have the following features:

Type of blower	Centrifuge
Number of blowers	4 + 1 (one for standby)
Air (Nm^3/h/unit)	9,960
Power (KW/unit)	192

(4) Secondary Clarifiers

The mixed liquor will be conveyed to the secondary clarifiers, where the biological solids will be separated.

4 secondary clarifiers shall be implemented with 35m diameter, with circular concrete structures with central feed.

Sludge will be accumulated through a mechanical scraper system which will convey the sludge up to the clarifier center. The secondary sludge shall be withdrawn through centrifuge pumps located on the sludge pumping station.

This same equipment makes the superficial scum removal, which shall be conveyed to a well.

The plant effluent will be discharged into a reinforced concrete culvert to be conveyed to the receiving body (Sapopemba river).

The main features of the secondary clarifiers and the main design parameters are shown below:

Type of clarifier	Circular
Number of clarifiers	4
Sludge and scum withdrawal driving gear	central
Feeding	central
Sludge withdrawal	scraper
Diameter (m)	35
Water depth in the wall (m)	4.0
Bottom declivity (v:h)	1:12
Overflow rate ($m^3/m^2/d$)	24.5 for average daily
Superficial load of solids ($kg/m^2/d$)	122 for average daily
Excess sludge production (kg/d TSS)	11,793 for average daily

(5) Sludge Pumping Station

Sludges from four secondary clarifiers are withdrawn by pumps installed in sludge pumping station.

The sludge are withdrawn and raised to an outfall box; from this box it will continue through gravity up to the aeration tanks through two ductile cast iron pipelines.

Its structure shall be of two floors, one being at the ground level and the other below where the centrifuge pumps and of progressive cavity will be sheltered. Besides these pumps, it is foreseen a well pump to drain the pumps well.

Each reflux pump will exclusively consider one clarifier; it is also foreseen 1 (one) spare pump which will remain at the storehouse.

The excess sludge is withdrawn from the outfall box, located at the outflow of the reflux pumps of the sludge return pumping station, through 2 progressive cavity pumps. This box shall have a "stop-log" separating the casting of each two reflux pumps. The third pump shall be normally used to pump the floating matter removed from the clarifiers, also being a spare unit.

Each reflux pump for withdrawal of excess sludge is equipped with a speed varying to adjust the upsetting outflow. Magnetic outflow meters are foreseen at the system outflow and sludges reflux and discard.

The main features of the sludge recirculation and discard system are shown below.

1) Return Sludge Pumps

Type of pump	Centrifuge
Speed	Variable
Number of pumps	4 + 1 (one for standby)
Capacity (m^3/min/unit)	8.4 to 12.0
Power (KW/unit)	17.5

2) Excess Sludge Pumps

Type of pump	Progressive Cavity
Speed	Variable
Number of pumps	2 + 1 (one for standby)
Capacity (m^3/min/unit)	0.90 - 1.80
AMT (bar)	4
Power (KW/unit)	20.0

3) Auxiliary Equipment

The sludge return pumping stations have the following facilities:

Overhead crane and Tackle;

Service water system to seal the pumps;

Draining system, with submerged motor pump for 6 l/s and 6 mca head.

(6) EQUIPMENT

The following list shows main equipment of the secondary treatment units:

Table 17 List of Secondary Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (kw/unit)	National(N) Imported(I)
Aeration Tank	Diffusers system	-	8	-	I
Aeration Tank	Blowers	166	5 (4+1)	192	N
Secondary Clarifier	Sludge and Scum scrapers	-	4	1	I
Sludge Pumping Station	Centrifuge pumps	12.0	5 (4+1)	17.5	N
Sludge Pumping Station	Progressive Cavity Pumps	1.8	3 (2+1)	20	N

2.2.4 SLUDGE TREATMENT

(1) Sludge Thickening and Dewatering

The treatment is done in the Sludge Treatment Building, inside which are located the equipment necessary for performance of the centrifuge thickening, mechanical dewatering and drying stages.

(2) Gravity Thickener

The primary sludge withdrawn from the primary clarifiers has 1.0 to 1.5% concentration of solids. It will be thickened to 4-5% by gravity thickeners. There are 4 (four) thickeners with 8.0 m diameter and 3.5 m water depth next to the wall.

Inlet of the primary sludge will be through the center of the thickener and drive of bottom scrapers is central type. The sludge settled in the bottom are withdrawn through gravity and conveyed up to the sludge raising well from where it is alternately pumped to each digester.

(3) Thickening of EXCESS Sludge

The excess sludge and the floating material removed from the secondary clarifiers will be pumped to the sludge treatment building where they will be chemically conditioned with polymer for its thickening in the centrifuges.

The thickened excess sludge will be conveyed up to the thickened sludge pumping station to be mixed with the gravity thickened primary sludge.

The liquid withdrawn from the thickening process through draining (centered) returns to sewage treatment process.

The main features of the centrifugal thickening system are shown below.

1) Thickening Centrifuges

Number of units	2 + 1 (one for standby)
Operation	7 days/week, 20h/d
Solids loading (kg/h/unit)	295 for average daily
Hydraulic load (m^3/h/unit [1])	46 for average daily
Thickened sludge concentration (%)	5.0

(Assuming a minimum concentration of 6 400 mg/l of TSS in the sludge excess.)

2) Pumps of Thickened Excess Sludge

The centrifuges thickened sludge is conveyed to the collection well and then, pumped up to the thickened sludge pumping station.

Type	Progressive Cavity
Speed	variable
Number of pumps	1 + 1 (one for standby)
Capacity (m^3/min/unit)	0.72 - 1.44
AMT (bar)	2.0
Power (KW/unit)	10.0

3) Dosing and Dilution Unit

Polymer is applied as conditioner for the excess sludge thickening processes.

Number of Units	2
Polymer concentration applied (%)	0.05 - 0.5
Polymer consumption (kg of polymer/ton sludge)	2
Water outflow for dilution (l/min/unit)	3 - 20

4) Mixer

Type	Submersible
Number of mixers	1
Motor power (kW per mixer)	1.9

(4) Anaerobic Digestion

3 primary digesters and 1 secondary digester with dimensions 16.5m diameter and 17.5m height are installed to digest both thickened primary and excess sludges.

Recirculation of the liquid inside the digesters are done with centrifuge pumps, that will operate 24 hours per day, pumping the sludge alternately from the upper to the lower part and vice-versa every 2 hours.

1) Sludge Reflux Pumps in the Digester

Type of pump	Vertical centrifuge
Number of pumps	6
Capacity (m^3/min/unit)	31.2
Power (KW/unit)	34

2) Digested Sludge Pumps

The digested sludge is conveyed through pumps up to the dewatering process.

Type	Progressive cavity
Speed	variable
Number of pumps	1 + 1 (one for standby)
Capacity (m^3/min/unit)	0.12 - 0.6
AMT (bar)	2.0
Power (KW/unit)	4.5

(5) Mechanical Sludge Dewatering

The digested sludge shall is mechanically dewatered by centrifuges. A total of two centrifuges (one operational and one standby) will dewater the sludge to solids concentration of 25%.

The sludge is chemically conditioned through addition of polymer before being supplied to the centrifuges. The sludge cake resulting from dewatering will be unloaded in a conveying screws system which will convey them up to the thermal drying system.

The conveying screws system will replace the existing mats and will consist of a set of horizontal and tilted screws. The liquid waste from the dewatering process will return to the plant inlet.

The main features of the sludge mechanical dewatering system are shown below:

1) Dewatering Centrifuges

Number of units	1 + 1 (one for standby)
Operation (7days/week)	20 h/d
Solids loading (kg/h/unit)	729 for average daily
Hydraulic load (m^3/h/unit)	208 for average daily
Dewatered sludge concentration (%)	25.0

2) Dosing and Diluting Unit

Polymer is applied as conditioner for the sludge dewatering processes.

Number of Units	1
Concentration of polymer in the application (%)	0.05 - 0.5
Polymer consumption (kg of polymer/ton sludge)	10
Water outflow for dilution (l/min/unit)	55 - 240

3) DEWATERED Sludge Conveying System

Dewatered sludge is conveyed through conveying screws to the thermal drying system. The conveying screws comply with the sludge volume produced by the dewatering centrifuges.

(6) Equipment

The list of main equipment of the sludge treatment area is shown below:

Table 18 List of Sludge Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (kw/unit)	National (N) Imported (I)
Sludge Treatment	Thickening Centrifuges	46.0 (*)	3 (2+1)	45	I
Sludge Treatment	Dewatering Centrífuges	20.8 (*)	2 (1+1)	45	I
Sludge Treatment	Dosing and Diluting Units	-	3		I
Sludge Treatment	Thermal dryer	-	1	105	I
Pumping of thickened excess sludge	Progressive cavity Pumps	1.44	2 (1+1)	10	N
Pumping of digested sludge	Progressive cavity Pumps	0.6	2 (1+1)	4.5	N
Digester	Vertical centrifuge pumps	31.2	6	34	N

Note: (*) Capacity in m^3/h/unit

2.2.5 DESIGN CALCULATION

Design Calculations of Acari WWTP are shown in bellow.

ETE ACARI (WWTP ACARI)

1) Eficiências p/ Tratamento (Efficiency)

1)	BOD_5 removed	=	30%	(primary treatment)
2)	TSS removed	=	50%	(primary treatment)
3)	BOD_5	=	91%	(secondary treatment)
4)	TSS	=	92%	(secondary treatment)
5)	VSS/TSS	=	0.75	
6)	BOD influent	=	230	mg/l
7)	BOD effluent	=	20	mg/l
8)	TSS influent	=	250	mg/l
9)	TSS effluent	=	20	mg/l

2) Caixa de Areia (Grit Chamber)

1)	Qmáx	=	1.98	m^3/s	
2)	Number of units	=	2		
3)	Qunit	=	0.99	m^3/s	
4)	Surface-loading rate	=	1000	$m^3/m^2.d$	(ranger 600-1300)
5)	Width	=	10	m	
6)	Water depht	=	0.65	m	
7)	Velocity	=	0.15	m/s	

3) Decantador Primário (Primary Clarifier)

1)	Qavg	=	1.1	m^3/s		
2)	Qmax	=	1.98	m^3/s		
3)	Number of units	=	4			
4)	Qunit	=	0.50	m^3/s		
5)	Diameter	=	25	m		
6)	Water depht	=	3.5	m	(> 2,0 m)	
7)	Unit Area	=	490.9	m^2		
8)	Surface-loading rate	=	87.1 - 48.4	$m^3/m^2.d$	max-avg	(ranger 0 - 120)
9)	Hydraulics detention time (max)	=	2.2	h		
10)	Hydraulics detention time (min)	=	1.0	h		
11)	Weir-loading rate	=	302.5	$m^3/m.d$	(ranger 0 - 720)	
12)	Solids concentration (outflow)	=	1.2%		(ranger 1 - 2)	
13)	TSS	=	12,889.0	kg SS/d		
14)	Total sludge flow	=	44.8	m^3/h		
15)	Slope	=	1/12	m/m		

4) Tanque de Aeração (Aeration Tank)

1)	BOD influent (So)	=	161.00	mg/l	
2)	Soluble BODeffluent (S)	=	10.56	mg/l	
3)	Qavg	=	1.10	m^3/s	
4)	Maximum yield coef. (Y)	=	0.55	kgMLVSSV/kgBOD	
5)	Endogenous decay coef. (Kd)	=	0.08	1/dia	
6)	Rate Biodegradable VSS (F'b)	=	0.80		
7)	Sludge age (θ)	=	8.00	dias	
8)	Rate recycle	=	0.60		
9)	Number of units	=	8.00		
10)	Rate Biodegrad. VSS after sludge age (Fb)	=	0.71		$Fb = F'b / (1 + (1 - F'b) \times Kd \times \theta)$
11)	MLSS (X)	=	**2,411**	mg/l	
12)	MLVSS (Xv)	=	**1,664**	mg/l	
13)	Water depth	=	5.00	m	
14)	Length	=	50.00	m	
15)	Width	=	13.00	m	
16)	Unit Volume (V)	=	**3250**	**m^3**	
17)	Total Volume	=	**26000**	**m^3**	$V = Yx\ \theta \times Qavg \times (So - S)/(Xv \times (1 + Kd \times Fb \times \theta))$
18)	Hydraulics detention time	=	6.60	h	
19)	Concentration in return (Xr)	=	6,431	mg/l	
20)	Rate Food/Microorg (F/M)	=	0.35	kgBOD5/kgMLVSS.dia	(ranger 0,07 - 1)
21)	Rate Food/Microorg (F/M)	=	0.24	kgBOD5/kgMLSS.dia	
22)	Net specific growth rate (U)	=	0.33	kgBOD5/kgMLVSS.dia	(ranger 0,06 - 1)
23)	Flowrate Wasted (Qex)	=	1,834	m^3/d	
24)	Solids removed (Px)	=	11,793	kg/d	

5) Decantador Secundário (Secondary Clarifier)

1)	Qavg	=	1.10	m3/s			
2)	Rate recycle (R)	=	0.60				
3)	Recycle flowrate	=	0.66	m3/s			
4)	Diameter	=	35	m			
5)	Water depth	=	4	m			
6)	Slope	=	1/12	m/m			
7)	Number units	=	4				
8)	Unit Volume	=	3,848	m3			
9)	Unit Area	=	962	m2			
10)	Hydraulics detention time	=	3.9	h	>	1.5	h
11)	Surface-loading rate (TH)	=	24.7	m3/m2/d			
12)	Solids loading rate	=	122	kg/m2/d	<	144	kg/m2/d

MLSS<3000mg/l - R>=0.25 e TH<=36

MLSS>=3000mg/l e <4500mg/l - R>=0.50 e TH<=24

MLSS>=4500mg/l - R>=1 e TH<=16

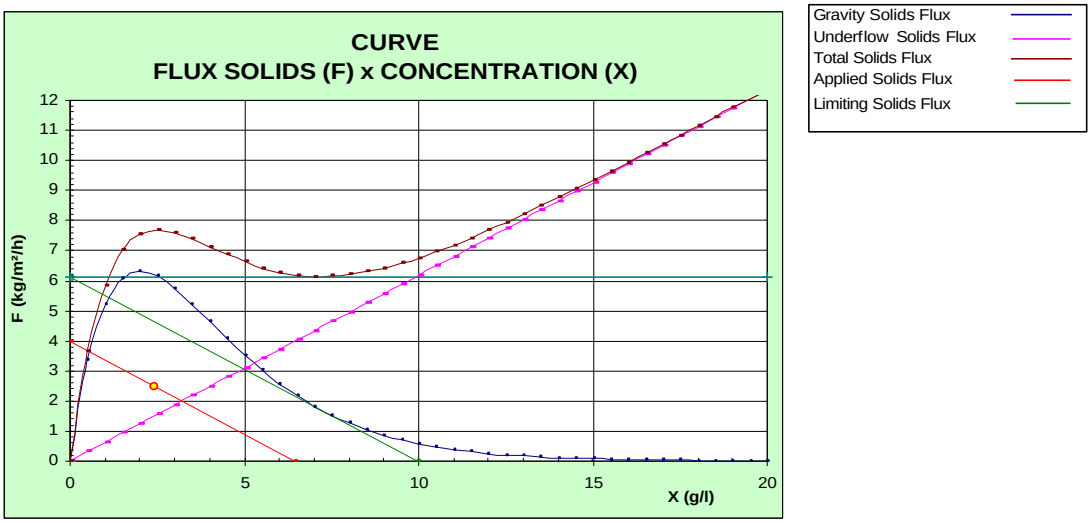

Figure 2 Solids - Concentration Curve

6) Adensador por Gravidade (Gravity Thickening)

1)	Concentration in influent	=	12,000	mg/l	=	12	kg/m3
2)	Concentration in effluent	=	4.0%			(ranger 0 - 10)	
3)	TSS	=	12,889.0	kg SS/d			
4)	Number of units	=	4				
5)	TSS for unit	=	3,222.0	kg SS/d			
6)	Diameter	=	8	m			
7)	Unit Area	=	50.3	m²			
8)	Solids loading rate	=	64.1	kg SS/m².d	(ranger 0 - 150)		
9)	TSS effluent	=	11,600	kg SS/d			
10)	Sludge flow effluent	=	12.1	m³/h			
11)	TSS in supernatant	=	1,289	kg SS/d			
12)	Supernatant flow	=	32.7	m³/h			
13)	Water depht	=	3.50	m	(>=3,0m)		
14)	Unit Volume	=	175.6	m3			
15)	Hydraulics detention time	=	12.58	h	(<= 24 h)		
16)	Surface-loading rate	=	5.3	m³/m².d			
17)	Solids recovery	=	90.0%				
18)	Declividade do fundo	=	1/12	m/m			

7) Centrífugas de Adensameto (Centrifuge Thickening)

1)	TSS influent	=	11,794.0	kg SS/d
2)	Concentration influent in centrifuge	=	0.64%	
3)	Concentration effluent in centrifuge	=	5.0%	
4)	Flowrate to Centrifuge	=	18.8	l/s
5)	Solids recovery	=	95.0%	
6)	TSS effluent	=	11,204.0	kg SS/d
7)	Blended sludge	=	2.6	l/s
8)	Thinckener effluent	=	18.6	l/s
9)	Number operation centrifuge	=	2.0	
10)	Operation time	=	20	h/d
11)	Hydraulics flow	=	45.8	m3/h/unit

Polymers aplication

12)	Dosage	=	2		kg Pol / t SS
13)	Polymers Concentration	=	30.0%		
14)	Concentration application polymers	=	0.20% -	0.05%	
15)	Total polymers	=	23.6		kg/d de pol

8) Digestores (Digesters)

7.1) Primary Digester

1)	Type	=	High rate		
2)	TSS influent	=	22,804.0	kg SS/d	
3)	VSS/TSS	=	0.721		
4)	Concentration Solids	=	3.5%		
5)	High rate digestion	=	1.2 -	6.0	kg VSS/m3
6)	Sludge Volume influent (Vf)	=	502.1	m3/d	
7)	Sludge Volume effluent (Vd)	=	408.6	m3/d	
8)	Digestion time(t)	=	25	dias	
9)	Sludge Volume in digesters (V)	=	10,994.2	m3	V={Vf - 2/3 x (Vf - Vd)} x t
10)	Number digester	=	3		
11)	Diameter	=	16.5	m	
12)	Heigth	=	17.5	m	
13)	Volume Unit	=	3,741.9	m3	

7.2) Digestor Secundário

1)	Number	=	1	
2)	Diameter	=	16.5	m
3)	Heigth	=	17.5	m
4)	Volume Unit	=	3,741.9	m3

9) Centrífugas de Desidratação (Centrifuge Dewatering)

1)	TSS influent	=	14,588.0	kg SS/d
2)	Concentration influent in centrifuge	=	3.5%	
3)	Concentration effluent in centrifuge	=	25.0%	
4)	Flowrate to Centrifuge	=	4.8	l/s
5)	Solids recovery	=	95.0%	
6)	TSS effluent	=	13,858.0	kg SS/d
7)	Sludge Flow dewatering	=	0.6	l/s
8)	Filtrate	=	4.2	l/s
9)	Number operation centrifuge	=	1.0	
10)	Operation time	=	20	h/d
11)	Hydraulics flow	=	20.8	m3/h/unit

Polymers aplication

12)	Dosage	=	10		kg Pol / t SS
13)	Polymers Concentration	=	30.0%		
14)	Concentration application polymers	=	0.20% -	0.05%	
15)	Total polymers	=	145.9		kg/d de pol

10) Consumo de Oxigênio (Oxygen-Transfer)

10.1) Oxygen Requirements from removel of Carbonaceous organic matter (DOC)

1)	DOC	=	13,195.0	kg O2/d	DOC = Qavg x (So-S) x (1,46 - (1,42 x Y)/(1+ Kd x Fb x θ))

10.2) Oxygen Requirement from Nitrification (DON)

1)	Population	=	390,000	hab	
2)	Nitrogen	=	8	g NTK/dia/p	
3)	Total Nitrogen	=	3,120.0	kg/dia	
4)	Concentration (CN)	=	32.8	mg/l	
5)	Efficiency from Primary treatment (effn)	=	20.0%		
6)	DON	=	11,406.7	kg O2/d	DON = (4,57 x Qavg x CN /1000) x (1-effn)

10.3) SOTE (standardized oxygen-transfer)

1)	SOTE = DOC + DON	=	24,601.3	kg O2/d

10.4) Oxygen Transfered under fiel condicions (OTR)

1)	α (oxygen-transfer correction fator for water). =	0.85		
2)	β (saturação de O2 no esgoto/na água)..... =	0.95		
3)	CL(operation oxigen concentration)..... =	2.0	mg/l	
4)	CS summer(O2 saturation in water)..... =	8.4	g/m3	
5)	CS 20 ºC(O2 saturation in water)..... =	9.2	g/m3	
6)	δ (coeff. temperature)..... =	1.024		
7)	Summer temperature..... =	25	ºc	
8)	OTR (summer)..... =	39,548.0	kg O2/d	$OTR = SOTE / (((\beta \times CS - CL) / CS(20^{o} C)) \times \alpha \times \delta^{(T-20)})$

10.5) Air Requirement

1)	Efficiency..... =	15.0%	
2)	Specific weight of air..... =	1.2	kg/m3
3)	O2 in air..... =	0.23	g O2 / g ar
4)	Air..... =	663.0	m3/min de ar

10.6) Power

1)	Specific weight of water..... =	1000	kg/m3
2)	Diffuser depth..... =	4.8	m
3)	Headloss..... =	0.87	m
4)	Efficiency..... =	80.0%	
5)	Power..... =	192	kW/unit
6)	Number of blowers..... =	4 + 1	

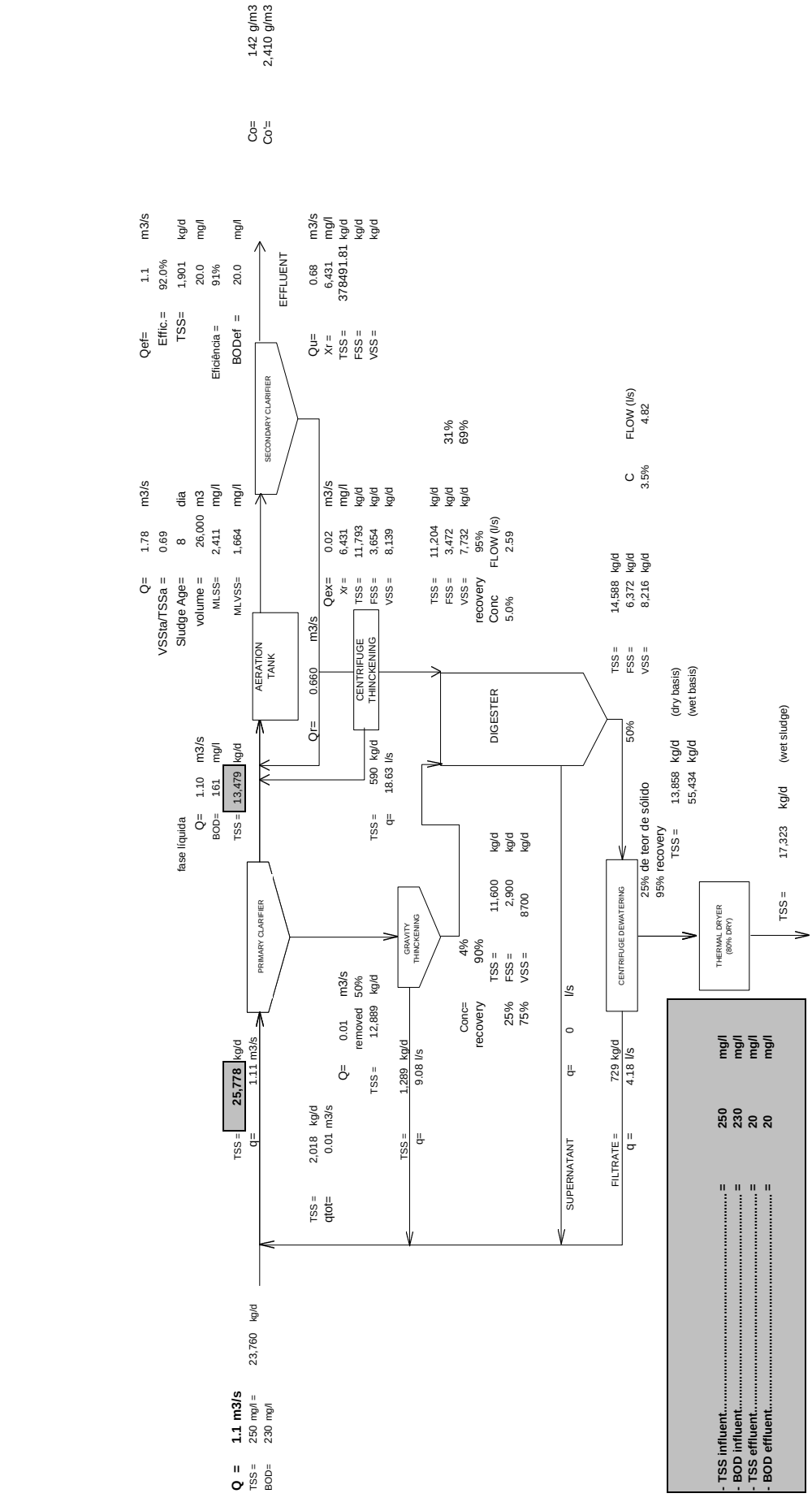

Figure 3 Mass Balance of Acari WWTP

2.3 SARAPUI WWTP

2.3.1 LOCATION OF SARAPUI WWTP

Sarapui WWTP is located at:

Rua Demóstenes, Jardim Ideal, Belford Roxo, RJ

The treated effluent is discharged to;

Rio Sarapuí

2.3.2 PRELIMINARY AND PRIMARY TREATMENT UNITS

(1) General

Preliminary and primary treatment units are shown below.

Raw Sewage Pumping Station; Grit chamber; Chemical Feed System; Primary Clarifier; Primary Sludge Pumping Station.

(2) Raw Sewage Pumping Station

The sewage flowing into the WWTP is conveyed up to the screen channel where the material with dimension larger than 5 cm is removed. The pumping station has the following characteristics:

Table 19 Specifications of Inlet Pumps

Facilities	Type	Number	Spec.
Inlet pumps	vertical centrifugal	2	Head: 14.3 m
Gates	slide	2 units/ bar screen	1,400 x 1,400 mm
Coarse bar screen	rack	1	depth: 11.2 m, bar spacing: 50 mm

(3) Grit Chambers

The grit removal system is performed by 3 (three) aerated and rectangular chambers with width 6 m, length 15 m and total depth 5.75 m. The material removed shall be washed and after this operation it shall be taken to the sanitary backfill. The grit chambers has the hereunder main characteristics:

Aeration system

type: 15 diffusers / tank coarse bubble, number of pumps:1, air flow requirement: 390 Nm^3/h per tank, blower: 390 Nm^3/h per tank, water depth: 4.81 m

Table 20 Specifications of Grit Chambers

Facilities	Type	Number	Spec.
Pump	Vortex pumps	1	0.96 m^3/min
	Screw pumps	1	0.96 m^3/min
Grit concentrator and washer	inclined screw	1	0.96 m^3/min
Gates	slide	2 units/bar screen	2,000 x 1,500 mm
Fine bar screen	rack	1	depth: 2.05 m, bar spacing: 13 mm

(4) Chemical Feed System

Ferric chloride (Fe Cl_3) will be used for the assisted chemical treatment. Application of ferric salts (Fe- Cl_3) as coagulant agent of the raw sewage can be made at 2 spots of the WWTP. A first application at the sewage inlet box, upstream the coarse racks and a second application at the fine racks channel.

Table 21 Specifications of Chemical Feed System

Facilities	Type	Number	Spec.
Tanks	-	1	150,000 L/tank material: fiber glass
Pumps	diaphragm pump	1	0.06 m^3/min

(5) Primary Clarifier

The settling system consists of 1 (one) circular primary clarifier with 40 m diameter, 4m total depth and 3.5 m water depth next to the wall. The outflow distribution to the clarifiers shall be made from the distribution box.

Feeding of clarifiers is made from the center of the unit and the scrapers driving system is central type.

Sludge and scum scrapers

type: circular, water depth next to the wall (m): 3.5, driving gear: central

feeding: central, sludge withdrawal: scraper, bottom declivity (v:h)1:12

overflow rate ($m^3/m^2/d$): 57.3 for average daily

(6) Primary Sludge Pumping Station

The primary sludge pumping station consists of a building with the dimensions 16.8 m x 7.0 m in plan, with the scum chamber next to it, with 2.7 m x 2.7 m dimensions in plan.

Table 22 Specifications of Primary Sludge Pumps

Facilities	Type	Number	Spec.
Pumps	piston pump	2	0.66 m^3/min

(7) Equipment

The list of main equipment of preliminary and primary units is shown below.

Table 23 List of Primary Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Pumping station	Inlet pump	4	3	1	84.00	280	N
	Coarse bar screen	3	2	1	126.00	2.2	N
	Slide gate	6	4	2	-	-	N
Grit chamber	Aeration system	3	2	1	-	-	N
	Voltex pump	3	2	1	0.96	10.5	N
	Screw pump	3	2	1	0.96	-	N
	Grit concentrator and washer	3	2	1	0.96	0.75	I
	Blower	3	2	1	-	11.2	I
	Fine bar screen	4	3	1	96.00	2.24	N
	Slide gate	8	6	2	-	-	N
Chemical Feedingsystem ($FeCl_3$)	Tank	3	2	1	-	-	N
	Diaphram pump	3	2	1	-	-	I
Primary clarifier	Sludge and scum scraaper	3	2	1	72.00	1.12	I
Primary sludge pumping station	Pistom pump	4	3	1	0.66	7.5	I

2.3.3 SECONDARY TREATMENT UNITS

(1) General

The biological treatment is done through the activated sludge process. The primary effluent is conveyed to the aeration units and then to secondary clarifier.

The secondary treatment consists of the following main units:

Intermediate Pumping Station, Aeration Tanks, Blowers Platform, Secondary Clarifier, Sludge Pumping Station

(2) Intermediate Pumping Station

The function of the intermediate pumping station is to lift the primary effluent up to the adequate elevation so the secondary treatment occurs through gravity up to the receiving river Sarapui.

Table 24 Specifications of Intermediate Pumps

Facilities	Type	Number	Spec.
Screw pumps	screw	1	0.96 m^3/min, head: 4.15 m screw diameter: 2,750 mm, inclination: 38°

(3) Blowers Platform

The blowers are installed adjacent to the aeration tanks, on concrete platforms, protected from bad weather. The platform has the dimensions of 49m x 10.5 m in plan. The blowers have the following features:

Table 25 Specifications of Blowers

Facilities	Type	Number	Spec.
Blowers	centrifuge	2	12,100 Nm^3/h

(4) Aeration Tanks

Primary effluent is conveyed directly to the aeration tanks. At the inlet of each six tanks with 24 m width, 48 m length and 6.2 m total depth, there is a distribution box which has the function to equally divide the outflow to each group of six aeration tanks .

From the total of 6 tanks, 4 have been constructed , and equipment was installed in just 3 tanks (PDBG-1). In this stage (F/S) the other 2 aeration tanks will be constructed and 2 more tanks will be equipped. In total, six tanks will be constructed out of which five tanks are equipped with diffusers.

Diffuser system

type: flexible membrane, number of diffusers: 2,340 units per tank, type of bubble: fine, depth of the diffuser (m): 5.2 m, oxygen standard requirement (kg/h per tank):797 for average daily, air outflow (Nm^3/h per tank): 10,000 for average daily

Table 26 Specifications of Aeration Tanks

Facilities	Type	Number	Spec.
Tanks	-	2	water depth: 5.5 m, volume: 6,340 m^3 per tank

(5) Secondary Clarifiers

The mixed liquor is conveyed to the secondary clarifiers, where the biological solids will be separated. The settling system will consist of 2 (two) circular secondary clarifiers with 46 m diameter, with circular concrete structures with central feed. Three out of five clarifiers are already constructed and two others will be constructed.

Sludge removal is done through a mechanical scraper system which will convey the sludge up to the clarifier center. The secondary sludge is withdrawn through centrifuge pumps located at the sludge pumping station.

Sludge and scum scrapers

type: circular, water depth next to the wall (m): 4.0, driving gear: central

feeding: central, sludge withdrawal: scraper, bottom declivity (v:h)1:12

overflow rate ($m^3/m^2/d$): 26.0 for average daily

Excess sludge production (kg/d SST)

average daily: 15,800

(6) Sludge Pumping Station

Sludge pumps installed in sludge pumping station withdraw the sludges from the six secondary clarifiers. 2 pumping stations are installed for each set of 3 secondary clarifiers.

The withdrawn sludge is raised to an outfall box; from which it returns to aeration tanks by gravity through two ductile cast iron pipelines.

The excess sludge is withdrawn from the outfall box, located at the outflow of the reflux pumps of the sludge pumping station, through 2 progressive cavity pumps, conveying the sludge to the further the process.

Each pumping station consists of a 13 m x 5 m building in plan, with the scum well and the pumped sludge channel next to it.

Table 27 Specifications of Sludge Pumps

Facilities	Type	Number	Spec.
Return sludge pumps	vertical centrifuge	2	15 –30 m^3/min head: 7.5 m, speed: variable
Excess sludge pumps	progressive cavity	2	1.08 m^3/min, head: 26.0 m, speed: variable

(7) Equipment

The list of main equipment of secondary treatment units is shown below.

Table 28 List of Secondary Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Intermediate pumping station	Screw pump	4	3	1	96.00	112	N
Blower bldg.	Blowers	6	4	2	-	373	I
Aeration tank	Diffusers system	5	3	2	-	-	I
Secondary clarifier	Sludge and scum scraaper	5	3	2	48.00	1.12	I
Return sludge pumping station	Vertical centrifuge pumps	6	4	2	30.00	37.3	N
Return sludge pumping station	Progressive cavity pumps	4	2	2	1.08	14.9	N

2.3.4 SLUDGE TREATMENT

(1) Sludge Treatment Building

The purpose of sludge treatment is to reduce and stabilize sludges by dewatering and chemical stabilization prior to the final disposal. The treatment is performed in the sludge treatment building, where sludge pumping equipment, sludge dewatering, polymer application pumps and the sludge alkaline stabilization equipment are located. The following units are used for sludge treatment.

Thickening, Dewatering, Lime stabilization, Thermal drying

The sludge treatment building consists of two floors with 37 m x 20 m dimensions in plan.

(2) Sludge Thickening and Dewatering

Thickening centrifuges

operation period: 7 days/week, 24h/d, number of centrifuges: 2

solids loading (kg/h/unit):330 for average daily,

hydraulic loading (m^3/h/unit):47.1 for average daily,

thickened sludge concentration (%): 5 to 7

Dewatering centrifuges

operation type: 7 days/week, 24h/d, number of centrifuges: 2+1

solids loading (kg/h/unit):1,350 for average daily,

hydraulic loading (m^3/h/unit):32.4 for average daily

dewatered sludge concentration (%): 24 to 27

Polymer will be applied as conditioner for the sludge dewatering processes. These units will apply the polymer with pre-settled dosing.

(3) Lime Stabilization of Sludge and Further Drying

The dewatered sludge will be chemically stabilized by mixing alkaline material. Stabilized sludge is then dried by thermal dryer using natural gas. The expected moisture contents of stabilized and dried sludges are 64% and 20%, respectively.

The alkaline material used is the calcium oxide (CaO). It is mixed with dewatered sludge to lift its pH higher than 12 at least two hours after the application.

The lime coming from the “lime silo” is dosed and mixed with dewatered sludge in screw mixers located at the second floor of the building.

The lime amended sludge is then dried by thermal dryer to the moisture content as low as 20%. The dried sludge is unloaded at the second floor, through a hopper, to trucks parked at the ground floor which will convey the dried sludge to final disposal at a sanitary landfill site.

Lime silo

diameter (m): 3.66 m, height (m) 8.1, available capacity (m^3): 65

lime: 92%, dosing (kg CaO/ton dry sludge): 200 on average

operation (7 days/week): 24 h/d

Lime dosing

capacity (kg/h): 60 – 1,200, operation (7 days/week): 24 h/d

Sludge and lime mixer

capacity (kg/h – dry basis): 4,100, operation (kg/h):3,070 for average daily

detention time (s): 120

(4) Equipment

The list of main equipment of sludge treatment units is shown below.

Table 29 List of Sludge Treatment Equipment

Facilities	Equipment	Quantity			Capacity	Power	National(N) Imported(I)
		Total	PDBG	F/S	(m^3/min/unit)	(kw/unit)	
Sludge treatment bldg.	Thickening centrifuges	3	2	1	47.1	45	I
	Dewatering centrifuges	2	2	-	32.4	45	I
	Lime system	3	2	1	-	11.2	N
	Sludge and lime mixer	2	2	-	-	22	I
	Polimer system	2	1	1	-	-	N
Thermal dryer bldg.	Thermal dryer	2	1	1	-	215	I

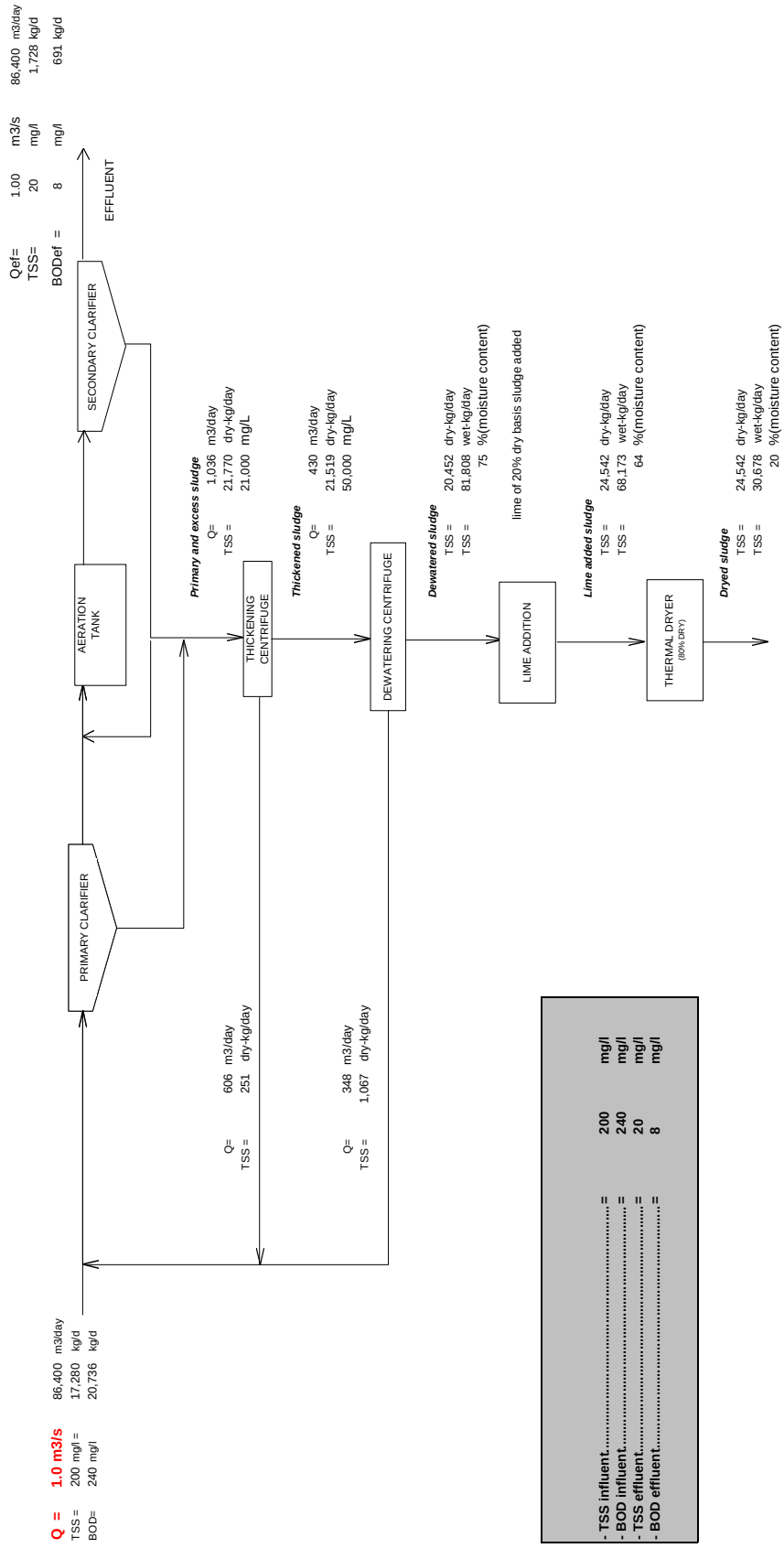

Figure 4 Mass Balance of Sarapui WWTP

2.4 BANGU WWTP

2.4.1 LOCATION OF BANGU WWTP

Bangu WWTP is located at;

Rua Três Marius, Bangu (Vila Catiri), Rio de Janeiro, RJ

The treated effluent is discharged to;

Rio das Tintas

2.4.2 PRELIMINARY AND PRIMARY TREATMENT UNITS

(1) General

Major preliminary and primary treatment units are shown below.

Raw Sewerage Pumping Station;

Grit chambers;

Primary Clarifier;

(2) Raw Sewage Pumping Station

The sewage flowing into the WWTP is conveyed up to the coarse bar screen chute where the material with dimension larger than 8 cm is removed.

The coarse bar screen chute has 2 (two) parallel segments and insulated by upstream floodgates and downstream the screens, in order to allow its maintenance.

The pumping station has 4 motor-pump sets, one of them is spare. Each set discharges 600 l/s it being 3 (three) groups with variable speed. The estimated head is 11.5 mca.

The sewage is conveyed through a channel to the fine screen (1 cm) system, where the channel is subdivided into 3 (three) smaller channels directing the sewage to each screen. Each rack is insulated by a system of sliding floodgates, upstream and downstream. The racked material shall be cast on conveying mats and then taken to a compacter.

(3) Grit Chambers

The grit is removed by 2 (two) mechanized and square chambers with 10m side, which shall remove particles with diameter less than 0.2 mm. The material removed will be washed taken to the sanitary landfill.

Measuring of the flow to the WWTP is done through Parshall downstream the Grit Chamber.

(4) Primary Clarifiers

The settling system consists of 4 (four) circular primary clarifiers with 25 m diameter and 3.5m water depth. The flow distribution to the clarifiers shall be made from the distribution chamber.

Feeding of clarifiers is made from the center of the unit and the scrapers driving system is central type.

The sludge settled in the clarifiers is conveyed to the unit center from where it is withdrawn through helical pumps.

(5) Equipment

The list of preliminary and primary treatment units is shown below.:

Table 30 List of Primary Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (KW/unit)	National (N) Imported (I)
Raw Sewerage Pumping Station	Coarse bar screen	54	2	2.0	N
	Slide gates	54	8	-	N
	Vertical Centrifuge Pump	36	4	100	N
	Fine bar screen	36	3	2.0	N
Grit Chamber	Bottom scraper	54	2	-	N
Grit Chamber	Screw for sand removal	-	2	-	N
Primary Clarifier	Sludge and Scum Scrapers	27	4	1	I
Primary Sludge Pumping Station	Progressive Cavity Pumps	-	5	-	N
Thickeners	Bottom Scrapers	0.68	4	0.37	N

2.4.3 SECONDARY TREATMENT UNITS

(1) General

The biological treatment is done through the activated sludge process. The primary effluent is conveyed to the aeration units and then to secondary clarifiers.

The secondary treatment consists of the following main units:

Aeration Tanks

Blowers

Secondary Clarifier

Sludge Return Pumping Station

(2) Aeration Tanks

Primary effluent is conveyed directly to the aeration tanks. At the inlet of each four tanks there is a chamber which has the function to equally divide the outflow to each group of four aeration tanks.

The liquid effluent to the chamber goes through a spiller, unloading individually into the aeration tank.

Inlet of the return sludge and the primary effluent into the aeration tank is controlled by two electrically driven floodgates.

The effluent of each group of four aeration tanks shall flow through a pipeline to two secondary clarifiers.

The process parameters are as hereunder:

Sludge age (days)	8
Retention time (hours)	6.4
Substratum / micro-organisms ratio F/M	0.35
Mixed liquor concentration (mg/l)	2,474 for average daily
Production of excess sludge (kg/d TSS)	10,720 for average daily
Excess sludge concentration (mg/l)	6,600 - 8,000
Demand of Oxygen (kg/h)	1,507

Main features of the aeration tanks are as hereunder:

Number of tanks	8
Width (m)	12
Length	48
Water depth (m)	5.0
Total depth (m)	6.0
Volume (m^3 per tank)	2,880

Air to the diffusers shall be supplied by a blowers system and distribution pipes (stainless steel for pipes that are not in contact with the sewage and glass fiber for internal pipeline to the aeration tanks). The air diffusion system has the following features:

Type of diffuser	Flexible membrane
Material	EPDM
Type of bubble	fine
Depth of the diffuser (m)	4.8
Oxygen standard requirement (kg/h per tank)	188 for average daily
Air outflow (Nm^3/h per tank)	4,550 for average daily

(3) Blowers Platform

The blowers shall be installed adjacent to the aeration tanks, in concrete platforms, protected from bad weather. These blowers have the following features:

Type of blower	Centrifuge
Number of blowers	4 + 1 (one for standby)
Air (Nm^3/h/unit)	9,100
Power (KW/unit)	175

(4) Secondary Clarifiers

The mixed liquor will be conveyed to the secondary clarifiers, where the biological solids will be separated.

4 secondary clarifiers shall be implemented with 33m diameter, with circular concrete structures with central feed.

Sludge will be accumulated through a mechanical scraper system which will convey the sludge up to the clarifier center. The secondary sludge shall be withdrawn through centrifuge pumps located on the sludge pumping station.

This same equipment makes the superficial scum removal, which shall be conveyed to a well.

The plant effluent will be discharged into a reinforced concrete culvert to be conveyed to the receiving body (Sapopemba river).

The main features of the secondary clarifiers and the main design parameters are shown below:

Type of clarifier	Circular
Number of clarifiers	4
Sludge and scum withdrawal driving gear	central
Feeding	central
Sludge withdrawal	scraper
Diameter (m)	33
Water depth in the wall (m)	4.0
Bottom declivity (v:h)	1:12
Overflow rate ($m^3/m^2/d$)	25.3 for average daily
Solids loading ($kg/m^2/d$)	125 for average daily
Production of excess sludge (kg/d TSS)	10,720 for average dauly

(5) Sludge Pumping Station

Sludges from four secondary clarifiers are withdrawn by pumps installed in sludge pumping station.

The sludge are withdrawn and raised to an outfall box; from this box it will continue through gravity up to the aeration tanks through two ductile cast iron pipelines.

Its structure shall be of two floors, one being at the ground level and the other below where the centrifuge pumps and of progressive cavity will be sheltered. Besides these pumps, it is foreseen a well pump to drain the pumps well.

Each reflux pump will exclusively consider one clarifier; it is also foreseen 1 (one) spare pump which will remain at the storehouse.

The excess sludge is withdrawn from the outfall box, located at the outflow of the reflux pumps of the sludge return pumping station, through 2 progressive cavity pumps. This box shall have a

"stop-log" separating the casting of each two reflux pumps. The third pump shall be normally used to pump the floating matter removed from the clarifiers, also being a spare unit.

Each reflux pump for withdrawal of excess sludge is equipped with a speed varying to adjust the upsetting outflow. Magnetic outflow meters are foreseen at the system outflow and sludges reflux and discard.

The main features of the sludge recirculation and discard system are shown below.

1) Return Sludge Pumps

Type of pump	Centrifuge
Speed	Variable
Number of pumps	4 + 1 (one for standby)
Capacity (m^3/min/unit)	7.2 to 10.8
Power (KW/unit)	16.0

2) Excess Sludge Pumps

Type of pump	Progressive Cavity
Speed	Variable
Number of pumps	2 + 1 (one for standby)
Capacity (m^3/min/unit)	0.6 - 1.5
AMT (bar)	4
Power (KW/unit)	18.0

3) Auxiliary Equipment

The sludge return pumping stations have the following facilities:

Overhead crane and Tackle;

Service water system to seal the pumps;

Draining system, with submerged motor pump for 6 l/s and 6 mca head.

(6) Equipment

The following list shows main equipment of the secondary treatment units:

Table 31 List of Secondary Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (KW/unit)	National(N) Imported(I)
Aeration Tank	Diffusers system	-	8	-	I
Aeration Tank	Blowers	152	5 (4+1)	175	N
Secondary Clarifier	Sludge and Scum scrapers	-	4	1	I
Sludge Pumping Station	Centrifuge pumps	10.8	5 (4+1)	16	N
Sludge Pumping Station	Progressive Cavity Pumps (excess)	1.5	3 (2+1)	18	N

2.4.4 SLUDGE TREATMENT

(1) Sludge Thickening and Dewatering

The treatment is done in the Sludge Treatment Building, inside which are located the equipment necessary for performance of the centrifuge thickening, mechanical dewatering and drying stages.

(2) Gravity Thickeners

The primary sludge withdrawn from the primary clarifiers has 1.0 to 1.5% concentration of solids. It will be thickened to 4-5% by gravity thickeners. There are 4 (four) thickeners with 8.0 m diameter and 3.5 m water depth next to the wall.

Inlet of the primary sludge will be through the center of the thickener and drive of bottom scrapers is central type. The sludge settled in the bottom are withdrawn through gravity and conveyed up to the sludge raising well from where it is alternately pumped to each digester.

(3) Thickening of EXCESS Sludge

The excess sludge and the floating material removed from the secondary clarifiers will be pumped to the sludge treatment building where they will be chemically conditioned with polymer for its thickening in the centrifuges.

The thickened excess sludge will be conveyed up to the thickened sludge pumping station to be mixed with the gravity thickened primary sludge.

The liquid withdrawn from the thickening process through draining (centered) returns to sewage treatment process.

The main features of the centrifugal thickening system are shown below.

1) Thickening Centrifuges

Number of units	2 + 1 (one for standby)
Operation	7 days/week, 20h/d
Solids loading (kg/h/unit)	223 for average daily
Hydraulic loading (m^3/h/unit [1])	41 for average daily
Thickened sludge concentration (%)	5.0

(Assuming a minimum concentration of 6600 mg/l of TSS in the excess sludge)

2) Pumps of Thickened Excess Sludge

The centrifuges thickened sludge is conveyed to the collection well and then, pumped up to the thickened sludge pumping station.

Type	Progressive Cavity
Speed	variable
Number of pumps	1 + 1 (one for standby)
Capacity (m^3/min/unit)	0.72 - 1.44
AMT (bar)	2.0
Power (KW/unit)	10.0

3) Dosing and Dilution Unit

Polymer is applied as conditioner for the excess sludge thickening processes.

Number of Units	2
Polymer concentration in application (%)	0.05 - 0.5
Polymer consumption (kg of polymer/ton sludge)	2
Water outflow for dilution (l/min/unit)	3 - 20

4) Mixer

Type	Submersible
Number of mixers	1
Motor power (kW per mixer)	1.9

(4) Anaerobic Digestion

3 primary digesters and 1 secondary digester with dimensions 16.5m diameter and 17.5m height are installed to digest both thickened primary and excess sludges.

Recirculation of the liquid inside the digesters are done with centrifuge pumps, that will operate 24 hours per day, pumping the sludge alternately from the upper to the lower part and vice-versa every 2 hours.

1) Sludge Reflux Pumps in the Digester

Type of pump	Vertical centrifuge
Number of pumps	6
Capacity (m^3/min/unit)	28.5
Power (KW/unit)	31

2) Digested Sludge Pumps

The digested sludge is conveyed through pumps up to the dewatering process.

Type	Progressive cavity
Speed	variable
Number of pumps	1 + 1 (one for standby)
Capacity (m^3/min/unit)	0.12 - 0.6
AMT (bar)	2.0
Power (KW/unit)	4.5

(5) Mechanical Sludge Dewatering

The digested sludge shall is mechanically dewatered by centrifuges. A total of two centrifuges (one operational and one standby) will dewater the sludge to solids concentration of 25%.

The sludge is chemically conditioned through addition of polymer before being supplied to the centrifuges. The sludge cake resulting from dewatering will be unloaded in a conveying screws system which will convey them up to the thermal drying system.

The conveying screws system will replace the existing mats and will consist of a set of horizontal and tilted screws. The liquid waste from the dewatering process will return to the plant inlet.

The main features of the sludge mechanical dewatering system are shown below:

1) Dewatering Centrifuges

Number of units	1 + 1 (one for standby)
Operation (7days/week)	20 h/d
Solids loading (kg/h/unit)	663 for average daily
Hydraulic load (m^3/h/unit)	189 for average daily
Dewatered sludge concentration (%)	25.0

2) Dosing and Diluting Unit

Polymer is applied as conditioner for the sludge dewatering processes.

Number of Units	1
Concentration of polymer in the application (%)	0.05 - 0.5
Polymer consumption (kg of polymer/ton sludge)	10
Water outflow for dilution (l/min/unit)	50 - 220

3) DEWATERED Sludge Conveying System

Dewatered sludge is conveyed through conveying screws to the thermal drying system. The conveying screws comply with the sludge volume produced by the dewatering centrifuges.

(6) Equipment

The list of main equipment of the sludge treatment area is shown below:

Table 32 List of Sludge Treatment Equipment

Place	Equipment	Capacity (m^3/min/unit)	Quantity	Power (kw/unit)	National (N) Imported (I)
Sludge Treatment	Thickening Centrifuges	41 (*)	3 (2+1)	45	I
Sludge Treatment	Dewatering Centrífuges	18.9 (*)	2 (1+1)	45	I
Sludge Treatment	Dosing and Diluting Units	-	3		I
Sludge Treatment	Thermal dryer	-	1	105	I
Pumping of thickened excess sludge	Progressive cavity pumps	1.44	2 (1+1)	10	N
Pumping of digested sludge	Progressive cavity pumps	0.6	2 (1+1)	4.5	N
Digester	Vertical centrifuge pumps	31.2	6	34	N

Note: (*) Capacity in m^3/h/unit

2.4.5 DESIGN CALCULATION

Design calculation of Bangu WWTP is shown bellow.

ETE BANGU (WWTP BANGU)

1) Eficiências p/ Tratamento (Efficiency)

1)	BOD_5 removed	=	30%	(primary treatment)
2)	TSS removed	=	50%	(primary treatment)
3)	BOD_5	=	91%	(secondary treatment)
4)	TSS	=	92%	(secondary treatment)
5)	VSS/TSS	=	0.75	
6)	BOD influent	=	230	mg/l
7)	BOD effluent	=	20	mg/l
8)	TSS influent	=	250	mg/l
9)	TSS effluent	=	20	mg/l

2) Caixa de Areia (Grit Chamber)

1)	Qmáx	=	1.8	m^3/s	
2)	Number units	=	2		
3)	Qunit	=	0.90	m^3/s	
4)	Surface-loading rate	=	1000	$m^3/m^2.d$	(ranger 600-1300)
5)	Width	=	9	m	
6)	Water depht	=	0.65	m	
7)	Velocity	=	0.15	m/s	

3) Decantador Primário (Primary Clarifier)

1)	Qavg	=	1	m^3/s		
2)	Qmax	=	1.8	m^3/s		
3)	Number units	=	4			
4)	Qunit	=	0.45	m^3/s		
5)	Diameter	=	24	m		
6)	Water depht	=	3.5	m	(> 2,0 m)	
7)	Unit Area	=	452.4	m^2		
8)	Surface-loading rate	=	85.9 - 47.7	$m^3/m^2.d$	max-avg	(ranger 0 - 120)
9)	Hydraulics detention time (max)	=	2.2	h		
10)	Hydraulics detention time (min)	=	1.0	h		
11)	Weir-loading rate	=	286.5	$m^3/m.d$	(ranger 0 - 720)	
12)	Solids concentration (outflow)	=	1.2%		(ranger 1 - 2)	
13)	TSS	=	11,717.0	kg SS/d		
14)	Total sludge flow	=	40.7	m^3/h		
15)	Slope	=	1/12	m/m		

4) Tanque de Aeração (Aeration Tank)

1)	BOD influent (So)	=	161.00	mg/l	
2)	Soluble BODeffluent (S)	=	10.56	mg/l	
3)	Qavg	=	1.00	m^3/s	
4)	Maximum yield coef. (Y)	=	0.55	kgMLVSSV/kgBOD	
5)	Endogenous decay coef. (Kd)	=	0.08	1/dia	
6)	Rate Biodegradable VSS (F'b)	=	0.80		
7)	Sludge age (θ)	=	8.00	dias	
8)	Rate recycle	=	0.60		
9)	Number units	=	8.00		
10)	Rate Biodegrad. VSS after sludge age (Fb)	=	0.71		Fb = F'b / (1 + (1 - F'b) x Kd x θ)
11)	MLSS (X)	=	**2,474**	mg/l	
12)	MLVSS (Xv)	=	**1,707**	mg/l	
13)	Water depth	=	5.00	m	
14)	Length	=	48.00	m	
15)	Width	=	12.00	m	
16)	Unit Volume (V)	=	**2880**	**m^3**	
17)	Total Volume	=	**23040**	**m^3**	V = Yx θ x Qavg x (So - S)/(Xv x (1 + Kd x Fb x θ))
18)	Hydraulics detention time	=	6.40	h	
19)	Concentration in return (Xr)	=	6,597	mg/l	
20)	Rate Food/Microorg (F/M)	=	0.35	kgBOD5/kgMLVSS.dia	(ranger 0,07 - 1)
21)	Rate Food/Microorg (F/M)	=	0.24	kgBOD5/kgMLSS.dia	
22)	Net specific growth rate (U)	=	0.33	kgBOD5/kgMLVSS.dia	(ranger 0,06 - 1)
23)	Flowrate Wasted (Qex)	=	1,625	m^3/d	
24)	Solids removed (Px)	=	10,720	kg/d	

5) Decantador Secundário (Secondary Clarifier)

1)	Qavg	=	1.00	m3/s			MLSS<3000mg/l - R>=0.25 e TH<=36
2)	Rate recycle (R)	=	0.60				
3)	Recycle flowrate	=	0.60	m3/s			MLSS>=3000mg/l e
4)	Diameter	=	33	m			<4500mg/l - R>=0.50 e TH<=24
5)	Water depth	=	4	m			
6)	Slope	=	1/200	m/m			MLSS>=4500mg/l - R>=1 e TH<=16
7)	Number units	=	4				
8)	Unit Volume	=	3,421	m3			
9)	Unit Area	=	855	m2			
10)	Hydraulics detention time	=	3.8	h	>	1.5	h
11)	Surface-loading rate (TH)	=	25.3	m3/m2/d			
12)	Solids loading rate	=	125	kg/m2/d	<	144	kg/m2/d

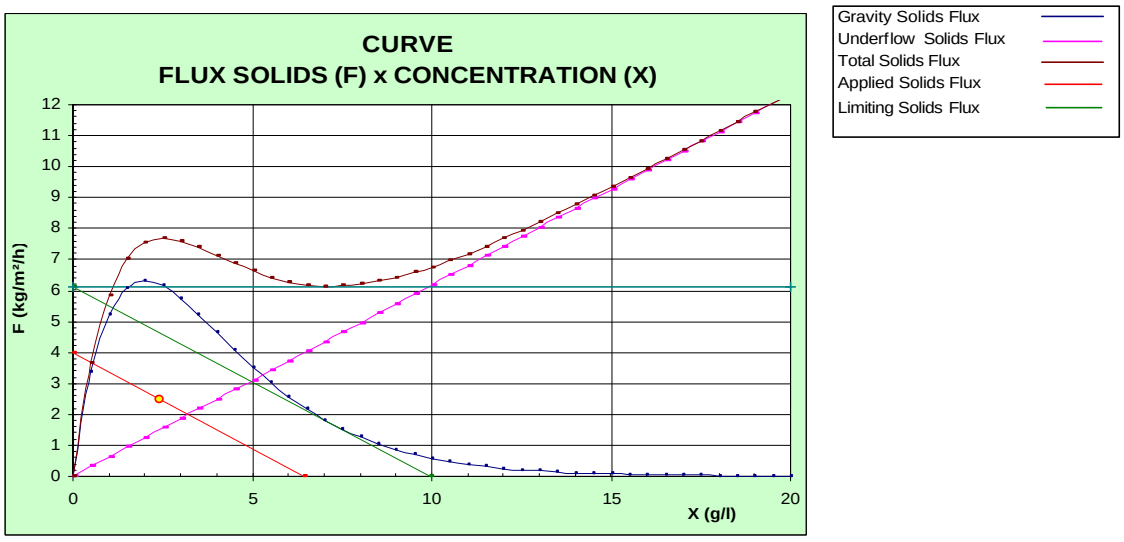

Figure 5 Solids - Concentration Curve

6) Adensador por Gravidade (Gravity Thickening)

1)	Concentration in effluent	=	4.0%		(ranger 0 - 10)		
2)	TSS	=	11,717.0	kg SS/d			
3)	Number units	=	4				
4)	TSS for unit	=	2,929.3	kg SS/d			
5)	Diameter	=	8	m			
6)	Unit Area	=	50.3	m²			
7)	Solids loading rate	=	58.3	kg SS/m².d	(ranger 0 - 150)		
8)	Concentration in influent	=	12,000	mg/l	=	12	kg/m3
9)	TSS effluent	=	10,545	kg SS/d			
10)	Sludge flow effluent	=	11.0	m³/h			
11)	TSS in supernatant	=	1,172	kg SS/d			
12)	Supernatant flow	=	29.7	m³/h			
13)	Water depht	=	3.00	m	(>=3,0m)		
14)	Unit Volume	=	156.4	m3			
15)	Hydraulics detention time	=	12.30	h	(<= 24 h)		
16)	Surface-loading rate	=	4.9	m³/m².d			
17)	Solids recovery	=	90.0%				
18)	Declividade do fundo	=	1/12	m/m			

7) Centrífugas de Adensameto (Centrifuge Thickening)

1)	TSS influent	=	10,720.5	kg SS/d
2)	Concentration influent in centrifuge	=	0.66%	
3)	Concentration effluent in centrifuge	=	5.0%	
4)	Flowrate to Centrifuge	=	18.8	l/s
5)	Solids recovery	=	95.0%	
6)	TSS effluent	=	10,184.4	kg SS/d
7)	Blended sludge	=	2.4	l/s
8)	Thinckener effluent	=	16.5	l/s
9)	Number operation centrifuge	=	2.0	
10)	Operation time	=	20	h/d
11)	Hydraulics flow	=	40.6	m3/h/unit

Polymers aplication

12)	Dosage	=	2		kg Pol / t SS
13)	Polymers Concentration	=	30.0%		
14)	Concentration application polymers	=	0.20% -	0.05%	
15)	Total polymers	=	21.4		kg/d de pol

8) Digestores (Digesters)

8.1) Primary Digester

1)	Type	=	High rate		
2)	TSS influent	=	20,729.7	kg SS/d	
3)	VSS/TSS	=	0.721		
4)	Concentration Solids	=	3.5%		
5)	High rate digestion	=	1.2 -	6.0	kg VSS/m3
6)	Sludge Volume influent (Vf)	=	456.4	m3/d	
7)	Sludge Volume effluent (Vd)	=	371.5	m3/d	
8)	Digestion time(t)	=	25	dias	
9)	Sludge Volume in digesters (V)	=	9,994.1	m3	V={Vf - 2/3 x (Vf - Vd)} x t
10)	Number digester	=	3		
11)	Diameter	=	16.5	m	
12)	Heigth	=	16.0	m	
13)	Volume Unit	=	3,421.2	m3	

8.2) Digestor Secundário

1)	Number	=	1	
2)	Diameter	=	16.5	m
3)	Heigth	=	16.0	m
4)	Volume Unit	=	3,421.2	m3

9) Centrífugas de Desidratação (Centrifuge Dewatering)

1)	TSS influent	=	13,260.8	kg SS/d
2)	Concentration influent in centrifuge	=	3.5%	
3)	Concentration effluent in centrifuge	=	25.0%	
4)	Flowrate to Centrifuge	=	4.4	l/s
5)	Solids recovery	=	95.0%	
6)	TSS effluent	=	12,597.8	kg SS/d
7)	Sludge Flow dewatering	=	0.6	l/s
8)	Filtrate	=	3.8	l/s
9)	Number operation centrifuge	=	1.0	
10)	Operation time	=	20	h/d
11)	Hydraulics flow	=	18.9	m3/h/unit

Polymers aplication

12)	Dosage	=	10		kg Pol / t SS
13)	Polymers Concentration	=	30.0%		
14)	Concentration application polymers	=	0.20% -	0.05%	
15)	Total polymers	=	132.6		kg/d de pol

10) Consumo de Oxigênio (Oxygen-Transfer)

10.1) Oxygen Requirements from removel of Carbonaceous organic matter (DOC)

1)	DOC	=	11,995.1	kg O2/d	DOC = Qavg x (So-S) x (1,46 - (1,42 x Y)/(1+ Kd x Fb x θ))

10.2) Oxygen Requirement from Nitrification (DON)

1)	Population	=	360,000	hab	
2)	Nitrogen	=	8	g NTK/dia/p	
3)	Total Nitrogen	=	2,880.0	kg/dia	
4)	Concentration (CN)	=	33.3	mg/l	
5)	Efficiency from Primary treatment (effn)	=	20.0%		
6)	DON	=	10,529.3	kg O2/d	DON = (4,57 x Qavg x CN /1000) x (1-effn)

10.3) SOTE (standardized oxygen-transfer)

1)	SOTE = DOC + DON	=	22,524.4	kg O2/d

10.4) Oxygen Transfered under fiel condicions (OTR)

1)	α (oxygen-transfer correction fator for water).	=	0.85		
2)	β (saturação de O2 no esgoto/na água).....	=	0.95		
3)	CL(operation oxigen concentration).....	=	2.0	mg/l	
4)	CS summer(O2 saturation in water).....	=	8.4	g/m3	
5)	CS 20 ^{o}(O2 saturation in water).....	=	9.2	g/m3	
6)	δ (coeff. temperature)	=	1.024		
7)	Summer temperature.....	=	25	^{o}c	
8)	OTR (summer).....	=	36,209.4	kg O2/d	$OTR = SOTE / (((\beta \times CS - CL) / CS(20^{o} C)) \times \alpha \times \delta^{(T-20)})$

10.5) Air Requirement

1)	Efficiency.....	=	15.0%	
2)	Specific weight of air.....	=	1.2	kg/m3
3)	O2 in air.....	=	0.23	g O2 / g ar
4)	Air.....	=	607.4	m3/min de ar

10.6) Power

1)	Specific weight of water.....	=	1000	kg/m3
2)	Difuser depth.....	=	4.8	m
3)	Headloss.....	=	0.87	m
4)	Efficiency.....	=	80.0%	
5)	Power.....	=	175	kW/unit
6)	Number of blower.....	=	4 + 1	

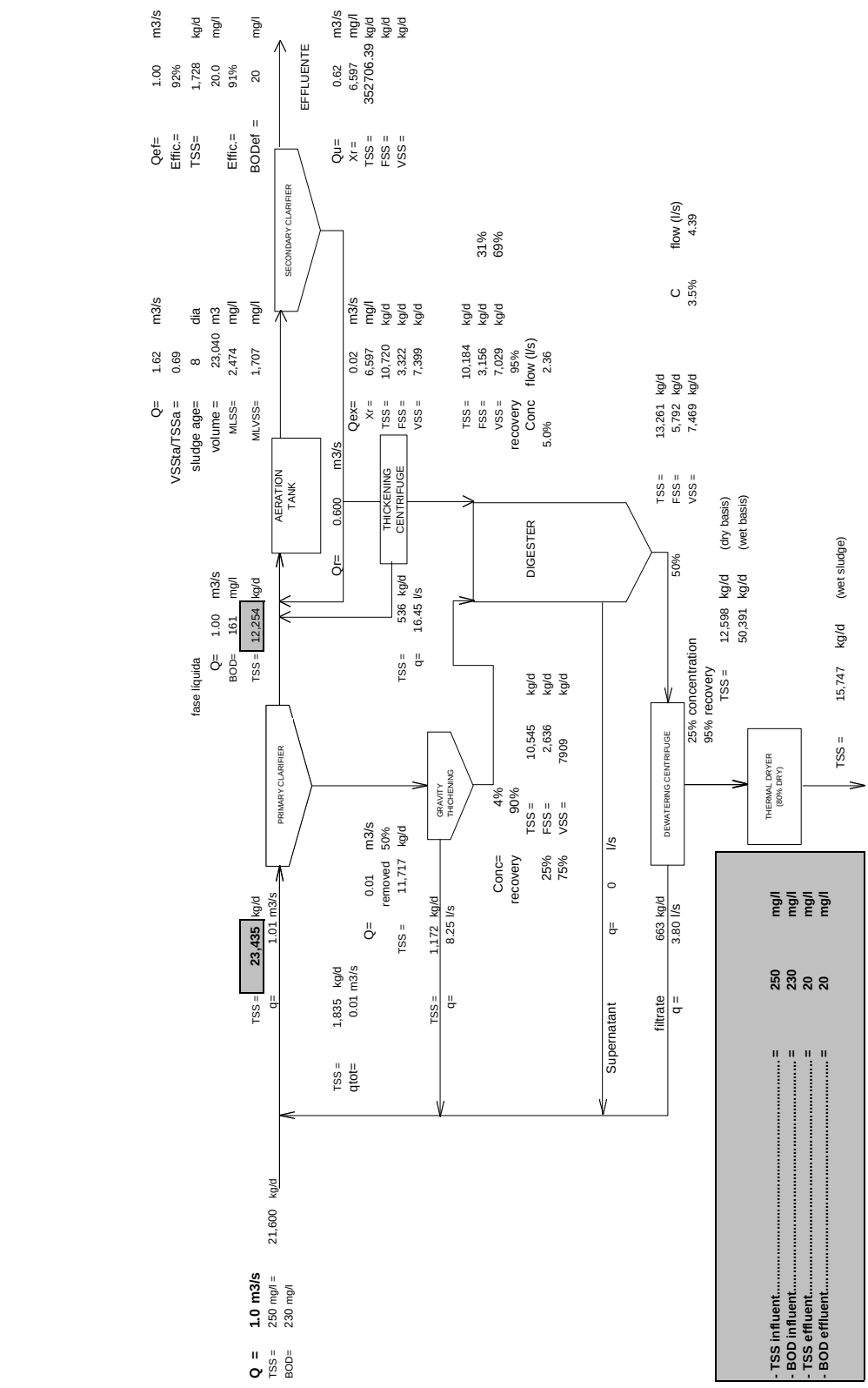

Figure 6 Mass Balance of Bangu WWTP