

# **HYDRAULIC ENGINEERING**

**REHABILITATION OF THE SAUDI MATERNITY HOSPITAL**

**KASSALA HEALTH CITADEL  
SUDAN**

**DETAILED DESIGN**

**WASTEWATER CALCULUS**

System Type		I																		
Stack	Equipment				Section				Total				Material	Nominal Diameter (EN 12056 - Table 12)	Interior Diameter	Ventilation Type	Type of entries	Maximum Flow	Secondary ventilation	Verification
	Wc	Shower	Wash basin	Floor gully	Frequency Factor	DU Section	Max Q/appliance	Qww section	$\Sigma(k^2 \cdot DU)$	Qww total	Total Flow	Calculated Flowrate								
	2.5	0.6	0.5	1.5	K		l/s	l/s		l/s	l/s	l/s						(mm)		
Ref.	Nº	Nº	Nº	Nº																
TQ1	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ2	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ3	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ4	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ5	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ6	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ7	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ8	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ9	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK
TQ10	2	1	1	1	0.70	7.60	1.58	1.93	3.72	1.930	1.930	1.93	P.V.C.	110	102.4	Primary	Square	4	NA	OK

		Equipment						Section				Total		Material	DN	Int. Diameter	Slope	Drainage flow conditions			H/Dcalc ≤ H/D max	Max Pipe Flow (Colebrook-White)	Verification						
		Wc	Bath	Shower	Wash basin	Kitchen sink	Floor gully	Frequency Factor	DU Section	Max Q/appliance	Q <sub>ww</sub> section	Σ(k² * DU)	Total Flow					Calculated Flowrate	H/Dn	Vel.				Tractive Force					
																									K	l/s	l/s	m/s	N/m²
Upstream	Downstream	Nº	Nº	Nº	Nº	Nº	Nº	K		l/s	l/s		l/s	l/s	mm	mm	(%)		m/s	N/m²		[l/s]							
A1	A2	2			1		1	0.70	7.00	1.58	1.85	3.43	1.853	1.85	P.V.C.	110	102.4	1.0%	31.3%	0.86	1.78	OK	4.37	OK					
A2	A10				3			0.70	1.50	0.71	0.86	4.17	2.041	2.04	P.V.C.	110	102.4	1.0%	32.9%	0.88	1.85	OK	4.37	OK					
A3	A5				2	1		0.70	1.80	0.89	0.94	0.88	0.940	0.94	P.V.C.	110	102.4	1.0%	22.1%	0.71	1.32	OK	4.37	OK					
A4	A5	1			1		1	0.70	4.50	1.58	1.48	2.21	1.485	1.58	P.V.C.	110	102.4	1.0%	28.8%	0.82	1.66	OK	4.37	OK					
A5	A8	1			1	2		0.70	4.60	1.58	1.50	5.34	2.312	2.31	P.V.C.	110	102.4	1.0%	35.1%	0.91	1.95	OK	4.37	OK					
A6	A7	1			2		1	0.70	5.00	1.58	1.57	2.45	1.566	1.58	P.V.C.	110	102.4	1.0%	28.8%	0.82	1.66	OK	4.37	OK					
A7	A8							0.70	0.00	0.00	0.00	12.05	3.472	3.47	P.V.C.	125	116.4	1.0%	36.5%	1.00	2.28	OK	6.10	OK					
A8	A9							0.70	0.00	0.00	0.00	17.40	4.171	4.17	P.V.C.	125	116.4	1.0%	40.4%	1.05	2.46	OK	6.10	OK					
A9	A10							0.70	0.00	0.00	0.00	17.40	4.171	4.17	P.V.C.	125	116.4	1.0%	40.4%	1.05	2.46	OK	6.10	OK					
A10	EX1A				3			0.70	1.50	0.71	0.86	22.30	4.722	4.72	P.V.C.	125	116.4	1.0%	43.3%	1.08	2.59	OK	6.10	OK					
E1	E2	2			2	3		0.70	8.40	1.58	2.03	4.12	2.029	2.03	P.V.C.	110	102.4	1.0%	32.8%	0.88	1.85	OK	4.37	OK					
E2	E3	1						0.70	2.50	1.58	1.11	5.34	2.312	2.31	P.V.C.	110	102.4	1.0%	35.1%	0.91	1.95	OK	4.37	OK					
E3	A7	1		2	4		2	0.70	8.70	1.58	2.06	9.60	3.100	3.10	P.V.C.	110	102.4	1.0%	41.3%	0.98	2.20	OK	4.37	OK					
C1	C3	1		2	2		1	0.70	6.20	1.58	1.74	3.04	1.743	1.74	P.V.C.	110	102.4	1.0%	30.3%	0.84	1.73	OK	4.37	OK					
C2	C3	3		2	2		1	0.70	11.20	1.58	2.34	5.49	2.343	2.34	P.V.C.	110	102.4	1.0%	35.4%	0.91	1.96	OK	4.37	OK					
C3	SeptTnk1							0.70	0.00	0.00	0.00	8.53	2.920	2.92	P.V.C.	110	102.4	1.0%	39.9%	0.96	2.15	OK	4.37	OK					
F1	F2	1		2	4		1	0.70	7.20	1.58	1.88	3.53	1.879	1.88	P.V.C.	110	102.4	1.0%	31.5%	0.86	1.79	OK	4.37	OK					
F2	EX1F	3					2	0.70	10.50	1.58	2.27	8.67	2.945	2.95	P.V.C.	110	102.4	1.0%	40.1%	0.96	2.16	OK	4.37	OK					
F3	F4	3						0.70	7.50	1.58	1.92	3.68	1.918	1.92	P.V.C.	110	102.4	1.0%	31.8%	0.86	1.80	OK	4.37	OK					
F4	F5	1		2	4		1	0.70	7.20	1.58	1.88	7.20	2.684	2.68	P.V.C.	110	102.4	1.0%	38.1%	0.94	2.08	OK	4.37	OK					
F5	EX1F							0.70	0.00	0.00	0.00	7.20	2.684	2.68	P.V.C.	110	102.4	1.0%	38.1%	0.94	2.08	OK	4.37	OK					
EX1F								0.70	0.00	0.00	0.00	15.88	3.985	3.99	P.V.C.	110	102.4	1.0%	47.6%	1.04	2.43	OK	4.37	OK					
E4	E5					2		0.70	1.60	0.89	0.89	0.78	0.886	0.89	P.V.C.	110	102.4	1.0%	21.5%	0.70	1.29	OK	4.37	OK					
E5	E6					2		0.70	1.60	0.89	0.89	1.57	1.253	1.25	P.V.C.	110	102.4	1.0%	25.5%	0.77	1.50	OK	4.37	OK					
E6	E7							0.70	0.00	0.00	0.00	1.57	1.253	1.25	P.V.C.	110	102.4	1.0%	25.5%	0.77	1.50	OK	4.37	OK					
E7	E10	1						0.70	2.50	1.58	1.11	2.79	1.672	1.67	P.V.C.	110	102.4	1.0%	29.6%	0.83	1.70	OK	4.37	OK					
E8	E9					4		1.00	3.20	0.89	1.79	3.20	1.789	1.79	P.V.C.	110	102.4	1.0%	30.7%	0.85	1.75	OK	4.37	OK					
E9	E10	1		1	1		1	0.70	5.10	1.58	1.58	5.70	2.388	2.39	P.V.C.	110	102.4	1.0%	35.8%	0.91	1.98	OK	4.37	OK					
E10	E11							0.70	0.00	0.00	0.00	8.49	2.915	2.92	P.V.C.	110	102.4	1.0%	39.9%	0.96	2.15	OK	4.37	OK					
E11	E12							0.70	0.00	0.00	0.00	8.49	2.915	2.92	P.V.C.	110	102.4	1.0%	39.9%	0.96	2.15	OK	4.37	OK					
E12	E13							0.70	0.00	0.00	0.00	8.49	2.915	2.92	P.V.C.	110	102.4	1.0%	39.9%	0.96	2.15	OK	4.37	OK					
E13	J7							0.70	0.00	0.00	0.00	8.49	2.915	2.92	P.V.C.	110	102.4	1.0%	39.9%	0.96	2.15	OK	4.37	OK					
J1	J2	1			1		1	0.70	4.50	1.58	1.48	2.21	1.485	1.58	P.V.C.	110	102.4	1.0%	28.8%	0.82	1.66	OK	4.37	OK					
J2	J3	1					1	0.70	4.00	1.58	1.40	4.17	2.041	2.04	P.V.C.	110	102.4	1.0%	32.9%	0.88	1.85	OK	4.37	OK					
J3	J5							0.70	0.00	0.00	0.00	4.17	2.041	2.04	P.V.C.	110	102.4	1.0%	32.9%	0.88	1.85	OK	4.37	OK					
J4	J5	2		2	2		2	0.70	10.20	1.58	2.24	5.00	2.236	2.24	P.V.C.	110	102.4	1.0%	34.5%	0.90	1.92	OK	4.37	OK					
J6	J7	3		2	3		3	0.70	14.70	1.58	2.68	7.20	2.684	2.68	P.V.C.	110	102.4	1.0%	38.1%	0.94	2.08	OK	4.37	OK					
J7	J8							0.70	0.00	0.00	0.00	15.70	3.962	3.96	P.V.C.	125	116.4	1.0%	39.3%	1.03	2.41	OK	6.10	OK					
J8	EX1J							0.70	0.00	0.00	0.00	15.70	3.962	3.96	P.V.C.	125	116.4	1.0%	39.3%	1.03	2.41	OK	6.10	OK					
H1	H2	1		1	1		1	0.70	5.10	1.58	1.58	2.50	1.581	1.58	P.V.C.	110	102.4	1.0%	28.8%	0.82	1.66	OK	4.37	OK					
H2	H3	1		1	2		1	0.70	5.60	1.58	1.66	5.24	2.290	2.29	P.V.C.	110	102.4	1.0%	35.0%	0.90	1.94	OK	4.37	OK					
H3	H6	1		1	2		1	0.70	5.60	1.58	1.66	7.99	2.827	2.83	P.V.C.	110	102.4	1.0%	39.2%	0.95	2.12	OK	4.37	OK					
H4	H5	1				1		0.70	3.30	1.58	1.27	1.62	1.272	1.58	P.V.C.	110	102.4	1.0%	28.8%	0.82	1.66	OK	4.37	OK					
H5	H6							0.70	0.00	0.00	0.00	1.62	1.272	1.27	P.V.C.	110	102.4	1.0%	25.7%	0.77	1.51	OK	4.37	OK					
H6	EX1H							0.70	0.00	0.00	0.00	9.60	3.100	3.10	P.V.C.	110	102.4	1.0%	41.3%	0.98	2.20	OK	4.37	OK					
H7	H8		1	1	1		1	0.70	3.40	1.22	1.29	1.67	1.291	1.29	P.V.C.	110	102.4	1.0%	25.9%	0.78	1.52	OK	4.37	OK					
H8	H9		2	2	2		2	0.70	6.80	1.22	1.83	5.00	2.236	2.24	P.V.C.	110	102.4	1.0%	34.5%	0.90	1.92	OK	4.37	OK					
H9	H10		2	2	2		2	0.70	6.80	1.22	1.83	8.33	2.887	2.89	P.V.C.	110	102>												

		Equipment						Section				Total			Material	DN	Int. Diameter	Slope	Drainage flow conditions			H/Dcalc ≤ H/D max	Max Pipe Flow (Colebrook-White)	Verification
		Wc	Bath	Shower	Wash basin	Kitchen sink	Floor gully	Frequency Factor	DU Section	Max Q/appliance	Qww section	Σ(K² * DU)	Total Flow	Calculated Flowrate					H/Dn	Vel.	Tractive Force			
Upstream	Downstream	Nº	Nº	Nº	Nº	Nº	Nº	K		l/s	l/s		l/s	l/s	mm	mm	(%)		m/s	N/m²		[l/s]		
L9	L10	4		2	2		2	0.70	15.20	1.58	2.73	14.90	3.860	3.86	P.V.C.	110	102.4	1.0%	46.7%	1.03	2.40	OK	4.37	OK
L10	L11	4		2	2		2	0.70	15.20	1.58	2.73	22.34	4.727	4.73	P.V.C.	125	116.4	1.0%	43.3%	1.08	2.59	OK	6.10	OK
L11	L12	4		2	2		2	0.70	15.20	1.58	2.73	29.79	5.459	5.46	P.V.C.	125	116.4	1.0%	47.0%	1.12	2.74	OK	6.10	OK
L12	L13	4		2	2		2	0.70	15.20	1.58	2.73	37.24	6.103	6.10	P.V.C.	160	149.2	1.0%	34.9%	1.14	2.83	OK	11.68	OK
L13	L14							0.70	0.00	0.00	0.00	74.48	8.631	8.63	P.V.C.	160	149.2	1.0%	42.2%	1.24	3.26	OK	11.68	OK
L14	SeptTnk2							0.70	0.00	0.00	0.00	74.48	8.631	8.63	P.V.C.	160	149.2	1.0%	42.2%	1.24	3.26	OK	11.68	OK

GREASE SEPARATOR - KITCHEN			
Type of Kitchen	Hospital		
V <sub>m</sub>	20 l		
F	13		
Daily meals (M)	370		
Operation time (t)	8 h		
Q <sub>s</sub> = M . V <sub>m</sub> . F/ 3600 . t	3.35 l/s		
Affluent factors:			
Temperature (Ft):	> 60°C	1.3	
Rinsing / Detergents (fr):	Occasionally or Always	1.3	
Density (fd)		1	
Peak Flow	5.67 l/s		
Nominal Size (NS)	7		
Minimum Nominal Pipe Size	125 mm		
Minimum Retention Time	240 s		
Minimum surface of grease separation zone	1.75 m²		
Minimum volume of grease separation zone	1680 l		
Minimum volume of grease collection area	40 l x NS	280 l	
Sludge Trap?	Yes	Minimum Volume:	700.00 l

Design Parameters	
Estimated Population (P)	15 equiv. Pop.
Capitation of waste water (Cp)	80 l/pop/day
Capitation of digested sludge (Cd)	0.26 l/pop/day
Capitation fresh sludge (Cf)	1.1 l/pop/day
Retention time (tr)	3 days
Time between cleanings (tl)	720 days
Sludge digestion time (td)	40 days
Minimum Volume	
7 m³	
Septic Tank Sizing	
Number of compartments	1
Internal Dimensions	
internal wall thickness	0.2 m
Base / Ceiling Thickness	0.3 m
Entrance Cote (Csup = 0,00)	-0.60 m
height	1.3 m
width	1.6 m
Length C1	3.6 m
Volume C1	7.488 m³
Length C2	m
Volume C2	0 m³
Length C3	0 m
Volume C3	0 m³
Total Volume	7.488 m³
External Dimensions	
Length	4 m
Width	2 m
Height	1.9 m
Installation Depth	2.50 m



Design Parameters	
Estimated Population (P)	60 equiv. Pop.
Capitation of waste water (Cp)	80 l/pop/day
Capitation of digested sludge (Cd)	0.26 l/pop/day
Capitation fresh sludge (Cf)	1.1 l/pop/day
Retention time (tr)	3 days
Time between cleanings (tl)	720 days
Sludge digestion time (td)	40 days
<b>Minimum Volume</b>	
	<b>27 m<sup>3</sup></b>
Septic Tank Sizing	
Number of compartments	<b>2</b>
Internal Dimensions	
internal wall thickness	0.2 m
Base / Ceiling Thickness	0.3 m
Entrance Cote (Csup = 0,00)	-1.32 m
height	2 m
width	2.1 m
Length C1	4.3 m
Volume C1	18.06 m <sup>3</sup>
Length C2	2.2 m
Volume C2	9.24 m <sup>3</sup>
Length C3	0 m
Volume C3	0 m <sup>3</sup>
<b>Total Volume</b>	<b>27.3 m<sup>3</sup></b>
External Dimensions	
<b>Length</b>	<b>7.1 m</b>
<b>Width</b>	<b>2.5 m</b>
<b>Height</b>	<b>2.6 m</b>
<b>Installation Depth</b>	<b>3.92 m</b>

	Daily Effluent Volume Production				Infiltration Well Characteristics					Infiltration Capacity					Pit Depth	
	Mean daily water supply (Mdws)	Estimated Population (P)	Total Daily Water Volume (TDWV)	Total Watewater Daily Volume (80% TDWV)	Infiltration Flow	nr. of wells considered	Øpit / Length	Width	Permeabl e height	Drainage Surface	Infiltration flow per well	Total Infiltration Flow	n.º of necessary wells (estimated)	Infiltration time	Lower pipe Cote	Total depth
	(l/day/pop.)	equiv. Pop.	(l/day)	(l/day)	(L/m²/day)		(m)	(m)	(m)	(m²)	(l/day)	(l/dia)		nr. of days	m	m
P1	100.0	15.0	1500.0	1200.0	75.0	1.0	3		2	25.9	1943.9	1943.9	0.6	0.617	-1.0	3.200