

WATER BALANCE ANALYSIS WORKSHOP SESSION

Calculation of evapotranspiration-absorption area basal area by the water balance method.

Using the following information and your Course Notes, calculate the minimum basal area of an evapotranspiration-absorption area for a three bedroom / five person dwelling with tank water supply.

Bureau of Meteorology rainfall and pan evaporation data for the nearest station and appropriate crop factor data is provided below.

Site name: RICHMOND - UWS HAWKESBURY						Site number: 067021						
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Decile 5 (median) rainfall (mm)	74.3	75.8	66.5	50.4	30.9	38.6	27.6	24	32.8	43.2	66.2	55.6
Mean daily evaporation (mm)	5.9	4.9	4	3	2.1	1.7	1.9	2.7	3.8	4.6	5.2	5.7
Crop factor	0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8

Three test pits excavated on the proposed effluent application area indicate that the soils are 475 mm weakly structured clay loam overlying moderately structured light clay to a depth of 2,000 mm. Use the recommended design loading rate derived from Table L1 of AS/NZS 1547:2012 (see the Field Workshop and Design Exercise section of these Course Notes).

Assume the site has a 5% slope.

Calculate the evapotranspiration-absorption area using the worksheet provided on the following page.

The evapotranspiration-absorption area is to be constructed of imported aggregate and is to have a maximum depth of 400 mm with a minimum of 50 mm freeboard (i.e. maximum depth of stored effluent is 350 mm).

Calculation of irrigation area by the water balance method.

For the same scenario, but with a slope of 12% and assuming the soil has no storage (i.e. has a void space ratio of 1.0), calculate the required irrigation area.

Key site and soil data is summarised below:

moderately structured light clay subsoil	DLR	5 mm/day		
moderately structured light clay subsoil	DIR	3 mm/day		
Retained Rainfall Coefficient	RrC	0.9 Bed	5% slope	
Retained Rainfall Coefficient	RrC	0.8 Irrigation	12% slope	
Void Space Ratio	V	0.3 Bed	gravel media	
Void Space Ratio	V	1 Irrigation	soil/ no storage	

A blank water balance spreadsheet template and two worked examples are presented on the following pages.

Model Parameter				Units	Symbol	Source	Value													KEY					
Design Wastewater Load				L/day	Q	Wastewater generation		Notes 1. Patterson (2006)															User input		Calculated value
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)				mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE																			
Void Space Ratio				-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch) ¹																			
Retained Rainfall Coefficient				-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)																			
Nominated EAA				m ²	EAA _N	Nominated area by user																			
Monthly Parameters								Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual					
Days in month				days	D	-		31	28	31	30	31	30	31	31	30	31	30	31	365					
Precipitation				mm/month	P	Median monthly data (BoM or SILO)																			
Daily evaporation				mm/day	E _d	Mean daily data (BoM or SILO)																			
Evaporation				mm/month	E	$E_d \times D$																			
Crop Factor				-	Cf	0.4-0.9 ¹ (varies with crop type and season)																			
Model Inputs																									
Retained rainfall				mm/month	Rr	$P \times RrC$																			
Applied Effluent				mm/month	W	$(Q \times D) \div EAA_N$																			
Inputs				mm/month	I	$(Rr + W)$																			
Model Outputs																									
Evapotranspiration				mm/month	Et	$E \times Cf$																			
Percolation				mm/month	B	$DLR/DIR \times D$																			
Outputs				mm/month	O	$(Et + B)$																			
Model Storage																									
Monthly storage				mm/month	S _M	$(I - O) + V$																			
Cumulative storage				mm/month	S _C	$S_M + (S_M \text{ for month prior})$																			
Area required for no storage				m ² /month	EAA _S	$(Q \times D) + (ET-Rr+B)$																			
Model Results																									
Limiting storage				mm/month	S _L	Maximum monthly S _c value																			
EAA Required (no storage)				m ²	EAA	Maximum monthly EAA _s value																			

Model Parameter	Units	Symbol	Source	Value	Value												KEY	
					3-bedroom house with on-site (tank) supply												User input	Calculated value
Design Wastewater Load	L/day	Q	Wastewater generation	600	Notes 1. Patterson (2006) Table L'1 AS/NZS 1547:2012 moderately structured light clay subsoil Piped gravel bed EAA proposed 5% slope in proposed EAA													
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)	mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE	5														
Void Space Ratio	-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch) ¹	0.3														
Retained Rainfall Coefficient	-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)	0.9														
Nominated EAA	m ²	EAA _N	Nominated area by user	120														
Monthly Parameters					Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual	
Days in month	days	D	-		31	28	31	30	31	30	31	31	30	31	30	31	365	
Precipitation	mm/month	P	Richmond UWS Hawkesbury (BoM 067021)		74.3	75.8	66.5	50.4	30.9	38.6	27.6	24.0	32.8	43.2	66.2	55.6	1093.4	
Daily evaporation	mm/day	E _d	Richmond UWS Hawkesbury (BoM 067021)		5.9	4.9	4.0	3.0	2.1	1.7	1.9	2.7	3.8	4.6	5.2	5.7	5.0	
Evaporation	mm/month	E	E _d x D		182.9	137.2	124.0	90.0	65.1	51.0	58.9	83.7	114.0	142.6	156.0	176.7	1825.0	
Crop Factor	-	Cf	0.4-0.9 ¹ (varies with crop type and season)		0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8		
Model Inputs																		
Retained rainfall	mm/month	Rr	P x RrC		66.87	68.22	59.85	45.36	27.81	34.74	24.84	21.6	29.52	38.88	59.58	50.04		
Applied Effluent	mm/month	W	(Q x D) + EAA _N		155.0	140.0	155.0	150.0	155.0	150.0	155.0	155.0	150.0	155.0	150.0	155.0		
Inputs	mm/month	I	(Rr + W)		221.9	208.2	214.9	195.4	182.8	184.7	179.8	176.6	179.5	193.9	209.6	205.0		
Model Outputs																		
Evapotranspiration	mm/month	Et	E x Cf		146.3	109.8	99.2	63.0	45.6	35.7	41.2	58.6	79.8	114.1	124.8	141.4		
Percolation	mm/month	B	DLR/DIR x D		155.0	140.0	155.0	150.0	155.0	150.0	155.0	155.0	150.0	155.0	150.0	155.0		
Outputs	mm/month	O	(Et + B)		301.3	249.8	254.2	213.0	200.6	185.7	196.2	213.6	229.8	269.1	274.8	296.4		
Model Storage																		
Monthly storage	mm/month	S _M	(I - O) + V		-264.8	-138.5	-131.2	-58.8	-59.2	-3.2	-54.6	-123.3	-167.6	-250.7	-217.4	-304.4		
Cumulative storage	mm/month	S _C	S _M + (S _M for month prior)		0	0	0	0	0	0	0	0	0	0	0	0		
Area required for no storage	m ² /month	EAA _S	(Q x D) + (ET-Rr+B)		79	93	96	107	108	119	109	97	90	81	84	76		
Model Results																		
Limiting storage depth	mm/month	S _L	Maximum monthly S _c value	0														
EAA Required (no storage)	m ²	EAA	Maximum monthly EAA _S value	119														

Model Parameter			Units	Symbol	Source	Value	KEY												
Design Wastewater Load			L/day	Q	Wastewater generation	600	3-bedroom house with on-site (tank) supply Table M1 AS/NZS 1547:2012 moderately structured light clay subsoil Subsurface irrigation EAA proposed 12% slope in proposed EAA												
Design Loading Rate (DLR) / Design Irrigation Rate (DIR)			mm/day	DLR / DIR	AS/NZS 1547:2012 and SSE	3													
Void Space Ratio			-	V	1 (soil/ no storage), 0.3 (gravel media) 0.45 (sand media), 0.5 (arch) ¹	1													
Retained Rainfall Coefficient			-	RrC	0.7 (>30% slope), 0.8 (10-30% slope), 0.9 (0-10% slope), 1.0 (flat ground)	0.8													
Nominated EAA			m ²	EAA _N	Nominated area by user	190													
Monthly Parameters							Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
Days in month			days	D	-		31	28	31	30	31	30	31	31	30	31	30	31	365
Precipitation			mm/month	P	Richmond UWS Hawkesbury (BoM 067021)		74.3	75.8	66.5	50.4	30.9	38.6	27.6	24.0	32.8	43.2	66.2	55.6	1093.4
Daily evaporation			mm/day	E _d	Richmond UWS Hawkesbury (BoM 067021)		5.9	4.9	4.0	3.0	2.1	1.7	1.9	2.7	3.8	4.6	5.2	5.7	5.0
Evaporation			mm/month	E	E _d x D		182.9	137.2	124.0	90.0	65.1	51.0	58.9	83.7	114.0	142.6	156.0	176.7	1825.0
Crop Factor			-	Cf	0.4-0.9 ¹ (varies with crop type and season)		0.8	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	
Model Inputs																			
Retained rainfall			mm/month	Rr	P x RrC		59.44	60.64	53.2	40.32	24.72	30.88	22.08	19.2	26.24	34.56	52.96	44.48	
Applied Effluent			mm/month	W	(Q x D) + EAA _N		97.9	88.4	97.9	94.7	97.9	94.7	97.9	97.9	94.7	97.9	94.7	97.9	
Inputs			mm/month	I	(Rr + W)		157.3	149.1	151.1	135.1	122.6	125.6	120.0	117.1	121.0	132.5	147.7	142.4	
Model Outputs																			
Evapotranspiration			mm/month	Et	E x Cf		146.3	109.8	99.2	63.0	45.6	35.7	41.2	58.6	79.8	114.1	124.8	141.4	
Percolation			mm/month	B	DLR/DIR x D		93.0	84.0	93.0	90.0	93.0	90.0	93.0	93.0	90.0	93.0	90.0	93.0	
Outputs			mm/month	O	(Et + B)		239.3	193.8	192.2	153.0	138.6	125.7	134.2	151.6	169.8	207.1	214.8	234.4	
Model Storage																			
Monthly storage			mm/month	S _M	(I - O) + V		-82.0	-44.7	-41.1	-17.9	-16.0	-0.1	-14.3	-34.5	-48.8	-74.6	-67.1	-92.0	
Cumulative storage			mm/month	S _C	S _M + (S _M for month prior)		0	0	0	0	0	0	0	0	0	0	0	0	
Area required for no storage			m ² /month	EAA _S	(Q x D) + (ET-Rr+B)		103	126	134	160	163	190	166	140	125	108	111	98	
Model Results																			
Limiting storage depth EAA Required (no storage)			mm/month	S _L	Maximum monthly S _c value	0													
			m ²	EAA	Maximum monthly EAA _S value	190													