

On-site Wastewater Management Training Course

Evapotranspiration Systems and Sizing by Water Balance

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Terminology

Evapotranspiration Systems referred to as:

- Evapotranspiration Absorption Systems ETA – Australia (unlined)
- Evapotranspiration Seepage Systems ETS – New Zealand (unlined)
- Or simply Evapotranspiration Systems ET, if lined

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Purpose

ETA/S Systems designed to:

- Maximise evapotranspiration
- Reduce absorption (drainage) in unlined systems
- Avoid absorption in lined systems
- Provide alternative to conventional trenches/beds in areas of low permeability soils (<0.5-1.5 m/d) e.g. clay loams, light, medium and heavy clays

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AS/NZS 1547:2012 and NSW Guidelines

- Table L1 (AS/NZS 1547:2012) and Table 6-4 (NSW Guidelines) give recommended DLRs of between 12 mm/d (CL) and 5 mm/d (LC/MC) based on soil texture
- Secondary treated effluent is required in Category 6 soils
- Not necessary for annual evaporation to exceed annual precipitation
- Can use plant transpiration and void space storage to manage hydraulic load throughout seasons

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AS/NZS 1547:2012 and NSW Guidelines

- DLRs are conservative values
- Any variation to be justified by full water balance for 12-month cycle (Appendix Q)
- No higher DLRs for Secondary treated effluent (may be better to use conventional trench or bed)
- Plant with grasses and shrubs which tolerate wet conditions and have high evapotranspiration capacity
- Construction outlined in Appendix L (AS/NZS 1547:2012)

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Water Balance Design

- Background outlined in Appendix Q in AS/NZS 1547:2012
- Main factors:
 - Effluent largely disposed of through deep infiltration, interflow and evapotranspiration
 - Evapotranspiration is significant, but may not dominate water balance
 - Some deep infiltration is required to prevent salt build up
 - Not suited to shallow water tables unless using a lined system

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Important Components in ET Bed Design

- Crop Factors (Cf), Evaporation (E) and Evapotranspiration (ET) – explained further in water balance example later
- Capillary Water – movement of water laterally and upwards under surface tension
- Field Capacity (FC) – upper limit of available water storage in soil / medium
- Void Ratio (n) – proportion of bed available for water/air storage

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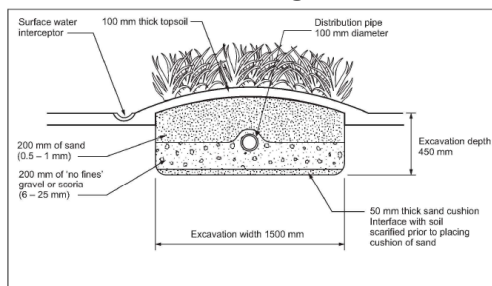
ETA Bed Design Considerations

- Generally constructed subsurface, with mounded upper surface to reduce rainfall ingress
- Suited to slopes <10%
- Important to consider Linear Loading Rate
- Prefer good exposure to sun and wind
- Maximum bed length 20m if gravity fed
- Prefer pressure dosing to ensure even distribution
- May require downslope Nutrient Uptake Area (NUA). Size with nutrient balance.

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AS/NZS 1547:2012 ETA Bed Design Detail

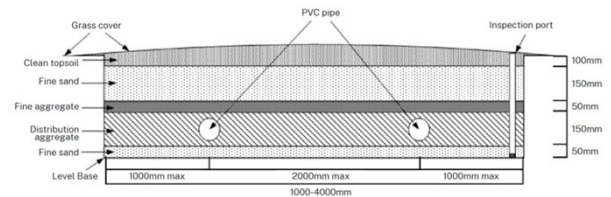


(Source: Standards Australia 2012)

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'Typical' ETA Bed Arrangement



(Source: DPHI 2025)

- Can be raised bed, but beware of potential for lateral seepage of stored effluent

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ETA Bed



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Raised ETA Bed

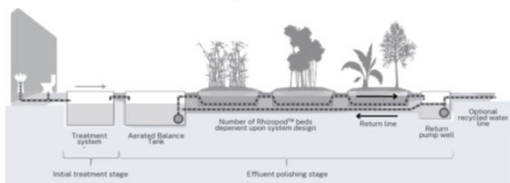


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Recirculating Evapotranspiration Channel System (Rhizopod®)

- With sufficient pods, can be configured as a no-release system
- Size using a water balance and to determine the number and frequency of pumpouts required



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Consideration of Climatic Data

- Pan evaporation (E)
 - From nearest climatically similar meteorological station
- Rainfall (R)
 - From nearest climatically similar meteorological station
- www.bom.gov.au
- Or use SILO data:
- <https://www.longpaddock.qld.gov.au/silo/>

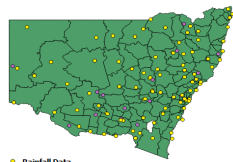
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'Class A' Evaporation Pan



- Total historical station coverage nationwide:
- ~17,750 rainfall stations
 - Only ~600 evaporation stations



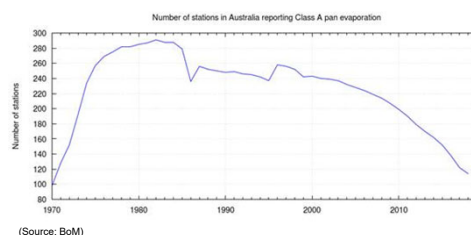
(Source: BoM)

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'Class A' Evaporation Pan

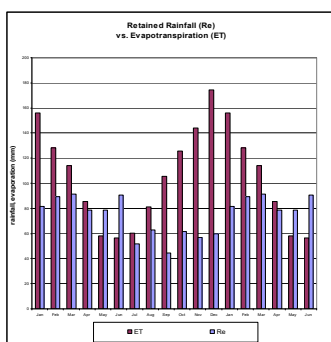
- Diminishing number of evaporation stations
- Move to SILO data (5km x 5km intersections)



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Inputs (Re) vs. Outputs (ET)



- ET dominates the WB, but not completely
- Excess rainfall can be managed for periods of the year provided that there is storage available in the system

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The Use of Water Balances

- Will work through an example of an unlined ETA bed
- Have provided a water balance template for both beds and irrigation areas
- Once you have practiced the skills required in doing water balances longhand they lend themselves to setting up spreadsheets to speed calculation

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Water Balance Exercise

- Calculate the minimum basal area (m^2) of an evapotranspiration-absorption area for a three bedroom / five person dwelling with tank water supply
- BoM rainfall and pan evaporation data / crop factor

Site name: HOBART AIRPORT WEST				Site number: 094008								
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Decile 5 (median) rainfall (mm)	32.2	27.2	29.3	28.5	30.5	27.9	31.2	42.1	34.4	39	40.3	43.4
Mean daily evaporation (mm)	6.3	5.5	4.2	2.9	1.9	1.3	1.4	2	3.1	4.1	4.9	6
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

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Water Balance Exercise

- 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)
- The site has a 5% gradient

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Water Balance Exercise

- Calculate the required evapotranspiration-absorption basal area using the worksheet provided following the PowerPoint slides
- The evapotranspiration-absorption area is to be constructed of imported aggregate, 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)
- Conventional beds may have between 300 mm and 600 mm of aggregate, ETA beds have 400 mm of aggregate and sand

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Model Parameter		Units	Symbol	Source	Value	KEY																					
Design Wastewater Load		L/day	Q	Wastewater generation		Green input		Calculated value																			
Design Loading Rate (DLR)		mm/day	DLR	AS/NZS 1547:2012 and SDE		Notes																					
Design Irrigation Rate (DIR)			V	1 (all no storage), 0.5 (gravel media)		1. Patterson (2006)																					
Bed Slope Rate				0.45 (sand media), 0.5 (gravel)																							
Recommended Rainfall Coefficient			R/C	0.7 (5-10% slope), 0.8 (10-30% slope), 0.9 (30-50% slope), 1.0 (flat ground)																							
Nominated EAA		m ² /beds	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 SLO)																							
Daily evaporation	mm/day	E _d		Mean daily data (BOM or SLO)																							
Evaporation	mm/month	E		E _d × D																							
Crop Factor		CF		0.4-0.9 (varies with crop type and season)																							
Model Inputs																											
Retained rainfall	mm/month	R _r		P × R/C																							
Applied Effluent	mm/month	W		(Q/D) × EAA _N																							
Inputs	mm/month	I		(R _r + W)																							
Model Outputs																											
Evapotranspiration	mm/month	E _t		E × CF																							
Precipitation	mm/month	P		DLR × R × D																							
Outputs	mm/month	O		(E _t + P)																							
Model Storage																											
Monthly storage	mm/month	S _m		(I - O) × V																							
Capillary storage	mm/month	S _c		S _m × (E _d / E _{max}) for month prior																							
Area required for no storage	m ² /month	EAA _N		(Q × D) / (E _t - R)																							
Model Results																											
Limiting storage	mm/month	S _L		Maximum monthly S _m value																							
EAA Required (no storage)	m ²	EAA		Maximum monthly EAA _N value																							

- Water Balance Spreadsheet Template

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Basal Area vs Storage Depth

- The water balance spreadsheet will calculate the required basal area for zero storage
- If the basal area is reduced, the depth of effluent stored in the bed will increase
- By adjusting the "Nominated area by User", the implications of reducing the basal area can be determined
- The depth of stored effluent must not exceed the bed depth (in this case, 400 mm) less any required freeboard (50 mm)

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References

- Patterson RA, (2006). Evapotranspiration Bed Designs for Inland Areas. Septic Safe Technical Sheet Reference 05/15. NSW Department of Local Government, July 2006

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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: HOBART AIRPORT WEST					Site number: 094008							
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Decile 5 (median) rainfall (mm)	32.2	27.2	29.3	28.5	30.5	27.9	31.2	42.1	34.4	39	40.3	43.4
Mean daily evaporation (mm)	6.3	5.5	4.2	2.9	1.9	1.3	1.4	2	3.1	4.1	4.9	6
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).

Model Parameter	Units	Symbol	Source	Value													KEY	
																	User input	Calculated value
Design Wastewater Load	L/day	Q	Wastewater generation		Notes 1. Patterson (2006)													
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	$(Q'D) \div EAA_N$															
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															