

Towards a Zero Discharge Dry Toilet: Evaporation of Source-Separated Urine

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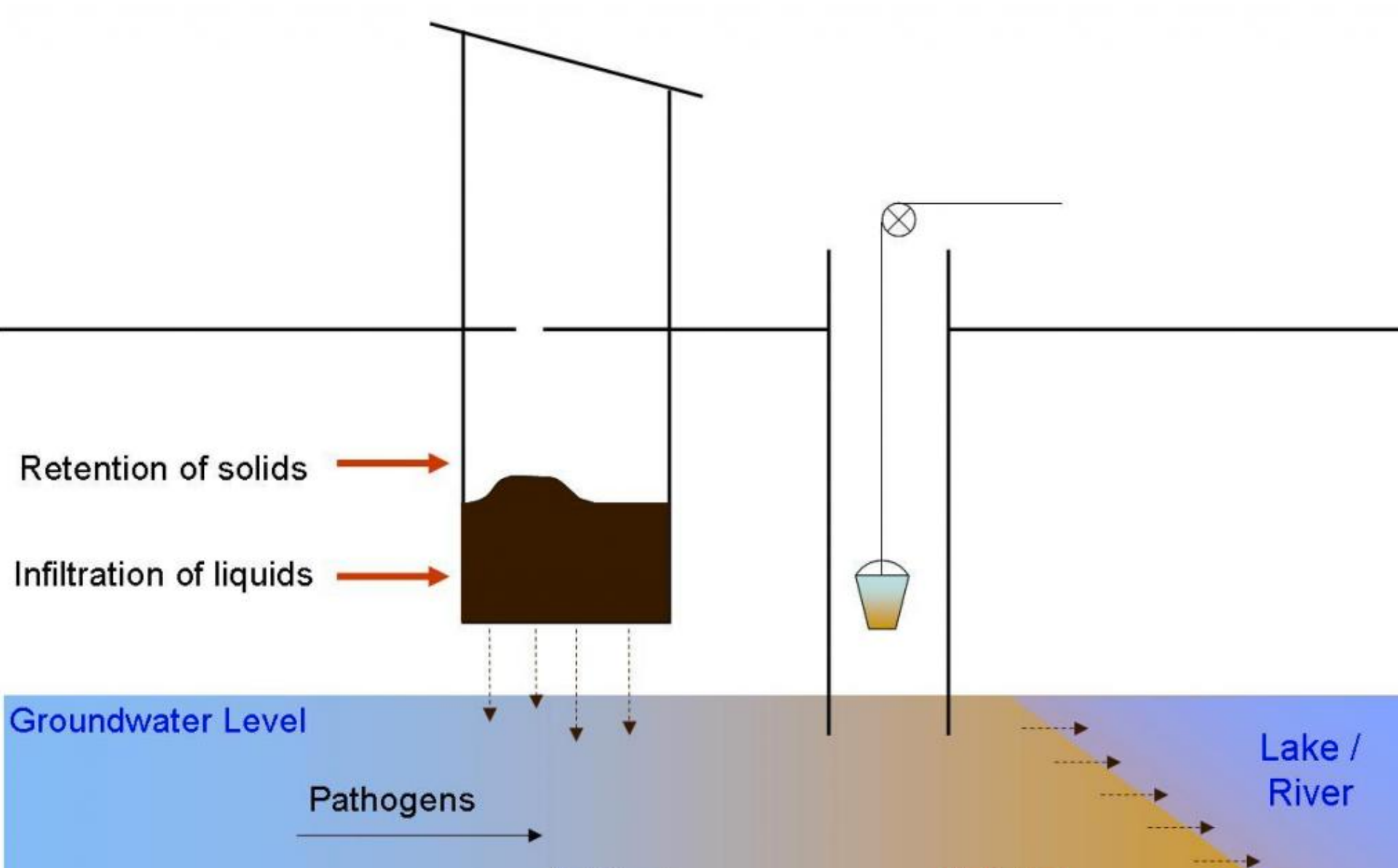
Rural Nicaragua

Latrine

Subsurface
flow



Credit: David Bethune 2010





Why Separate Urine from Faeces?

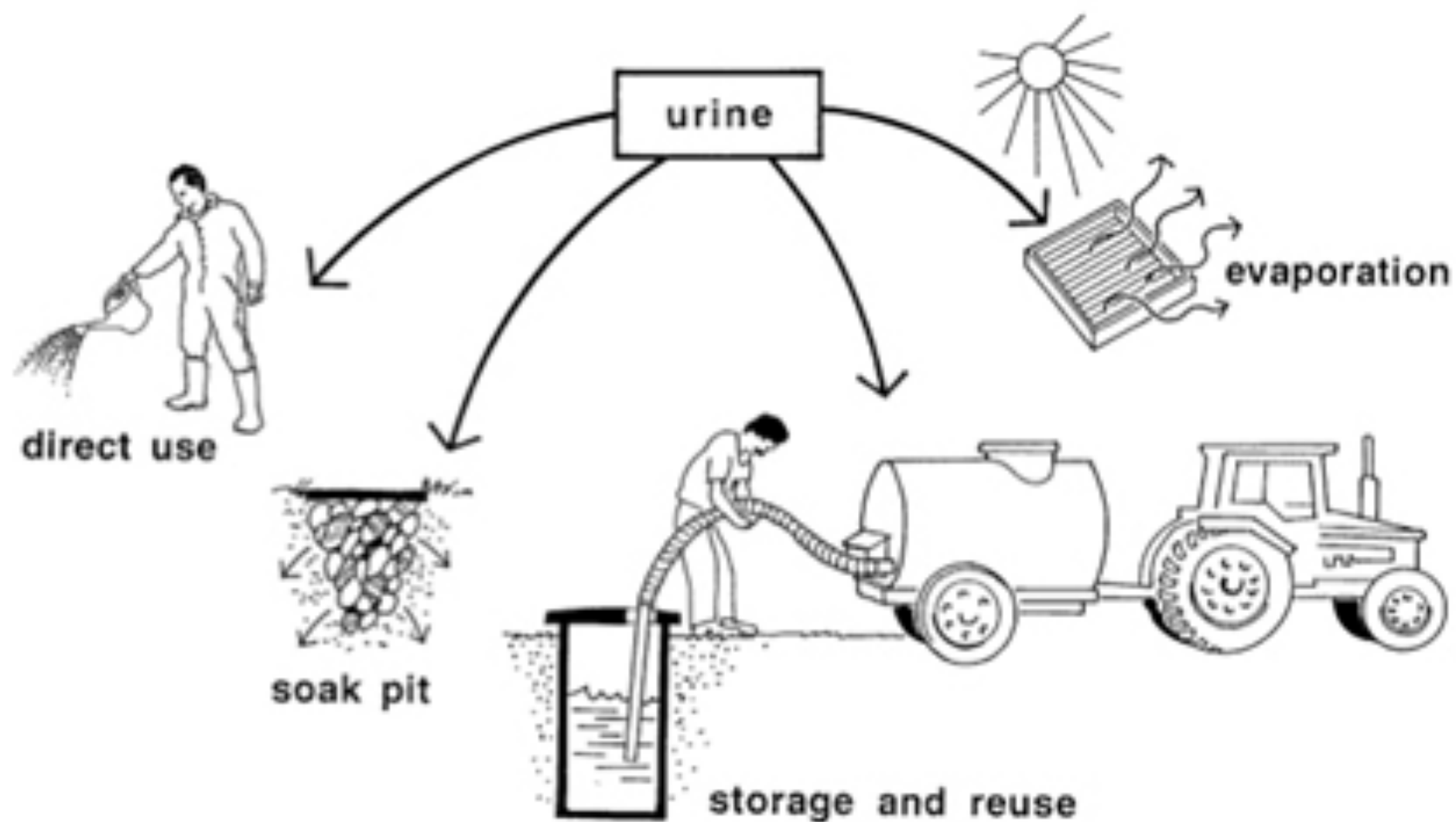


1. Urine contains majority of nutrients in human waste
N: 80%
P and K: 60%
2. When separate, urine and faeces can be kept pathogen free, more easily stabilized, treated and *re-used*.



3-5% organic and inorganic solutes

95-97% water





URINE
1750ml

954g



URINE
750ml

406g



GROWTH
3-25 Nov



URINE
ZERO

63g

Modern No-Mix or Urine Diversion Toilet





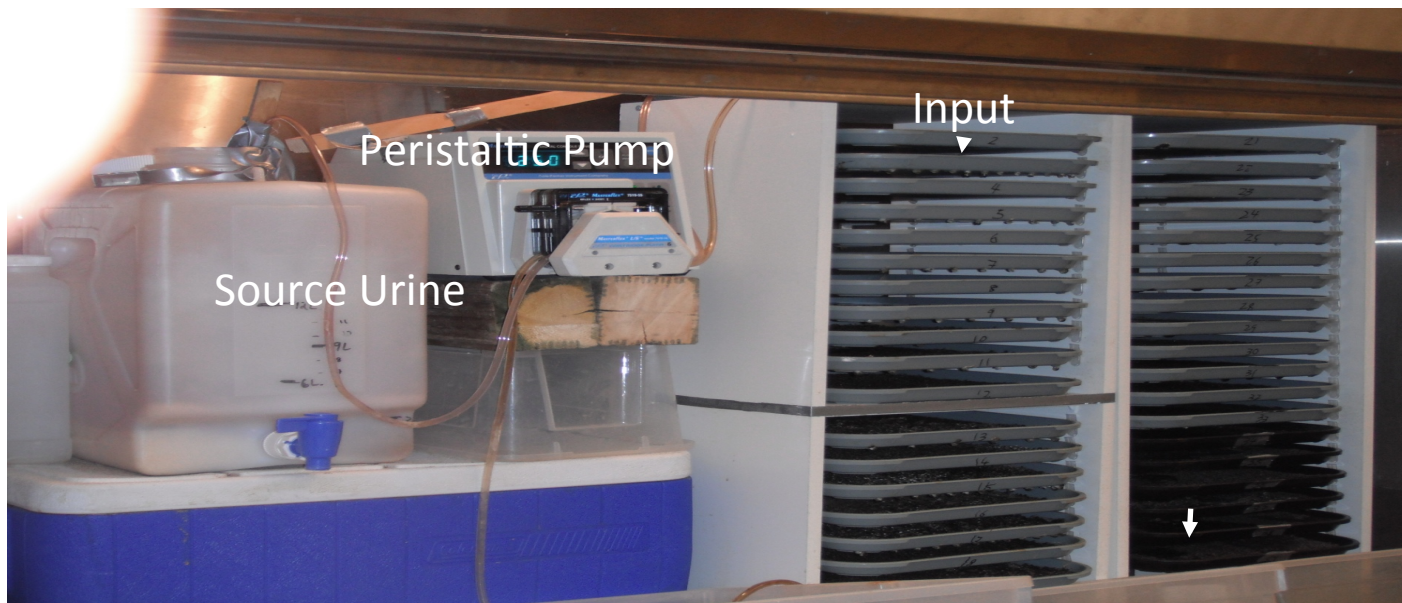
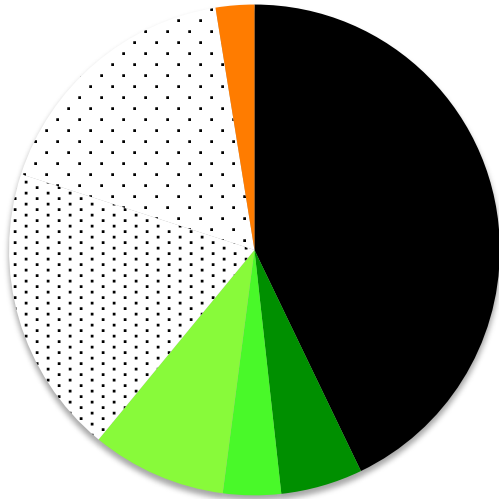


Figure 1b

Fresh



■ Urea

■ NH4+ + NH3

■ PO4

■ K

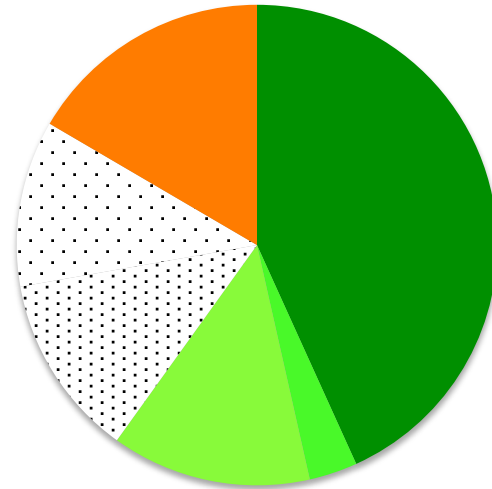
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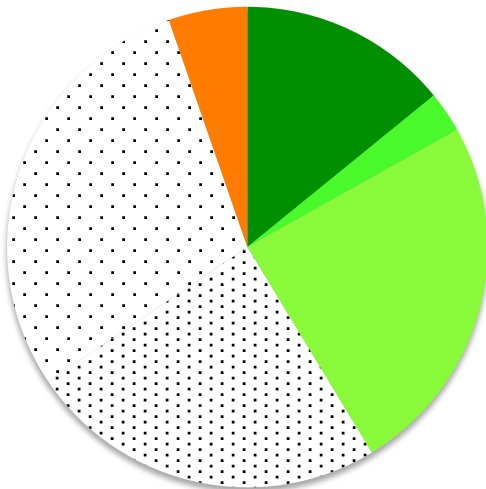
■ SO4

Hydrolysis

Stored



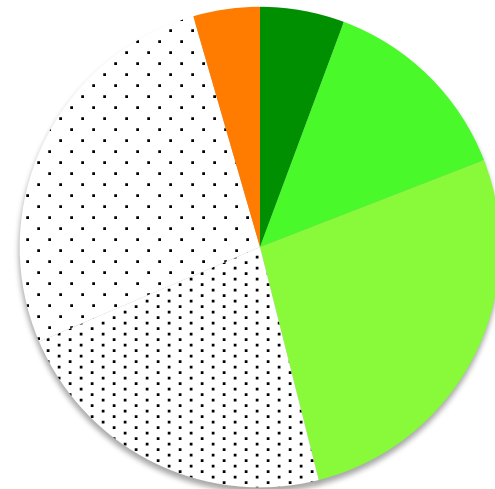
Residual Brine



Evaporation

Evaporation

Residual Solid



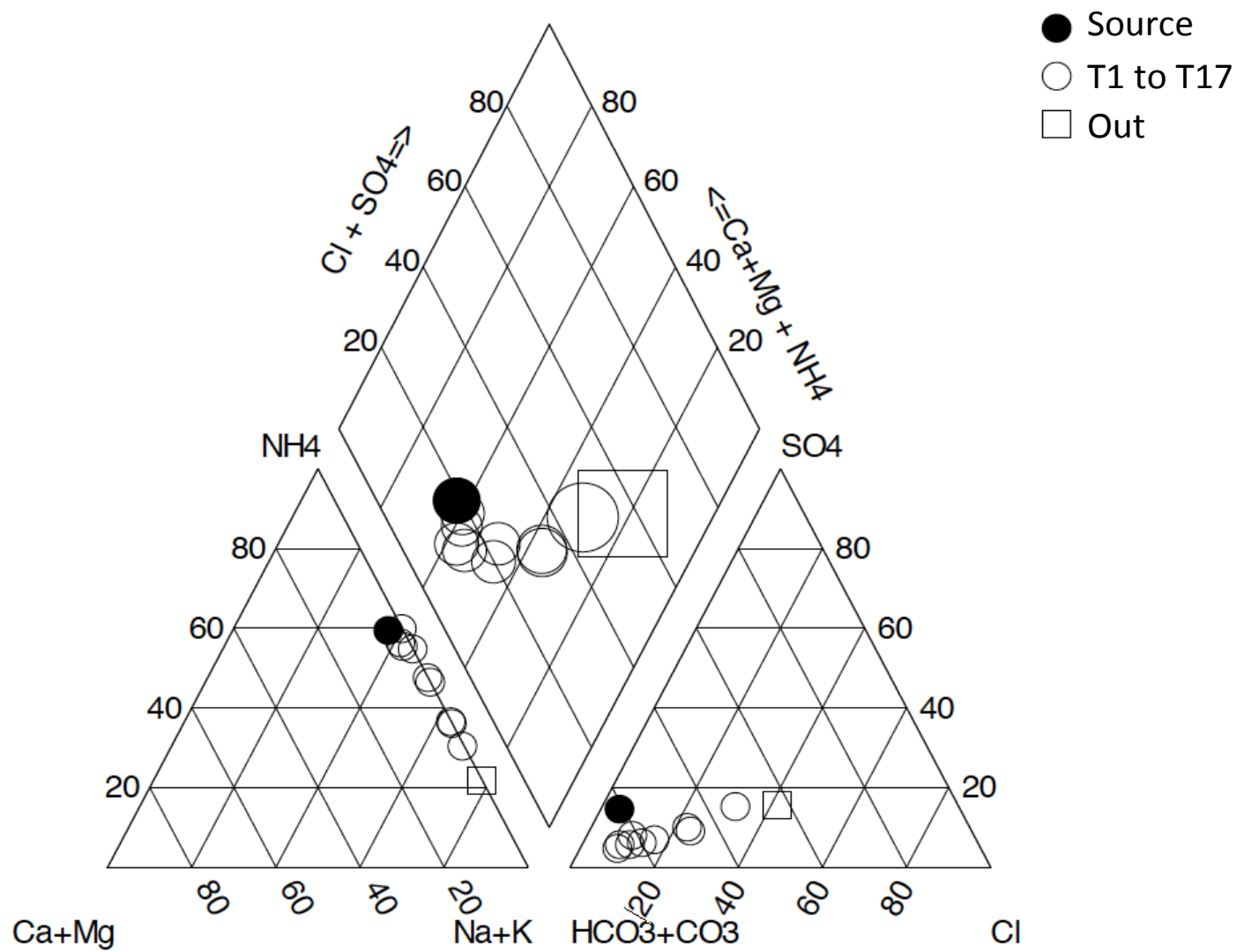
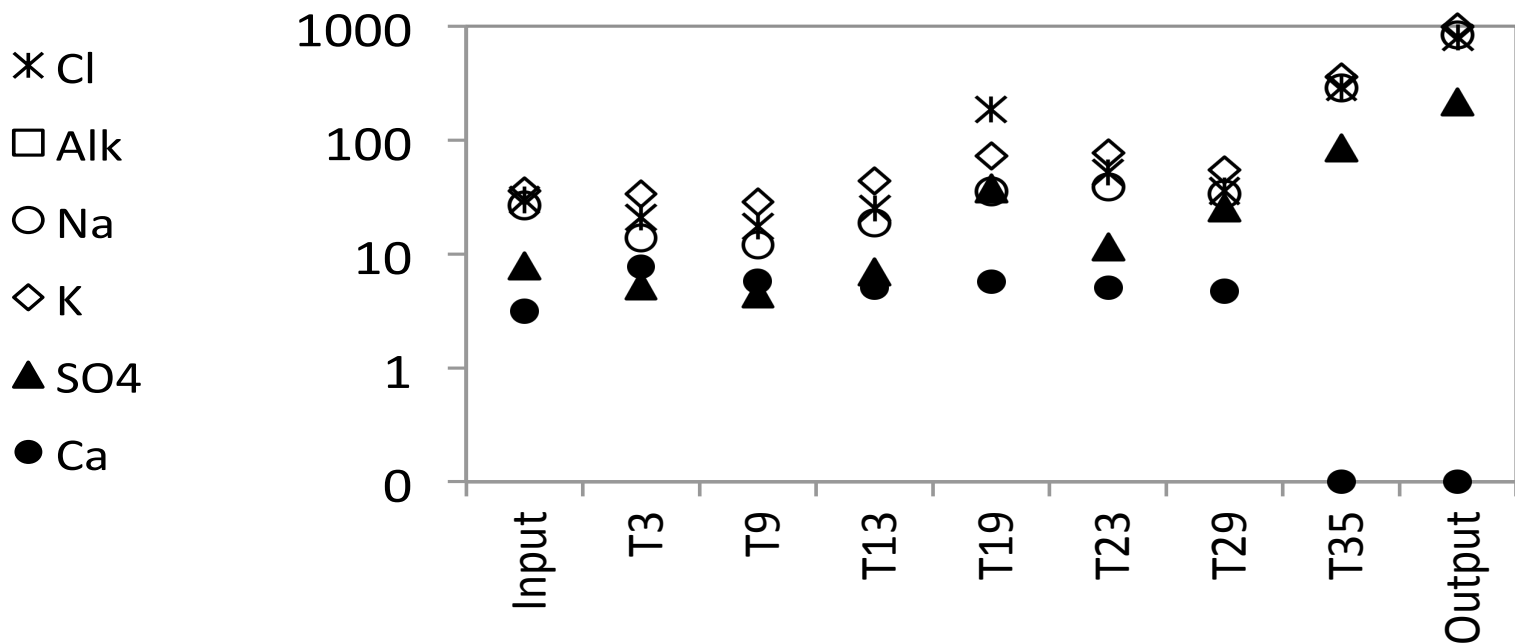
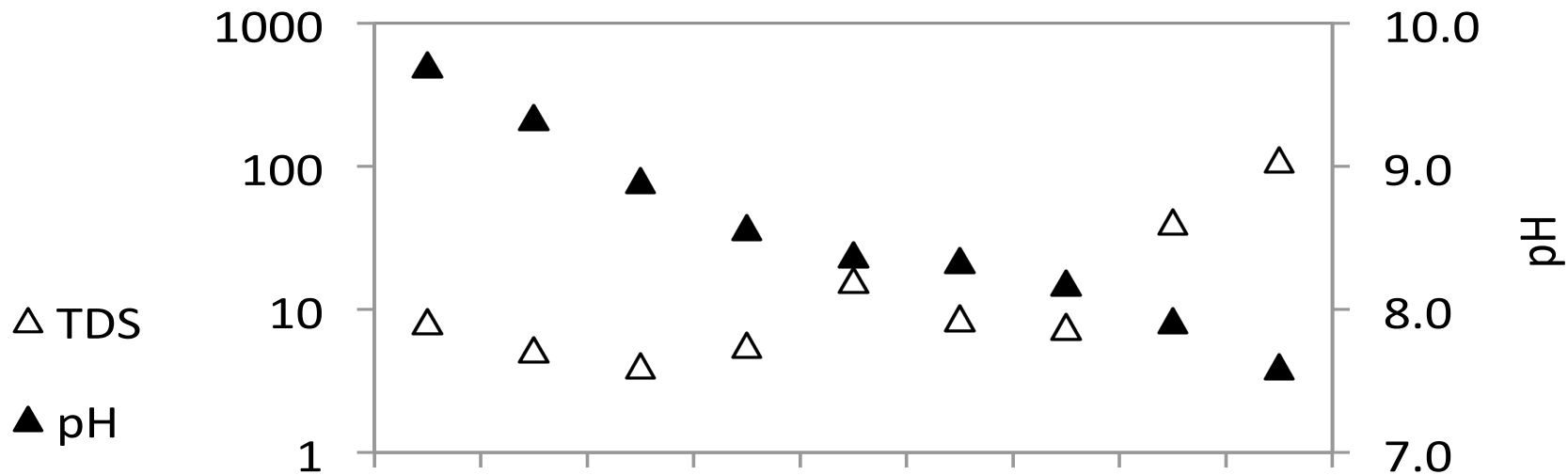
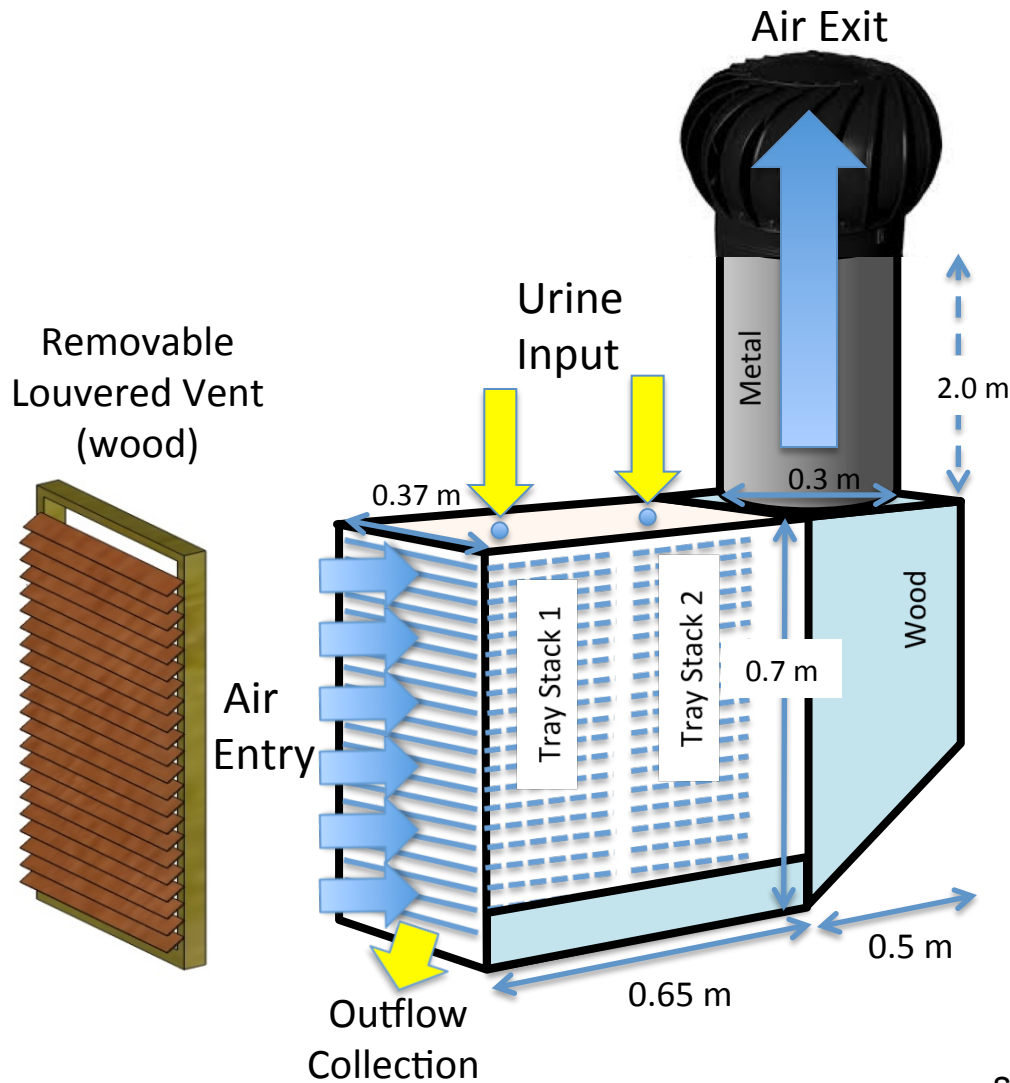


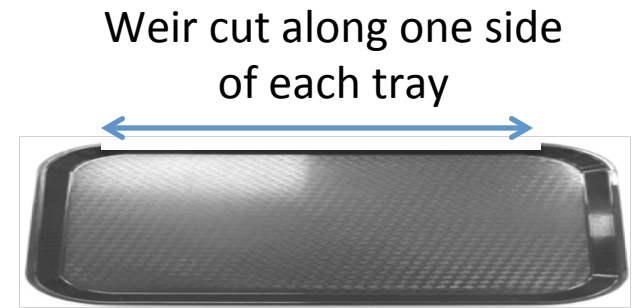
Figure 3

Day 81 (782 L applied)

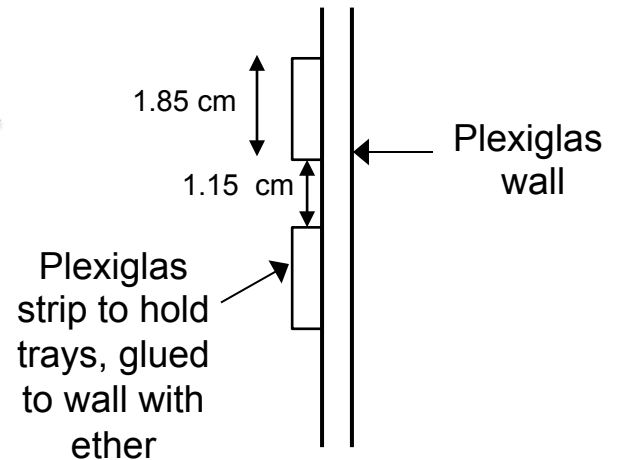




Not to scale

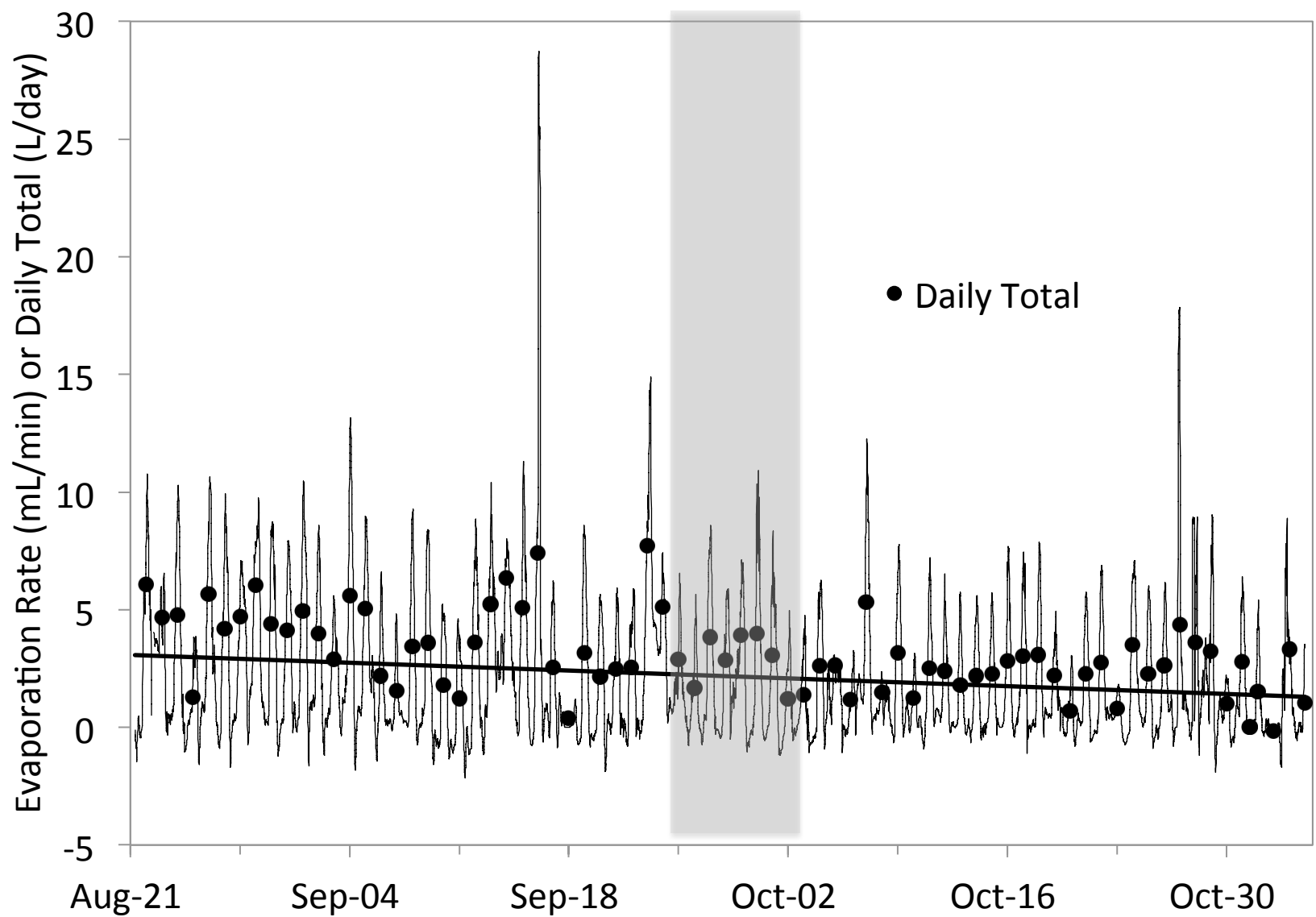


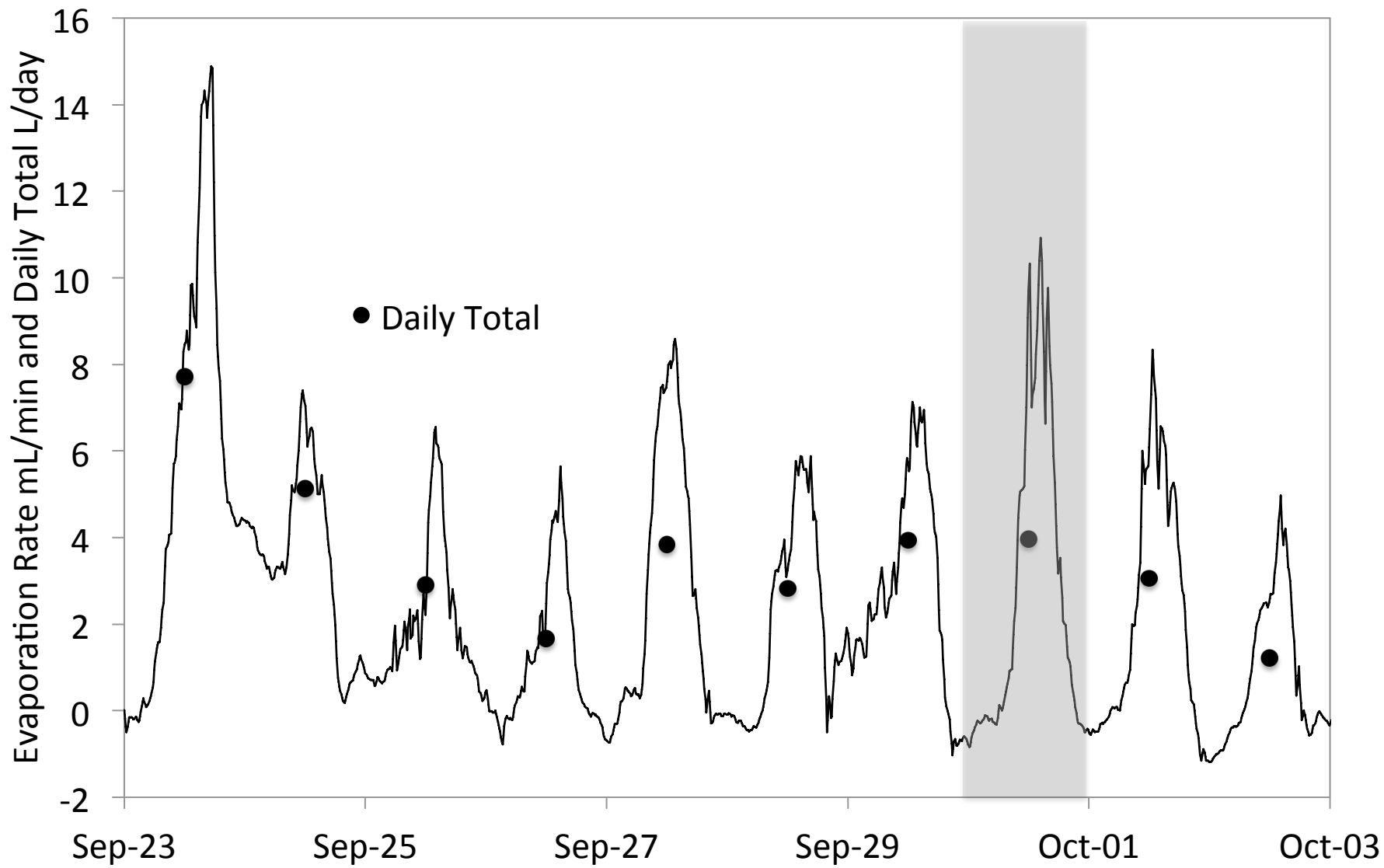
Tray Close-up

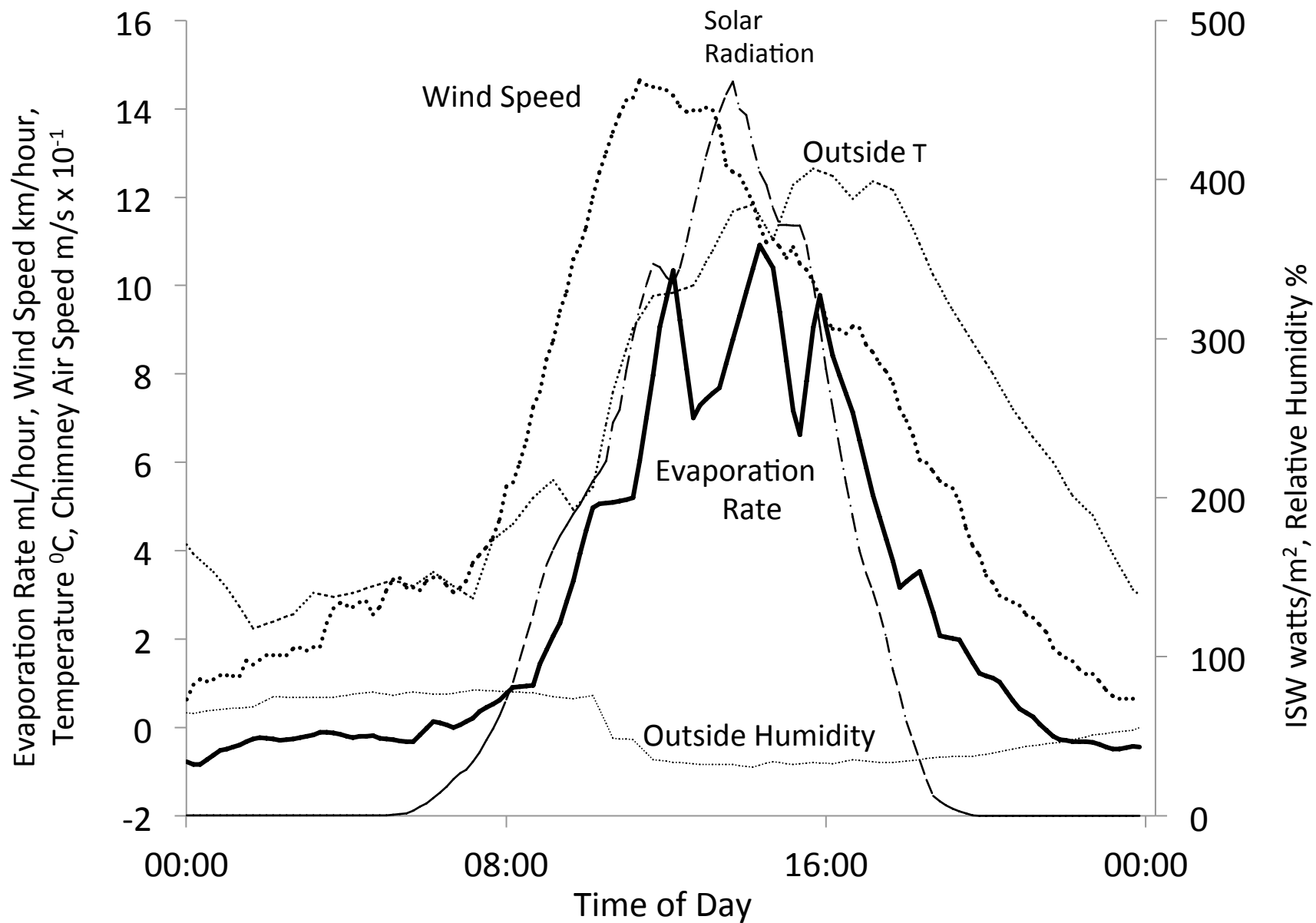


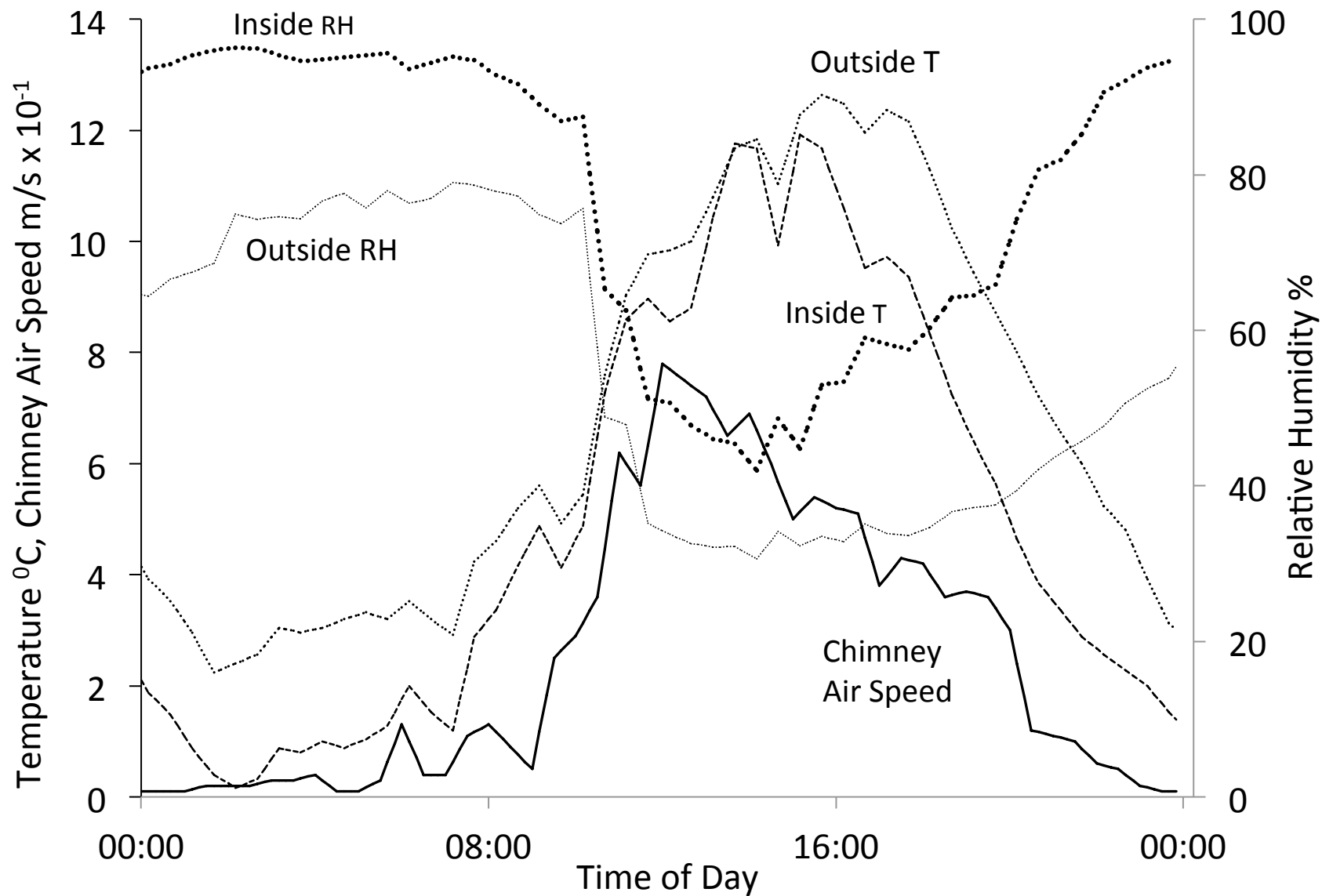
Plexiglas cross-sectional view











$$Evap = 0.03 T_{OUT} + 0.38 Wind + 0.01 Solar Rad - 0.79$$

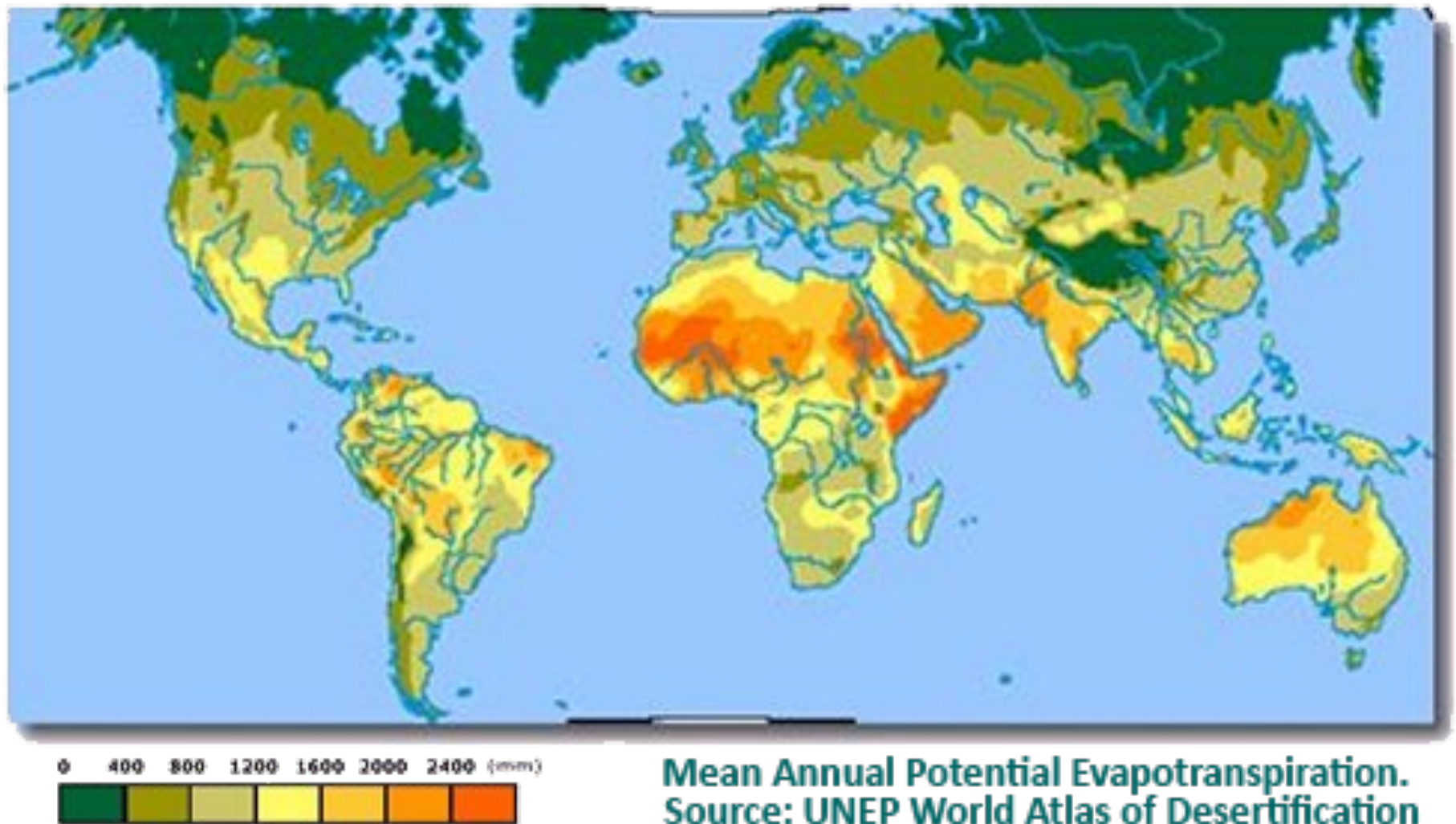
(L/day)

Date	Weather Conditions	UEU Evaporation	Correlation (R ² %)			
		L/day	All	Temp	Wind Speed	Solar Radiation
Aug-21 to Nov-5	n/a	3.2*	63	22	20	27
Sept-18 day	cloudy	0.4	58	25	32	9
Sept-30 day	sun and cloud	4	92	64	67	81

* mean daily evaporation rate over entire study period

~1100 L evaporation predicted for Apr-Oct in Calgary

Global Evaporation



Conclusions

- 3.2 L/day mean evaporation rate (max 8.8 L/day)
- Evaporation rate correlated to Solar Radiation, Air Temperature and Wind Speed
- 1100 L total evaporation predicted (Apr-Oct)
- Nutrients easily harvested, but >80% N losses

Thank-you



NSERC
CRSNG



Parks
Canada

Parcs
Canada



Alpine Club of Canada



UNIVERSITY OF
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BEES

Backcountry Energy Environmental Solutions

