Challenges in Monitoring ET Covers

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Outline

- Monitoring Needs and Requirements
- Indirect Drainage Measurements
- Direct Drainage Measurements
- Summary

Monitoring Requirements

- Surface Inspections
  - erosion
  - subsidence
  - isolation, biotic intrusion, and plant cover
- Ground Water
  - up-gradient wells (2) - water chemistry
  - down-gradient wells (3) – water chemistry
- Drainage
  - water intrusion control limits (1 to 3 mm/yr or less)

Drainage Criteria

Type	Permeability or K value (cm/s)	Drainage value (mm/yr)
RCRA-D (compacted soil)	1 E-05	3200
RCRA-C (compacted clay)	1 E-07	32
Hazardous (Colorado)	3.1 E-09	1.3
Radioactive (USDOE)	1.2 E-09	0.5

Drainage Monitoring

- What tools are available today that can be used to monitor drainage or estimate rates in the range from less than 0.5 mm/yr to 50 mm/yr or more with accuracy or precision of 10% or better?

All Models of Water Balance

Water Balance Equation:

$$D = P - ET - RO \pm \Delta S$$

D = Drainage/Net Infiltration/ Recharge
P = Precipitation
ET = Evapotranspiration
RO = Runoff
ΔS = Water Storage Change

Approach to Water Budgeting

- Drainage is Estimated from Mass Balance of Water Inputs/Losses from Soil Volume
- Model Inputs (with associated uncertainties) Include:
  - **Precipitation**
  - **Evaporative Demand (Climate and Surface)**
  - **Runoff Potential (Surface Characteristics)**
  - **Water Storage (Soil Hydraulic Properties**)

Simplified Models of Water Balance

Typical Water Balance (mm/yr)

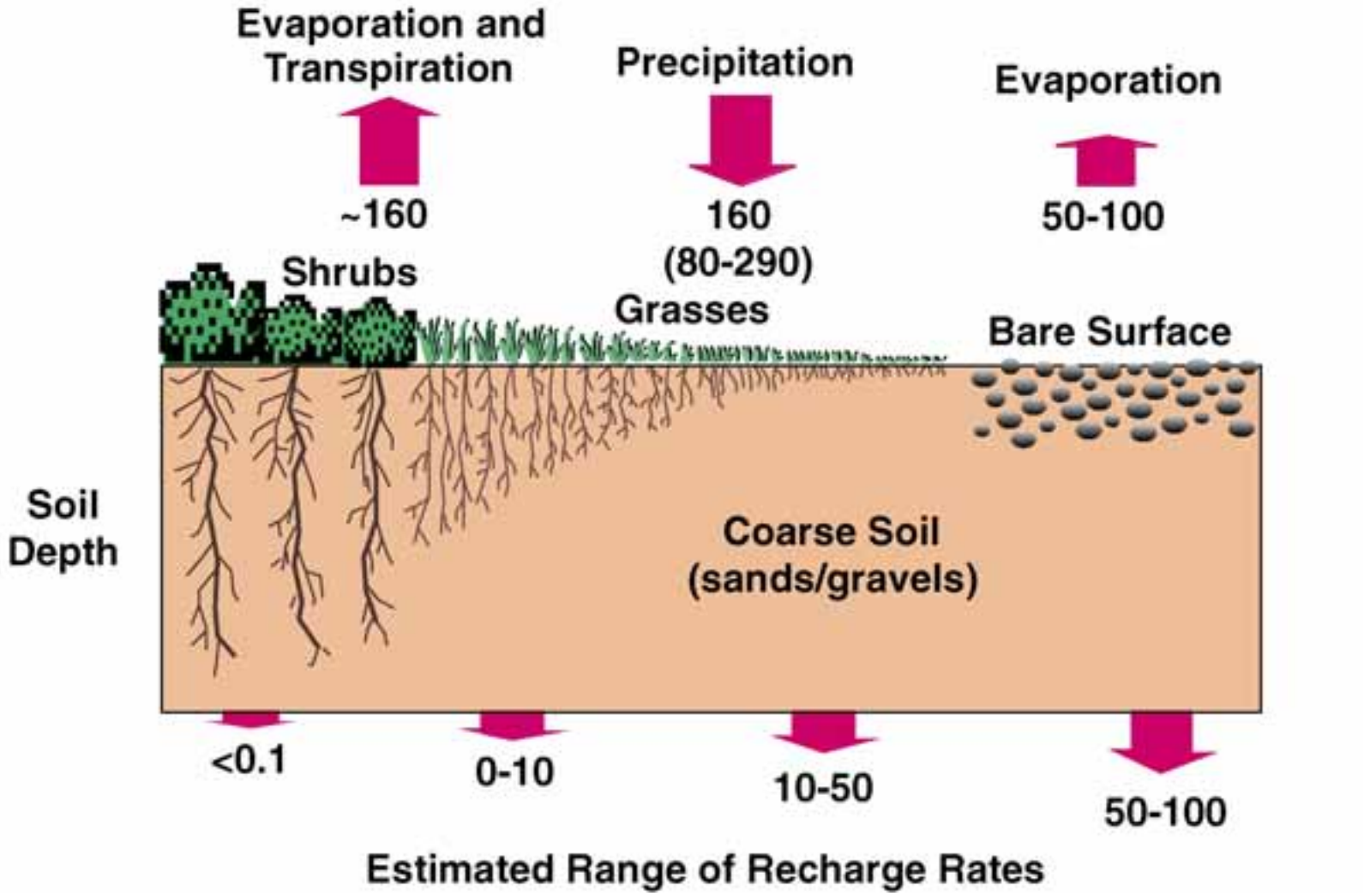
	P	ET	RO	D
Humid Site	1000	500	100	400
Arid Site	150	40-150	0	0-110*

*High values associated with bare,coarse soils

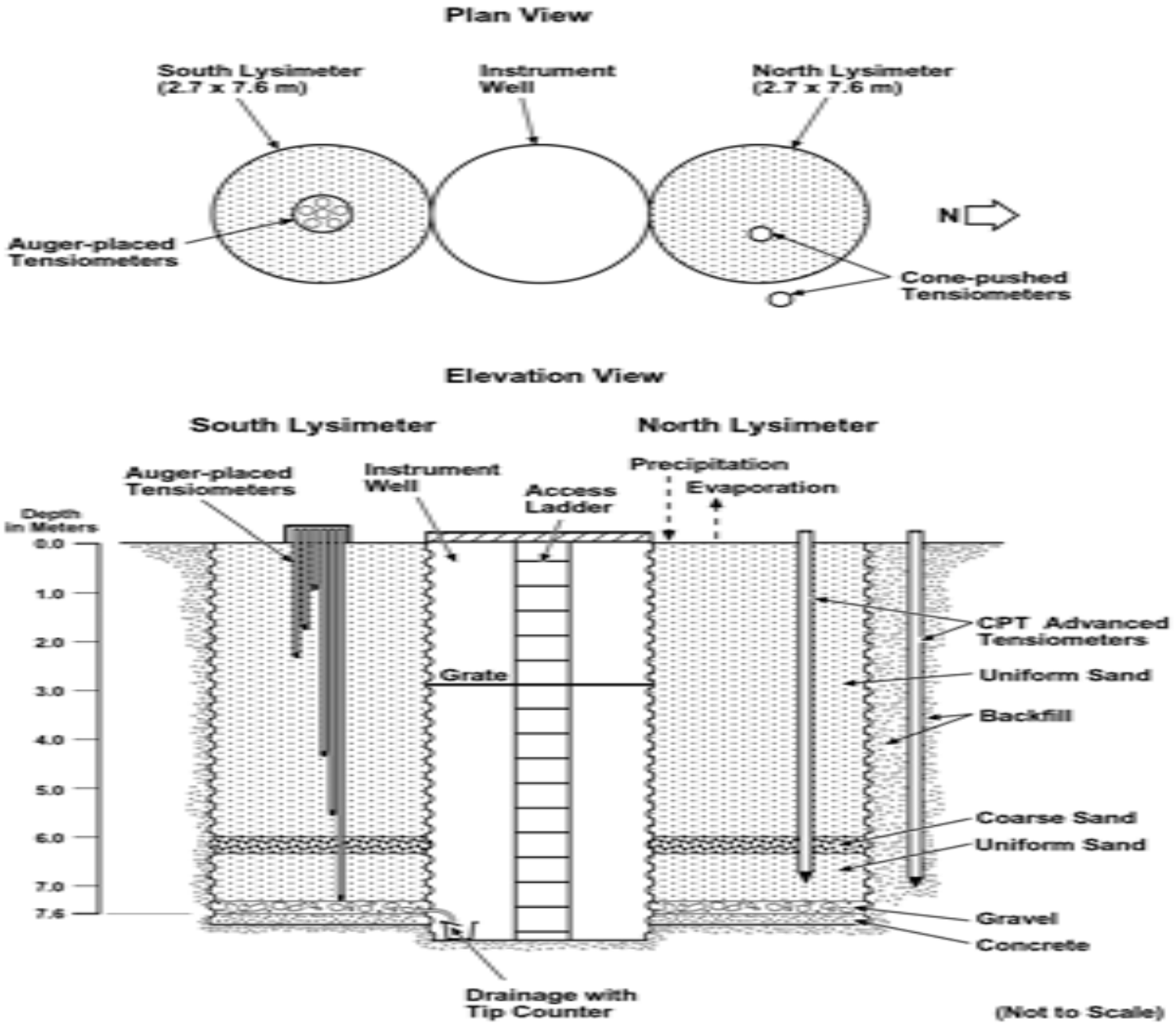
Drainage Uncertainties-Dry Site

	Method/Uncertainty	
	Micromet	Lysimeter
P [150]	10%	<10%
ET[148]	20%	<10%
RO [0]	--	--
D [2]	2000%	<10%

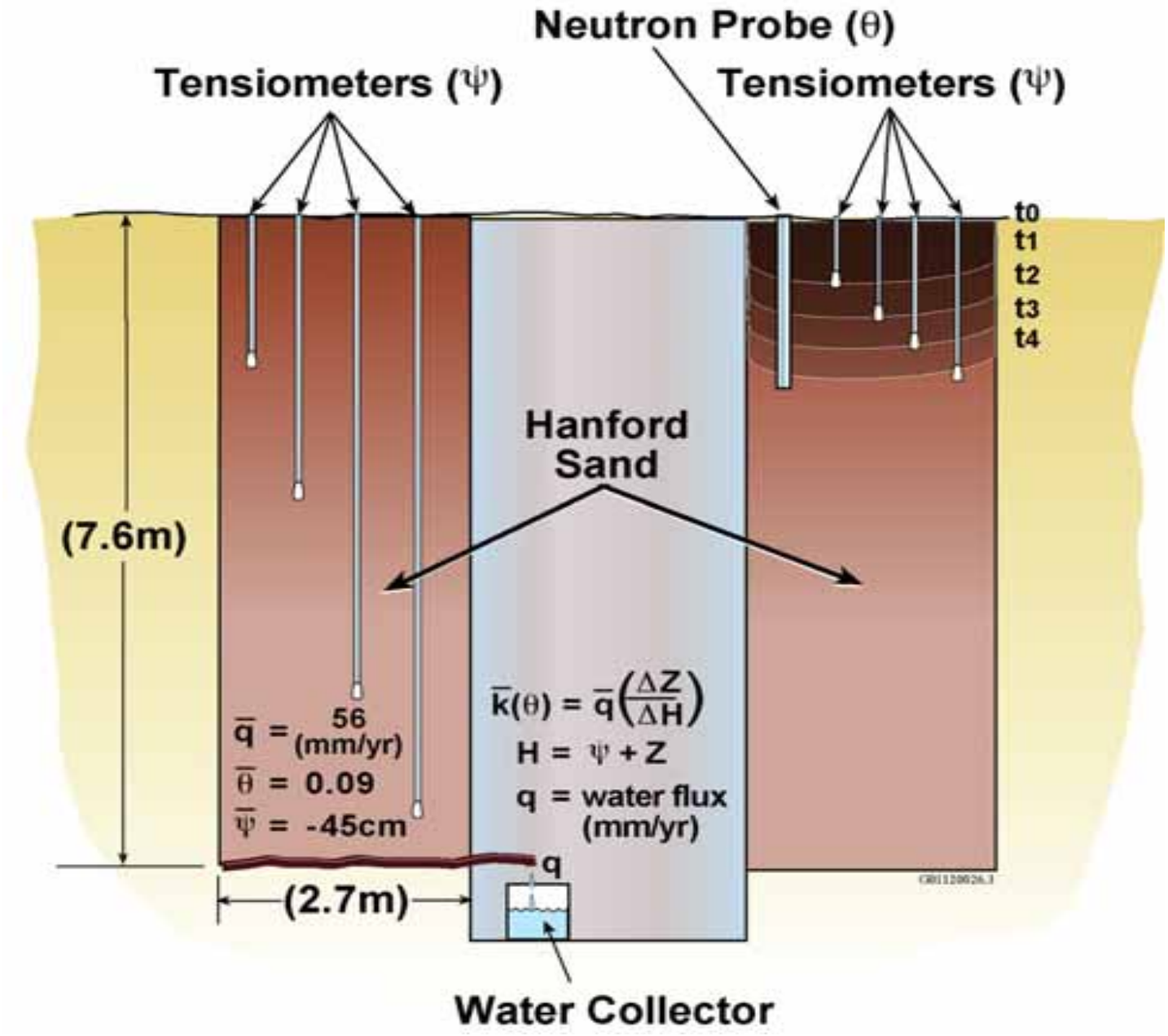
Hanford Site Water Balance (mm/yr)



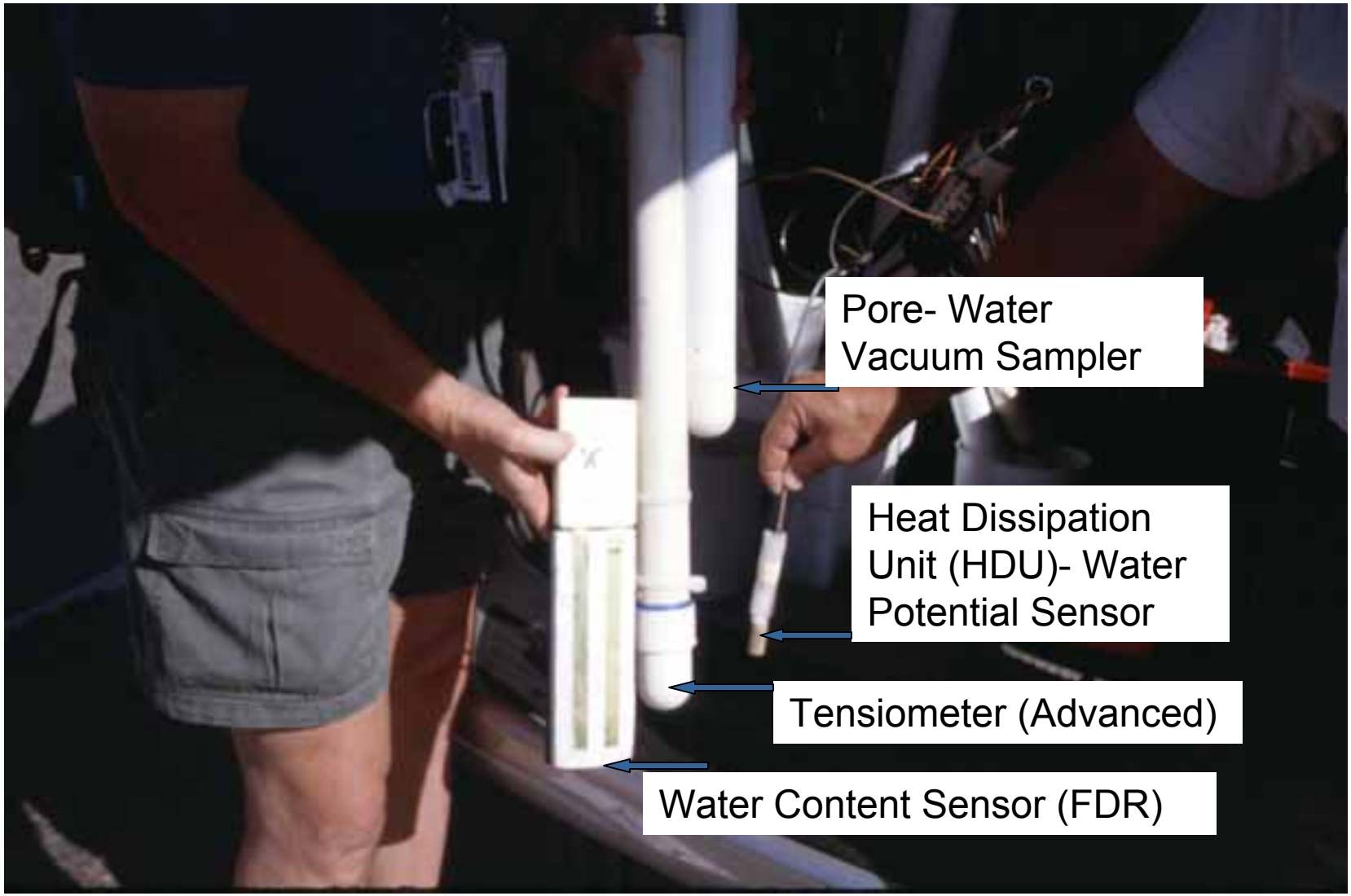
Lysimeter Test- Hanford Site, Washington



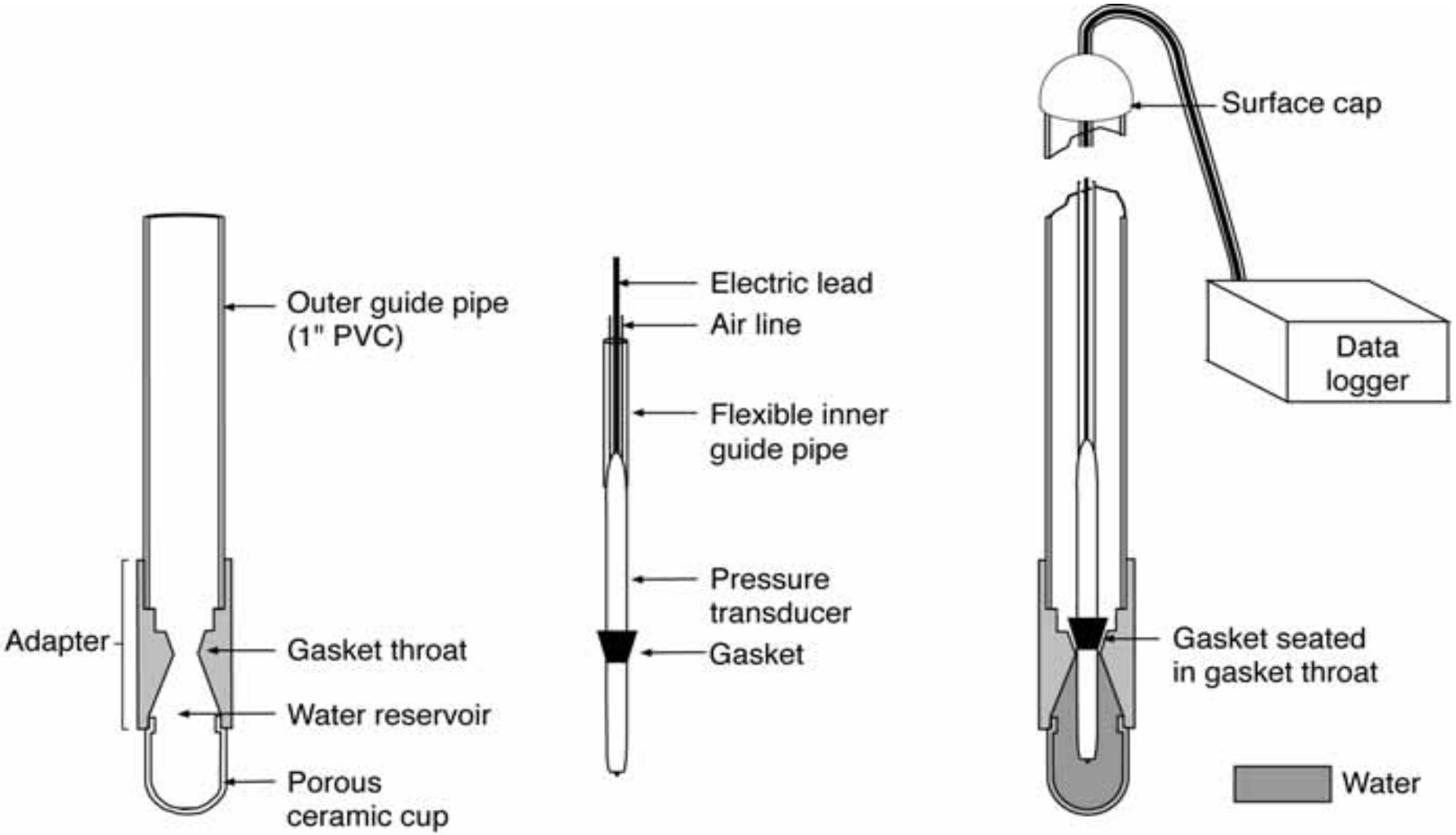
Hydraulic-Property Field Test



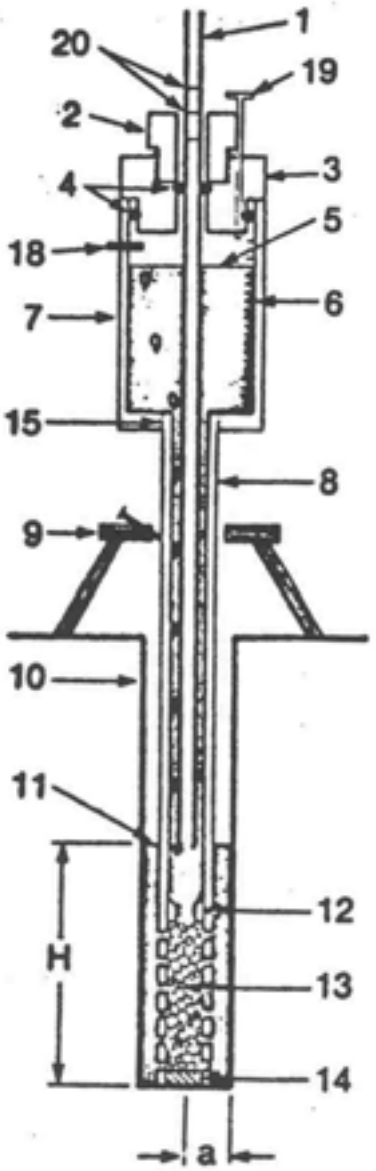
Soil Water Monitoring



Advanced Tensiometer –INEEL Design



Field-Guelph Permeameter

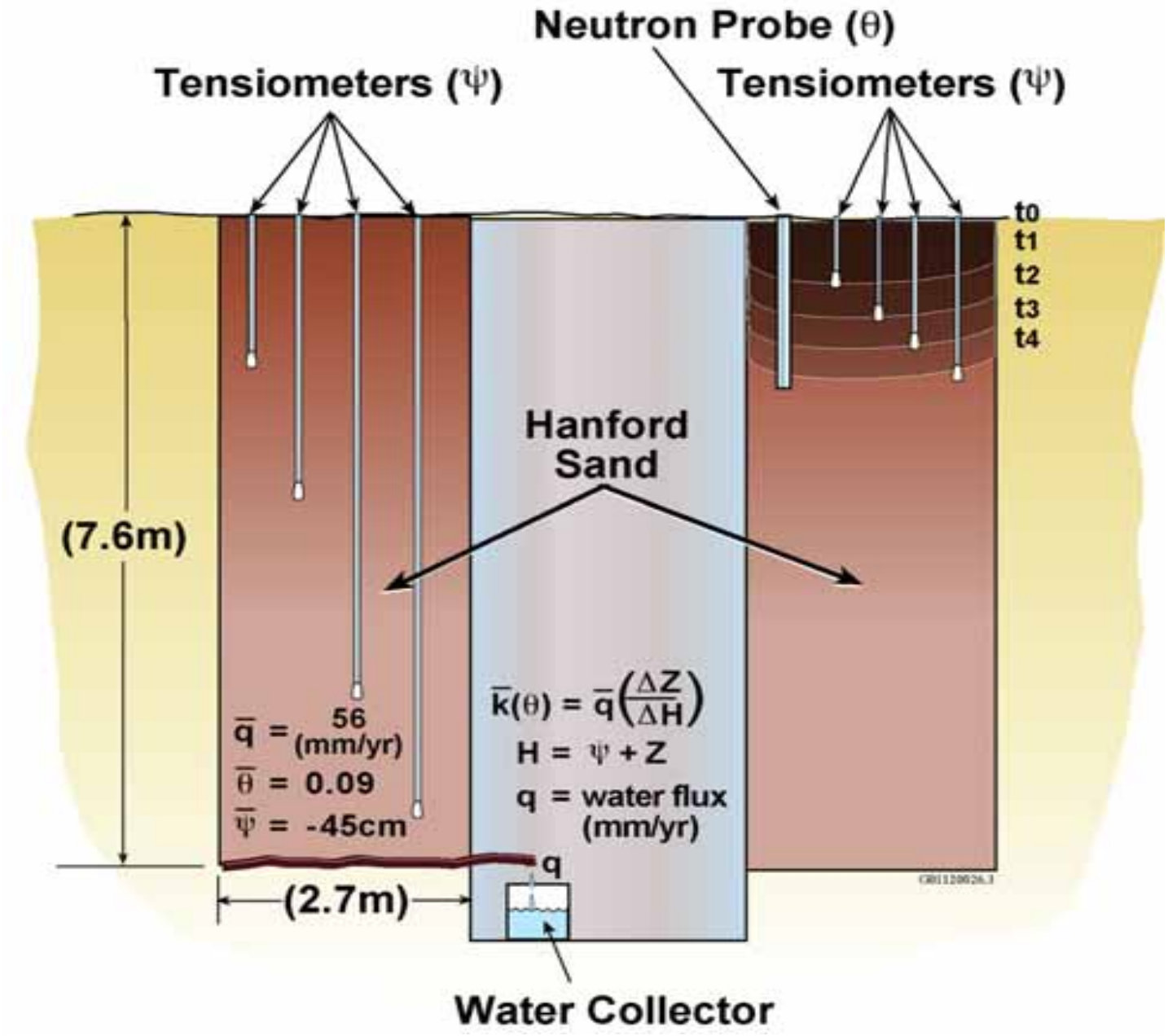


1. air-inlet tube (threaded at base)
2. threaded collar
3. removable cap
4. sliding air-tight seals
5. liquid surface in reservoir
6. measuring scale
7. reservoir tube
8. outlet tube
9. tripod assembly
10. well
11. steady liquid level in well
12. outlet port (threaded)
13. permeameter tip
14. rubber stopper
15. threaded coupling
18. pressure transducer (optional)
19. release valve
20. calibration lines

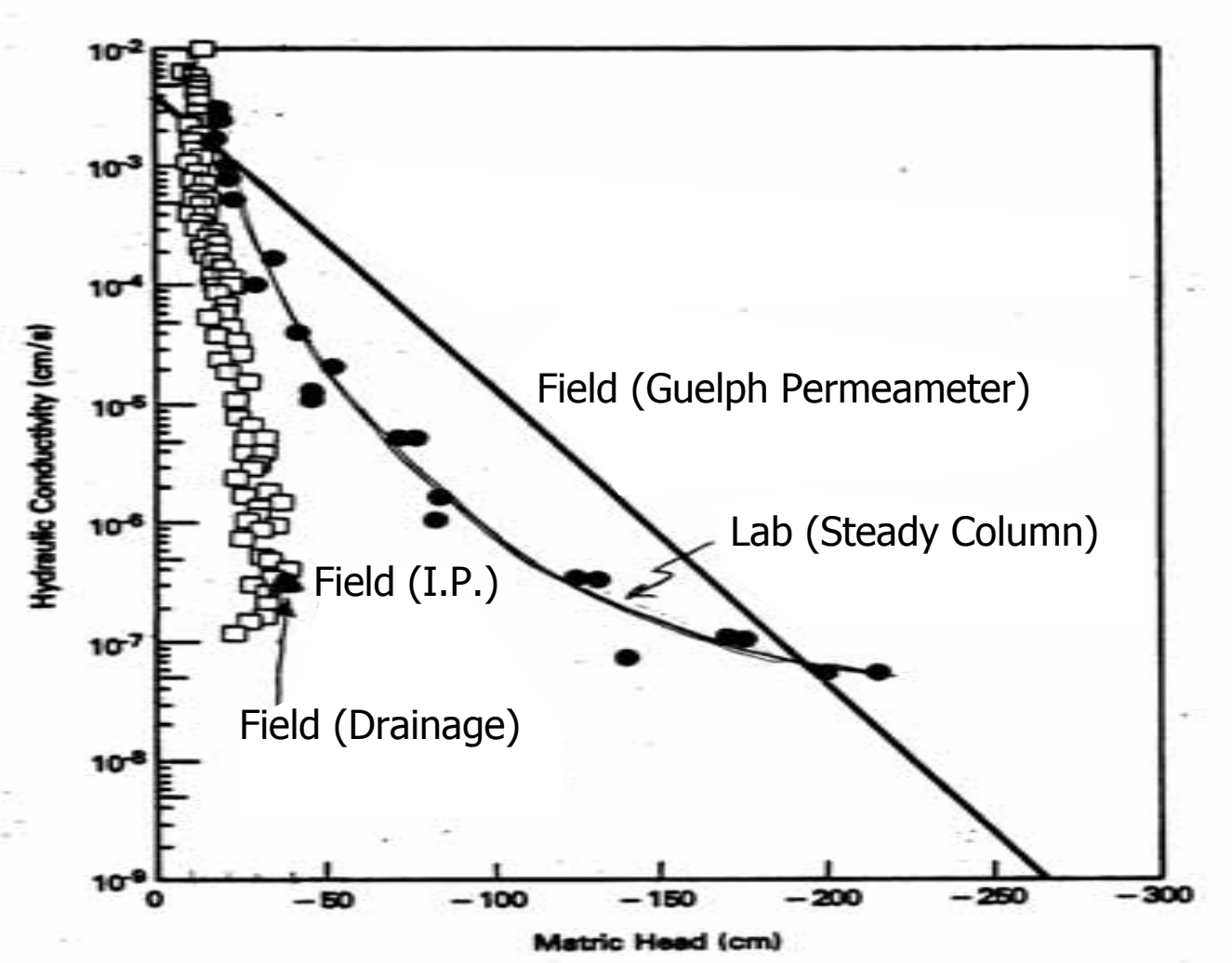
Drainage Monitoring

- Drainage Flux Estimates
  - Assumes that drainage can be estimated from water content or water potential measurements and an estimate of the unsaturated hydraulic conductivity
    - Drainage Flux = $-K(\theta)\,[\Delta\psi/\Delta z]$
      - $K(\theta)$ = unsaturated hydraulic conductivity
      - $\Delta\psi/\Delta z$ = water potential gradient
      - $\psi = f(\theta)$ through the soil water retention characteristic
    - $K(\theta)$ typically uncertain by more than an order of magnitude
    - Water content can be used to estimate water potential
    - More uncertainties in monitoring water contents or potentials

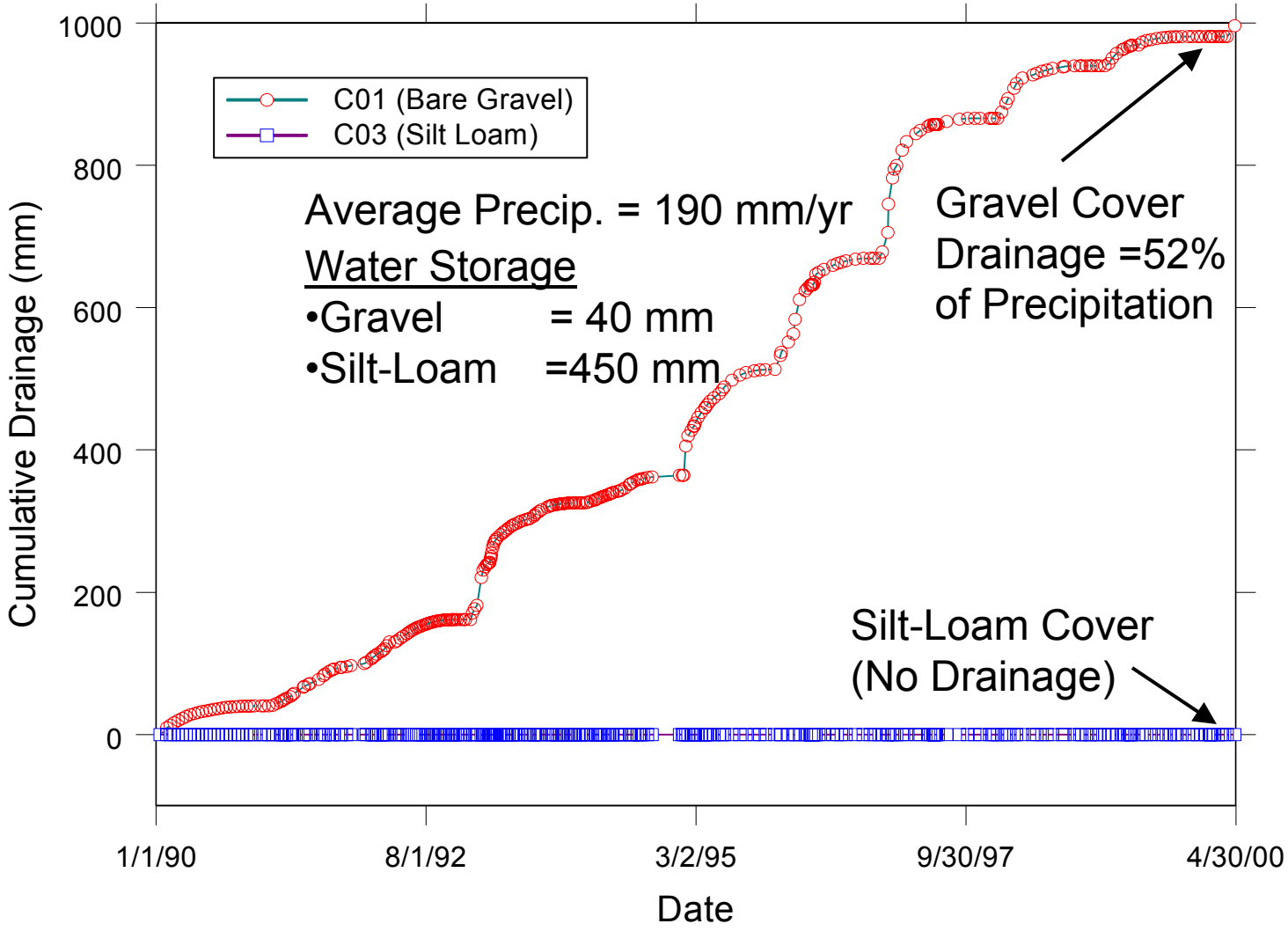
Hydraulic-Property Field Test



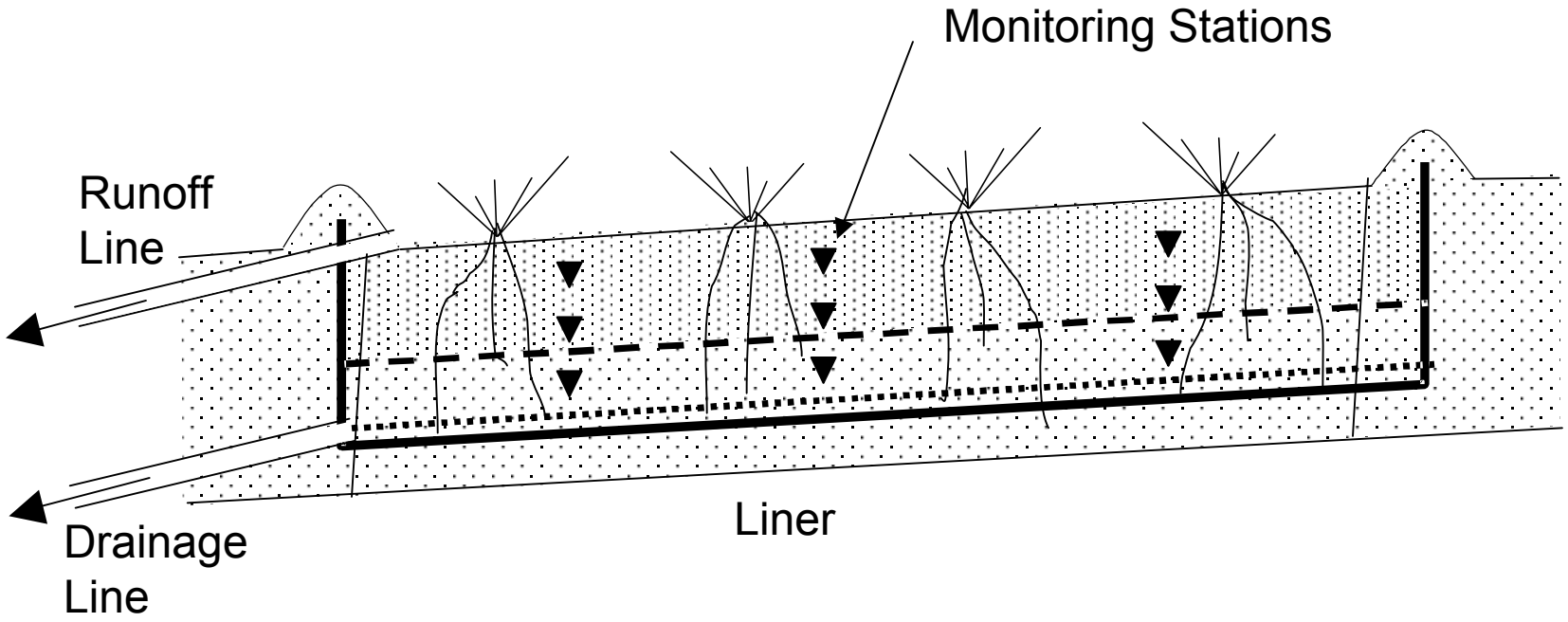
300 N Area - VZ Hydraulics



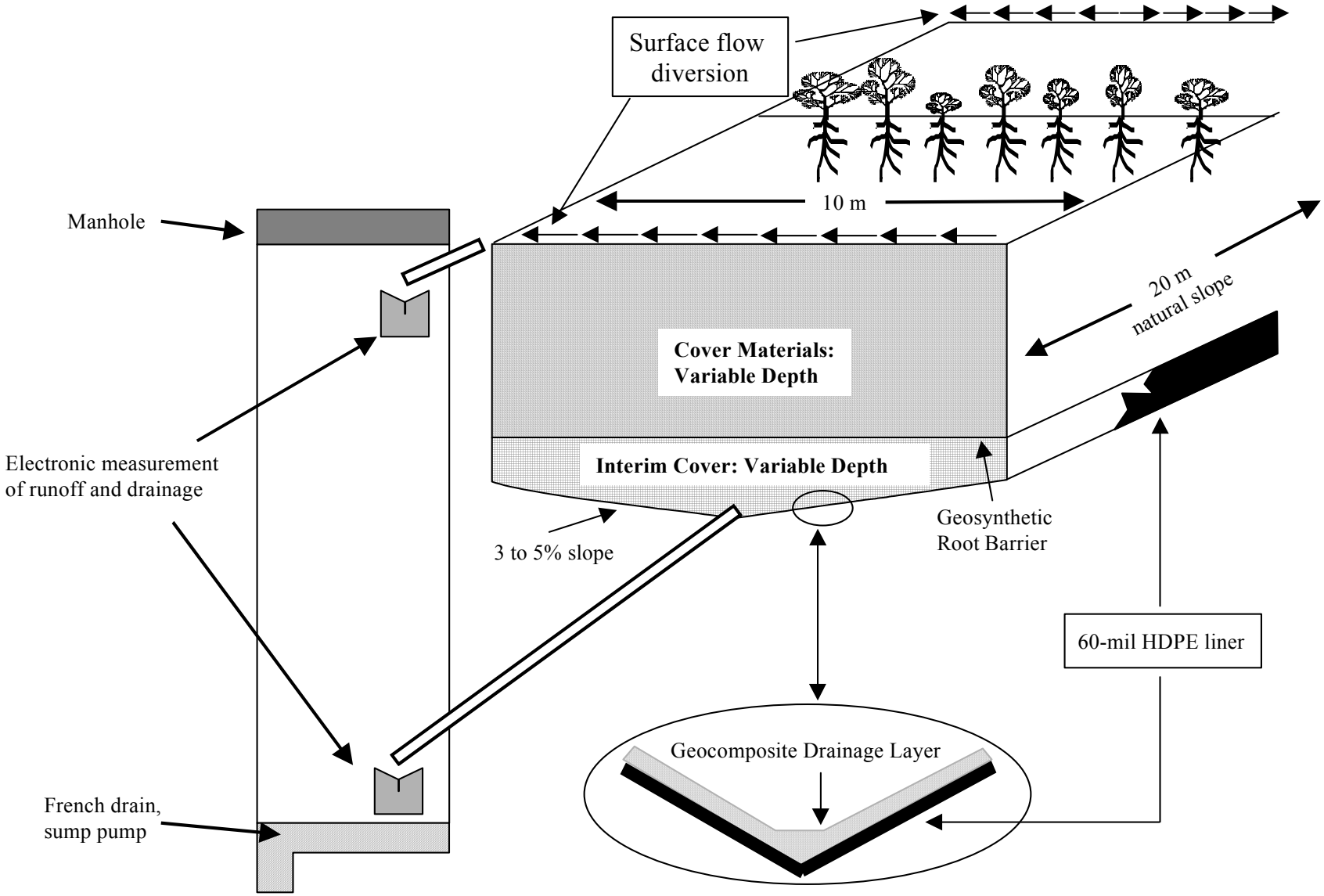
Dry-Climate Lysimeter Drainage



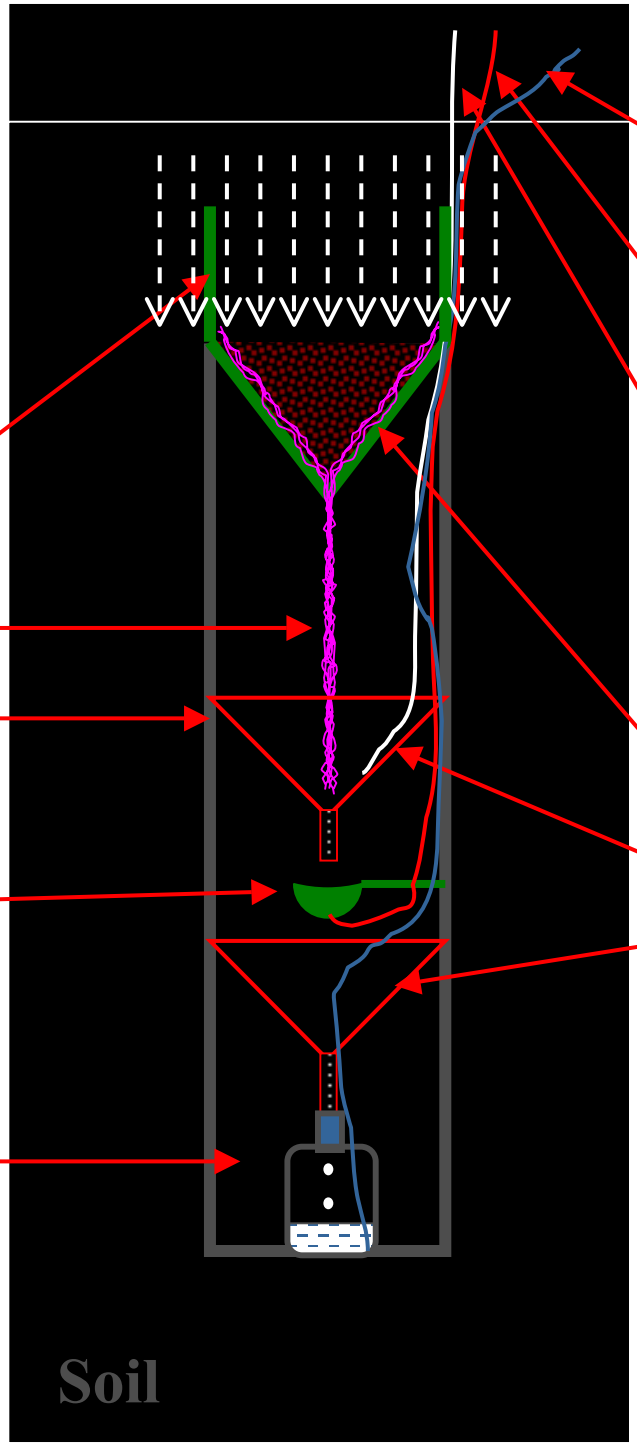
Lysimeter Test Pad –ACAP Sites



ACAP Drainage Collection



Water Flux Meter



Sampling Line

Wire to Data Logger

Calibration Tube

Divergence Barrier

Glass Fiber Wick

PVC Pipe

Tipping Bucket

Funnels

Drainage Collector

Water-Flux Meter

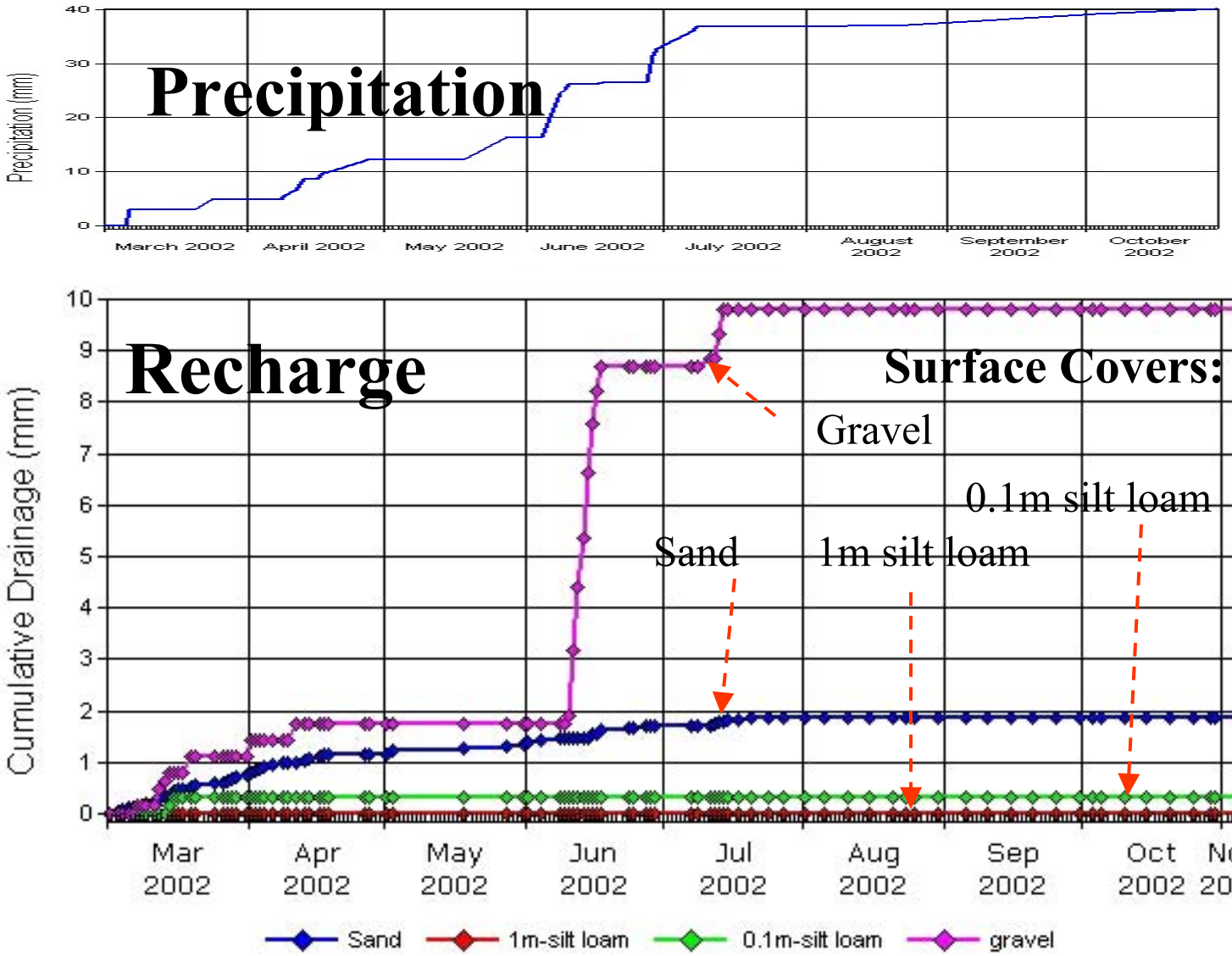
Divergence Barrier

Tipping Bucket

Installation of Funnel into Water Fluxmeter

Water Fluxmeter in Side-slope

Fluxmeter Drainage at Hanford Site



Summary

- Monitoring of an ET Cover for Long-Term Performance will be a challenge
- Erosion Control – observable, repairable
- Biointrusion Control- likely repairable
- Water Intrusion – the greatest challenge – Control will be site and design specific

Summary Cont.

- Water intrusion (drainage) monitoring
  - Indirect methods are too imprecise:
    - Water content sensing (TDR, Nprobes, electrical)
    - Water potential sensing (tensiometers, HDUs)
    - Water balance modeling (HELP, UNSATH, EPIC)
    - Tracer tests (possibly with more research)
  - Direct methods are required:
    - Test pad lysimeters (recharge less than a few mm/yr)
    - Water fluxmeters (possible, spatial measurements?)