Managed Aquifer Recharge of Stormwater: A Harris County Pilot Study

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Project Team

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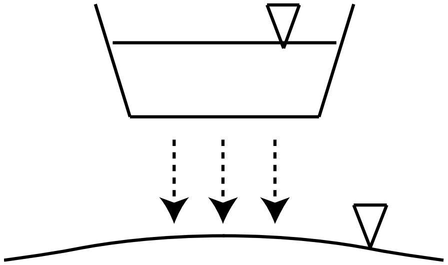
HARRIS COUNTY FLOOD CONTROL DISTRICT

HARRIS COUNTY PRECINCT 4
COMMISSIONER R. JACK CAGLE

Pilot site located in Tomball, Texas detention basin



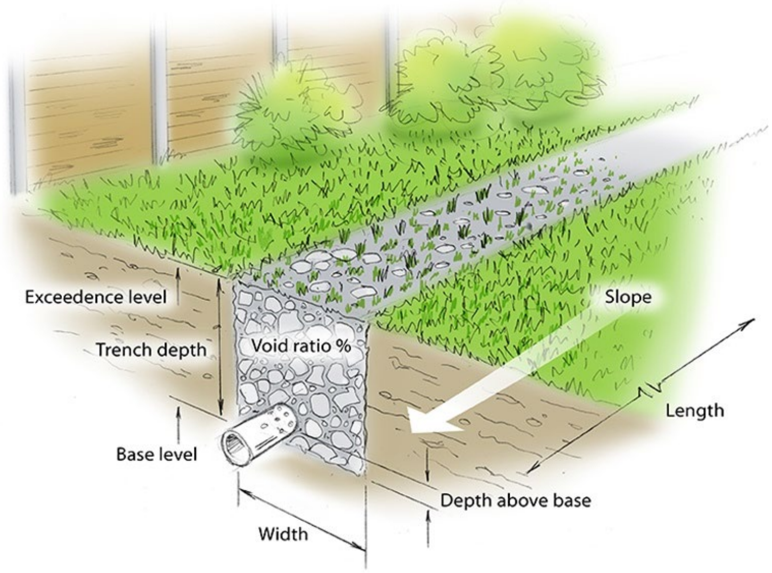
Infiltration

~~Stormwater~~

Basin

Tested three enhanced infiltration methods

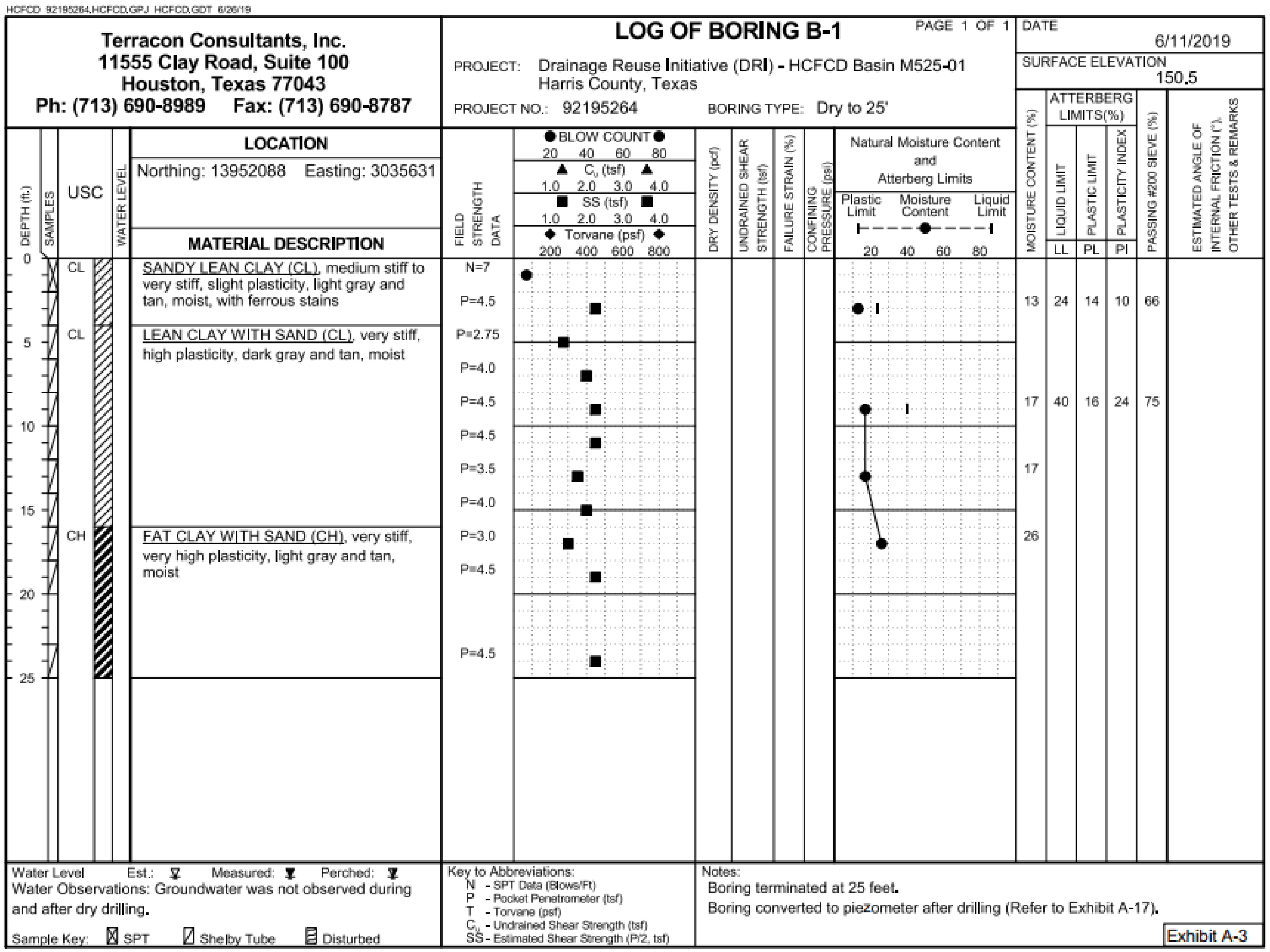
Infiltration Trenches



Proprietary System

Soil Amendments

Geotech investigations found sandy loam at surface, interbedded sands and clays at depth



HCFCD 92195264.HCFCD.GPJ HCFCD.GDT 6/26/19

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LOG OF BORING B-1

PAGE 1 OF 1

DATE 6/11/2019

SURFACE ELEVATION 150.5

PROJECT: Drainage Reuse Initiative (DRI) - HCFCD Basin M525-01
Harris County, Texas

PROJECT NO.: 92195264 BORING TYPE: Dry to 25'

LOCATION

Northing: 13952088 Easting: 3035631

USC	MATERIAL DESCRIPTION	FIELD STRENGTH DATA	MOISTURE CONTENT (%)	LIQUID LIMIT LL	PLASTIC LIMIT PL	PLASTICITY INDEX PI	PASSING #200 SIEVE (%)
CL	SANDY LEAN CLAY (CL), medium stiff to very stiff, slight plasticity, light gray and tan, moist, with ferrous stains	N=7					
		P=4.5	13	24	14	10	66
CL	LEAN CLAY WITH SAND (CL), very stiff, high plasticity, dark gray and tan, moist	P=2.75					
		P=4.0					
		P=4.5	17	40	16	24	75
		P=4.5					
		P=3.5	17				
		P=4.0					
CH	FAT CLAY WITH SAND (CH), very stiff, very high plasticity, light gray and tan, moist	P=3.0	26				
		P=4.5					
		P=4.5					

Water Level Est.: Measured: Perched:
Water Observations: Groundwater was not observed during and after dry drilling.

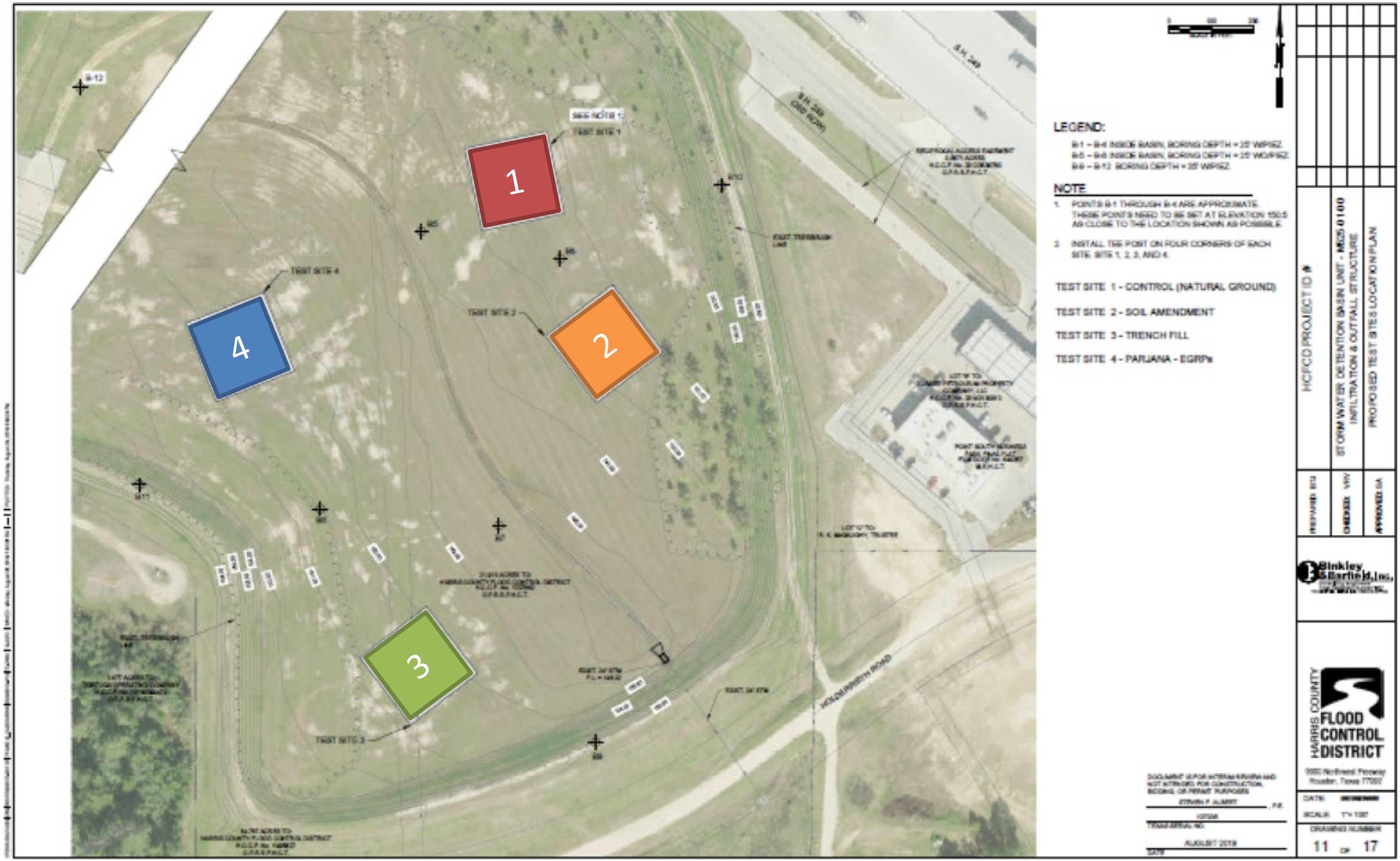
Sample Key: ☒ SPT ⍁ Shelby Tube ▤ Disturbed

Key to Abbreviations:
N - SPT Data (Blows/Ft)
P - Pocket Penetrometer (tsf)
T - Torvane (psf)
C_u - Undrained Shear Strength (tsf)
SS - Estimated Shear Strength (P/2, tsf)

Notes:
Boring terminated at 25 feet.
Boring converted to piezometer after drilling (Refer to Exhibit A-17).

Exhibit A-3

Experimental Design – General Layout



Experimental Design – Soil Amendment

Experimental Design - Trenches

Experimental Design – Proprietary System

Experimental Design – Outflow Control

Monitored site from Jan ‘20 to Dec ‘21

Cellular Data Logger
with Cloud Storage

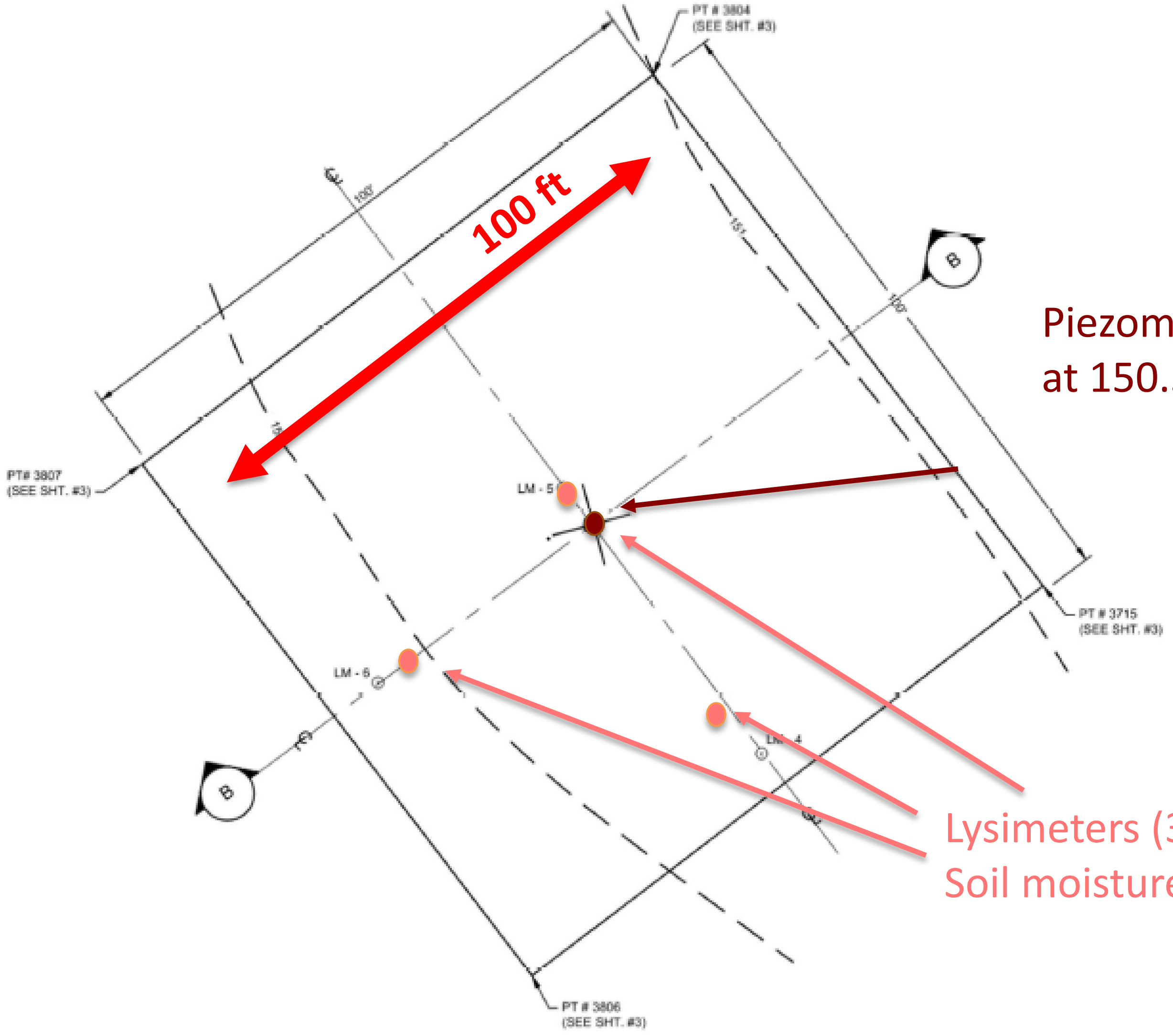
Water Level,
Electrical Conductivity,
Temperature Sensor

Soil Moisture,
Electrical Conductivity,
Temperature Sensor

All-in-One
Weather
Station

Drain Gauge
Passive Capillary
Lysimeter

Test Plots – Equipment Layout

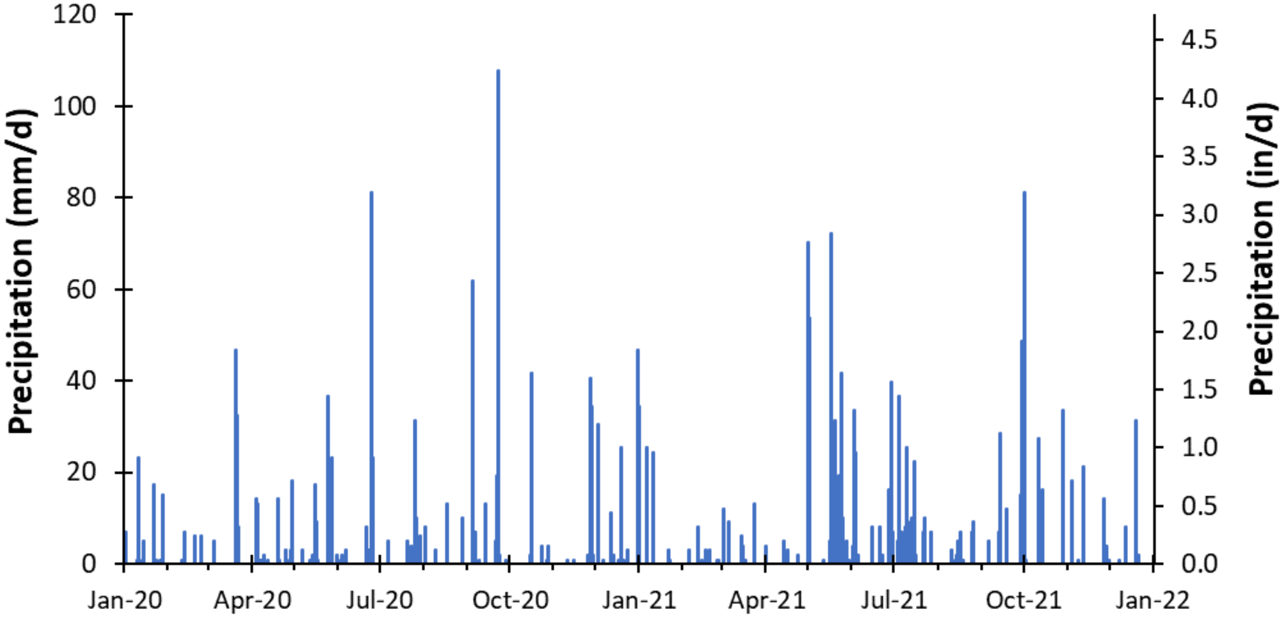


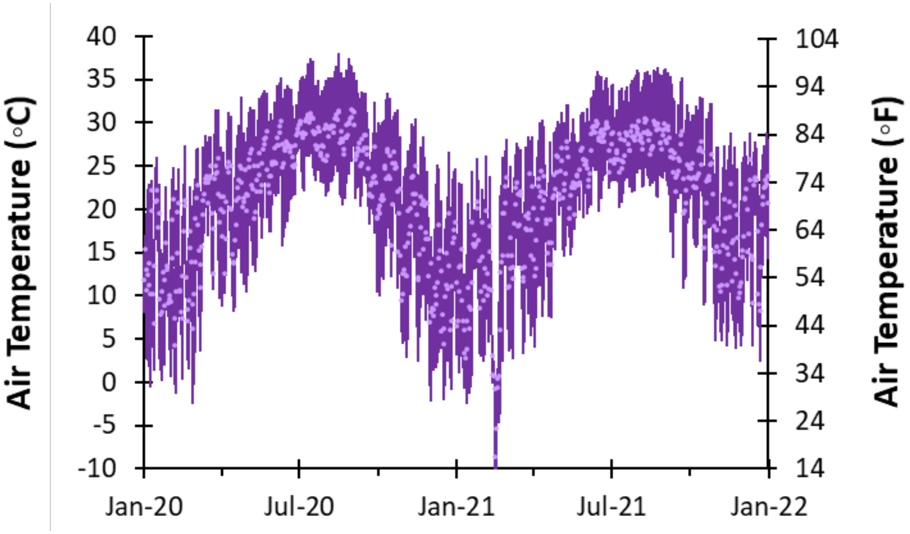
Piezometer/monitoring well at 150.5 fasl in center of plot

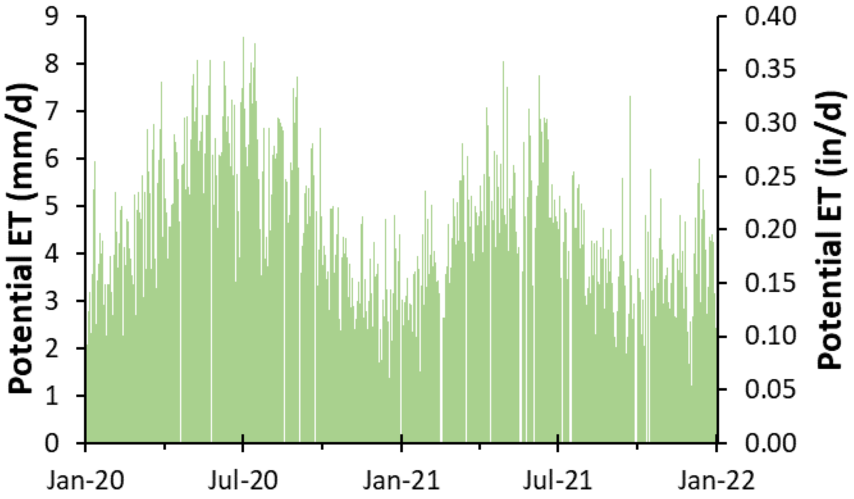
Lysimeters (3+ ft deep)

Soil moisture sensors (20 cm, 75 cm deep)

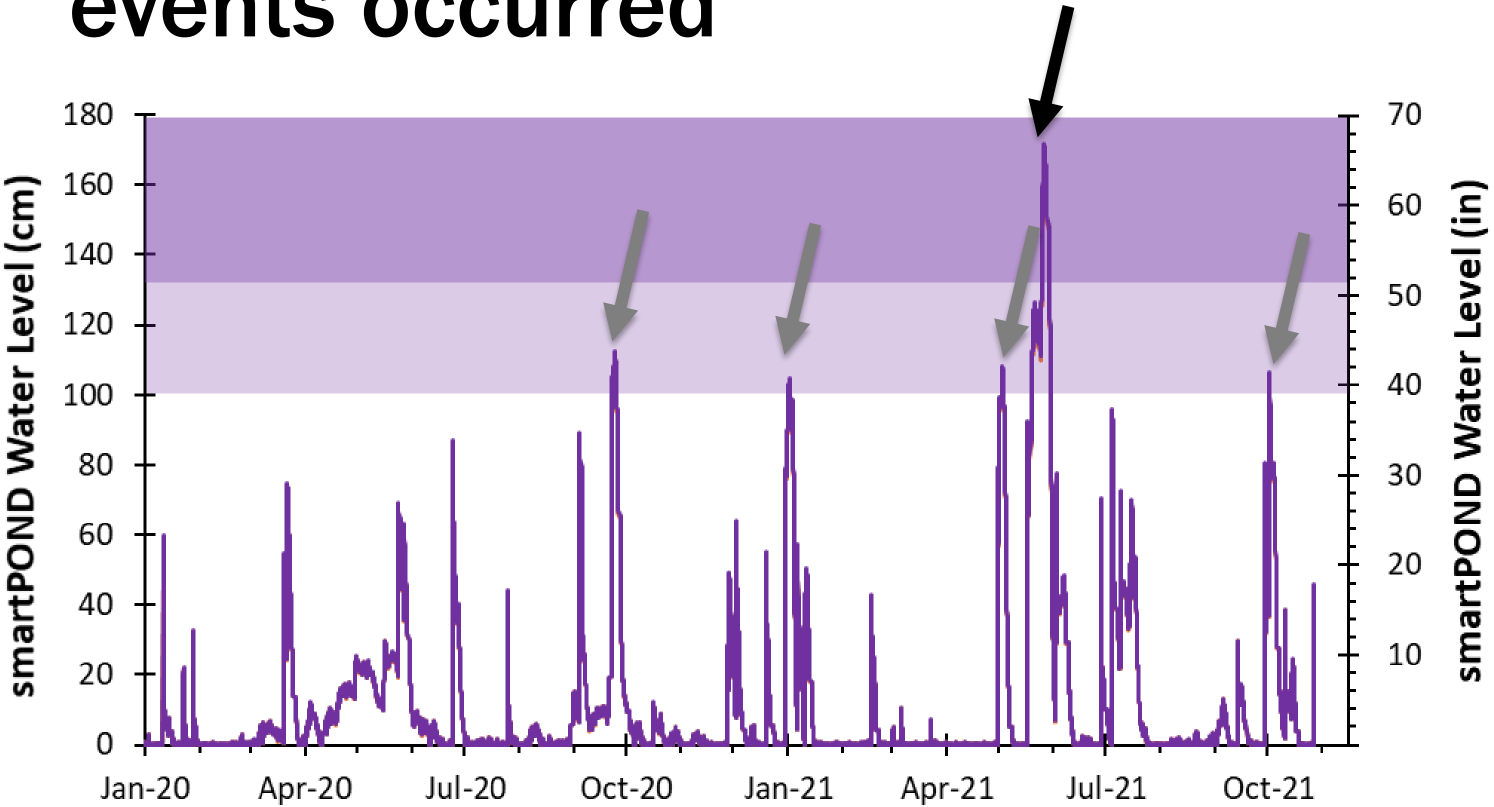
ENSO cycle impacted weather during study







One full inundation event and four partial events occurred



Sept 22, 2020

Dec 30, 2020

Apr 30, 2021

May 17/May 25, 2021

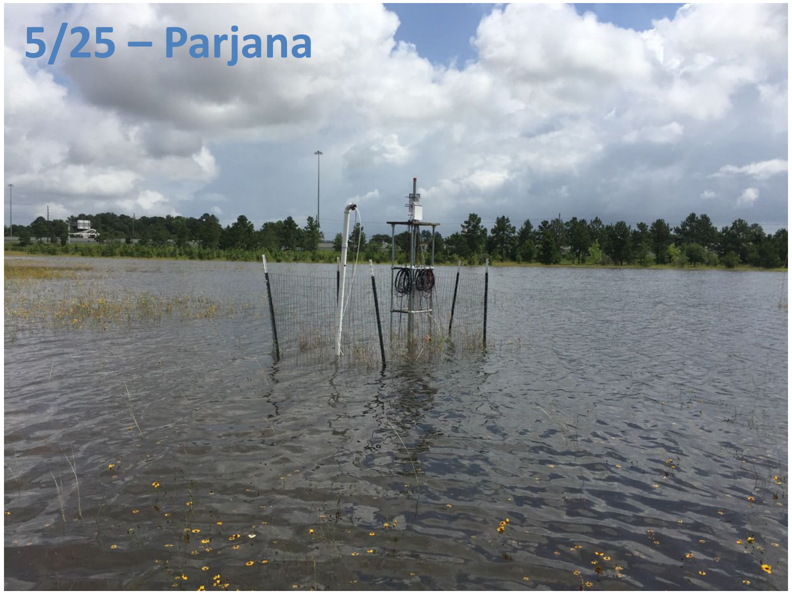
October 1, 2021

Images from day before peak

5/25 – Control

5/25 – Soil Amendment

5/25 - Trenches



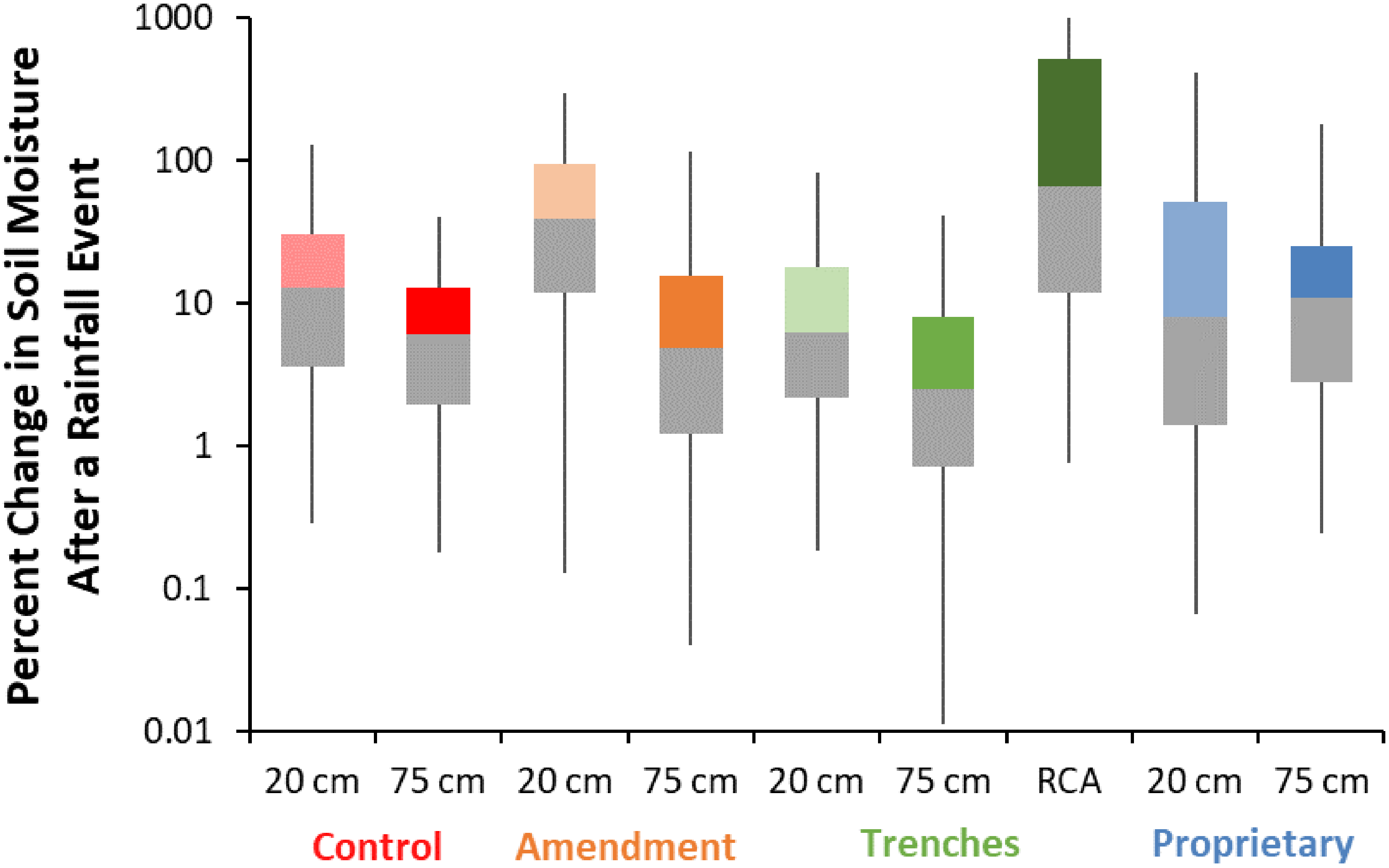
5/25 – Parjana

Infiltration - Modes of Action

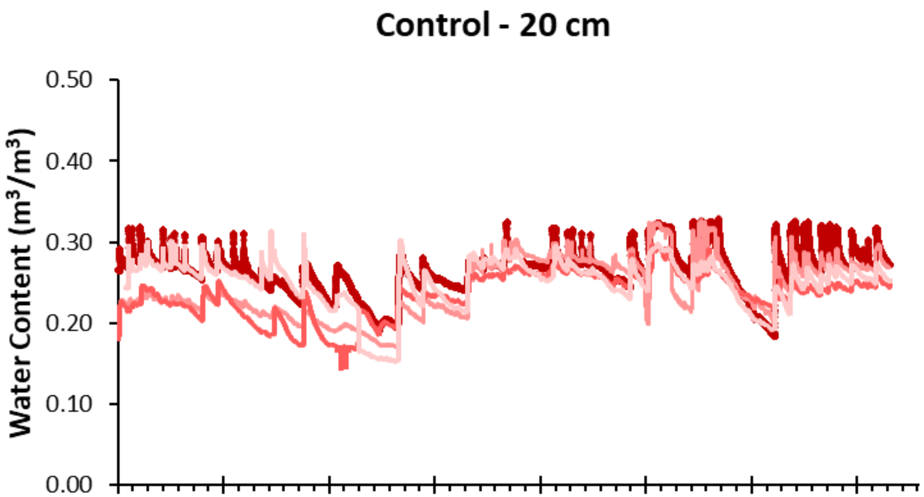
Each treatment type responds differently to rainfall

- Trenches – flashy large storage
- Soil amendment – sustained modest storage
- Proprietary system – spikes in storage at depth

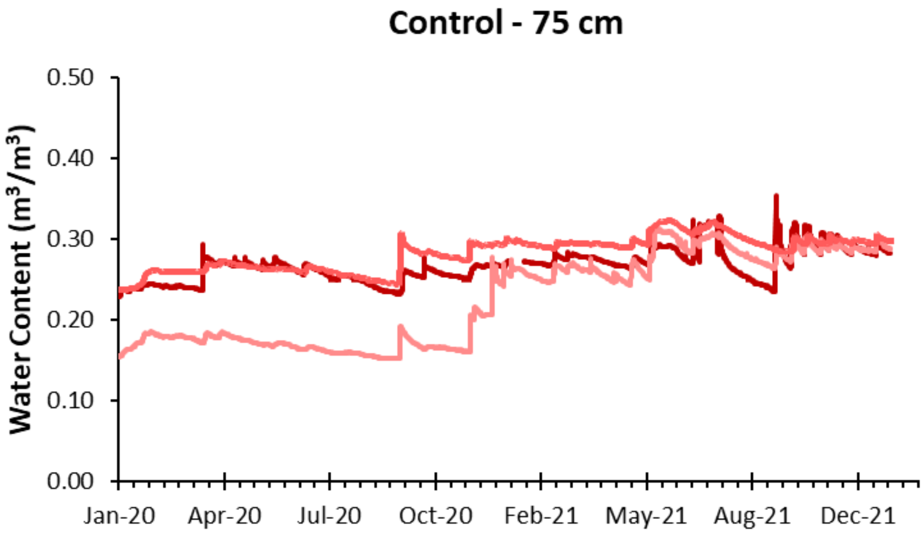
Response of soil moisture to rainfall shows different mechanisms of action



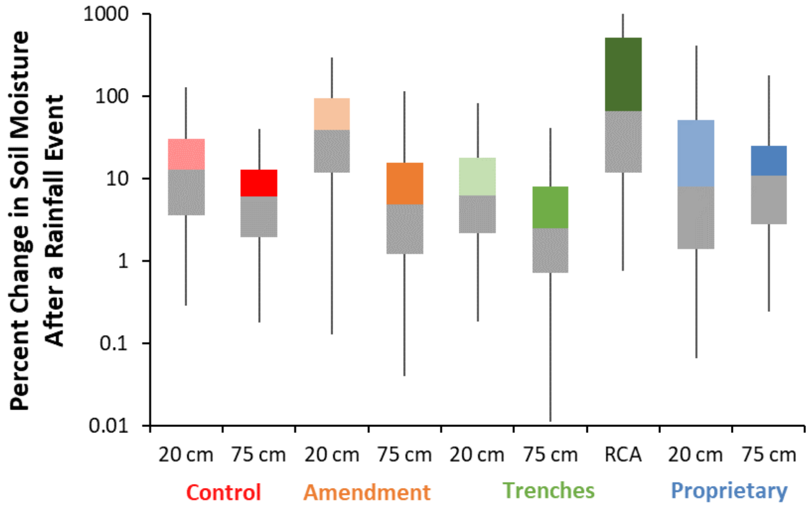
Control shows quick responses to rain in shallow soil, dampened in deep soil



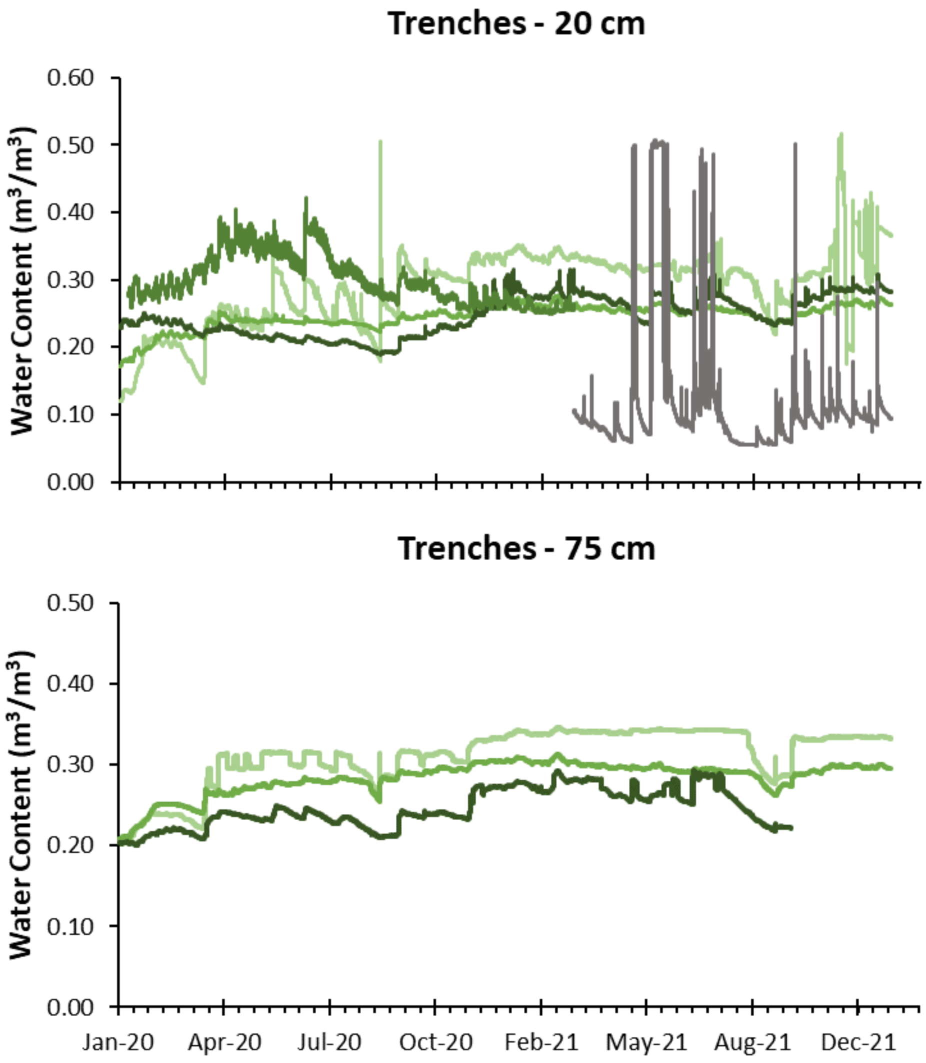
Control - 20 cm



Control - 75 cm

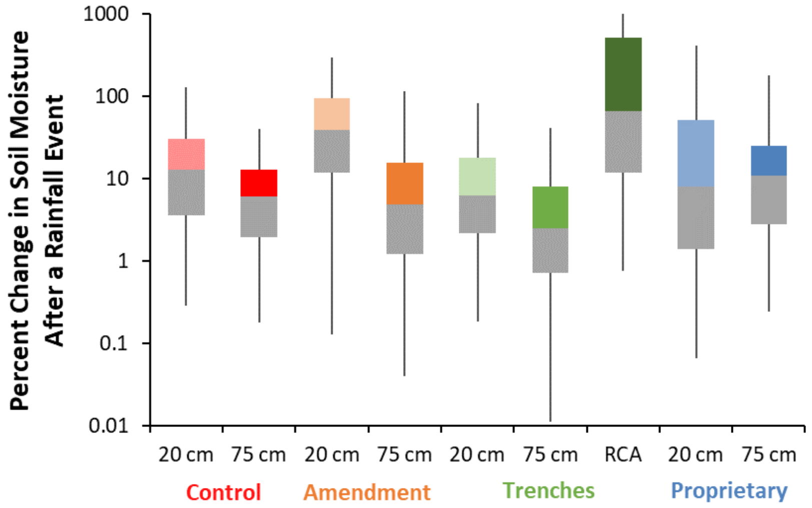


Trenches store water and release over next day, draining quickly

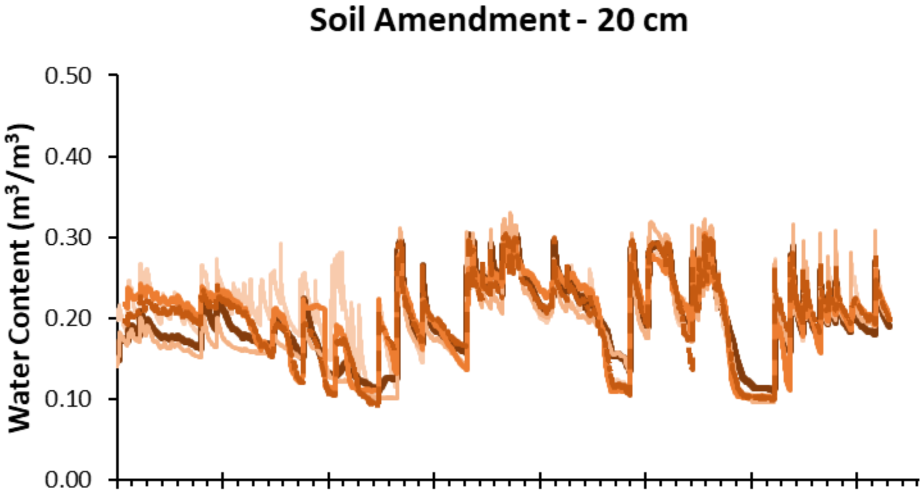


Trenches - 20 cm

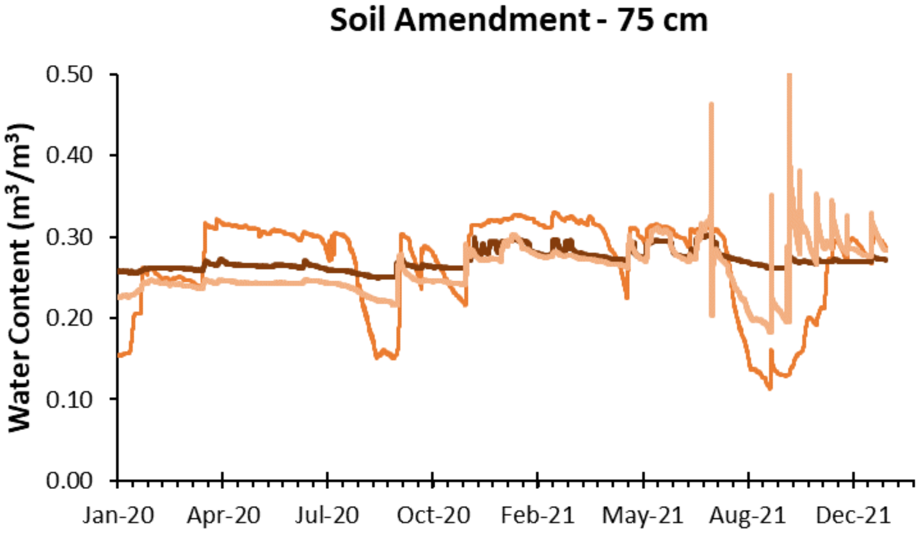
Trenches - 75 cm



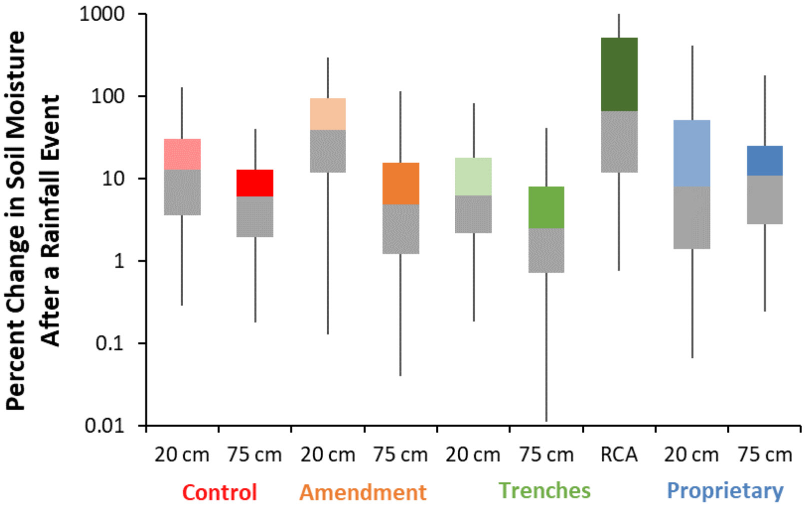
Soil amendment acts like a sponge at surface, drains over time



Soil Amendment - 20 cm

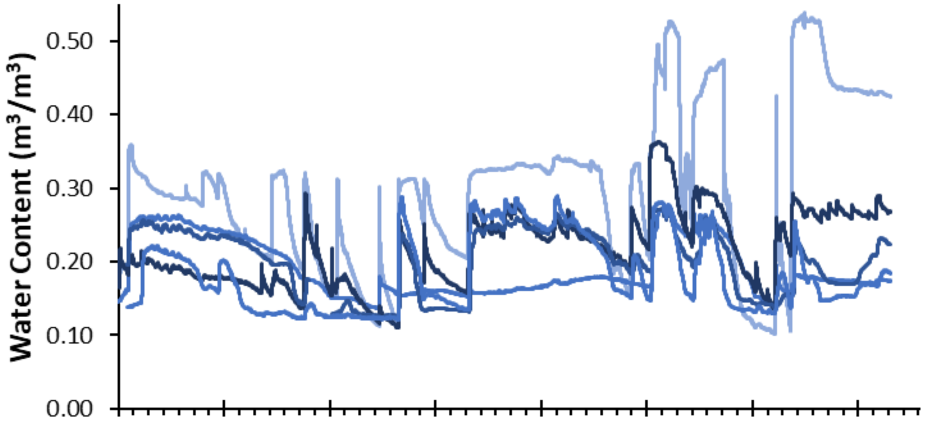


Soil Amendment - 75 cm

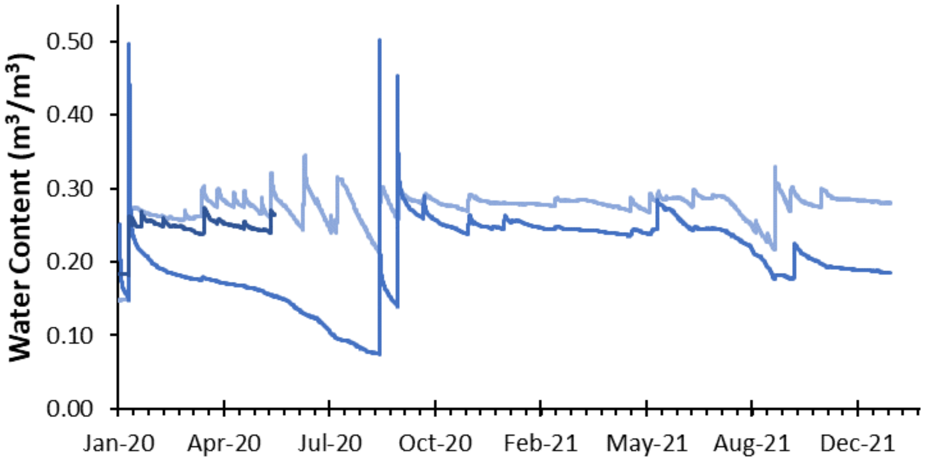


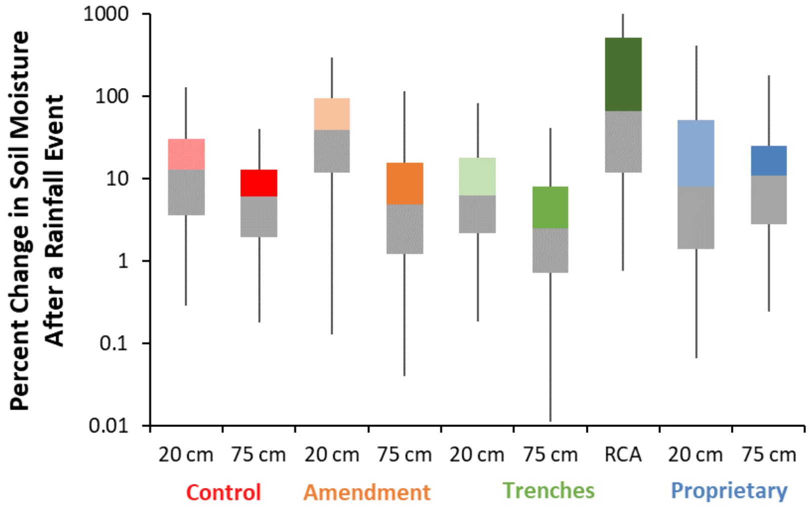
Proprietary system shows distinct soil moisture patterns, faster spikes

Proprietary - 20 cm



Properitary - 75 cm





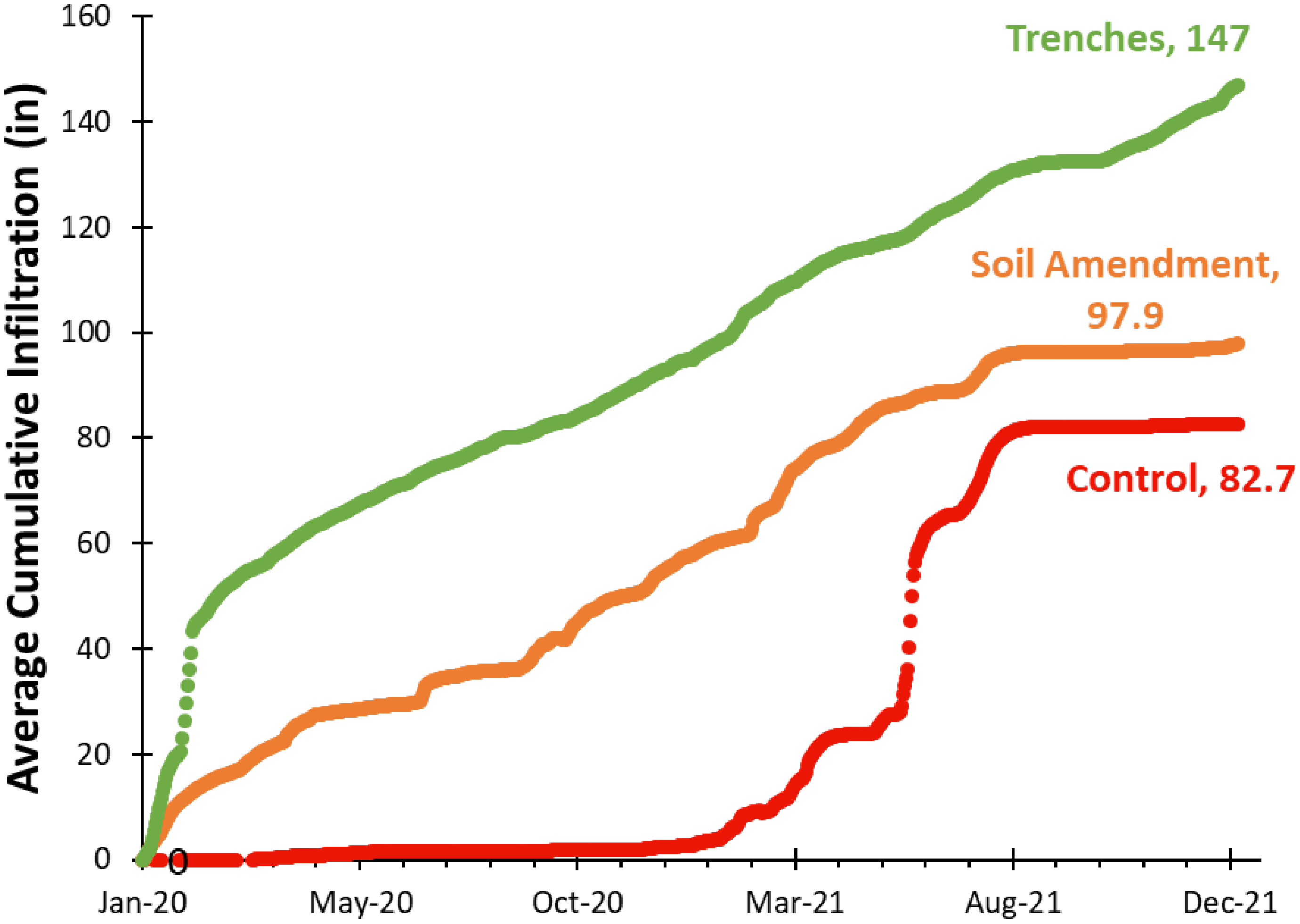
But no groundwater <25’ depth, and no infiltration measured by drain gauges…

Infiltration - Long-term Results

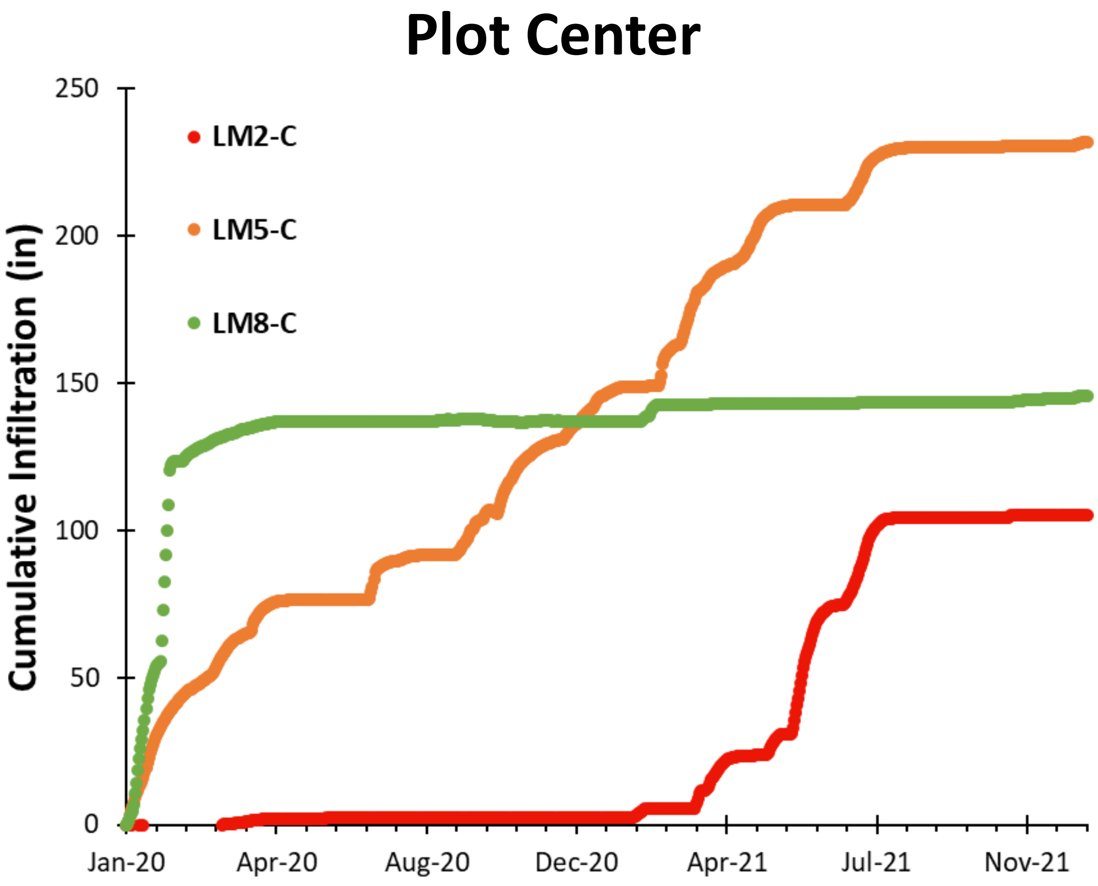
Increased infiltration from treatment plots

- Strongest evidence from drain gauge lysimeters
- Supporting evidence from groundwater and soil moisture

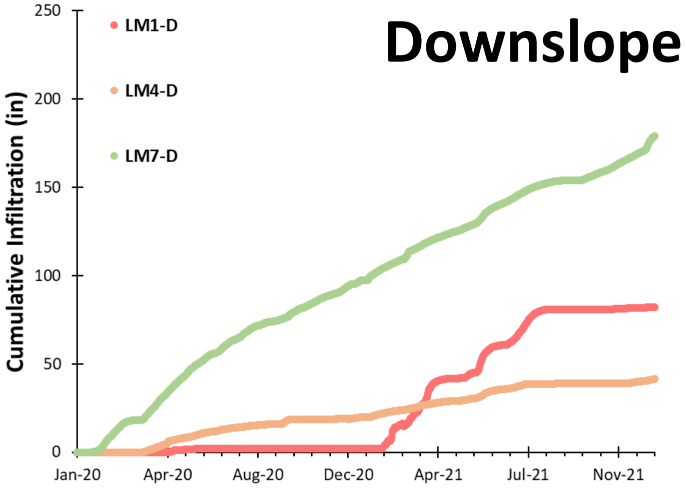
Trenches have highest infiltration rates over long-term



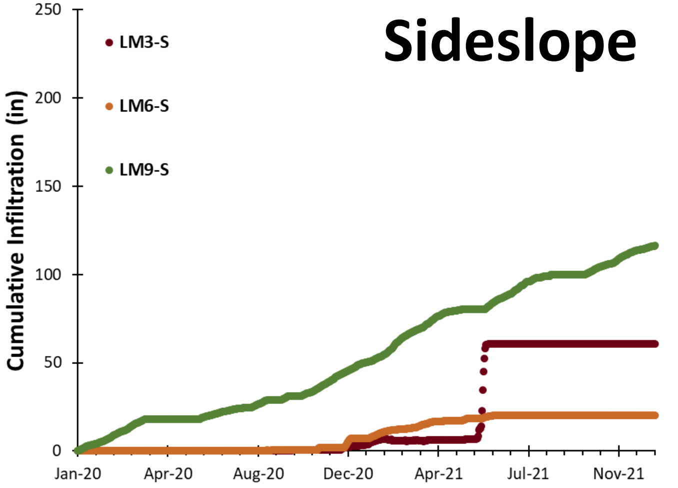
High degree of variability depending on location of infiltration measurement



Plot Center

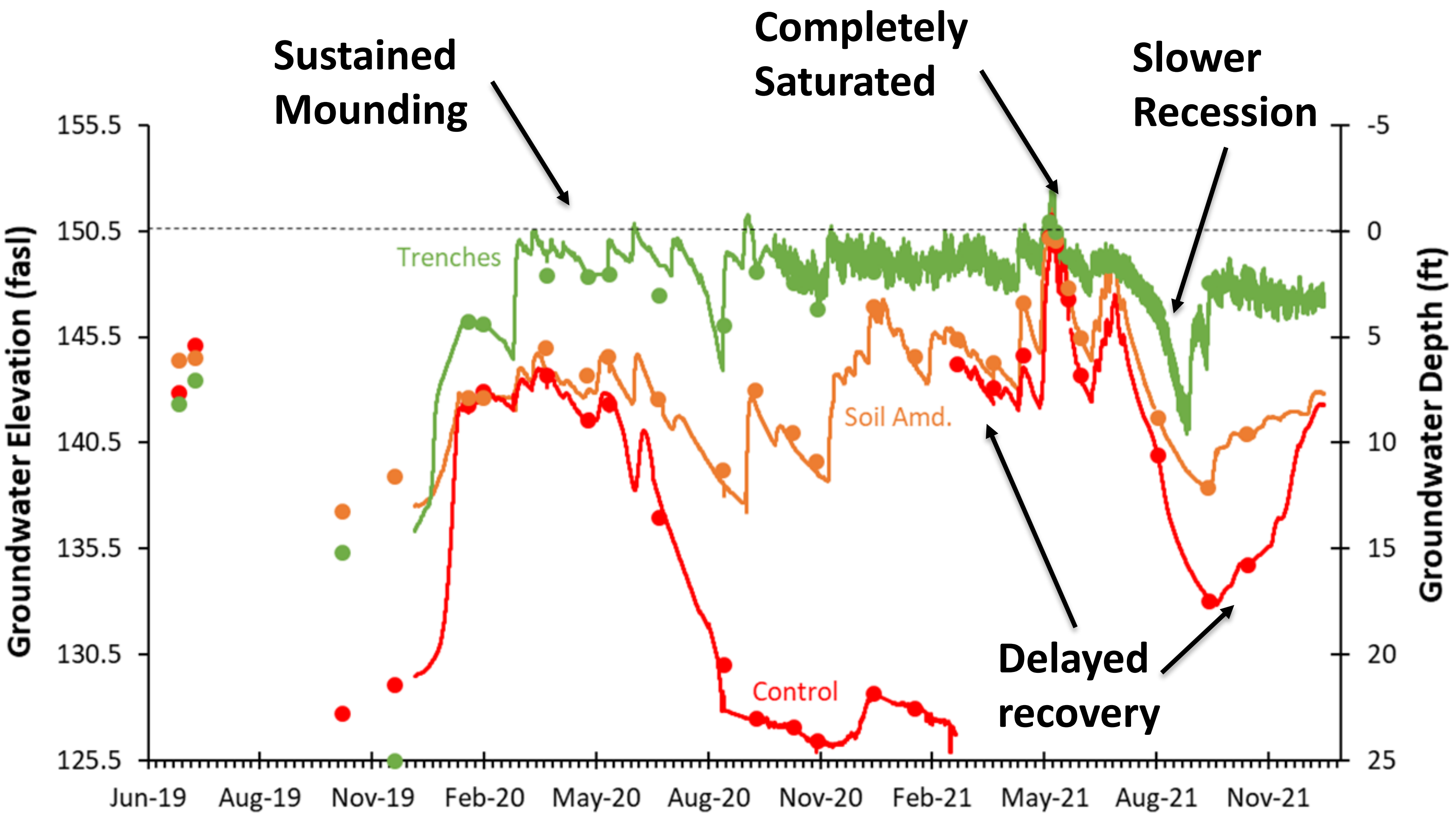


Downslope

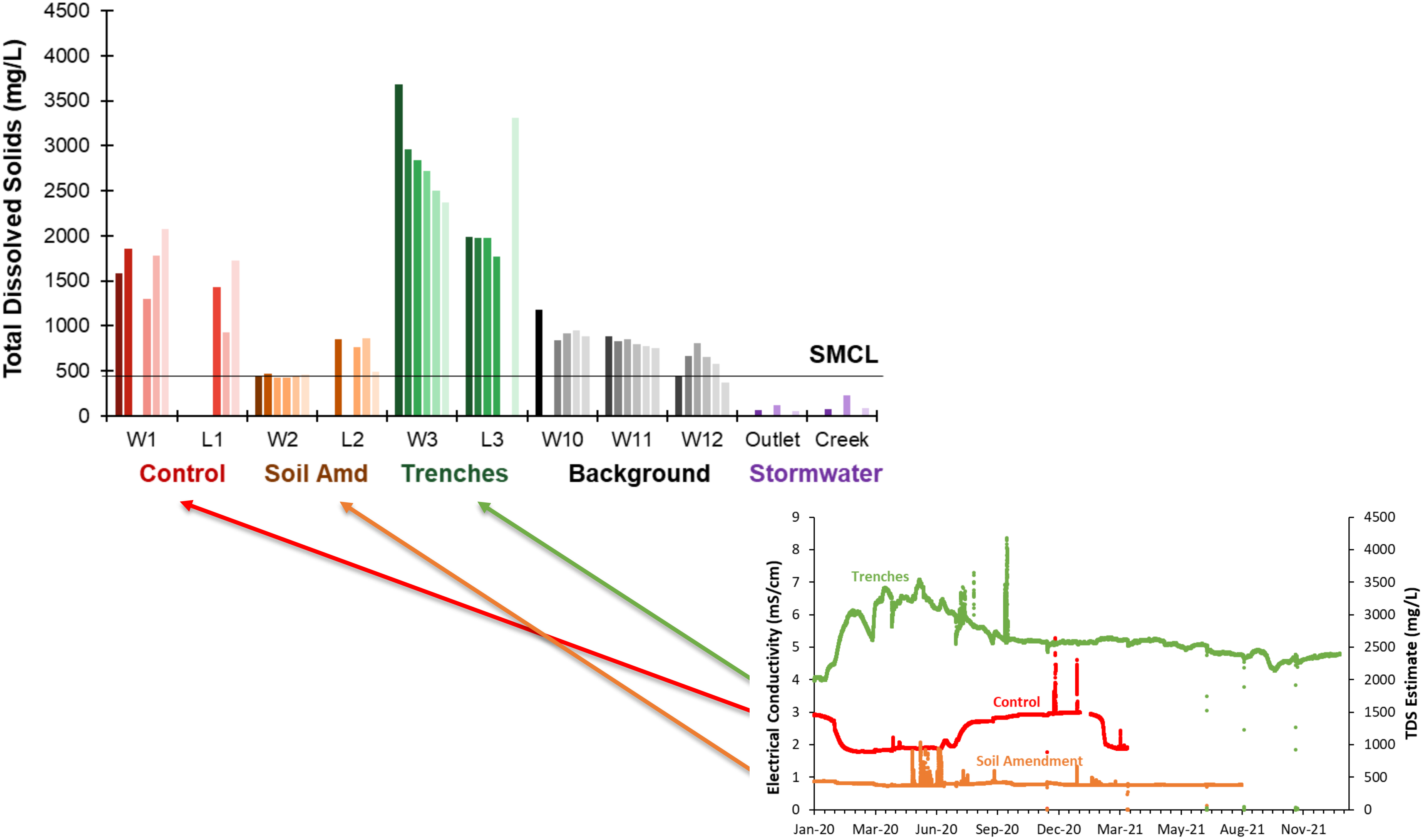


Sideslope

Groundwater fluctuations indicate that treatments enhance recharge

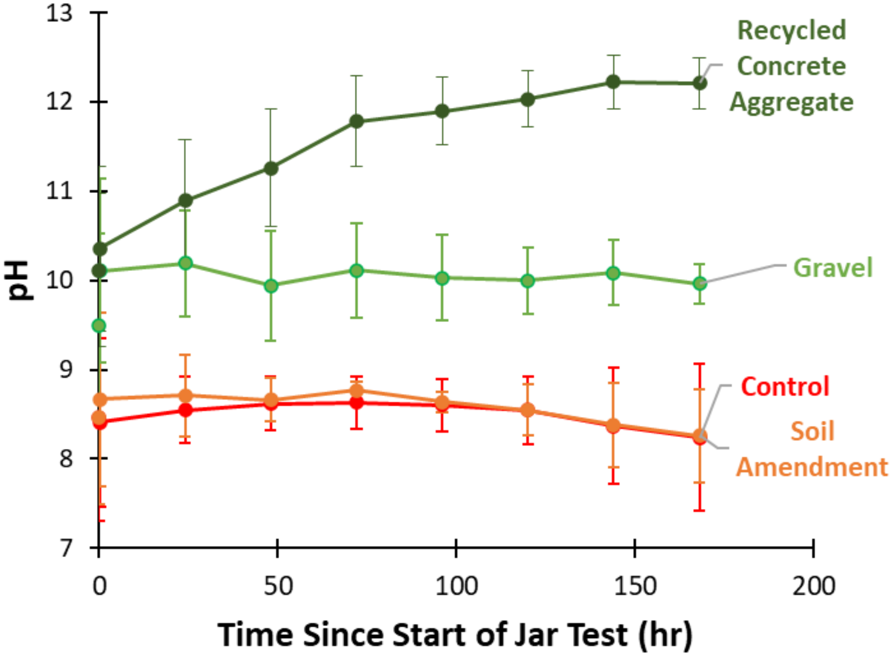


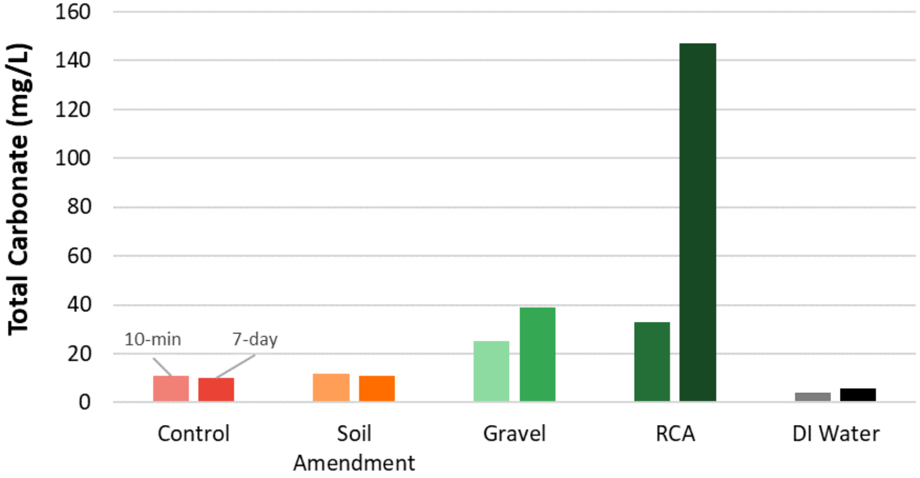
Initial flush of salt from trenches later stabilizes higher than background

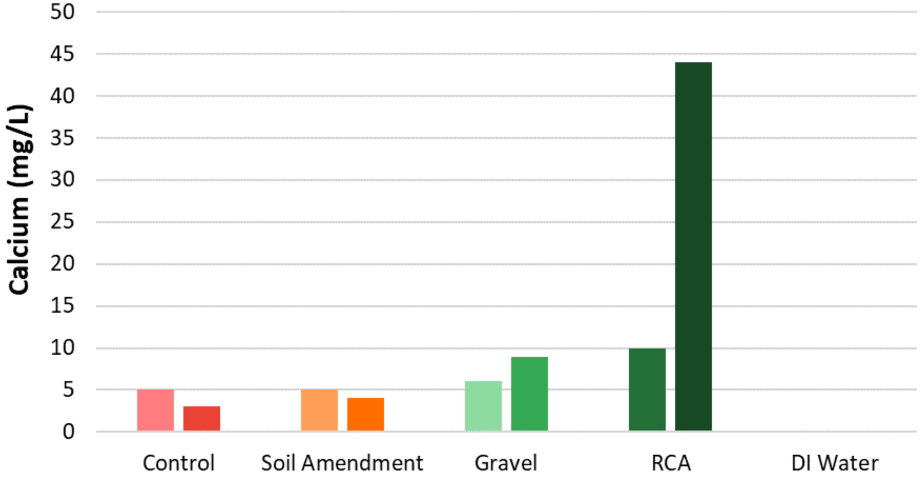


Recycled concrete aggregate in trenches appears to be the culprit

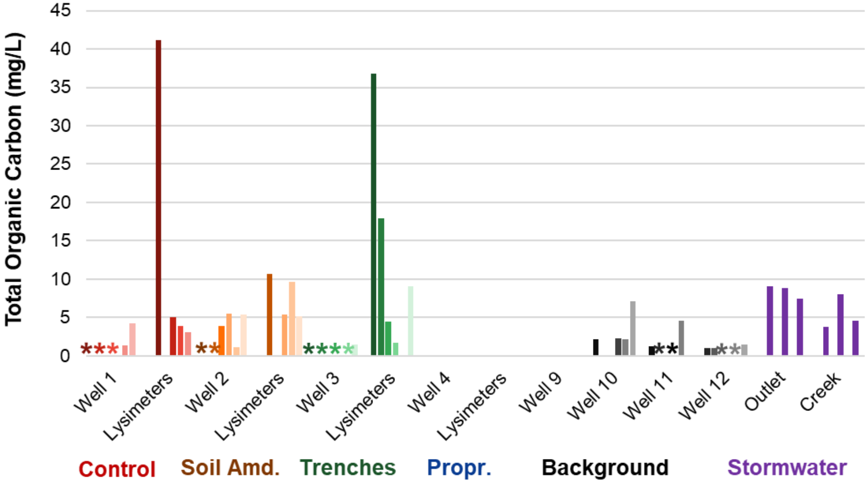
Recycled concrete aggregate in trenches appears to be the culprit

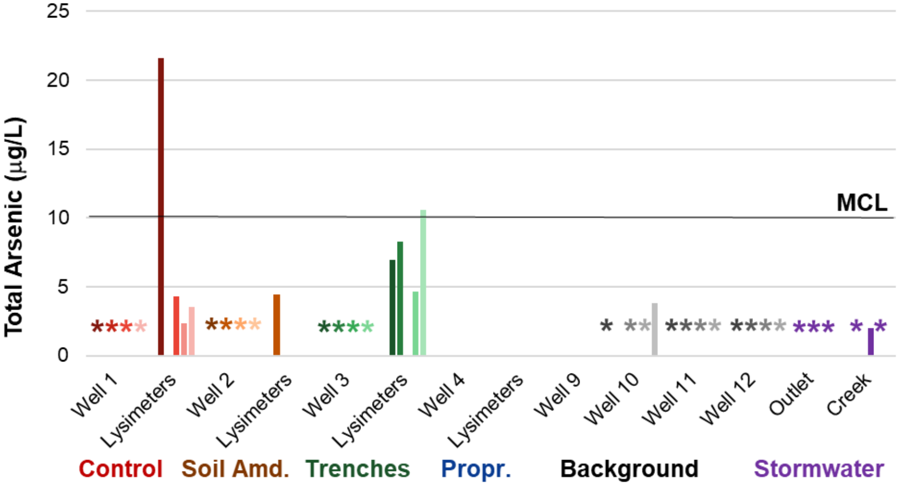


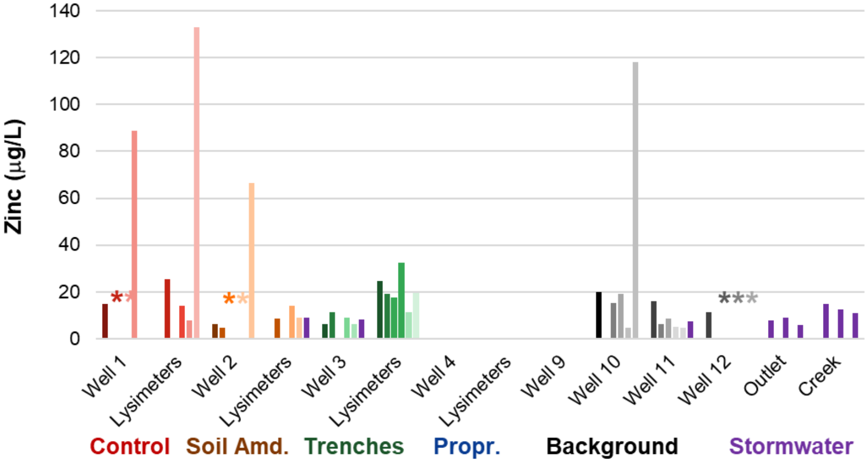


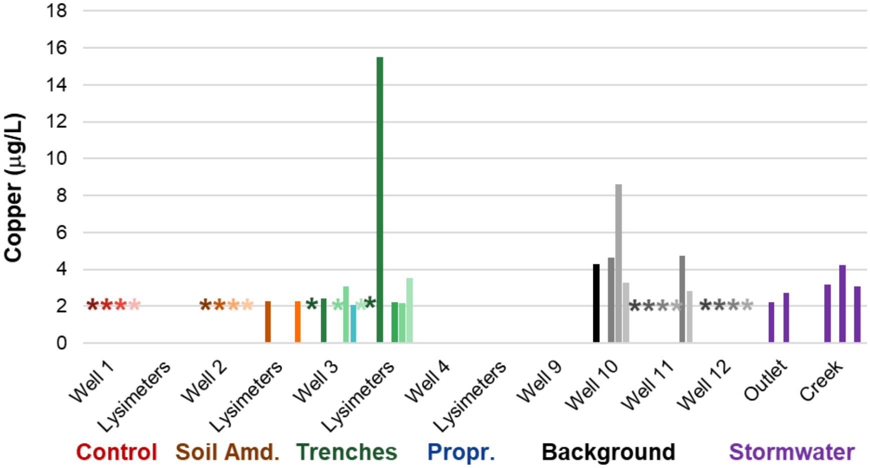


No long-term deterioration of underlying groundwater beyond salinity







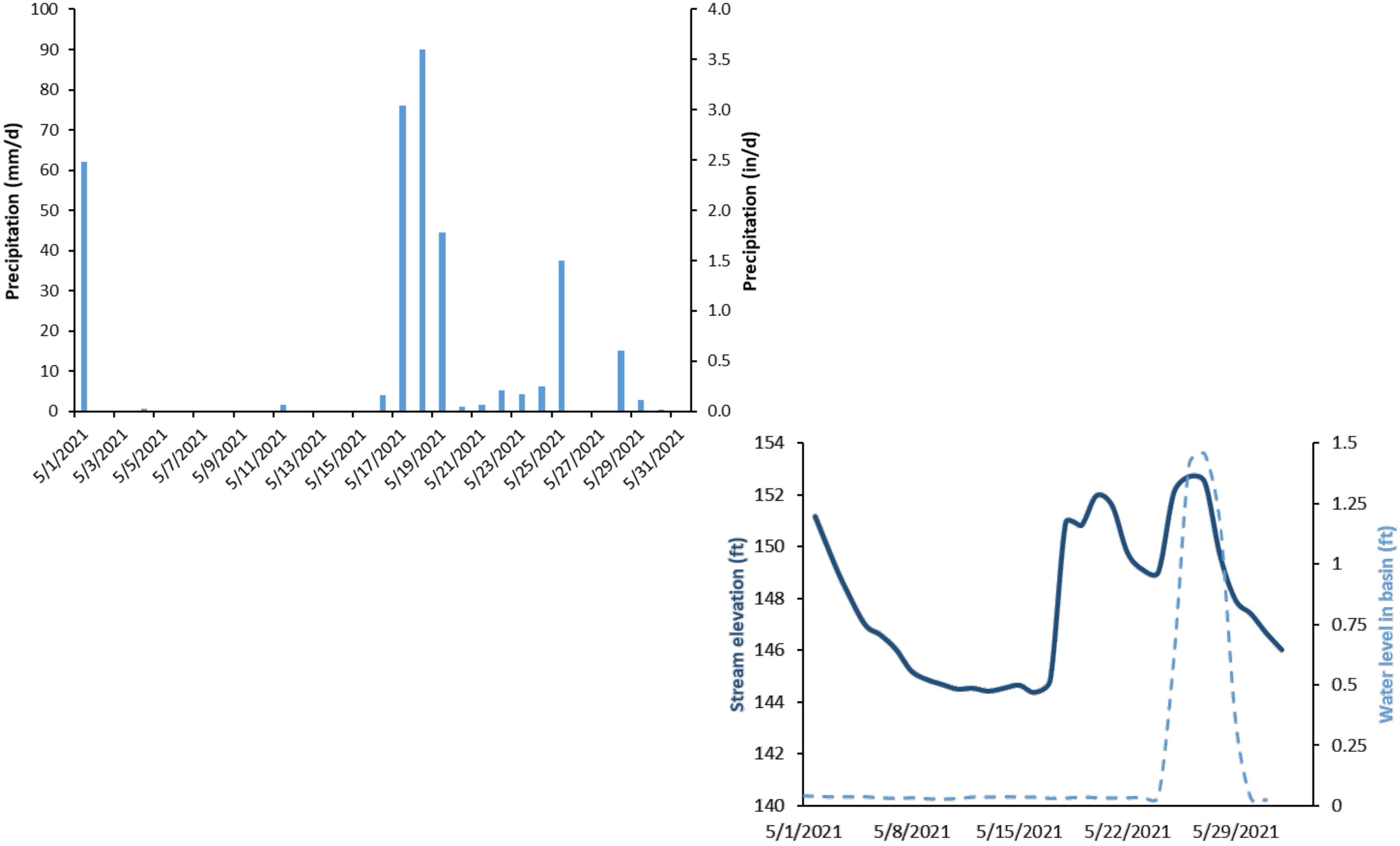


Infiltration - Inundation Events

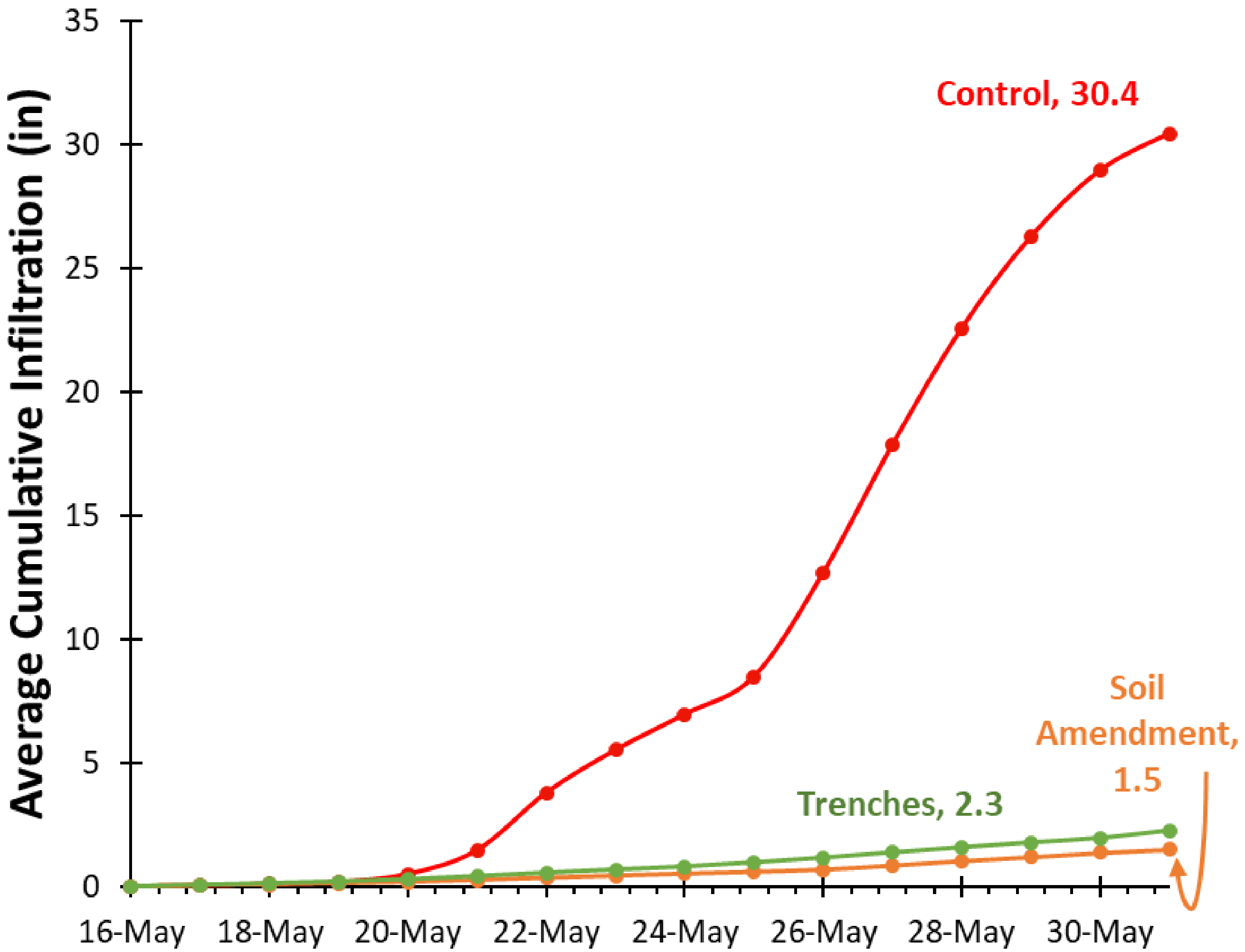
Disappointing performance of treatments

- Rainfall and partial events during winter kept water levels high under trenches and amendment
- Performance of these remained fairly steady
- Substantially higher infiltration in control plot

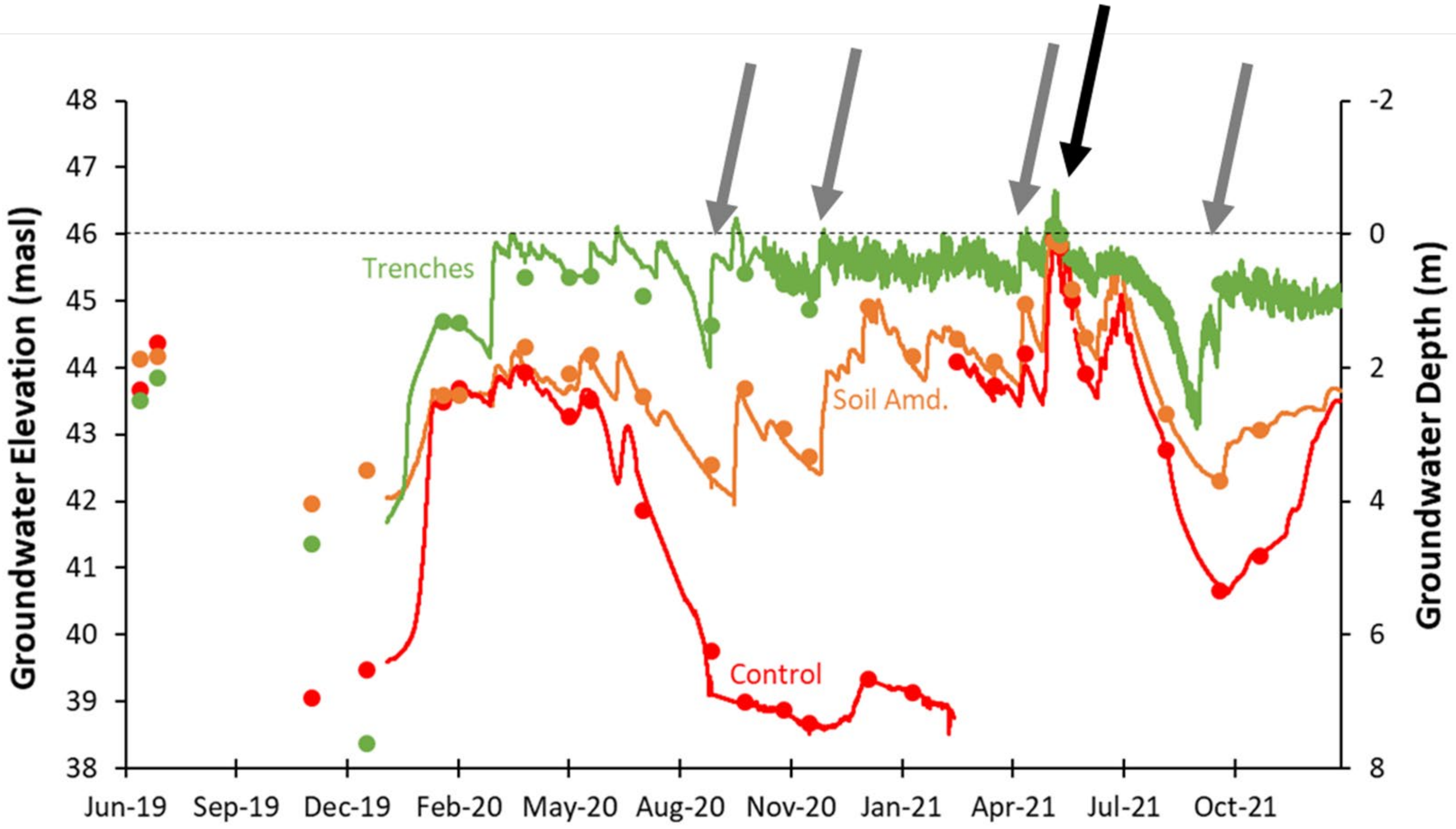
May inundation event lasted 10+ days



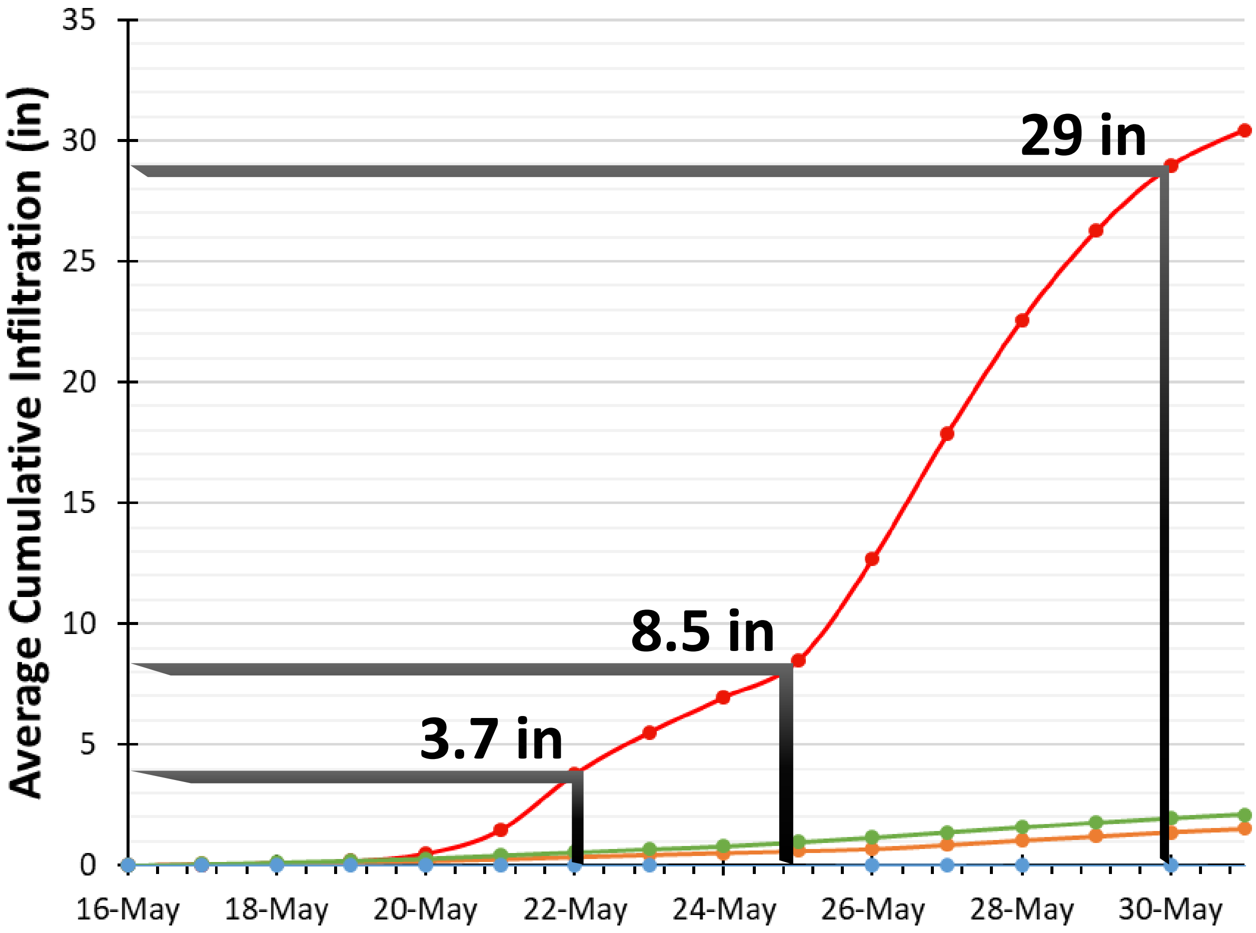
Control plot shows superior infiltration during event



Antecedent conditions explain lower "storage capacity" during events



Longer detention times translate to more infiltration from basin



General Conclusions & Recommendations

- To **achieve year-round groundwater recharge** aims:
  - Trenches lead to best infiltration quantity
  - Soil amendments improve infiltration quality

- To **improve flood control, stormwater quality**:
  - Consider longer detention times
  - Other basin modifications may not be necessary

- To **protect groundwater quality**:
  - Select materials and site carefully

Questions?

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