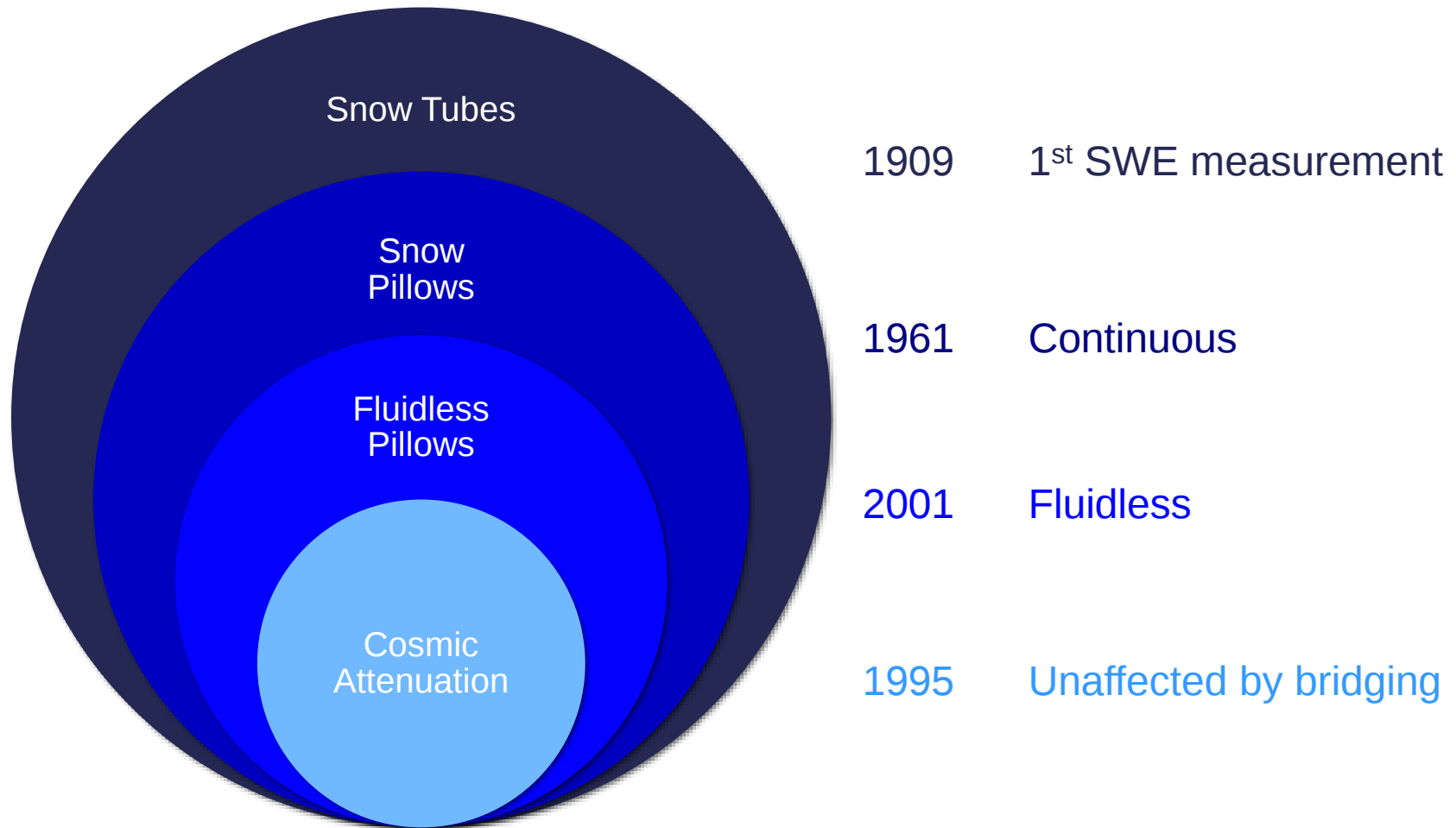


Research &
Development in
Advancing Snow Water
Content Monitoring



ALPINE
HYDROMET

Available high range SWE Sensors



Snow Pillow Limitations



Fluid based measurement

Environmental concerns

Vulnerable to damage

Weighing based principle



No fluid



Transportable

Helicopter, mule, truck, carry



1-day installation



Robust

10-15 years of low maintenance measurements



Simple system integration

Users
requests

Build a reliable, accurate, durable,
fluidless snow water content sensor.

GOAL

Dual Sensor Development



FSP - Fluidless Snow Pillow

- Removes fluid
- Familiar measurement principle
- Lower cost



CRD - Cosmic Ray Detector

- Eliminates existing limitations
- High confidence in measurement principle
- Potentially a longer period before turnkey

Snow Pillow Limitations



~~Fluid based measurement~~

FSP & CRD

~~Environmental concerns~~

FSP & CRD

~~Vulnerable to damage~~

FSP & CRD

~~Weighing based principle~~

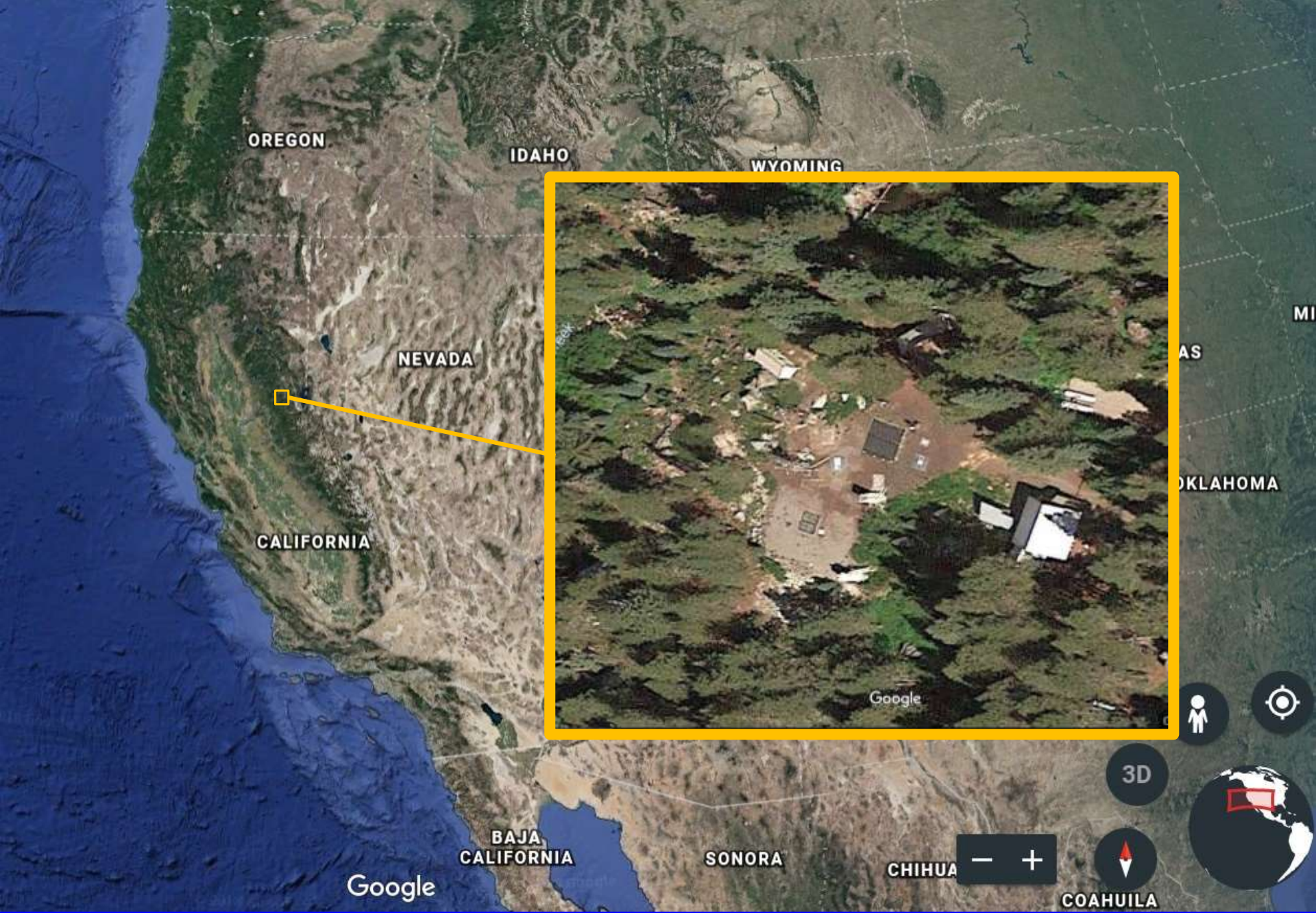
CRD



Full Prototype Testing

YEAR 1 OBJECTIVES

2016 - 2017





FSP9

Measurement area:

9 sq. Ft. (2.7 m²)

Total surface area:

81 sq. Ft. (24.7 m²)

Side panel buffer:

3 feet (0.91 m)

FSP5

9 sq. Ft. (2.7 m²)

25 sq. Ft. (7.6 m²)

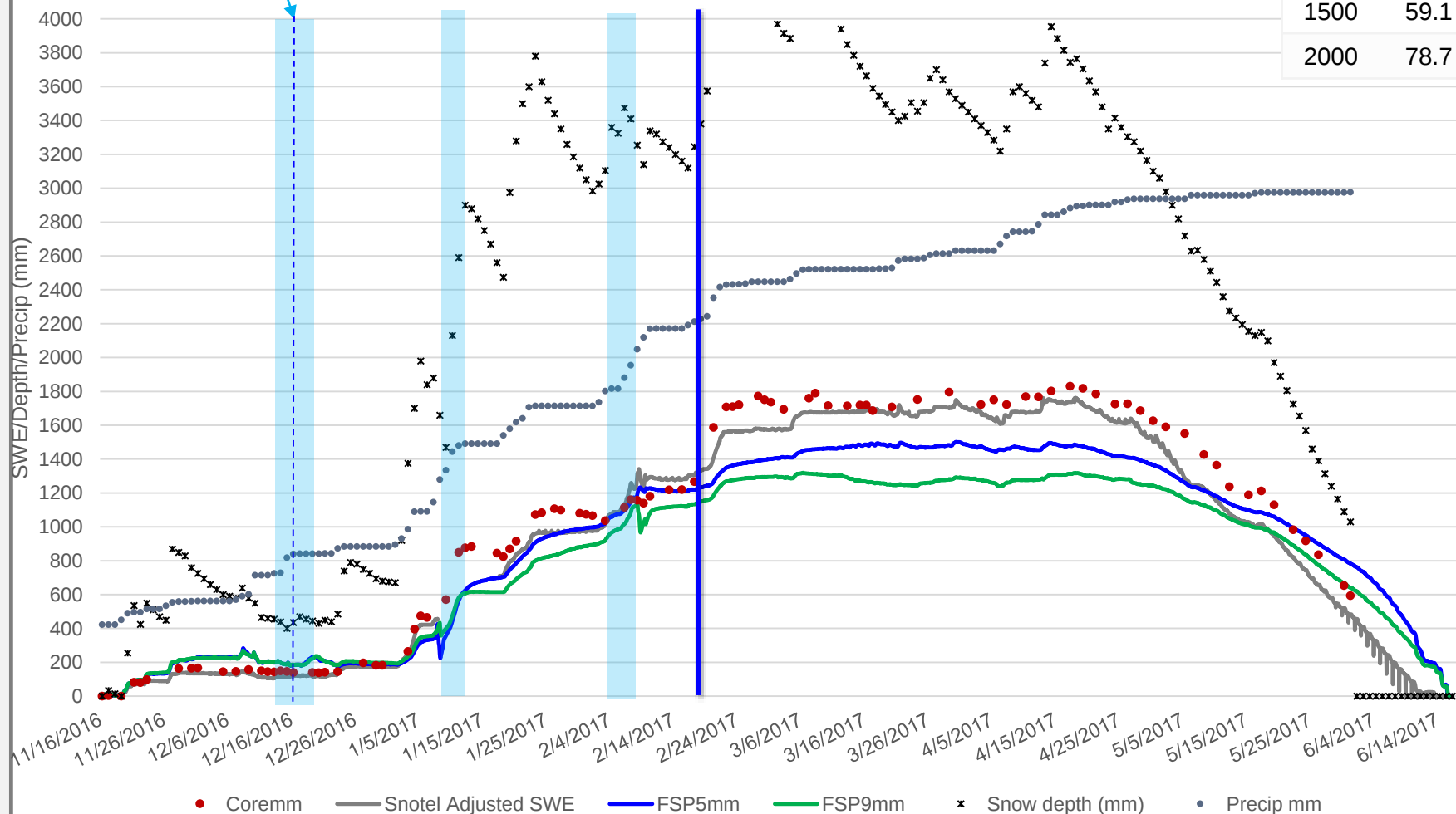
1 foot (0.3 m)

Rain on Snow

SWE Comparison Winter 2016-17

FSP5, FSP9, SNOTEL & Manual Measurements

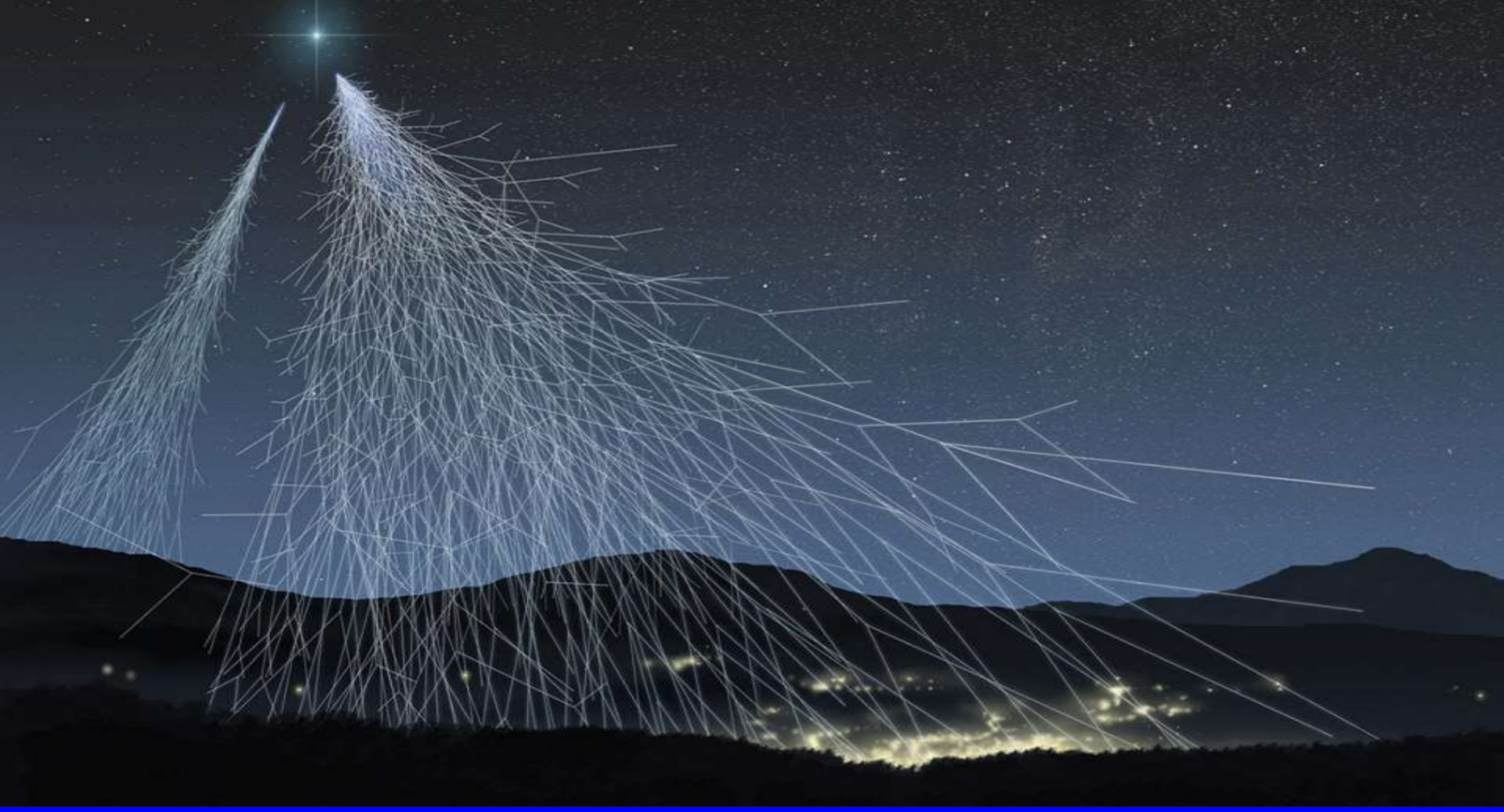
mm	inch
250	9.8
500	19.6
1000	39.4
1500	59.1
2000	78.7



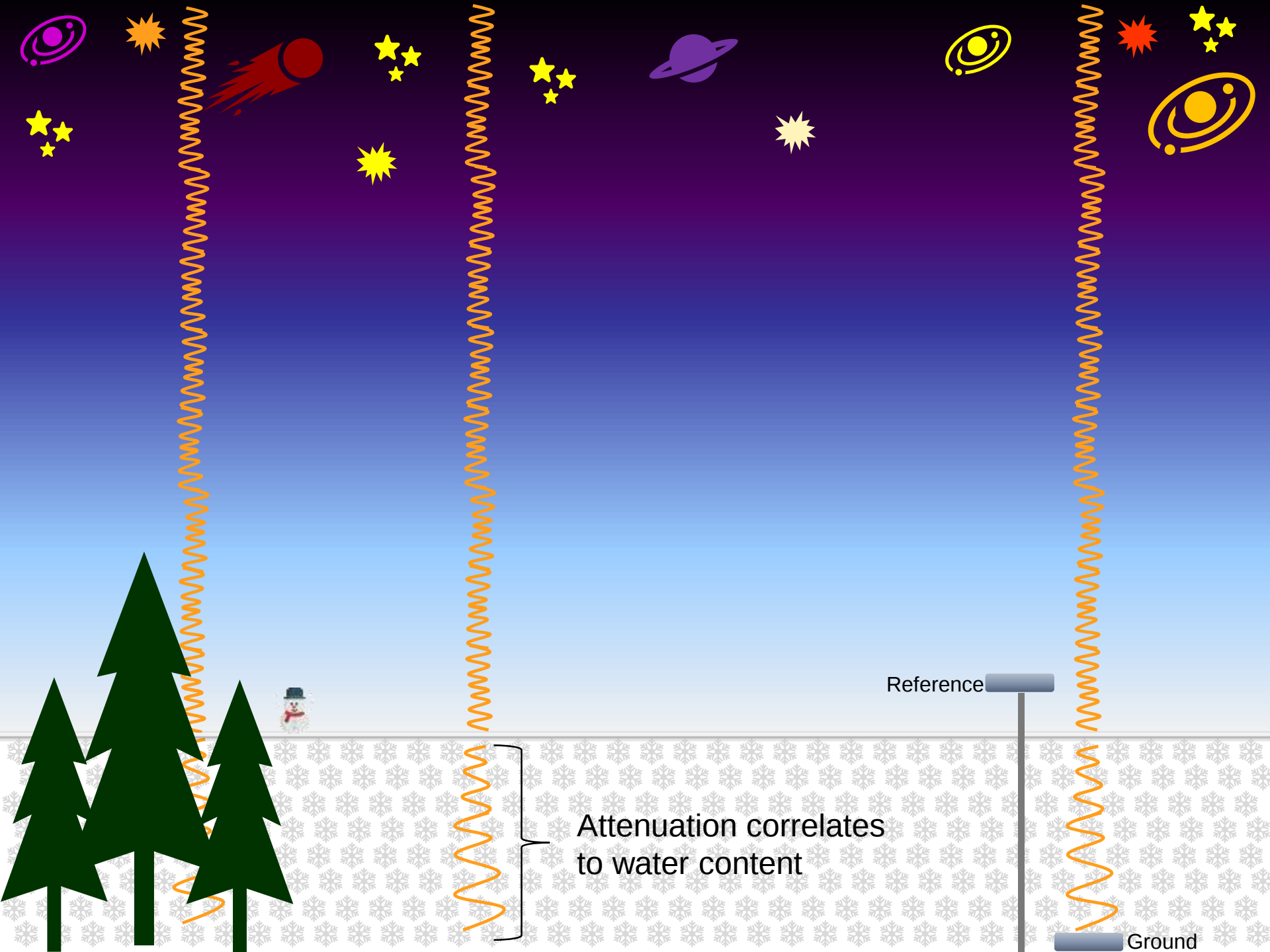
A vibrant, diagonal streak of light, resembling a cosmic ray or a comet, stretches across the frame from the bottom-left to the top-right. The streak is composed of a bright yellow-orange core surrounded by a diffuse, glowing purple and magenta aura. The background is a deep black space filled with numerous small, white stars of varying brightness.

Cosmic Ray Detector

YEAR 1 OBJECTIVE B



Passive cosmic rays scatter constantly through our atmosphere.



Attenuation correlates
to water content

Reference

Ground



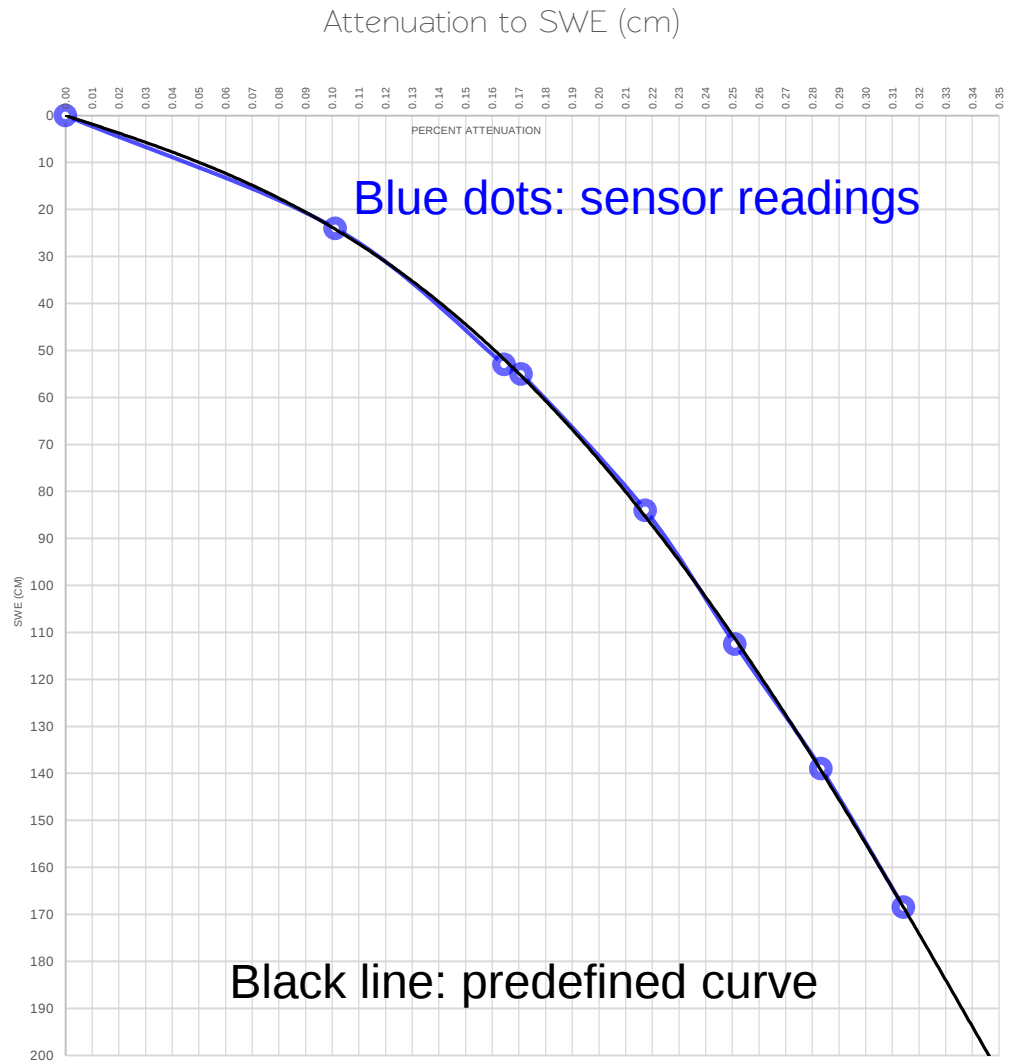
Cosmic Ray Detector (CRD)

- Improved enclosure design
 - Aluminum housing
 - Gasketed housing
 - IP68 Marine Grade Cable Gland
- Digital output – Ethernet port
- No – Low Maintenance



Testing for Accuracy

Tested under 66 inches
(~1700 mm) of water



B: Second year of FSP data & full
winter of CRD data

YEAR 2 OBJECTIVE

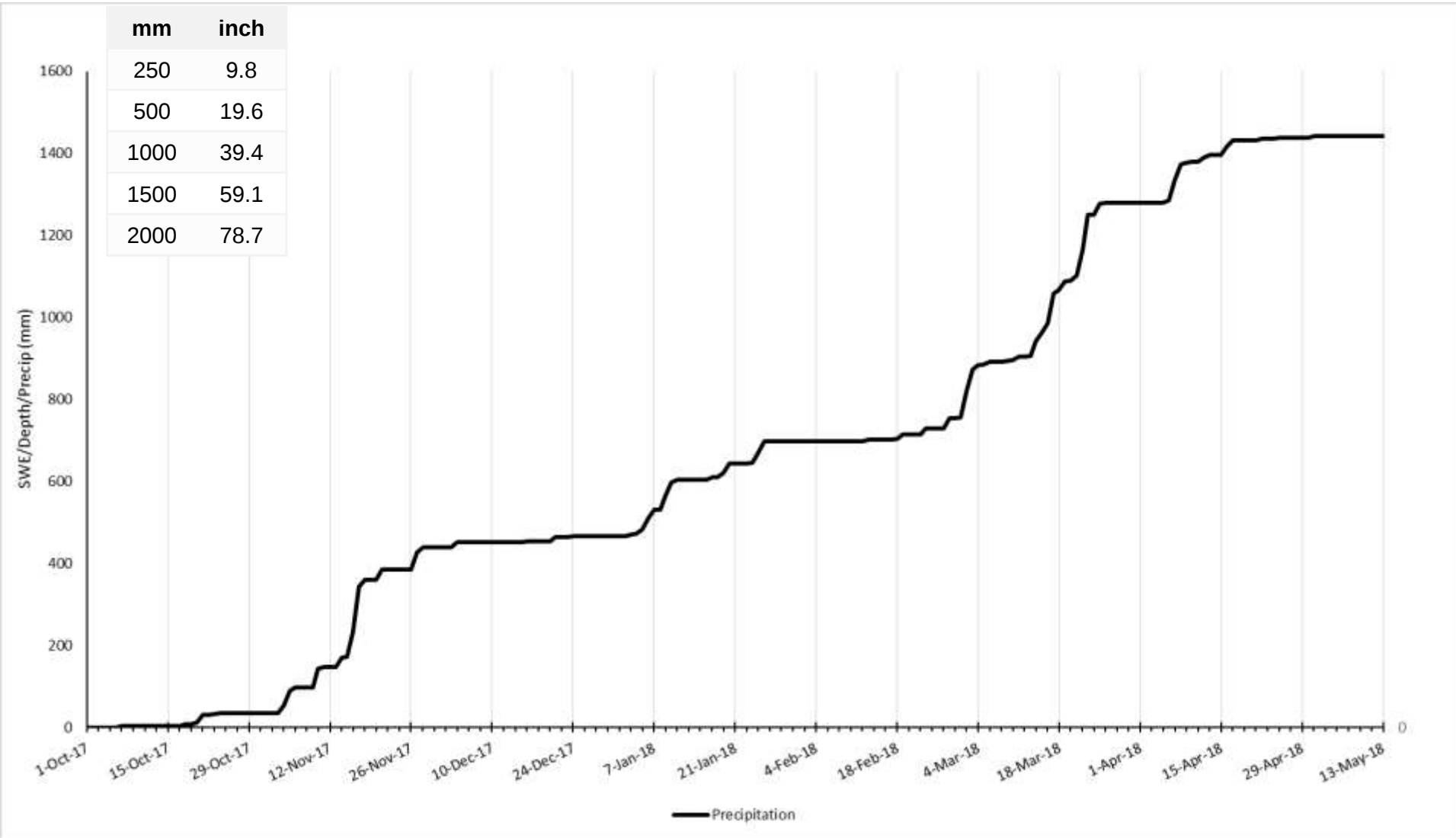


Winter 2017-18

- Comparison of:
 - FSP5 & FSP9
 - CRD
 - SNOTEL - Snow Pillow
 - Snow Cores

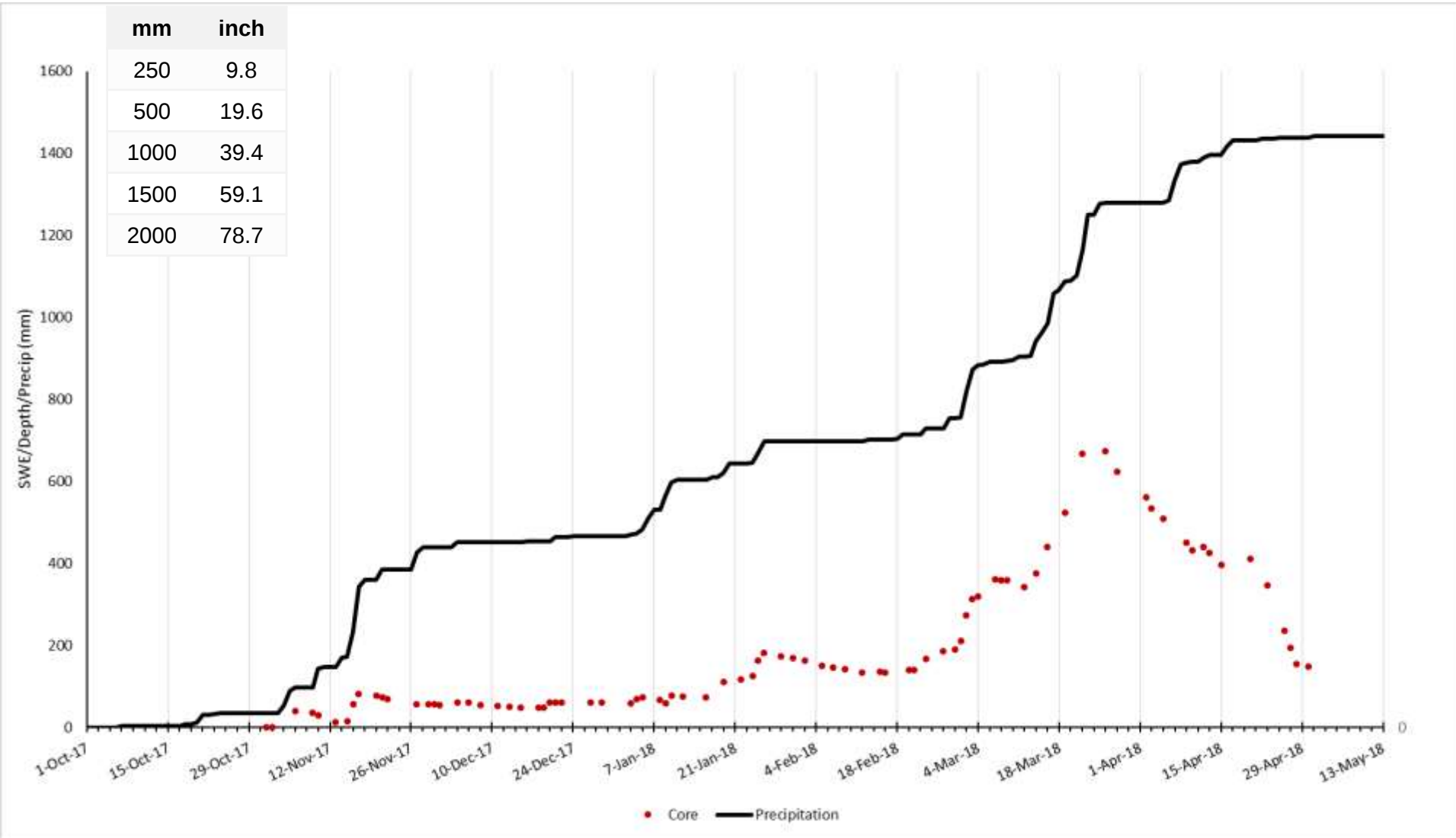
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



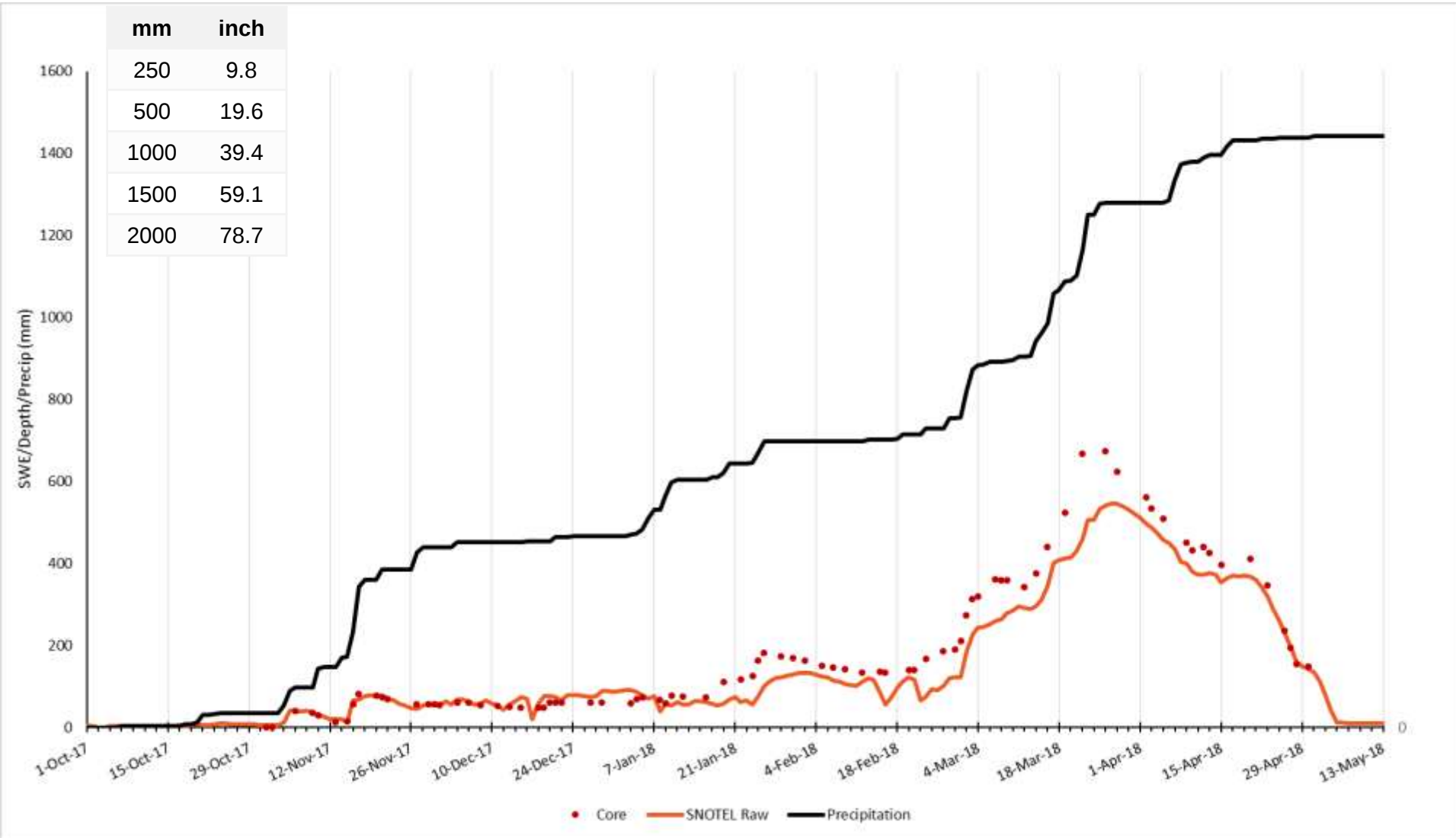
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



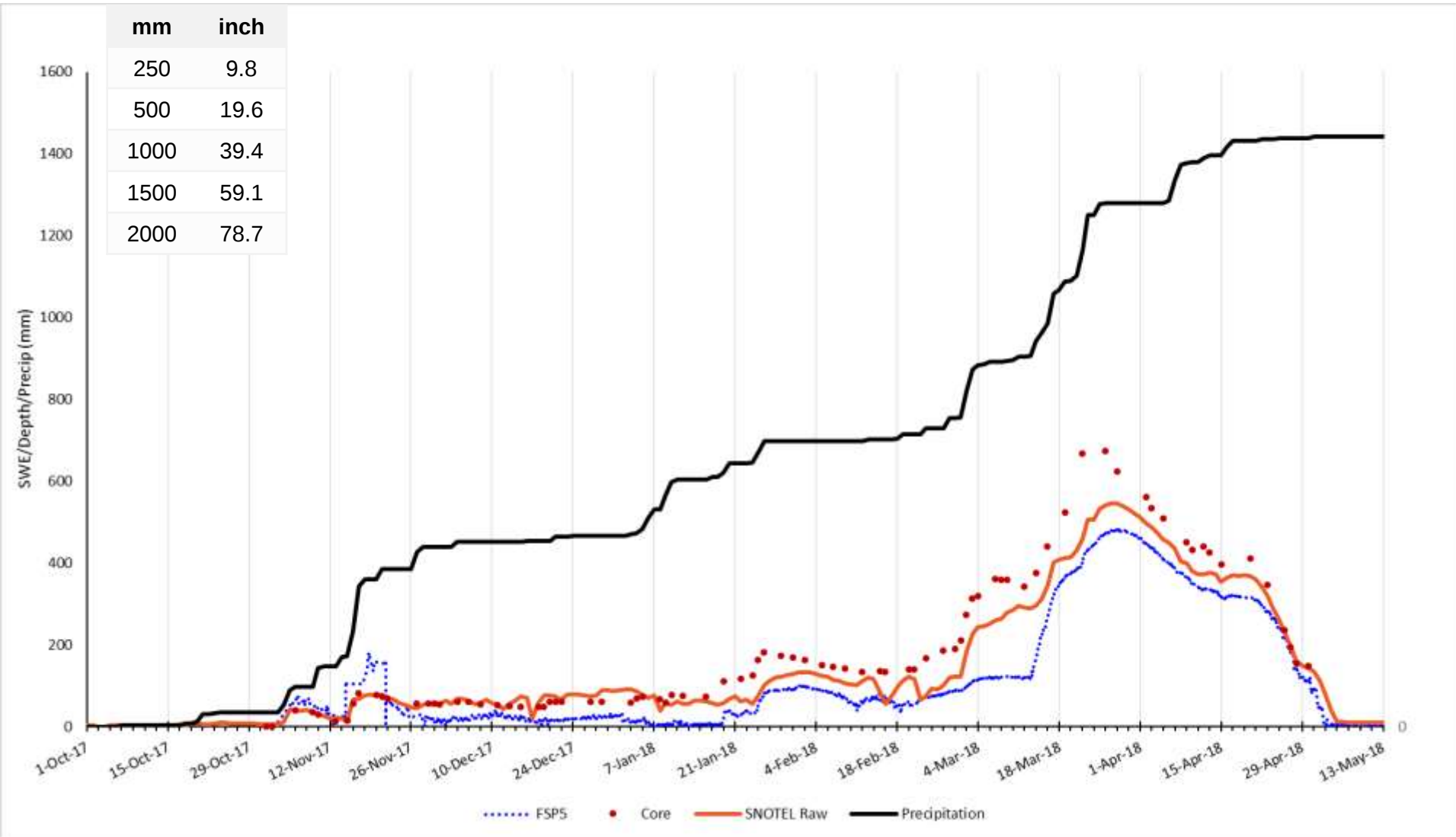
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



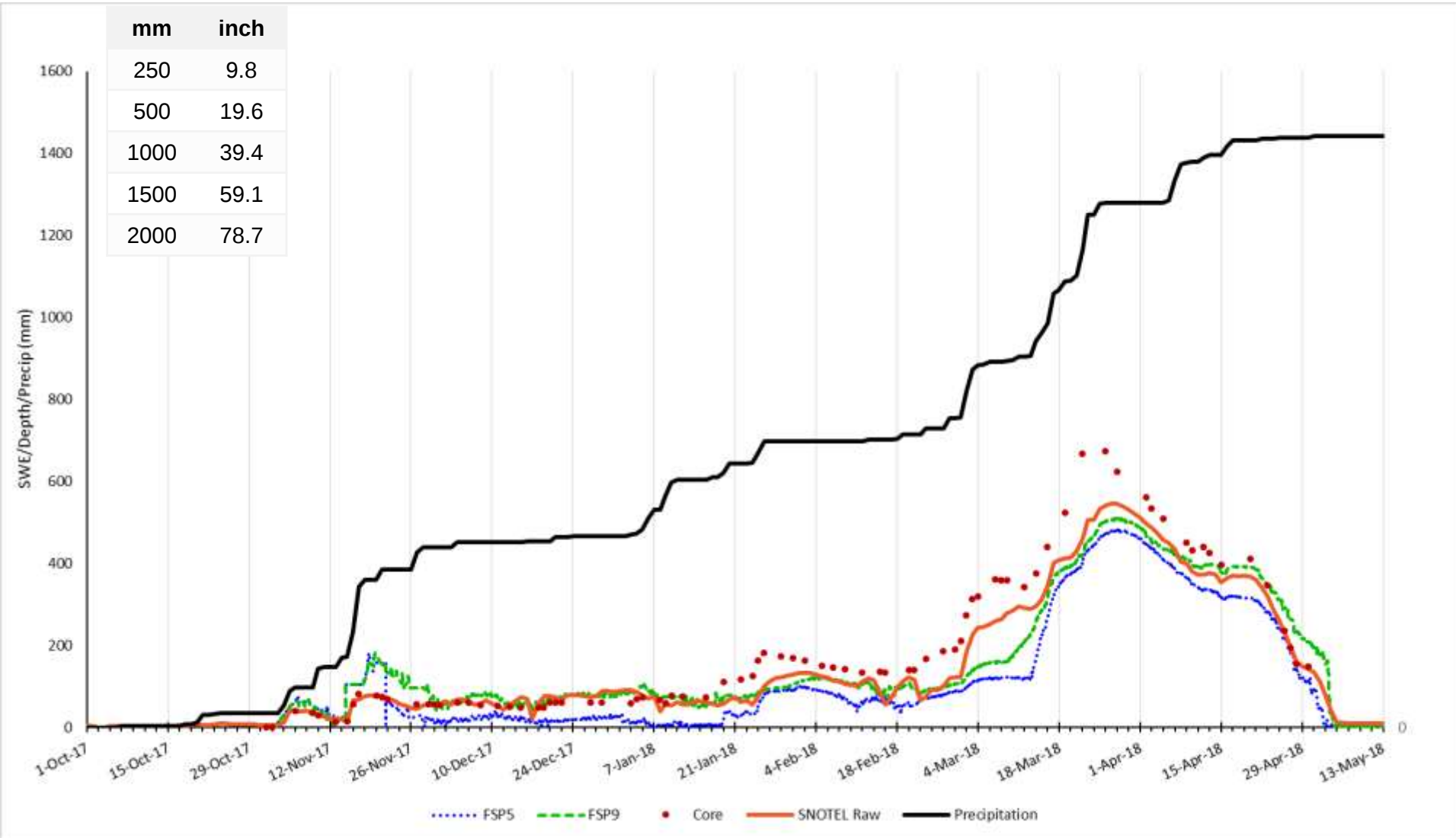
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



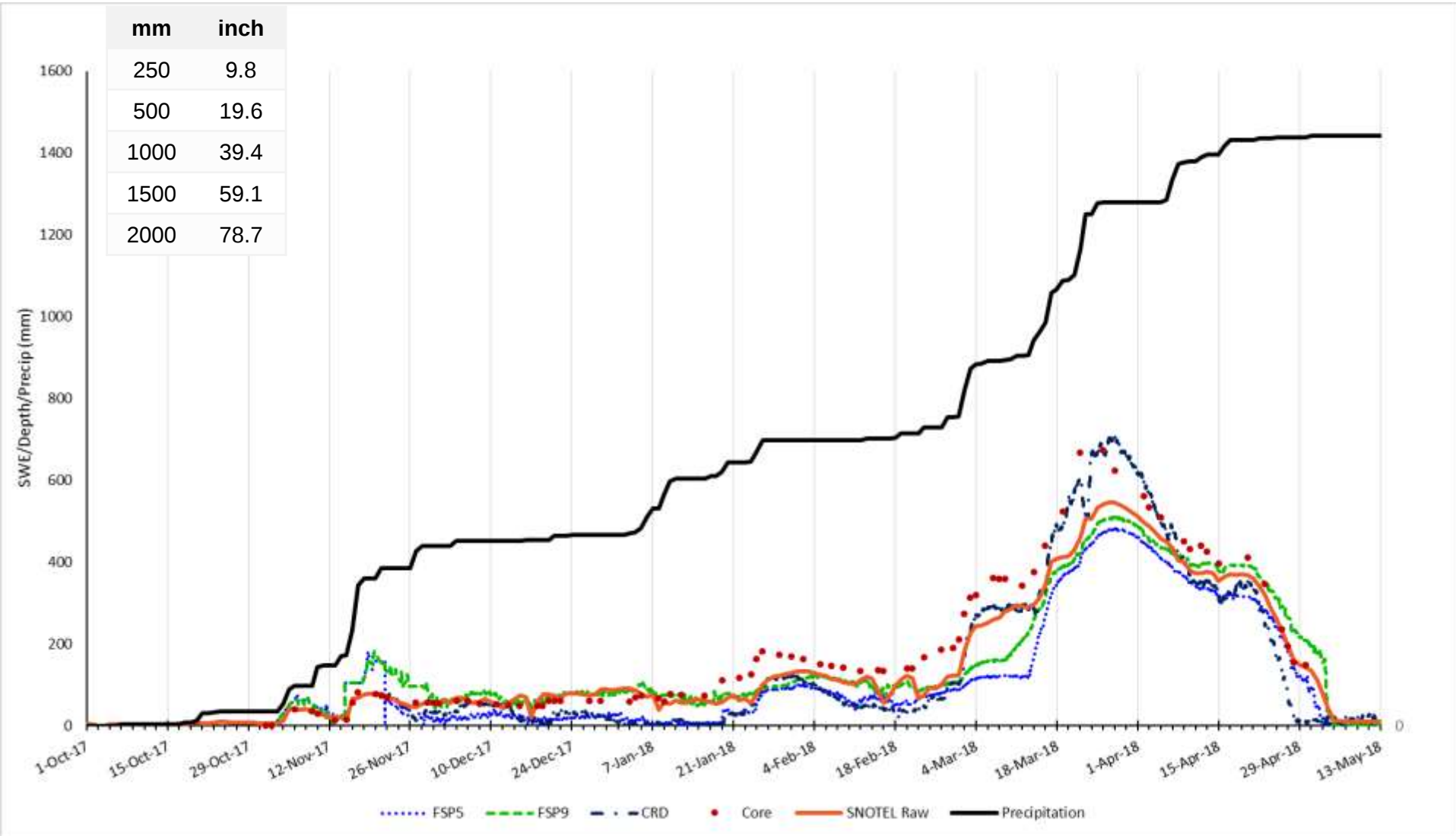
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



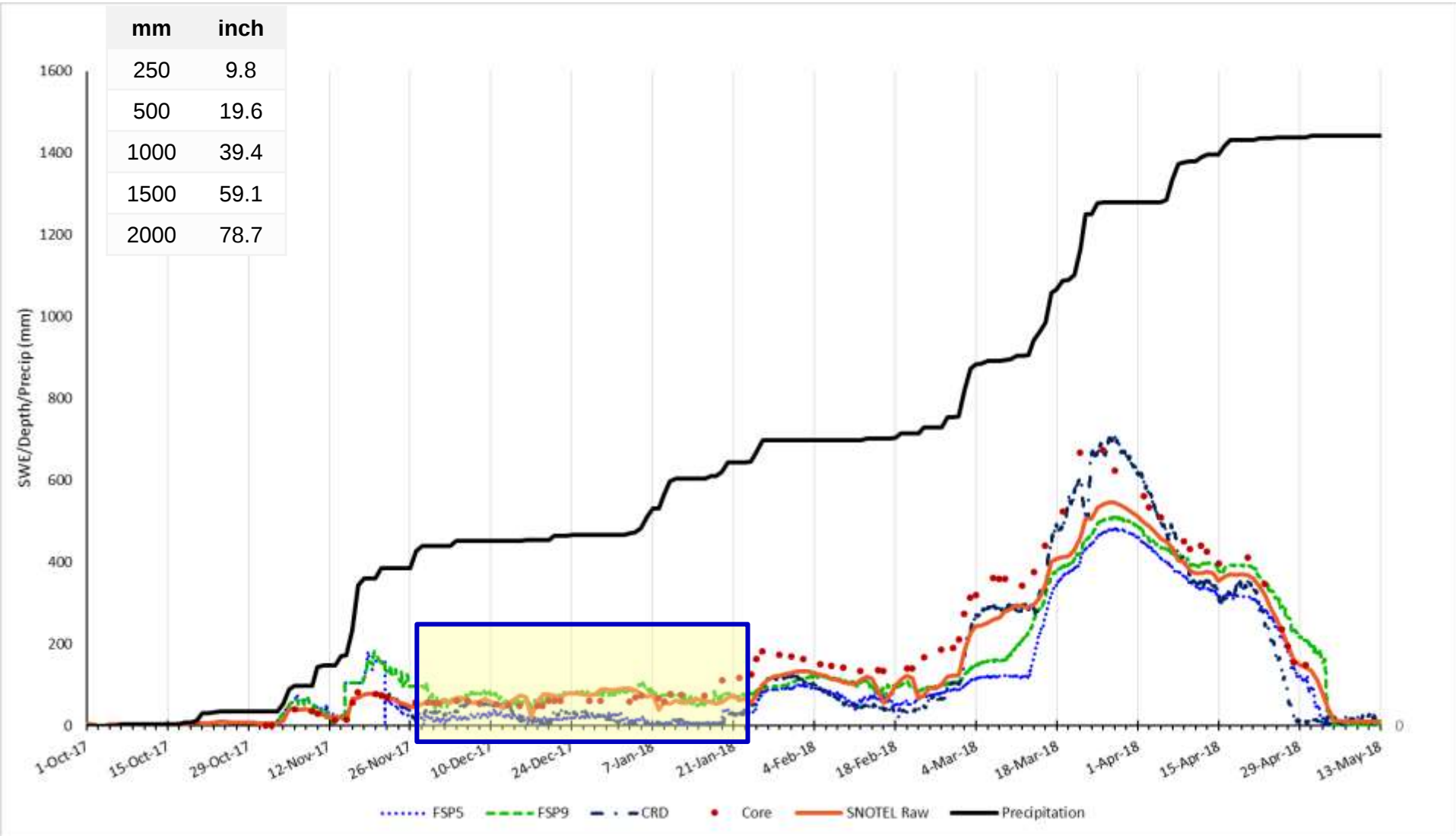
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements







Date & Time: Tue Feb 13 11:50:21 PST 2018

Position: +039.32569° / -120.36788°

Altitude: 6913ft

Datum: WGS-84

Azimuth/Bearing: 224° S44W 3982mils (True)

Elevation Angle: -12.7°

Horizon Angle: -00.9°

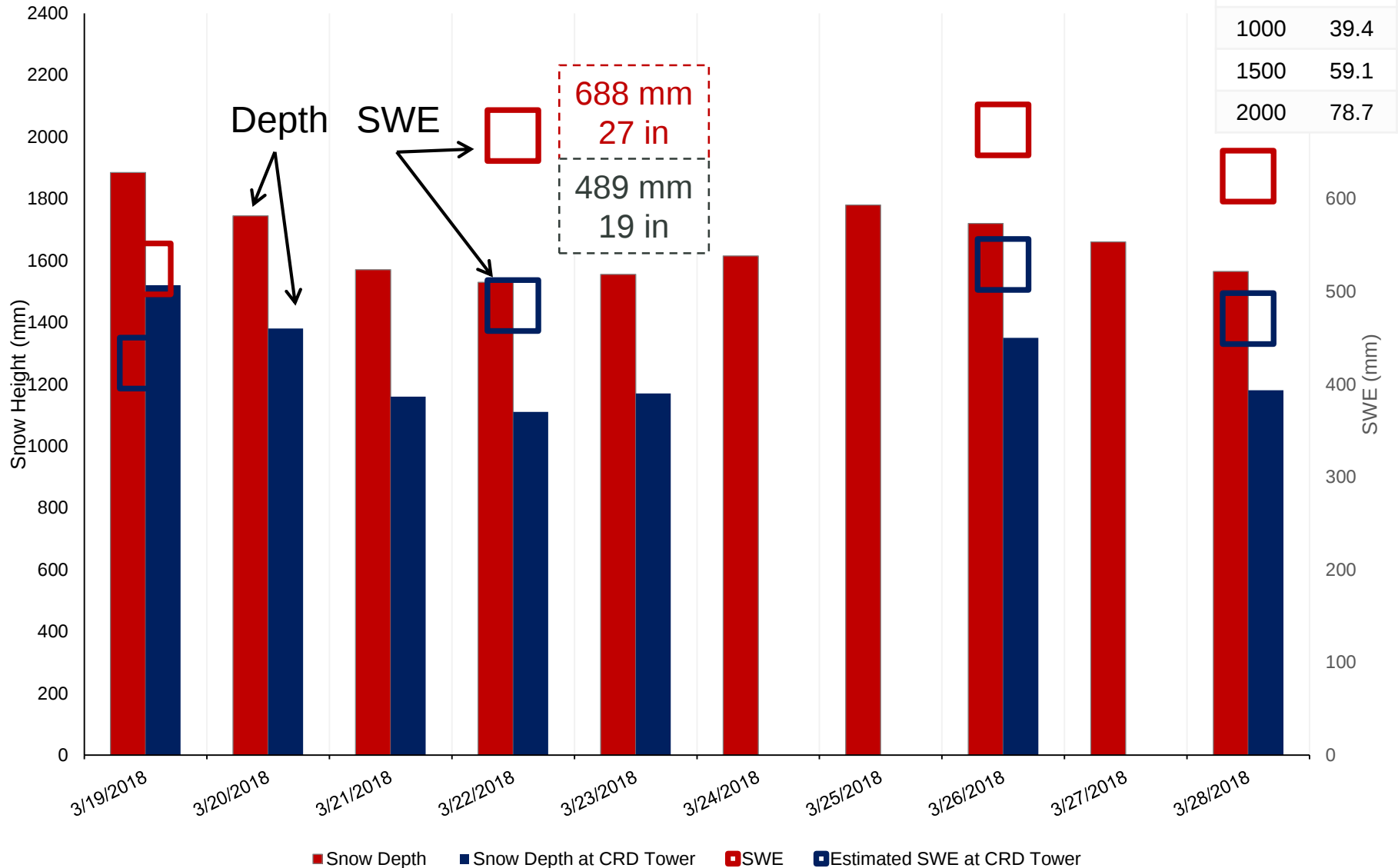
Zoom: 1X





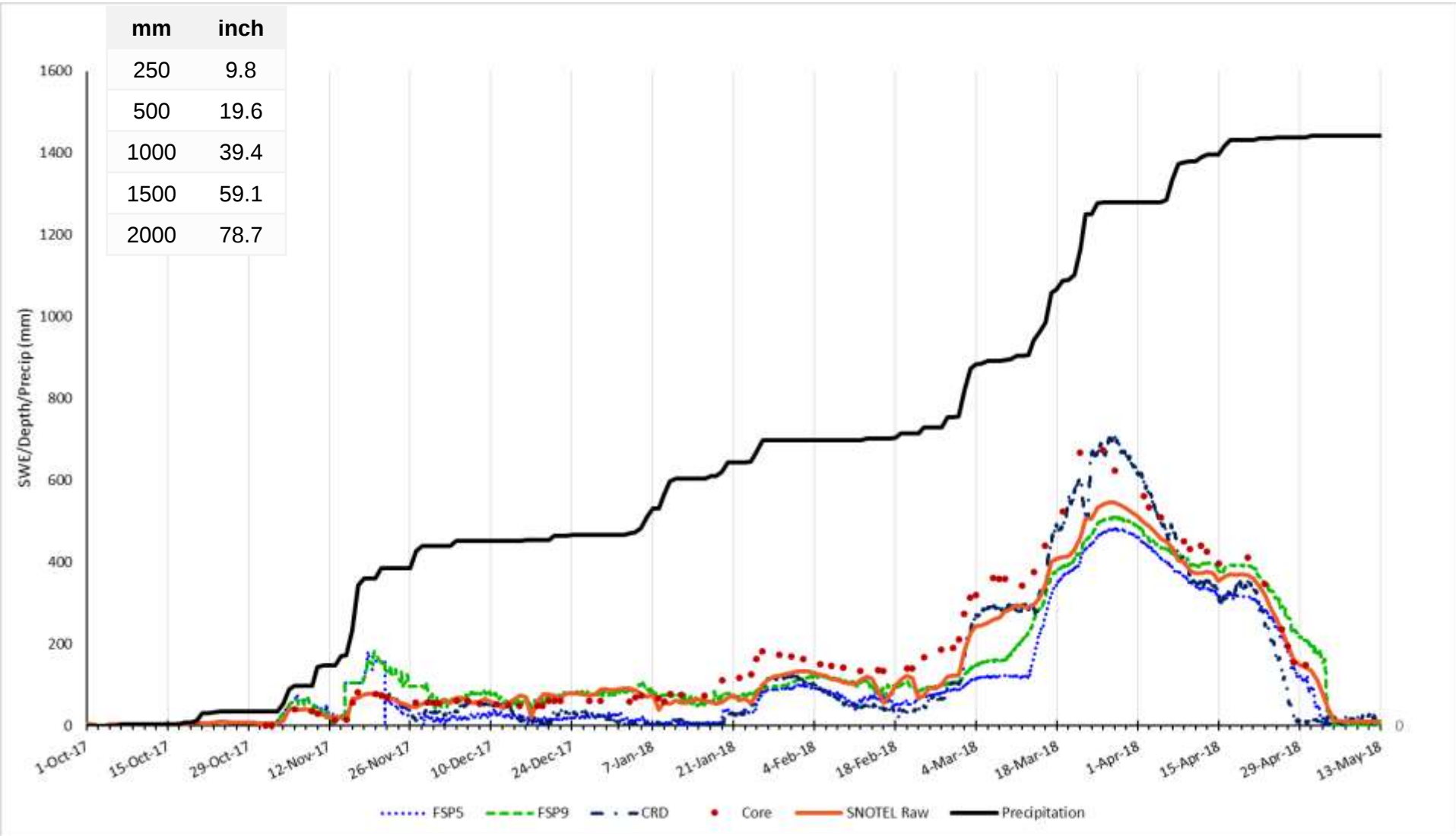
March 19, 2018

Test Field Distribution Snow Distribution March 19-28 2018



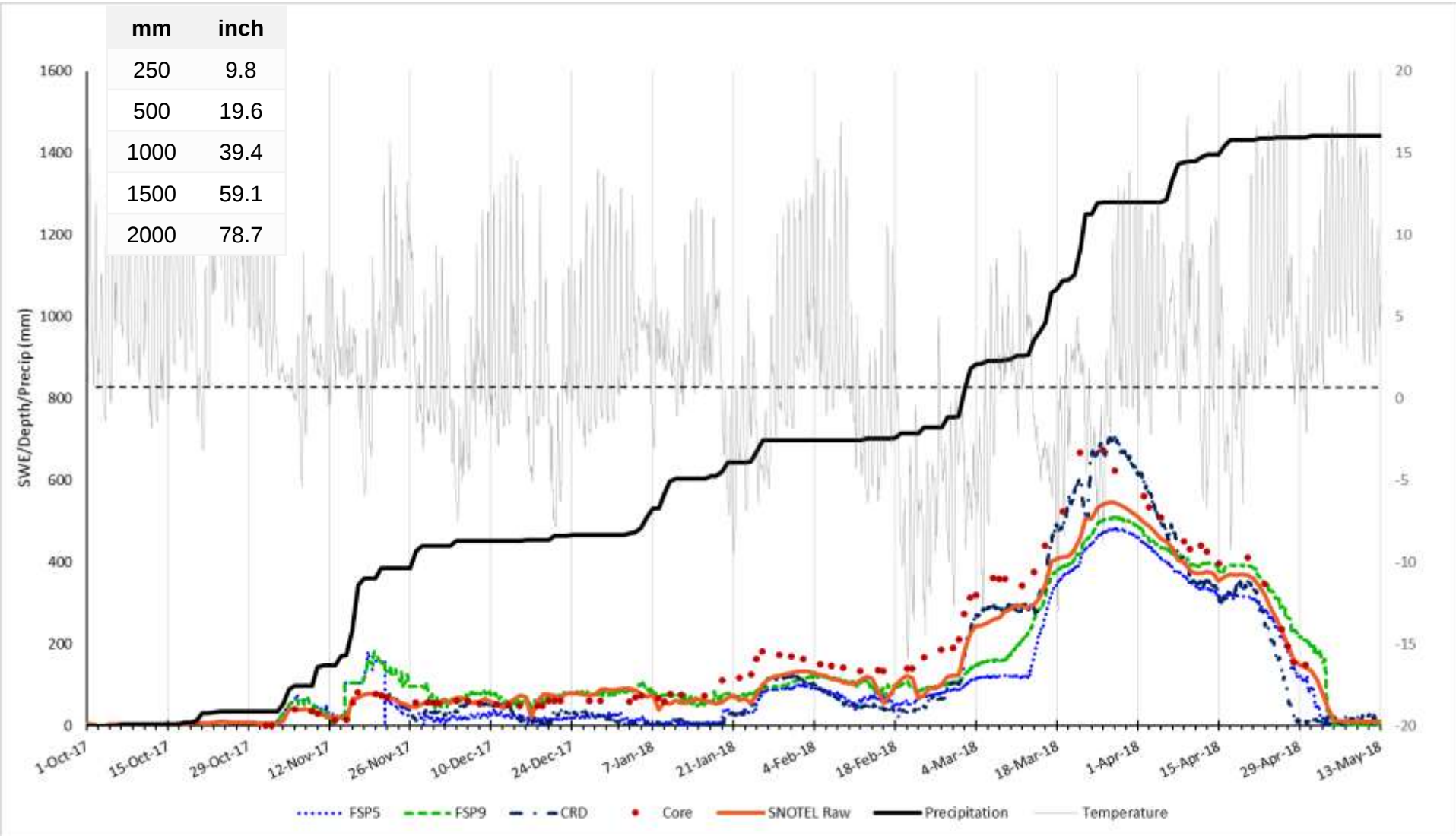
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



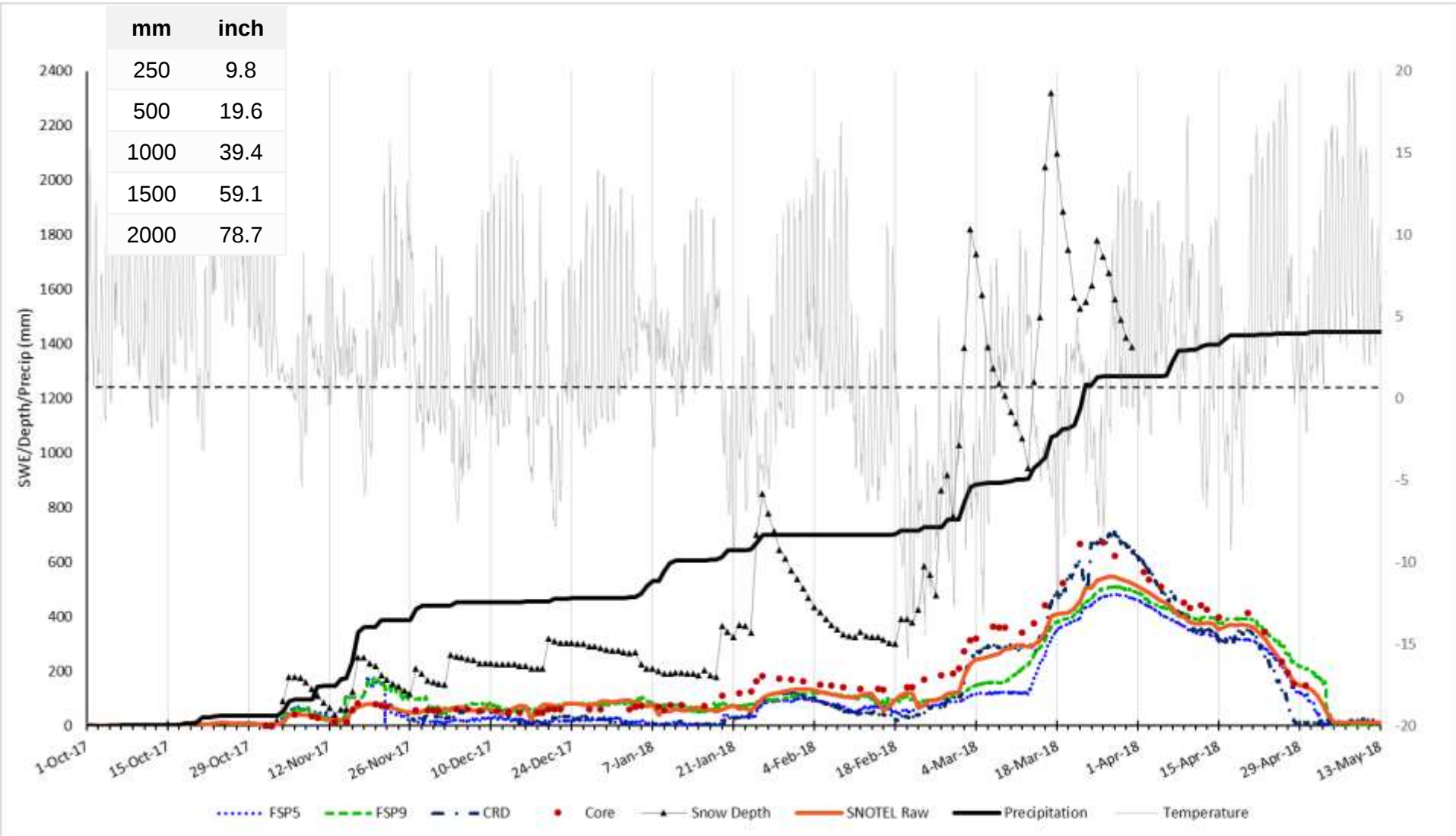
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



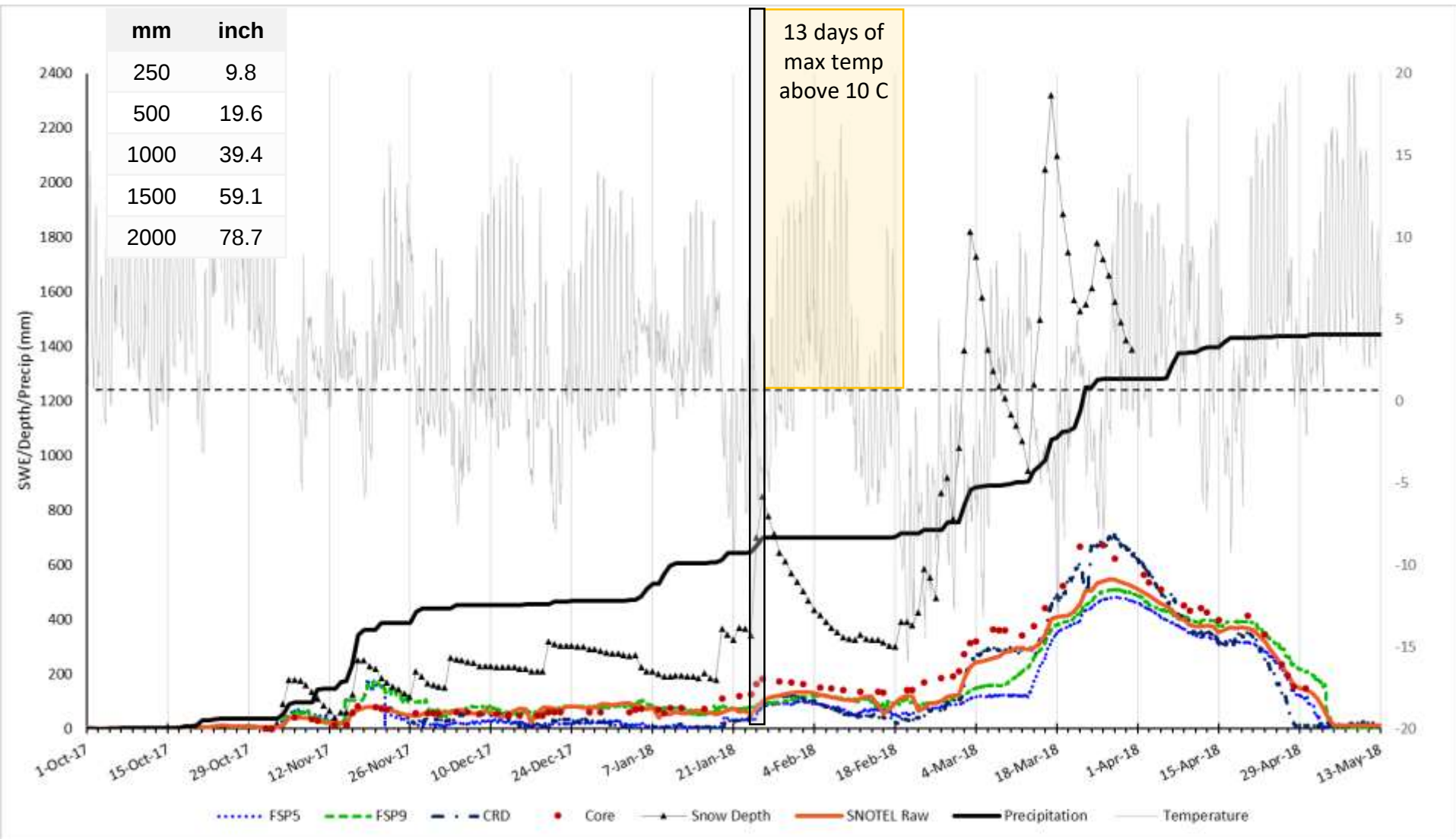
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



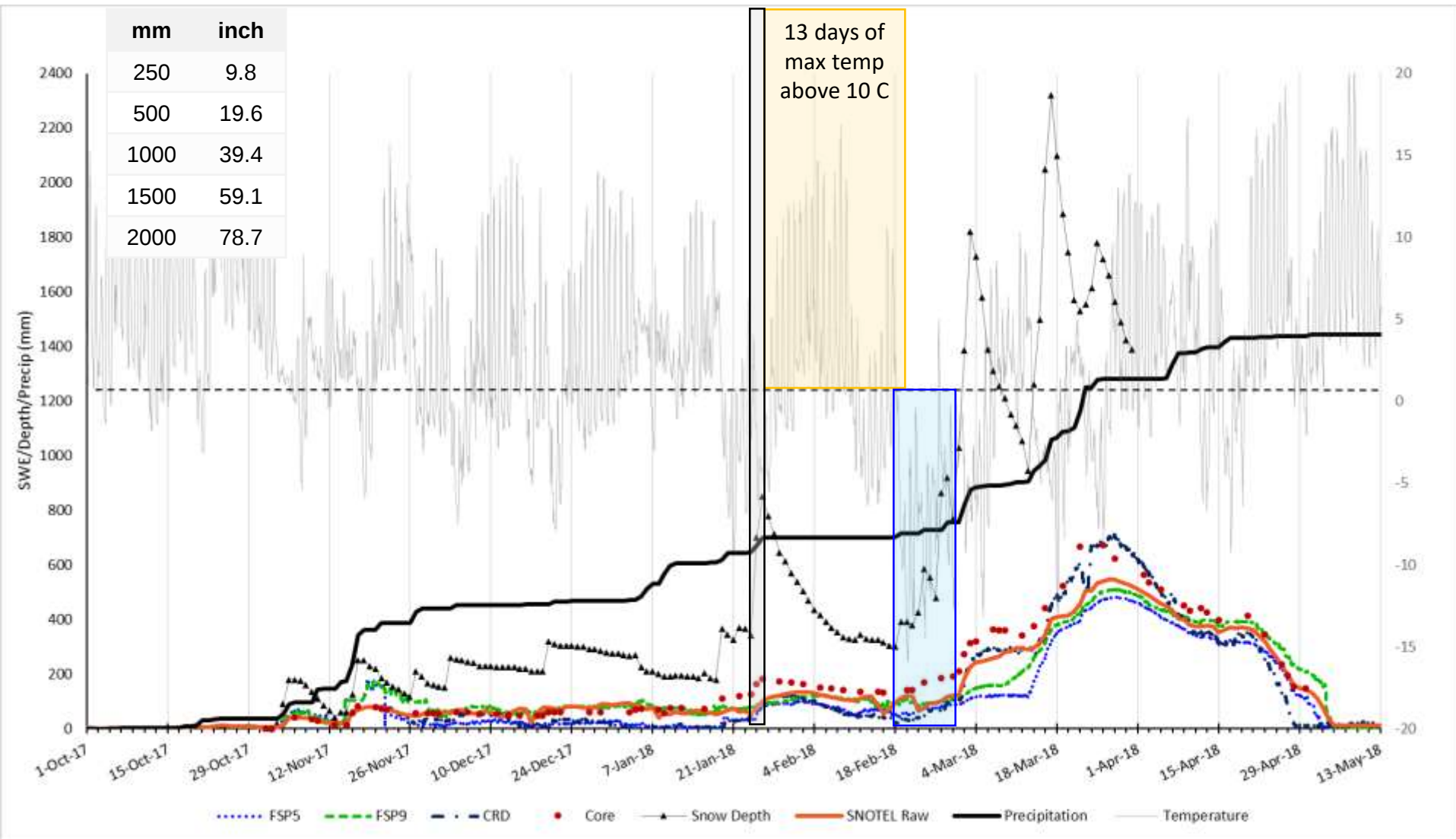
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



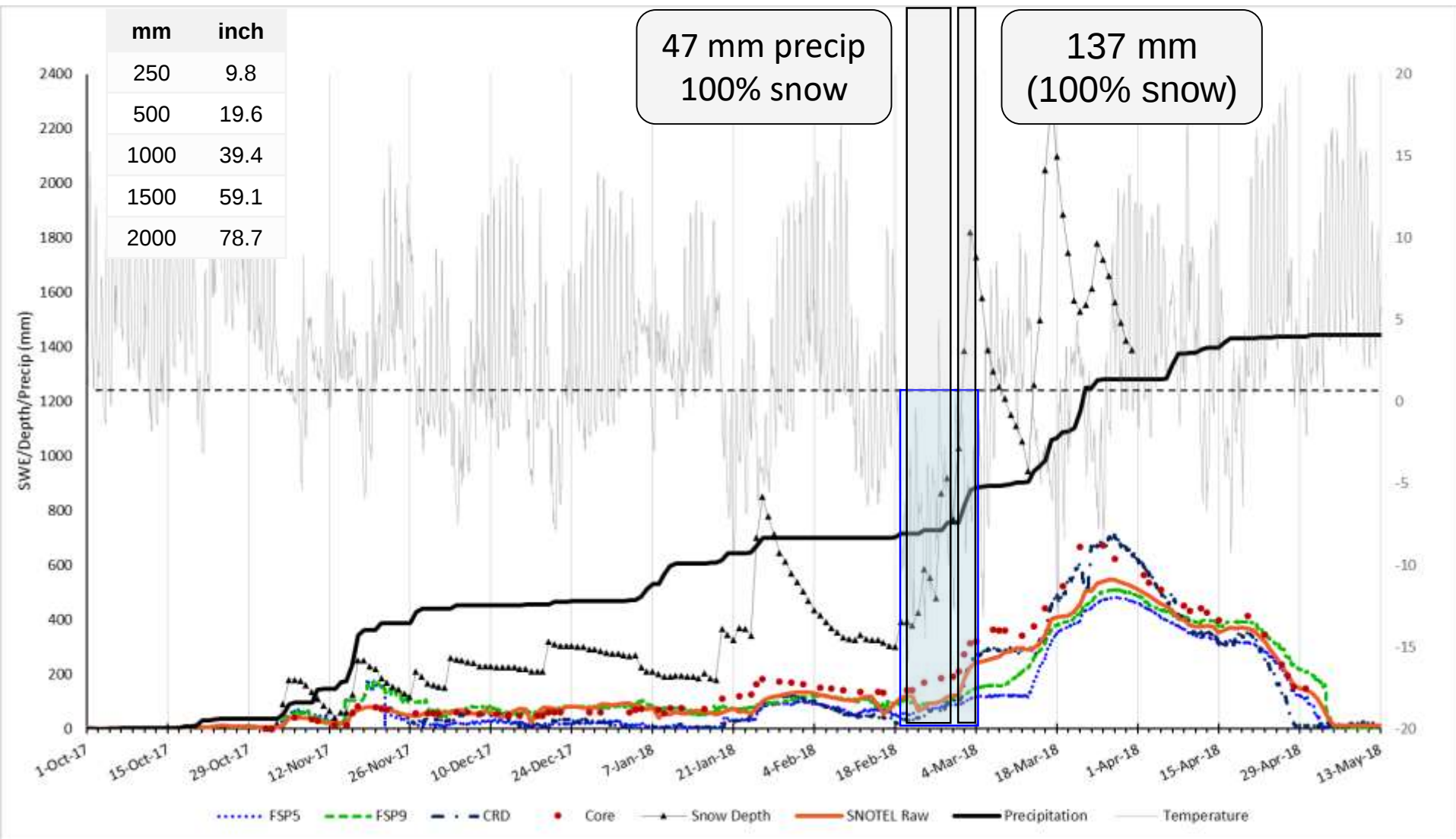
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements

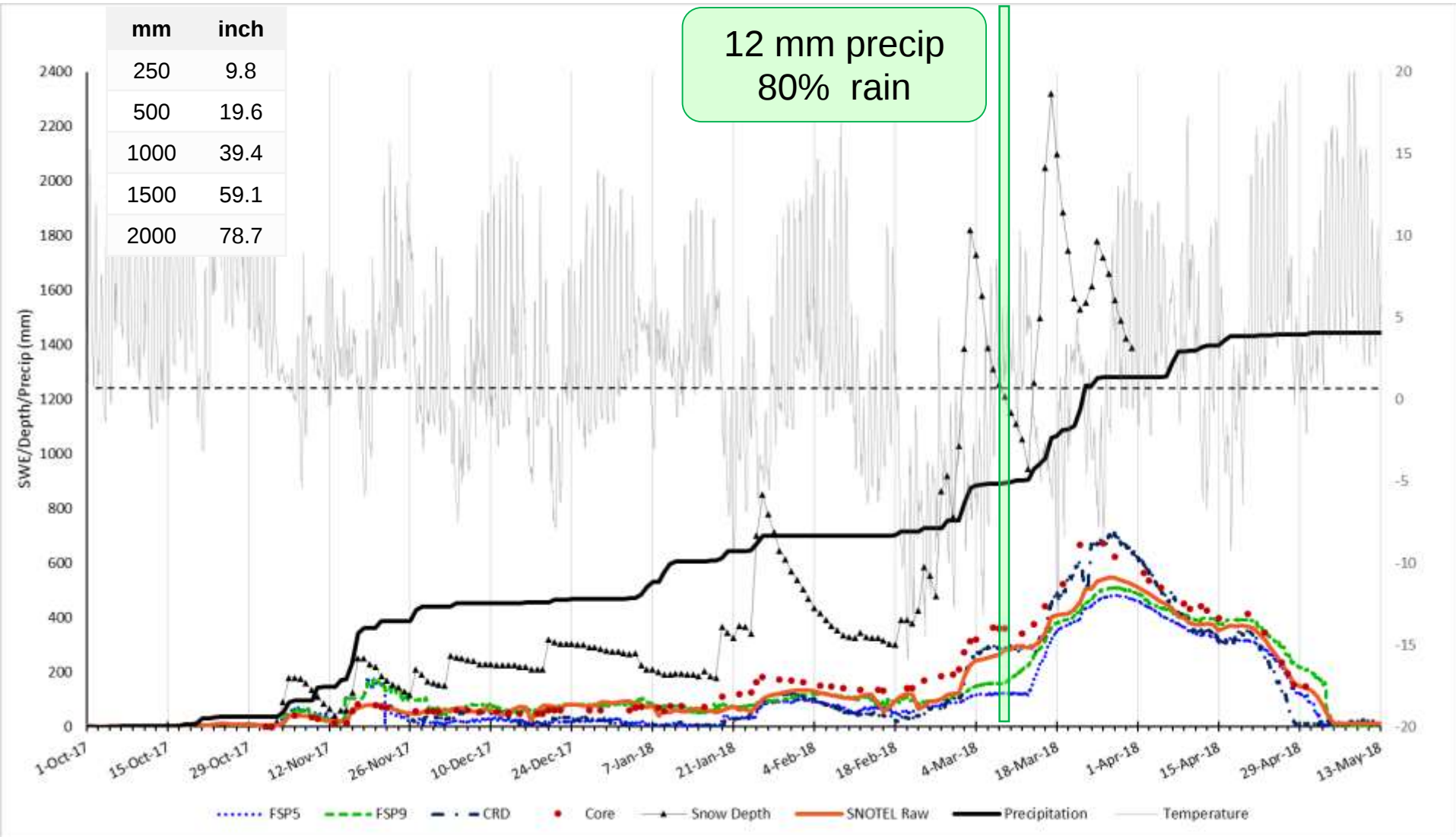


SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements

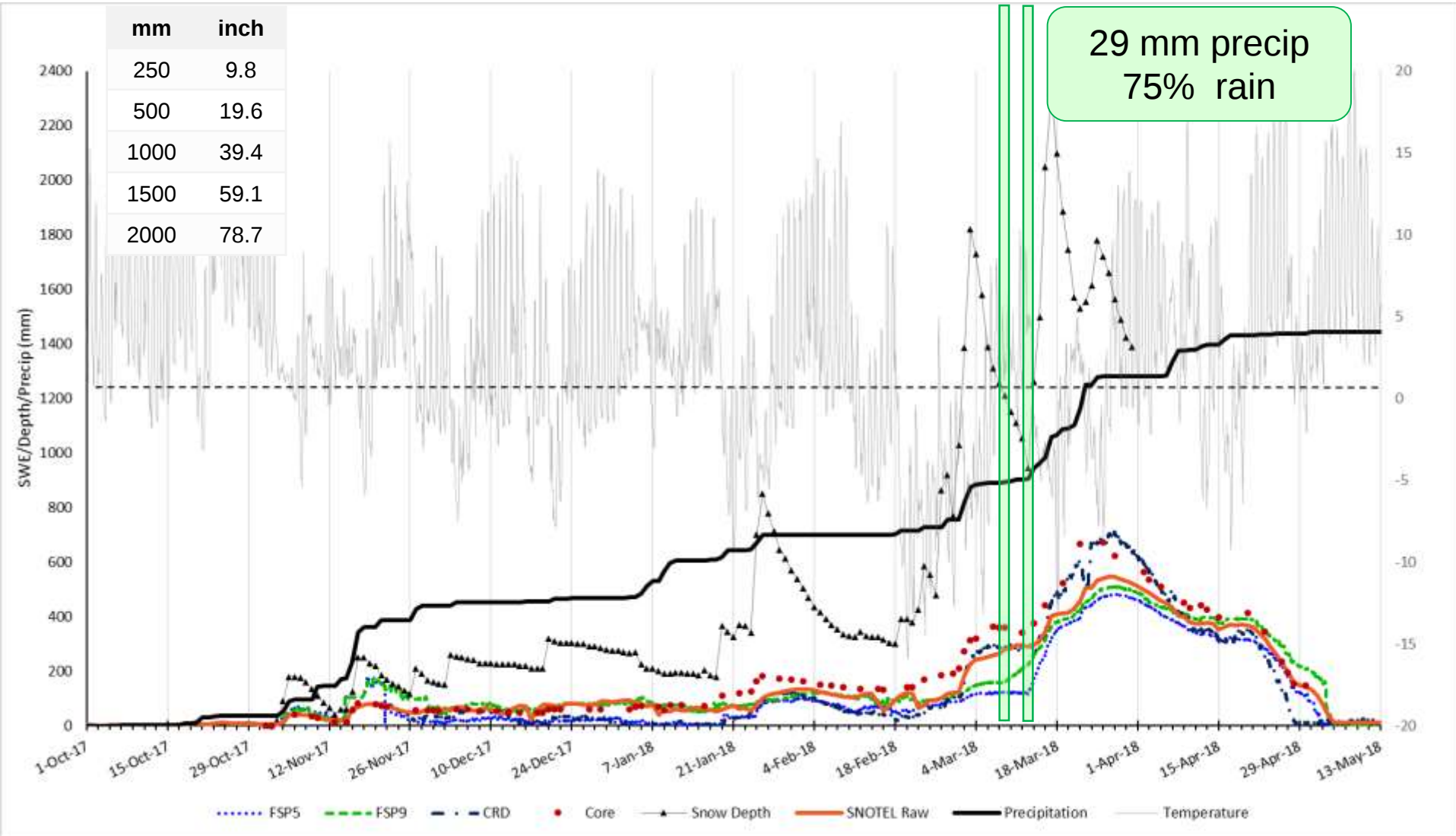
mm	inch
250	9.8
500	19.6
1000	39.4
1500	59.1
2000	78.7

12 mm precip
80% rain



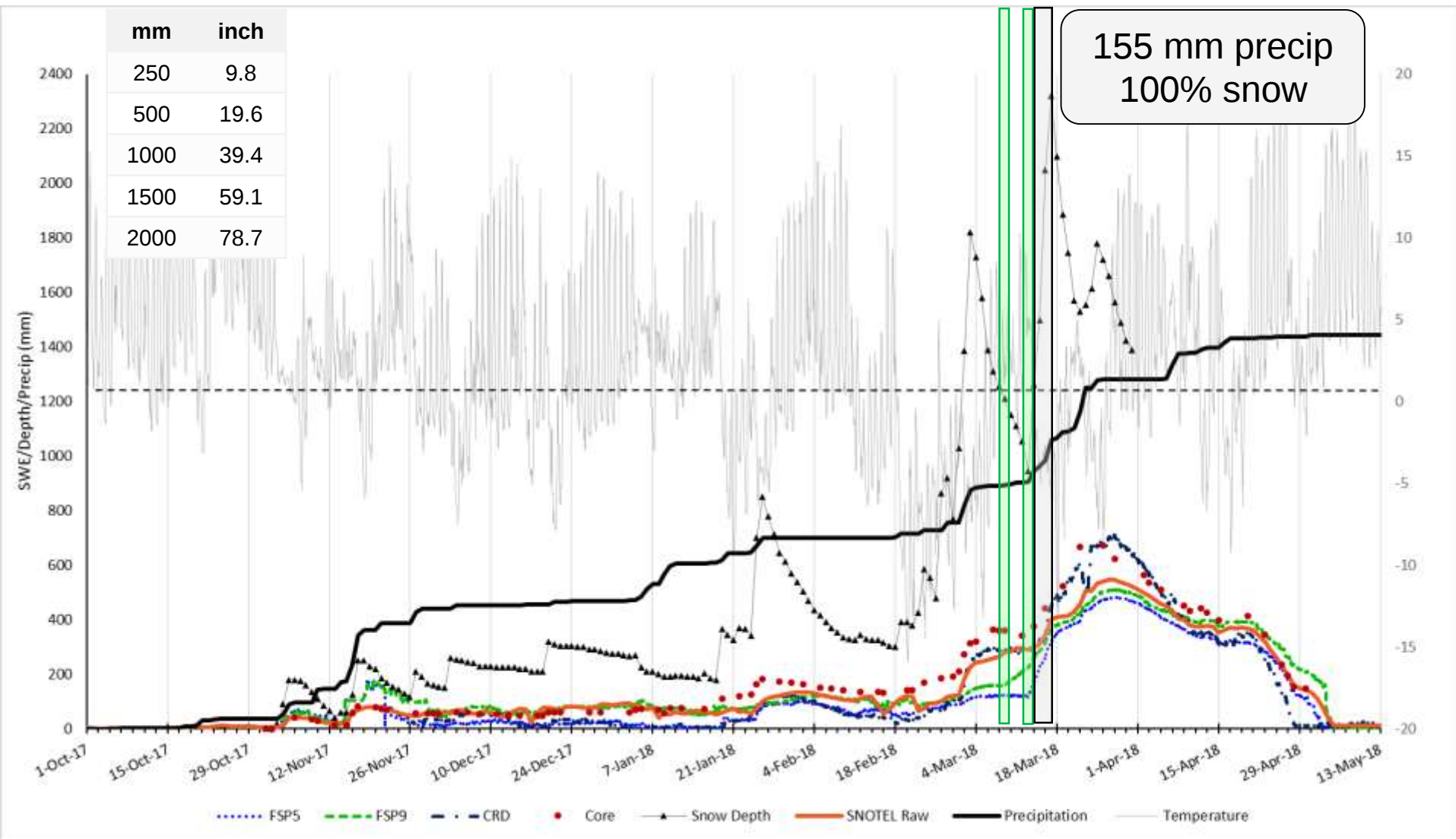
SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements

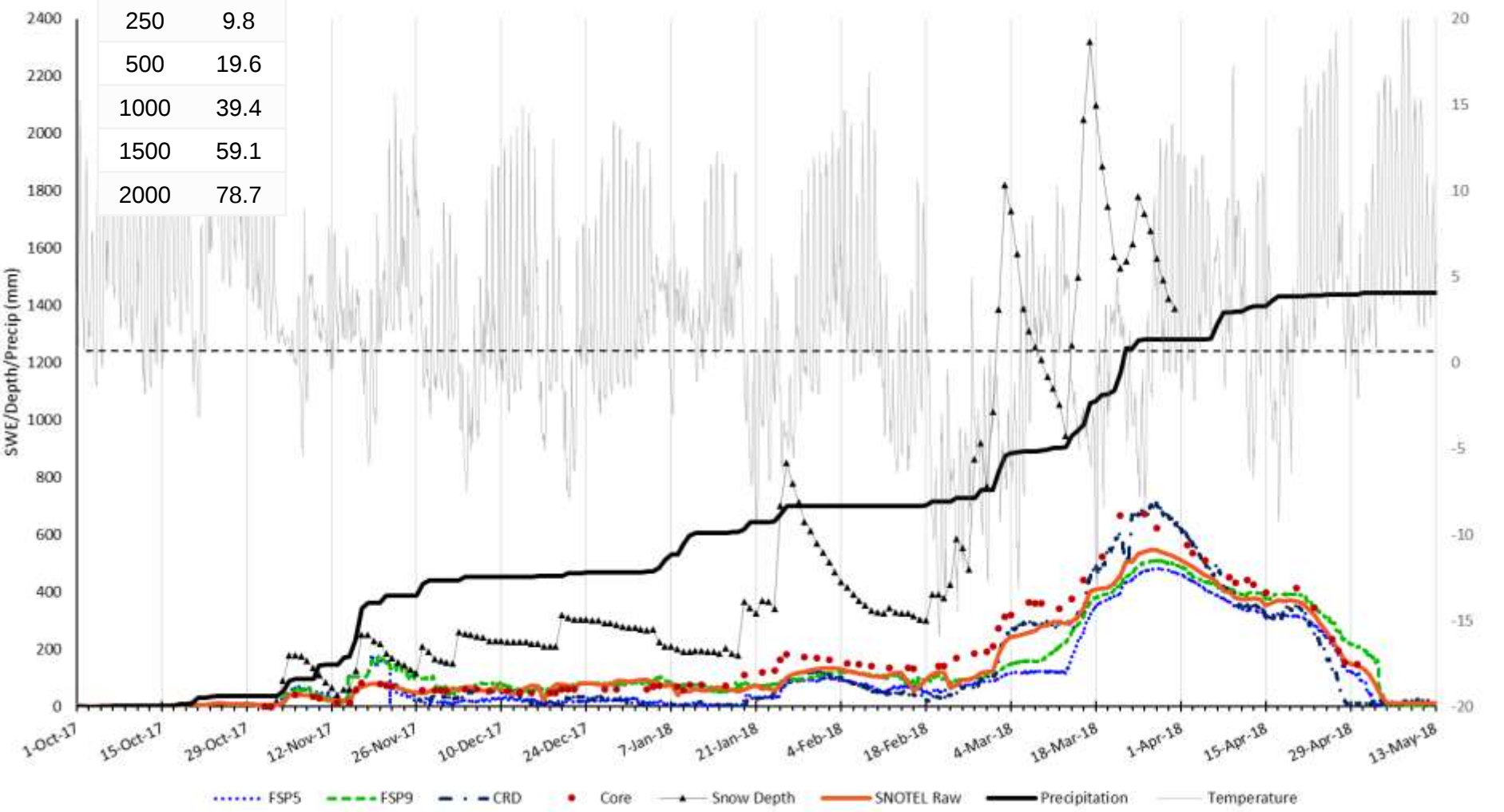


SWE Comparison Winter 2017-18

FSP5, FSP9, SNOTEL & Manual Measurements



mm	inch
250	9.8
500	19.6
1000	39.4
1500	59.1
2000	78.7





THANK YOU!



ALPINE
HYDROMET