Soil Moisture Sensors
a Practical Test

US Army Corps of Engineers
Sacramento District

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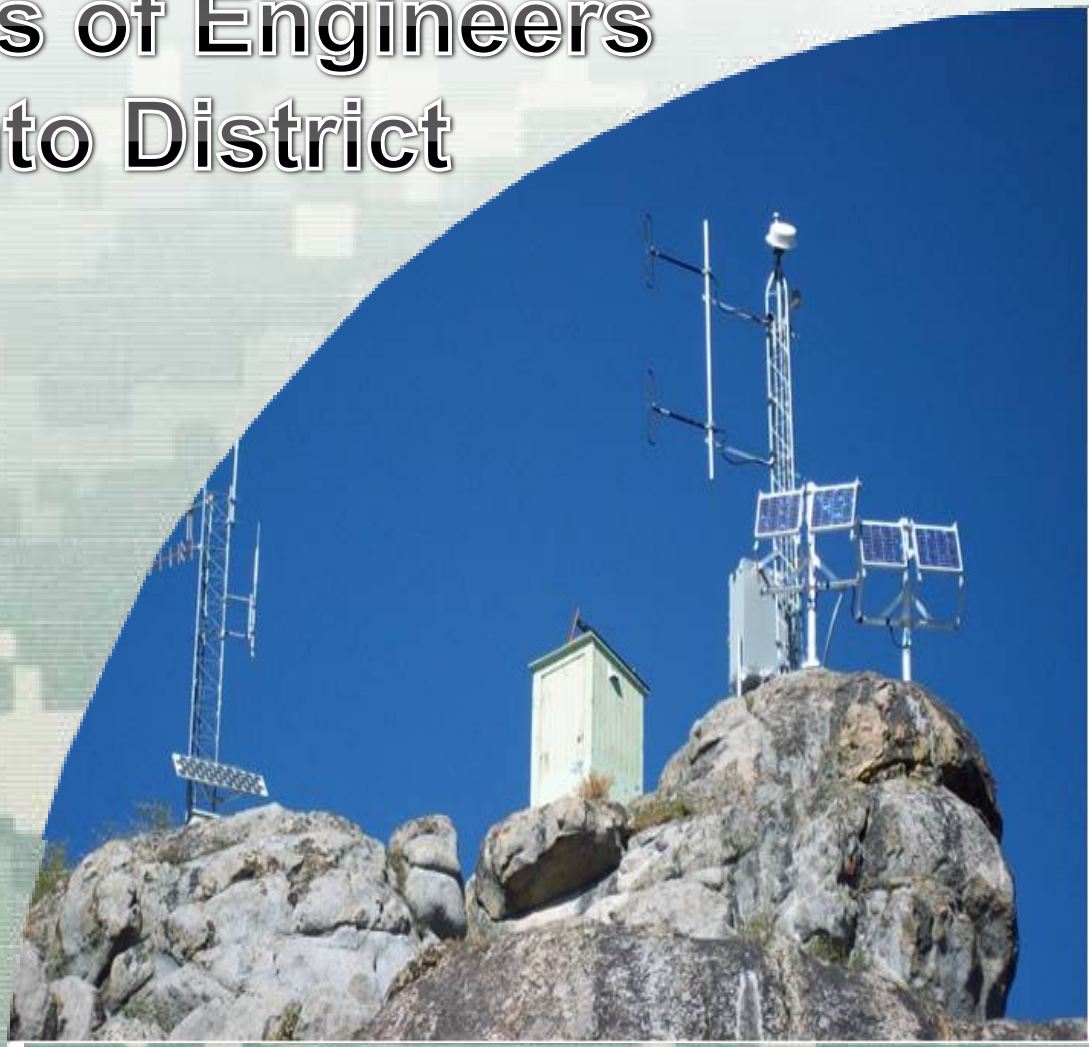
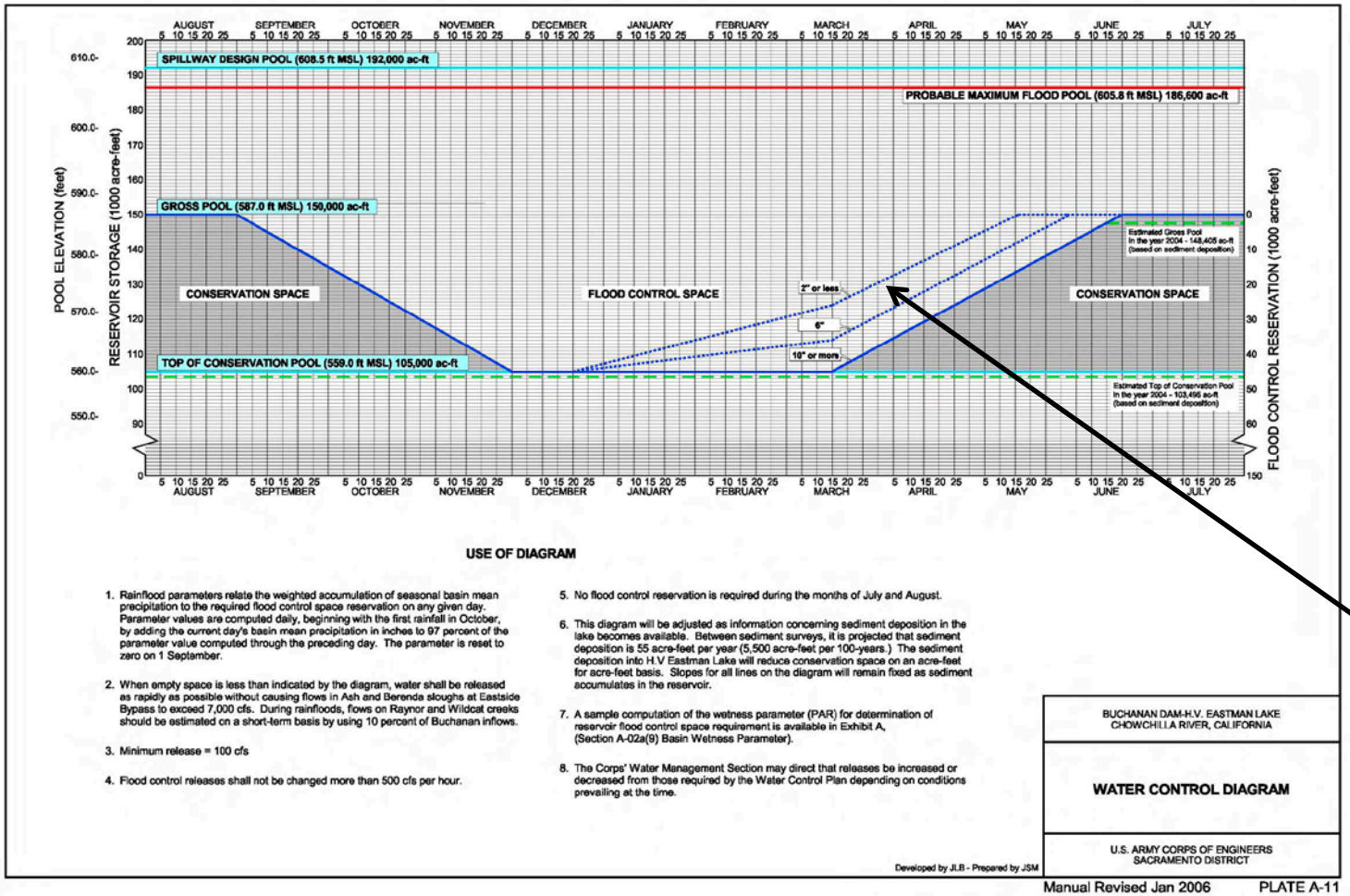


Why Soil Moisture Sensors?



USE OF DIAGRAM

1. Rainflood parameters relate the weighted accumulation of seasonal basin mean precipitation to the required flood control space reservation on any given day. Parameter values are computed daily, beginning with the first rainfall in October, by adding the current day's basin mean precipitation in inches to 97 percent of the parameter value computed through the preceding day. The parameter is reset to zero on 1 September.
2. When empty space is less than indicated by the diagram, water shall be released as rapidly as possible without causing flows in Ash and Berenda sloughs at Eastside Bypass to exceed 7,000 cfs. During rainfloods, flows on Raynor and Wildcat creeks should be estimated on a short-term basis by using 10 percent of Buchanan inflows.
3. Minimum release = 100 cfs
4. Flood control releases shall not be changed more than 500 cfs per hour.
5. No flood control reservation is required during the months of July and August.
6. This diagram will be adjusted as information concerning sediment deposition in the lake becomes available. Between sediment surveys, it is projected that sediment deposition is 55 acre-feet per year (5,500 acre-feet per 100-years.) The sediment deposition into H.V Eastman Lake will reduce conservation space on an acre-feet for acre-feet basis. Slopes for all lines on the diagram will remain fixed as sediment accumulates in the reservoir.
7. A sample computation of the wetness parameter (PAR) for determination of reservoir flood control space requirement is available in Exhibit A, (Section A-02a(9) Basin Wetness Parameter).
8. The Corps' Water Management Section may direct that releases be increased or decreased from those required by the Water Control Plan depending on conditions prevailing at the time.

BUCHANAN DAM-H.V. EASTMAN LAKE
CHOWCHILLA RIVER, CALIFORNIA

WATER CONTROL DIAGRAM

U.S. ARMY CORPS OF ENGINEERS
SACRAMENTO DISTRICT

Developed by JLB - Prepared by JSM

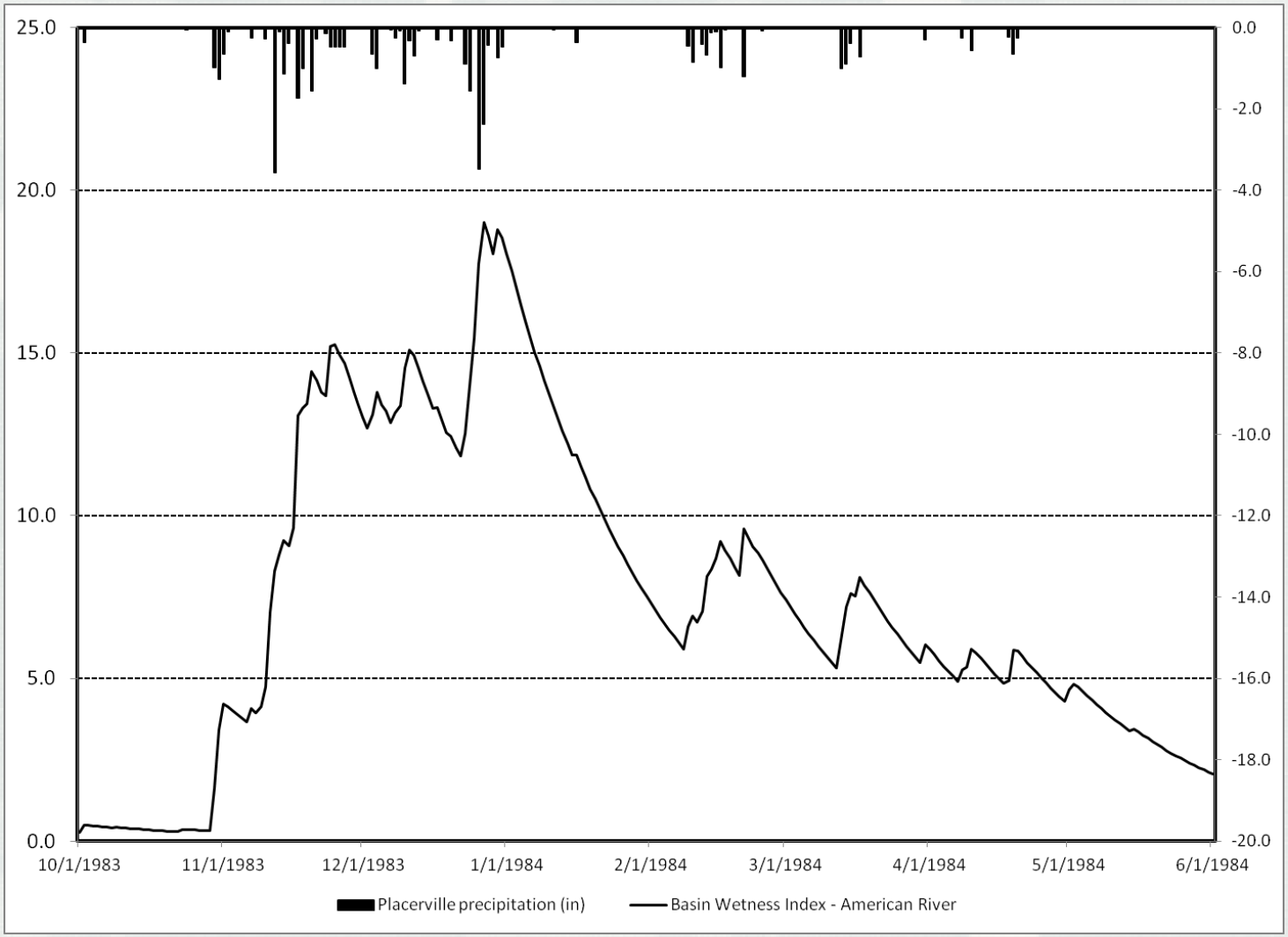
Manual Revised Jan 2006 PLATE A-11

Basin Wetness Index

The "Basin Wetness Index"

Typical Basin Wetness Index

(Decayed Rainfall Parameter)



Purpose and Shortcomings of The Basin Wetness Index

- Purpose:

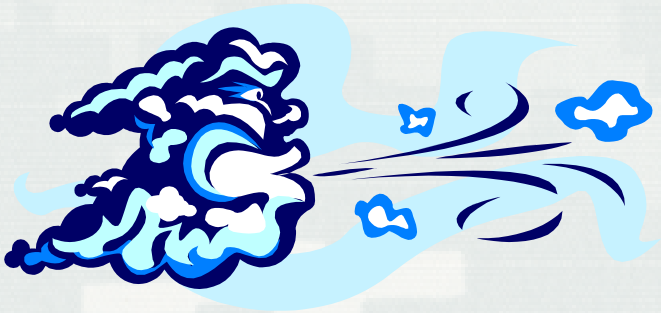
  To quantify ground saturation for runoff prediction

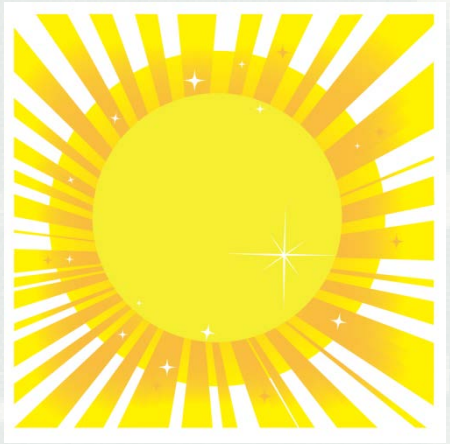
- Shortcomings:

  Does not consider temperature, humidity or wind effects

Perceived Advantage of Soil Moisture Sensing

Soil moisture is a function of rainfall, temperature, humidity, wind effects and soil make up



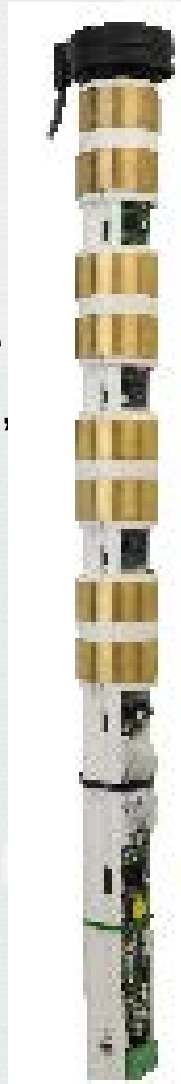


Practical Requirements for SMS

- Installed with Minimal Equipment and Manpower
- Minimal Disturbance of Local Soil Profiles
- Little or No Requirement for Laboratory Characterization of Soil
- Easily Repaired or Replaced
- Standard Data Bus
- Low Power & Light in Weight
- Commiserate with the Cost of Other Sensors

Army Corps Test Design

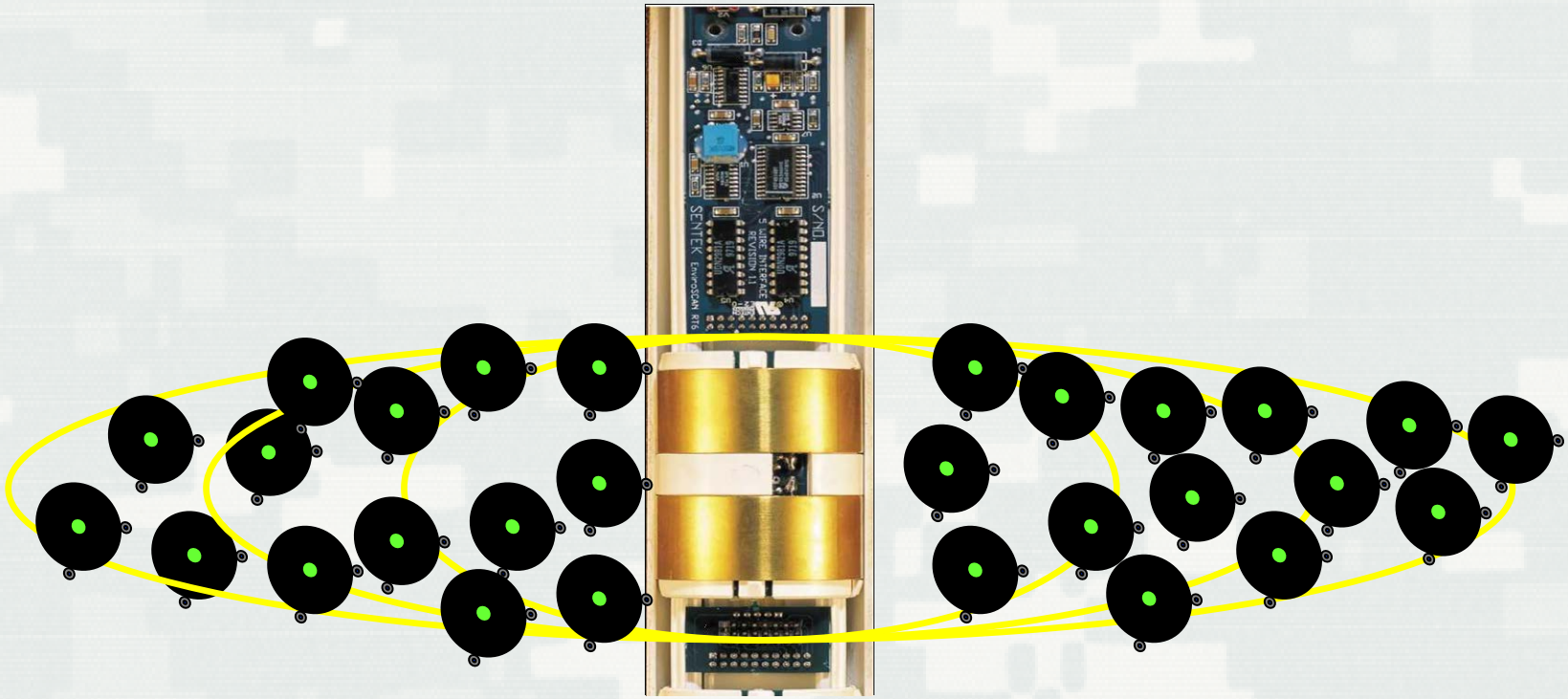
- Selected “Sentek” Sensors
  - By creating a high frequency electrical field around the sensor, extending through the access tube into the surrounding soil, the sensors detect the changes in dielectric constant, or permittivity, of the soil over time. At high frequency the measurement is affected predominantly by water molecules. The greater the amount of water, the smaller the frequency measured between the two brass rings of the sensor.
  - The soil moisture sensor gives an output in volumetric water content (mm of water per 100 mm of soil measured or %). This is converted from a scaled frequency reading using a default calibration equation, which is based on data obtained from numerous scientific studies in a range of soil textures.



http://www.sentek.com.au/products/sensors.asp#soil

Sentek “EnviroSCAN”

Measurement of Water



Army Corps Test Design

- Installed at Martis Dam Snow Lab (Truckee, CA) ~ Nov 2012

Army Corps Test Design

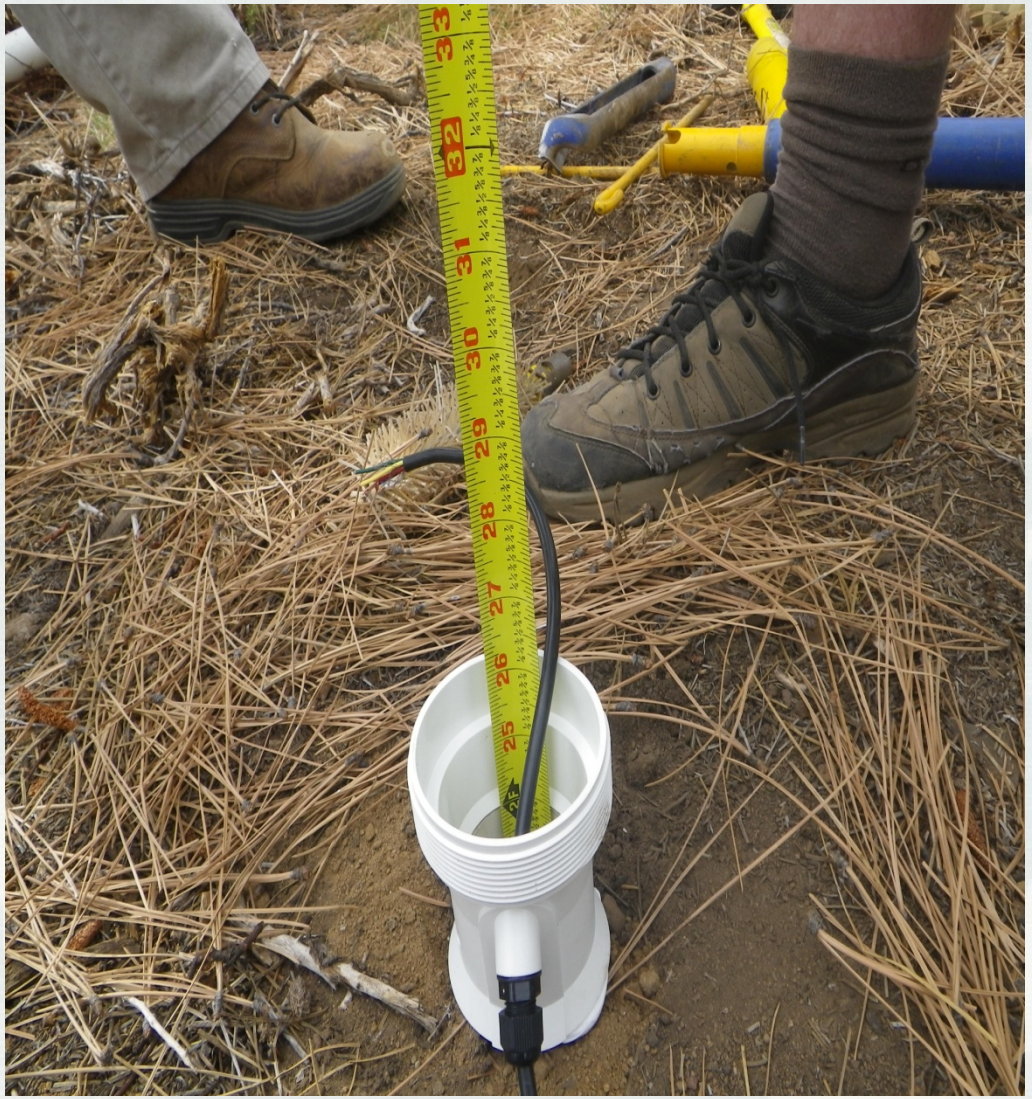
- Three SMS arrays installed:
  - North: 4”, 8”, 12”, 16”, 24”, 32” 40”
  - South: 4”, 8”, 12”, 16”, 24”, 32” 40”
  - Center: 4”, 8”, 12”, 16”, 20”, 24”
- Precipitation, Temp, Humidity and Wind Speed Sensors also in Station
- SDI Bus

Installation -
Step #1 – Find a Suitable Location & Drill Hole

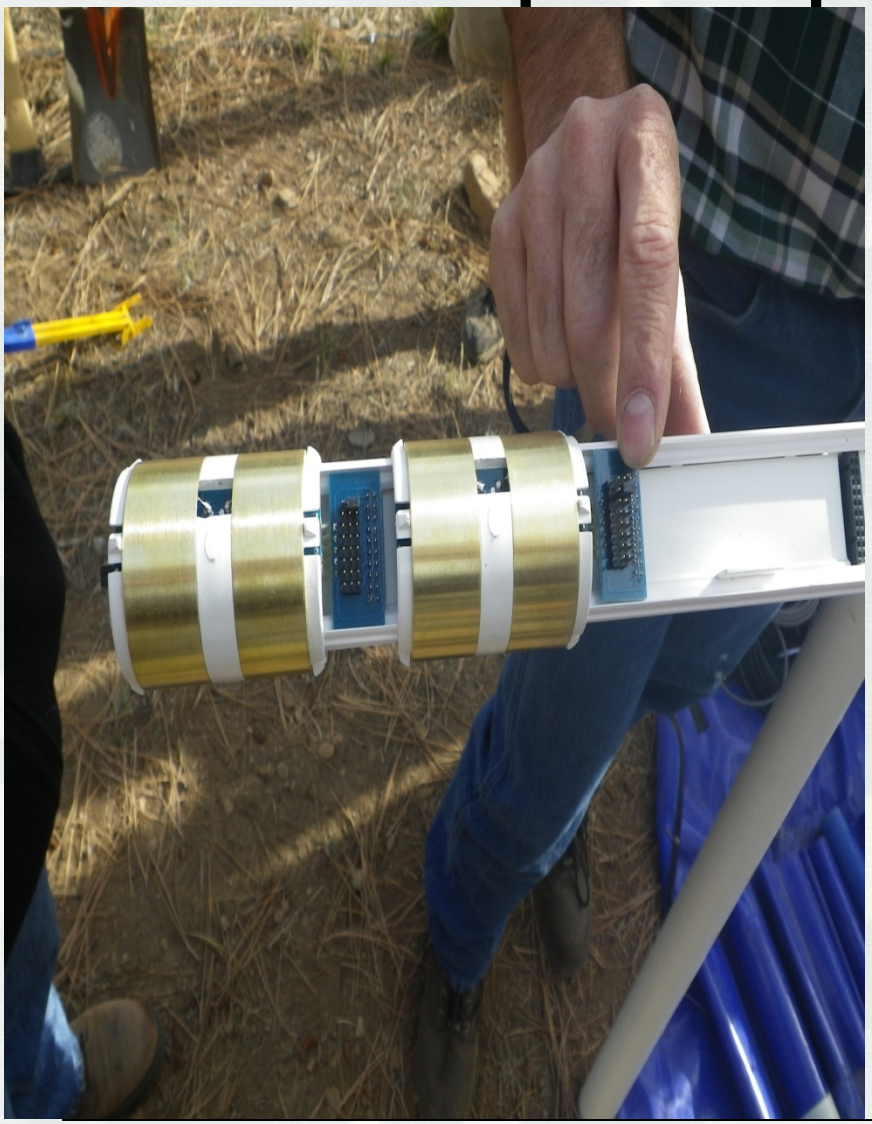
Installation -
Step #1.1 Get a BIGGER Drill & Save Samples

Installation -
Step #2 Prepare Casing and Drive into Soil

Installation -
Step #3 Cut, Clean, Plug and Measure Casing



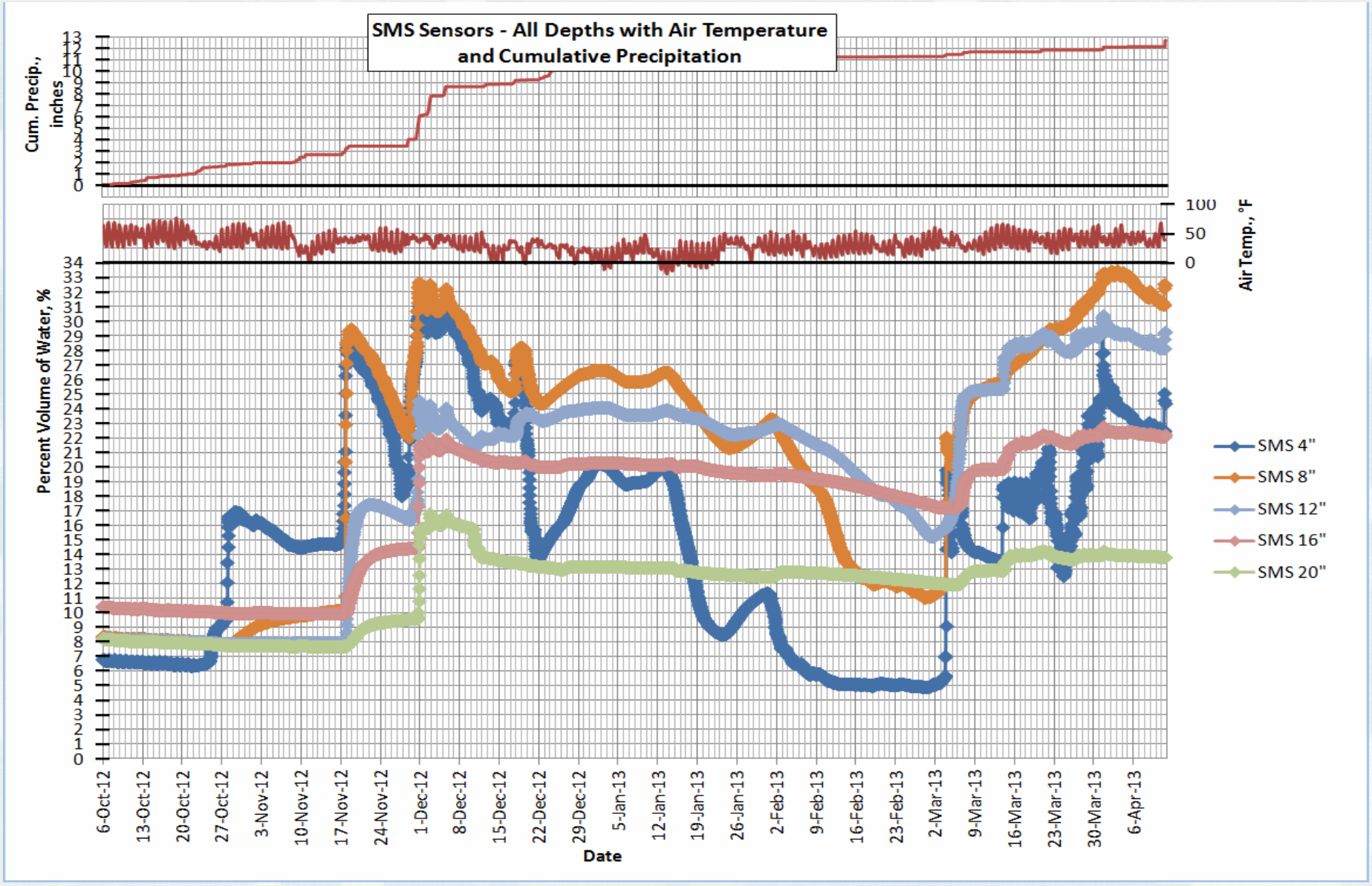
Installation -
Step #4 Prepare Sensor Array



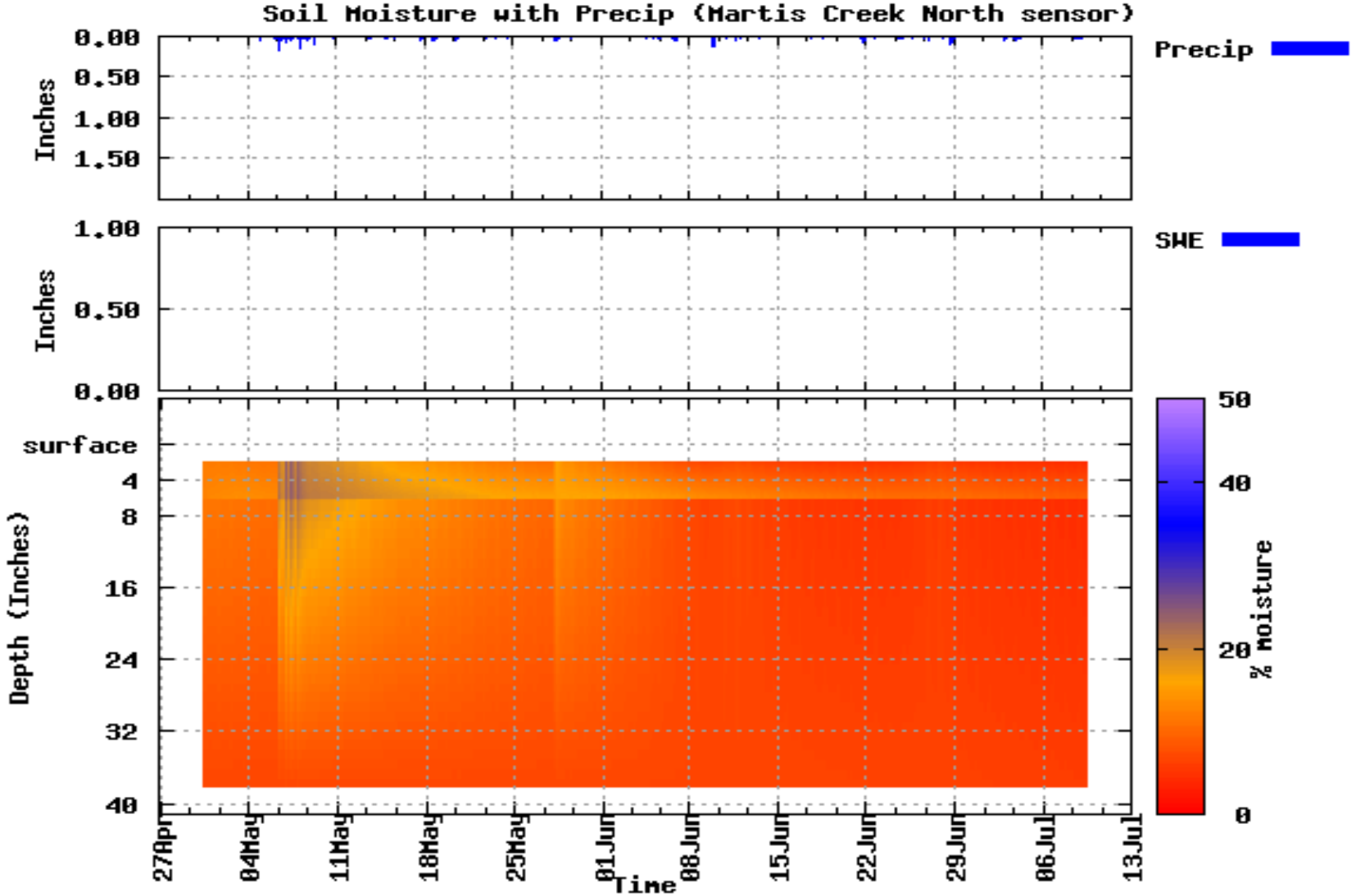
Installation -
Step #5 Insert Array and Wire to Logger

Maintenance -
Step #6 Easy Periodic Maint or Repair

Data (Graph 1)


SMS Sensors - All Depths with Air Temperature and Cumulative Precipitation
Cum. Precip., inches
Air Temp., °F
Percent Volume of Water, %
Date
SMS 4"
SMS 8"
SMS 12"
SMS 16"
SMS 20"

Data (Graph 2)


Soil Moisture with Precip (Martis Creek North sensor)
Inches
0.00
0.50
1.00
1.50
Precip
Inches
1.00
0.50
0.00
SWE
Depth (Inches)
surface
4
8
16
24
32
40
27Apr
04May
11May
18May
25May
01Jun
08Jun
15Jun
22Jun
29Jun
06Jul
13Jul
Time
50
40
20
0
% moisture

Conclusions

- “Pretty Easy” installation
- Very reliable for 1st year
- Easy to interface with (Sutron/SDI) logger
- “Volumetric” measure is intuitive
- DG saturation ~ 35%
- Unsure of “freezing” effect
- Graphs appear reasonable
- Dry winter yielded minimal data
- Will require years of data prior to inclusion in models

Questions?