Applications for Internet of Things (IoT) for Improved Agricultural Operational Efficiency

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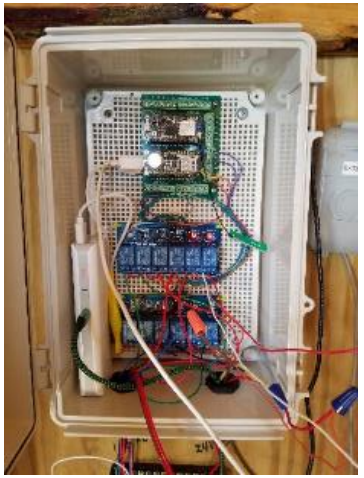

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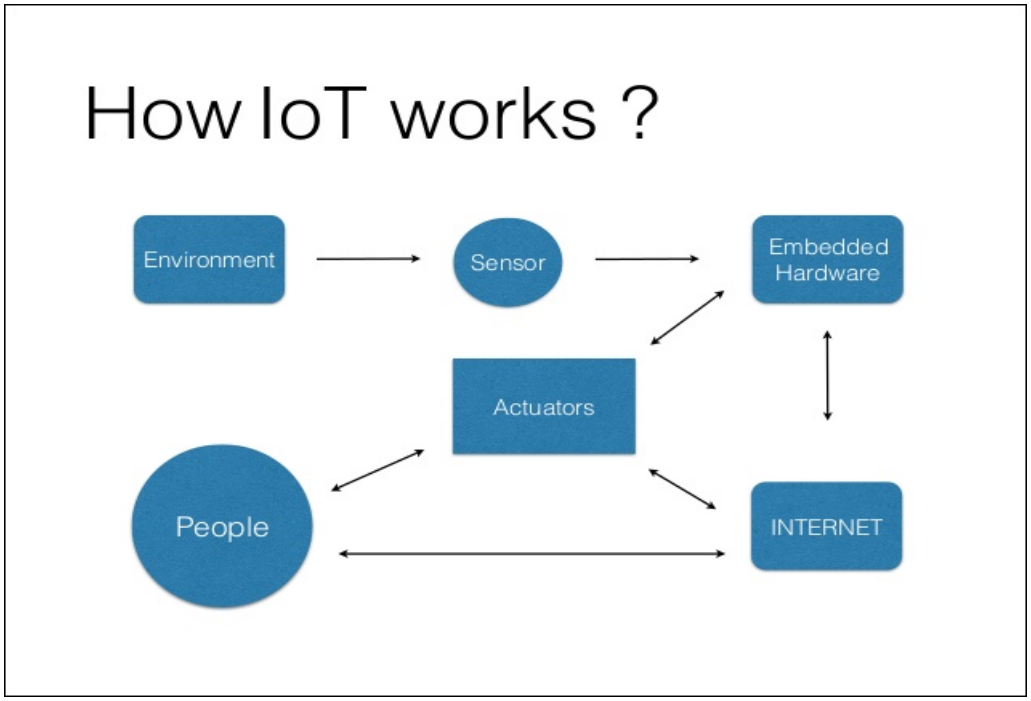
What is IoT (Internet of Things)?

A network of interconnected things/devices embedded with sensors, software (intelligent), network connectivity and necessary electronics.



Enables to collect, exchange, analyze data based upon the built-in analytics (Artificial Intelligence, Machine Learning, etc.)

Suggests and/or triggers an action plan

Increased farm productivity and environmental stewardship through enhanced operational efficiency

Why IoT (Internet of Things)?

World Population (9.5b by 2050)

Demand for Food, Fiber and Fuel to Double

Another Green Revolution Needed

(Technological Revolution)

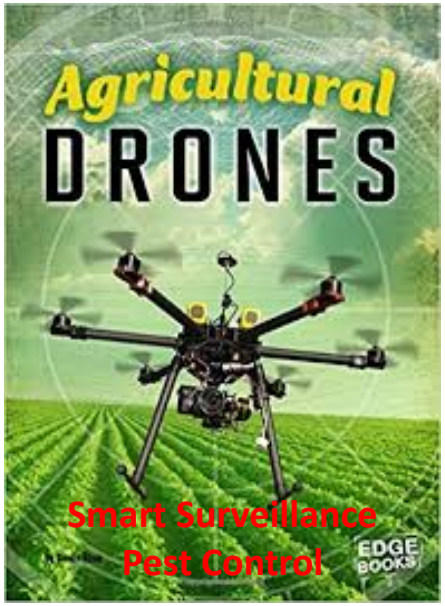
Application of AI, IoT and other Emerging Technologies for Ag Systems

More Efficient Utilization of Natural Resources

Better Timely Effective Management Decision Making

Further Increasing Farm Productivity and Minimize Environmental Impacts

AI & IoT Applications of Agricultural Systems



Irrigation scheduling in an avocado farm reducing the water cost by 75%
https://www.youtube.com/watch?v=1D0O4LGkKiY

USDA/NRCS Support to IoT

- Hackathon on Ag Applications at the World IoT Conference
- On-Farm Trials on Innovative Technology
- IBM -USDA Innovation Session on Agriculture and Conservation Platforms

Several Traditional CIGs

1. the Next Generation Technology for Monitoring Edge-of-Field Water Quality in Organic Agriculture at the Colorado State University;
2. the Internet of Agriculture (IoAg) Network and Services Platform at the White River Irrigation District, AR; and
3. Utilizing Deep-rooted Cover Crops to Enhance Water Quality, Soil Health, and Farm Profits While Reducing Soil Compaction in Coastal Plain Region at Clemson University, SC.

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Cover Crops

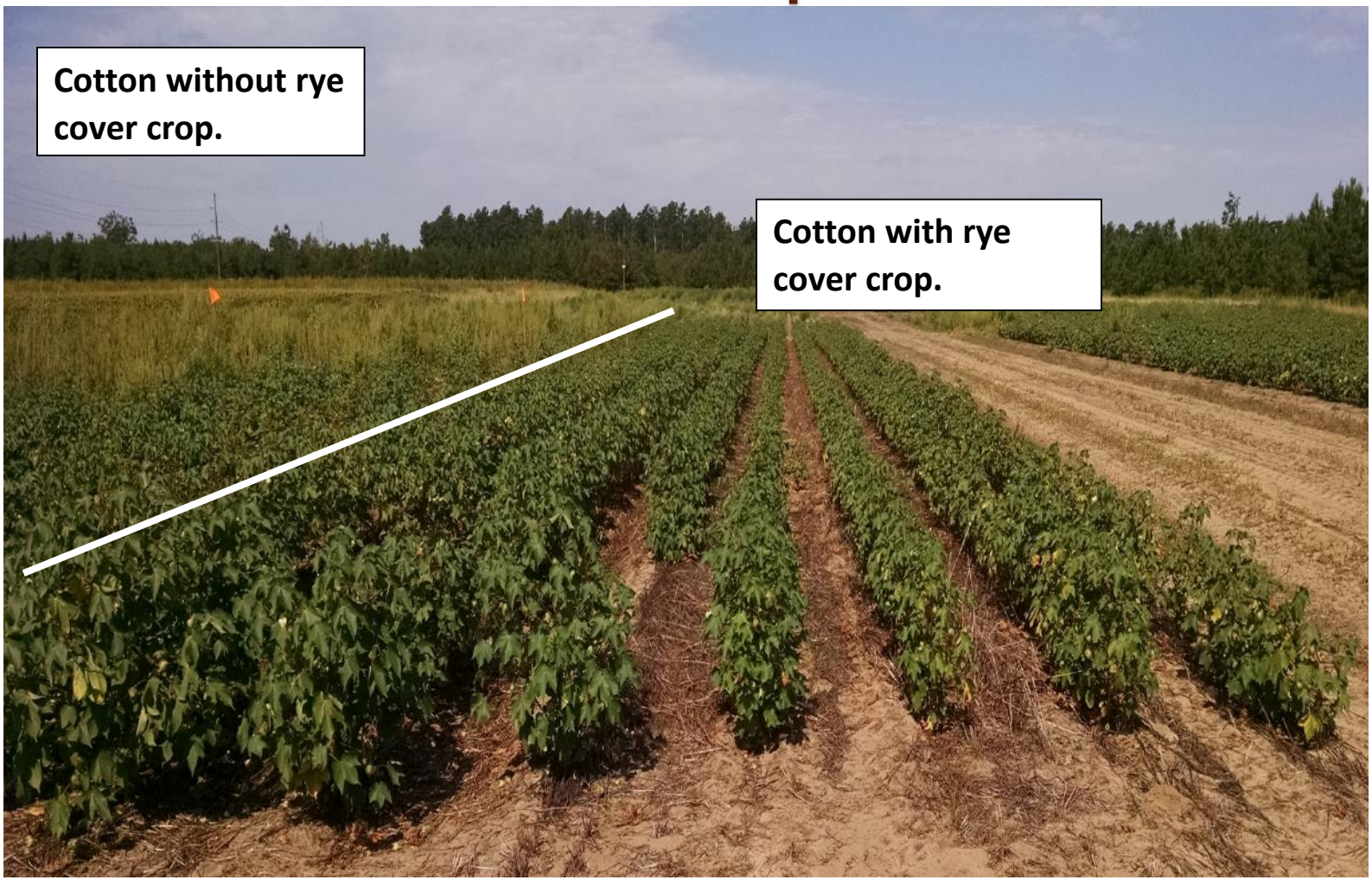
Cover Crop for Weed Suppression

Cover Crop Rolled and Terminated Prior to Planting

Effect of Residue Cover on Weed Seed Soil Bank

- Reduced light reaching soil surface
- Reduced temperature fluctuations in the upper soil profile
- Release of chemicals inhibit germination of small seeded weeds

Cotton Strip Plots w and w/o cover crop



GIG Project 2017-2020

Utilizing Cover Crops to Improve Water Quality and Reduce Soil Compaction in Coastal Plain Region

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CLEMSON UNIVERSITY

The University of Georgia
1785

CIG Project Objectives

- Establish cover crop demonstration sites in South Carolina and Georgia.
- Evaluate the impacts of cover crops on water infiltration, holding capacity, and quality.
- Implement training programs for county agents, growers, consultants on benefits of cover crops and water storage and quality.
- Develop IoT (Internet-of-Things) system for collecting soil moisture and water run-off from test sites.

CIG Project Methods:

- An Environmental Quality Monitoring site was established at Edisto REC in 2018.
- A six-acre field was subdivided into six one-acre sections (~100 by 500 ft).
- Each section was bermed to prevent water from entering from a neighbor section.
- At each outlet, a H-flume system was installed to measure and capture a portion of the run-off from each section

CIG Project Methods (cont)

- A rye crop was seeded in the fall in 3 of the 6 sections.
- Cover crops were terminated using herbicides in the spring of the following year.
- The cash crop (cotton or soybean) was planted after termination.

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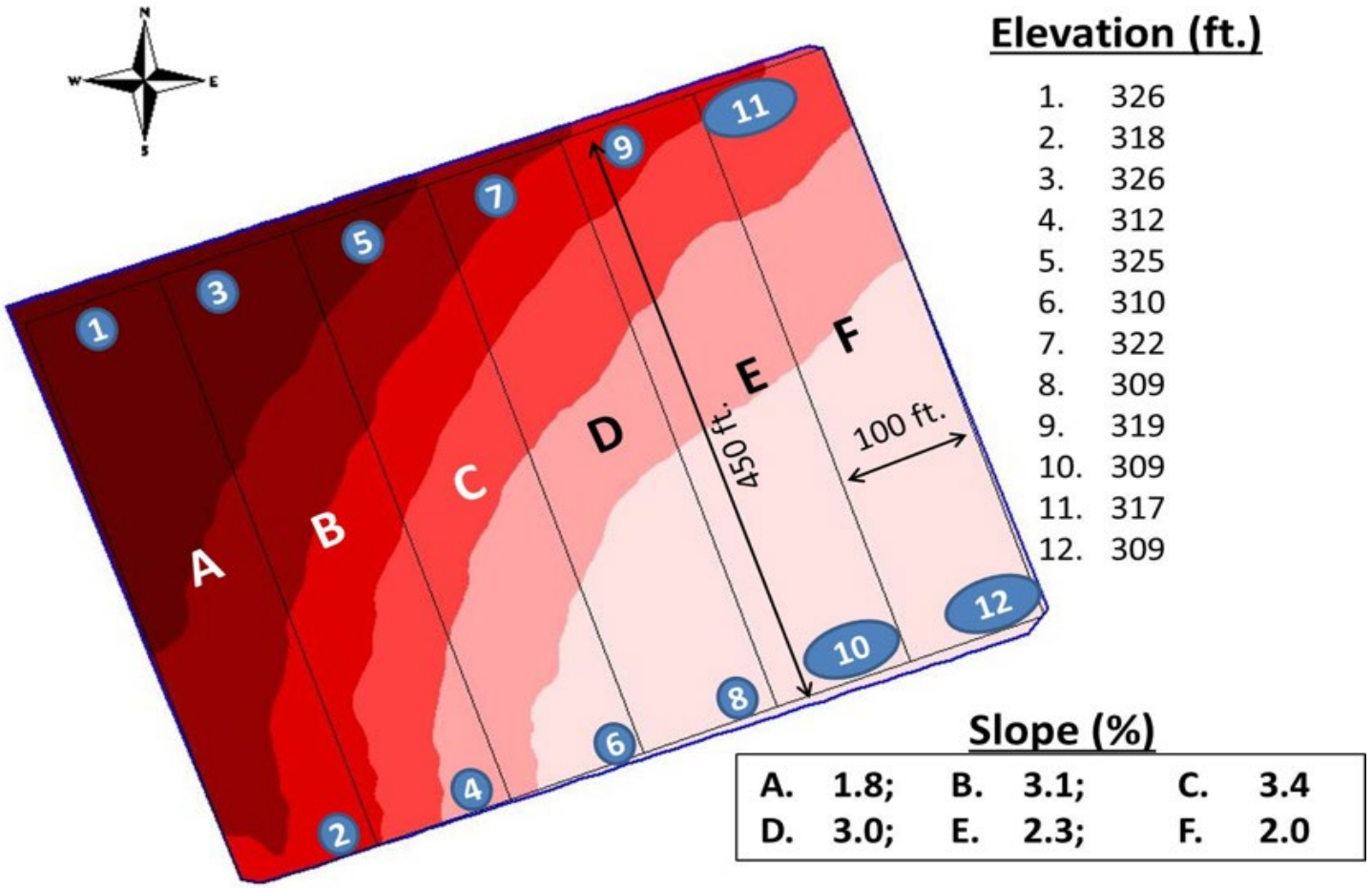
Components of an IoT System:

- Sensor/control device
- Microcontroller/Firmware
- Communication System among components (Radio)
- Connection to the Internet (WiFi/Cellurar)
- Internet server to receive/store data
- Website to display data
- Mobile App

Our IoT systems:

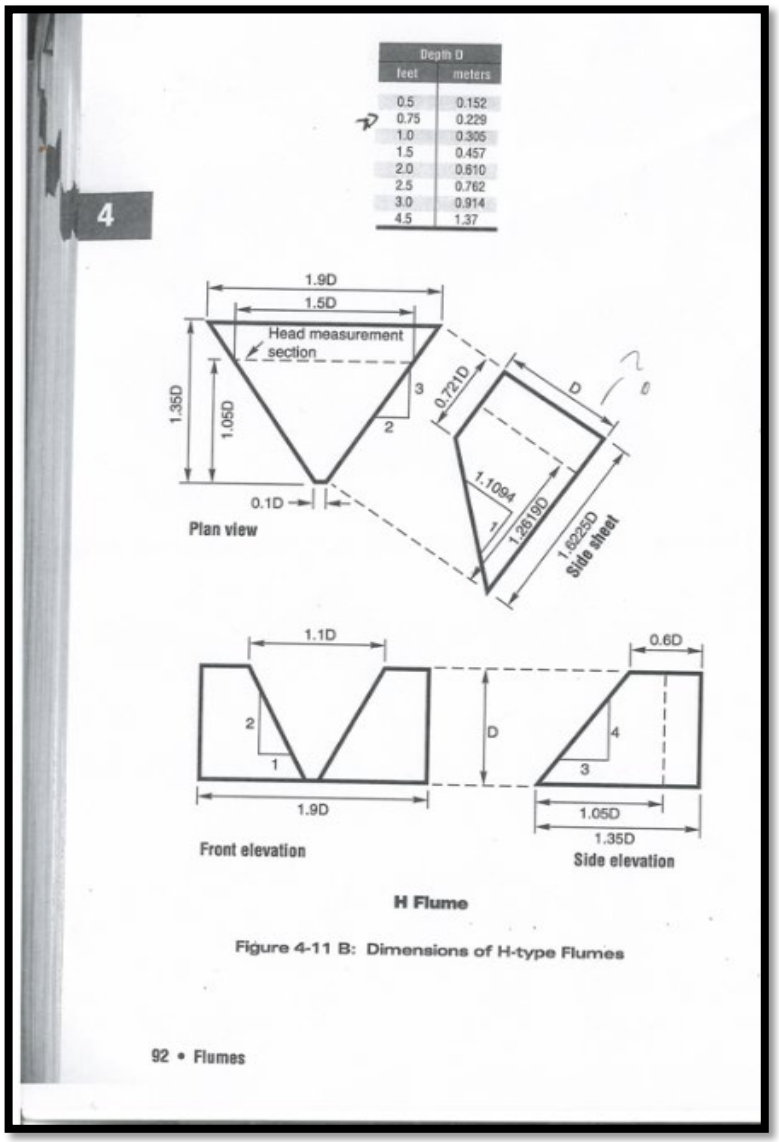
- Wireless sensor network
  - LoRa Radio + WiFi
- Cellular network

Demonstration site at Clemson



Flumes at UGA-Tifton

H-Flume design



Depth D	
feet	meters
0.5	0.152
0.75	0.229
1.0	0.305
1.5	0.457
2.0	0.610
2.5	0.762
3.0	0.914
4.5	1.37

Figure 4-11 B: Dimensions of H-type Flumes

92 • Flumes

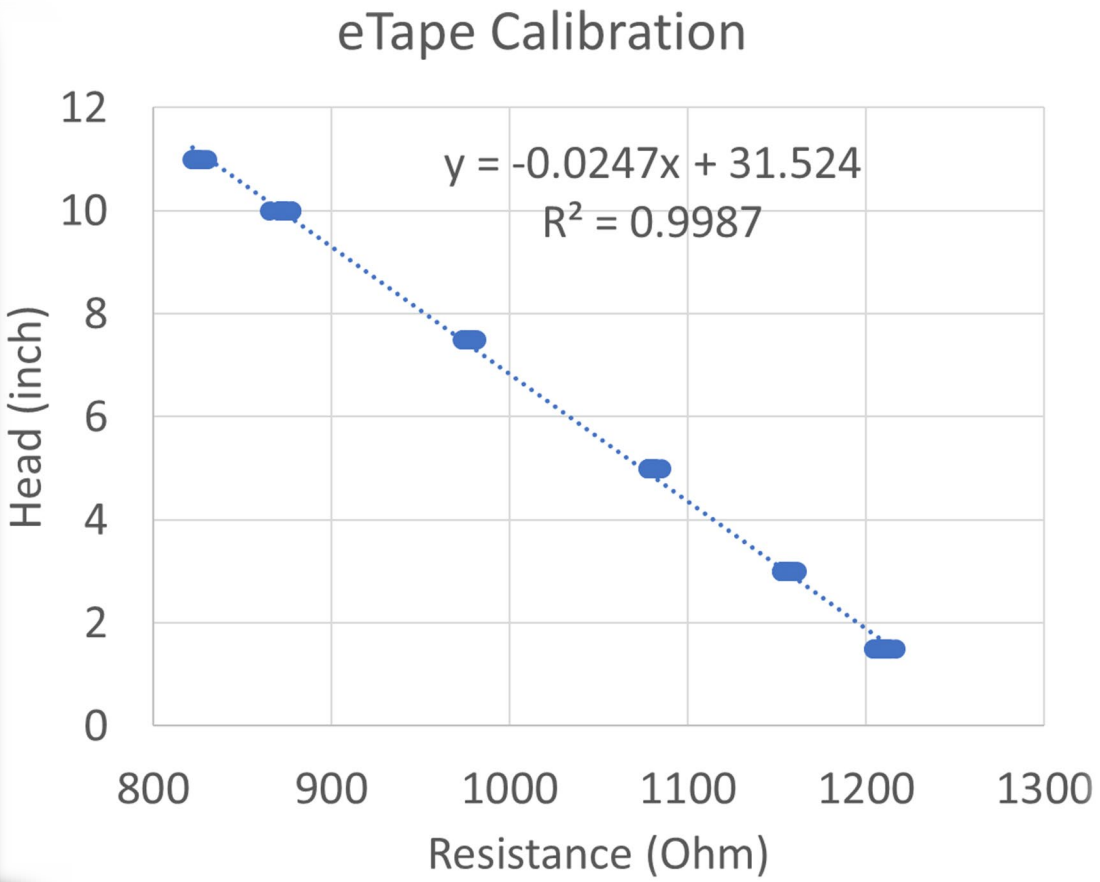
Table 17-6:
0.75 ft. H Flume Discharge Table with Head in Feet

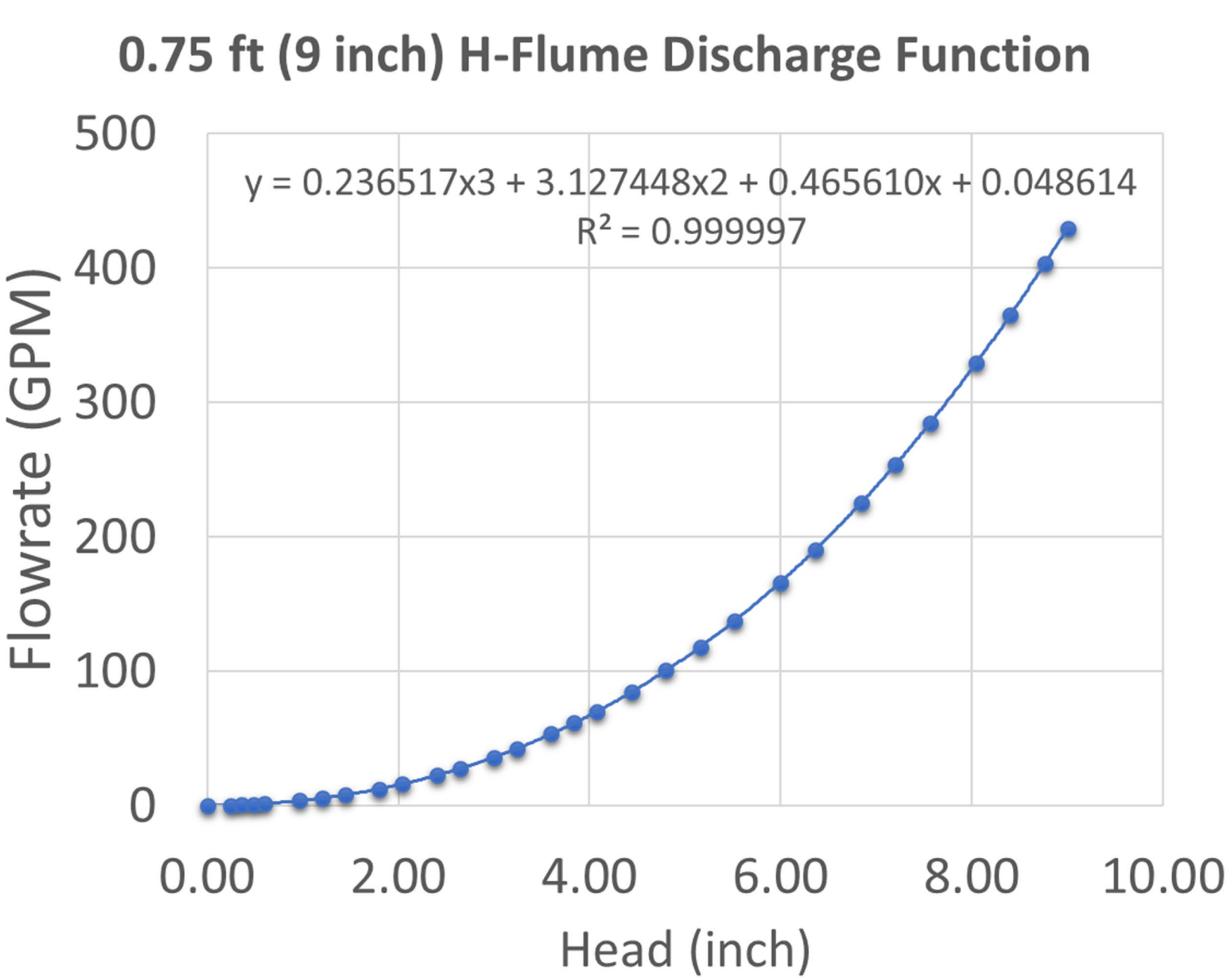
Source: U.S.D.A. Handbook No. 224

Head (feet)	CFS	GPM	MGD	Head (feet)	CFS	GPM	MGD
0.01				0.39	0.2110	94.70	0.1364
0.02	0.0006	0.2693	0.0004	0.40	0.2240	100.5	0.1448
0.03	0.0013	0.5834	0.0008	0.41	0.2370	106.4	0.1532
0.04	0.0022	0.9874	0.0014	0.42	0.2500	112.2	0.1616
0.05	0.0032	1.436	0.0021	0.43	0.2630	118.0	0.1700
0.06	0.0046	2.064	0.0030	0.44	0.2770	124.3	0.1790
0.07	0.0061	2.738	0.0039	0.45	0.2910	130.6	0.1881
0.08	0.0080	3.590	0.0052	0.46	0.3060	137.3	0.1978
0.09	0.0101	4.533	0.0065	0.47	0.3210	144.1	0.2075
0.10	0.0126	5.655	0.0081	0.48	0.3370	151.2	0.2178
0.11	0.0151	6.777	0.0098	0.49	0.3530	158.4	0.2281
0.12	0.0179	8.034	0.0116	0.50	0.3700	166.1	0.2391
0.13	0.0210	9.425	0.0136	0.51	0.3880	174.1	0.2508
0.14	0.0242	10.86	0.0156	0.52	0.4060	182.2	0.2624
0.15	0.0278	12.48	0.0180	0.53	0.4240	190.3	0.2740
0.16	0.0317	14.23	0.0205	0.54	0.4430	198.8	0.2863
0.17	0.0358	16.07	0.0231	0.55	0.4620	207.3	0.2986
0.18	0.0403	18.09	0.0260	0.56	0.4820	216.3	0.3115
0.19	0.0451	20.24	0.0291	0.57	0.5020	225.3	0.3244
0.20	0.0501	22.48	0.0324	0.58	0.5230	234.7	0.3380
0.21	0.0555	24.91	0.0359	0.59	0.5440	244.1	0.3516
0.22	0.0612	27.47	0.0396	0.60	0.5660	254.0	0.3658
0.23	0.0672	30.16	0.0434	0.61	0.5880	263.9	0.3800
0.24	0.0735	32.99	0.0475	0.62	0.6110	274.2	0.3949
0.25	0.0802	35.99	0.0518	0.63	0.6350	285.0	0.4104
0.26	0.0872	39.14	0.0564	0.64	0.6590	295.8	0.4259
0.27	0.0946	42.46	0.0611	0.65	0.6830	306.5	0.4414
0.28	0.1023	45.91	0.0661	0.66	0.7080	317.8	0.4575
0.29	0.1104	49.55	0.0714	0.67	0.7340	329.4	0.4744
0.30	0.1190	53.41	0.0769	0.68	0.7600	341.1	0.4912
0.31	0.1280	57.45	0.0827	0.69	0.7860	352.8	0.5080
0.32	0.1370	61.49	0.0885	0.70	0.8130	364.9	0.5254
0.33	0.1460	65.52	0.0944	0.71	0.8410	377.4	0.5435
0.34	0.1560	70.01	0.1008	0.72	0.8690	390.0	0.5616
0.35	0.1670	74.95	0.1079	0.73	0.8980	403.0	0.5804
0.36	0.1770	79.44	0.1144	0.74	0.9270	416.0	0.5991
0.37	0.1880	84.37	0.1215	0.75	0.9570	429.5	0.6185
0.38	0.1990	89.31	0.1286				

H-Flume Construction

eTape Sensor Calibration



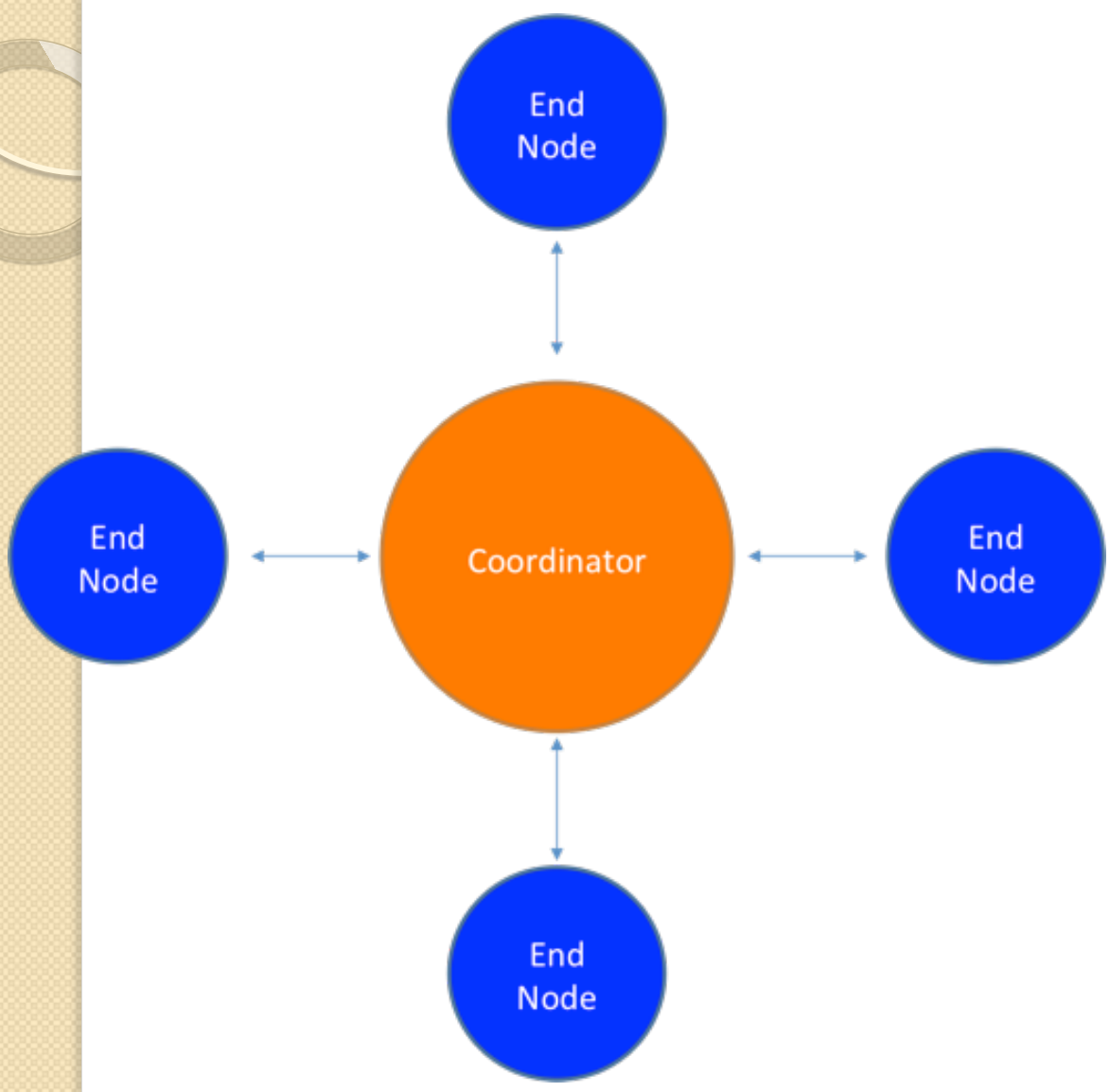

0.75 ft (9 inch) H-Flume Discharge Function
y = 0.236517x3 + 3.127448x2 + 0.465610x + 0.048614
R² = 0.999997
Flowrate (GPM)
500
400
300
200
100
0
0.00
2.00
4.00
6.00
8.00
10.00
Head (inch)

H-Flume field setup

Runoff Event

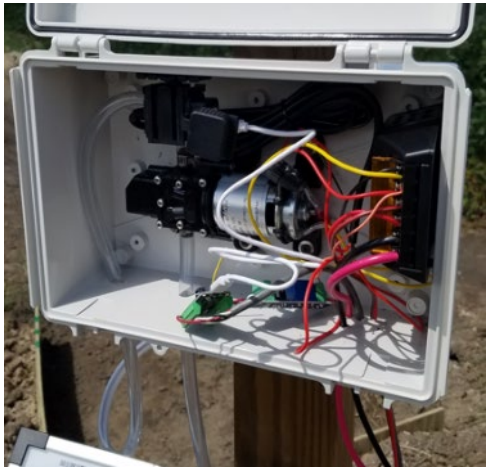
Water Quality Sampling

Wireless sensor network



Wireless Sensor Network

Coordinator



End Node

Weather station

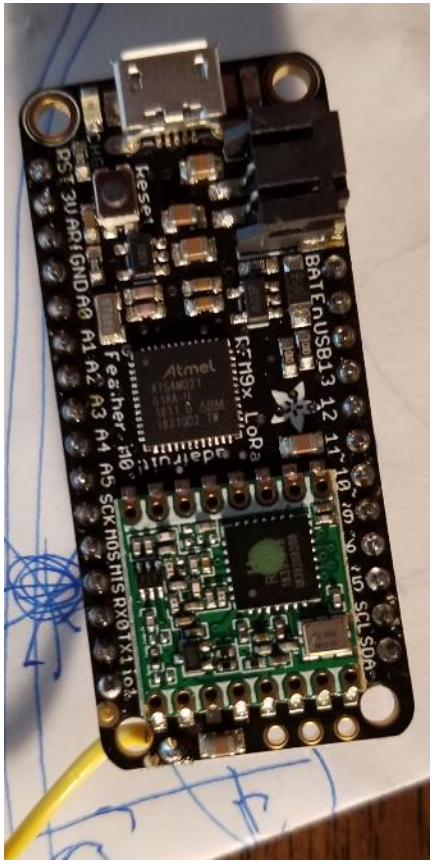
Soil Moisture Monitoring (Cellular)

Soil Moisture Monitoring System- Grower Field (Cellular)

Arduino-based devices

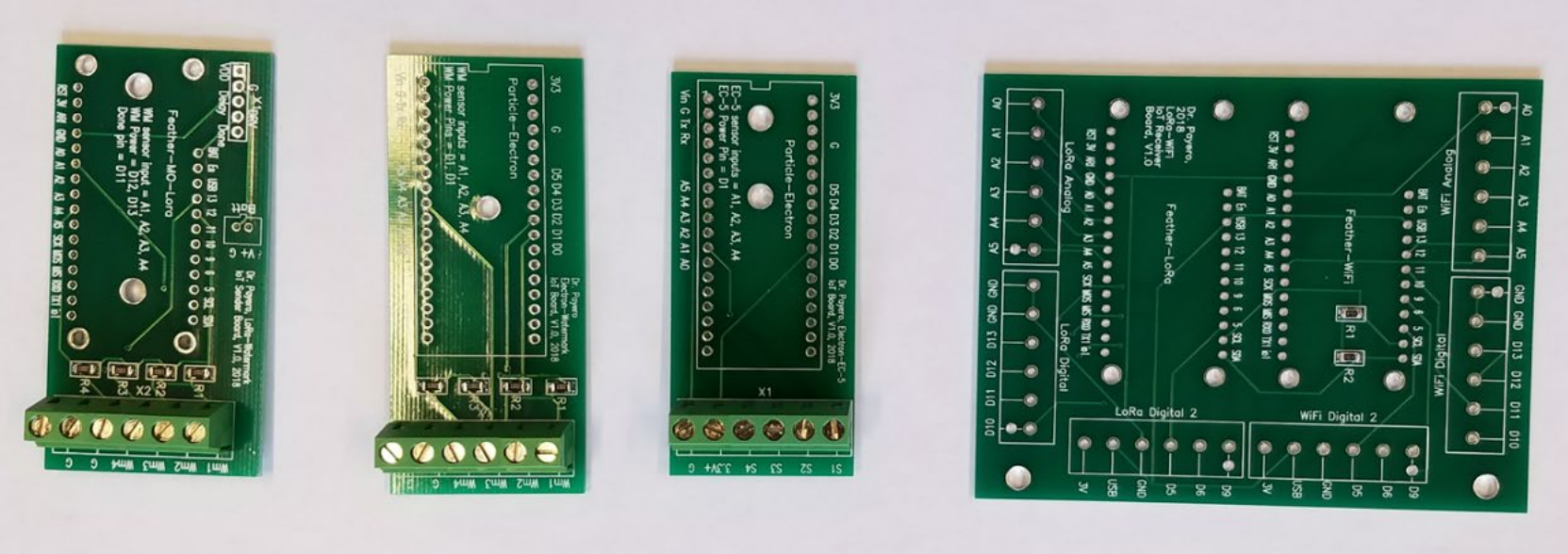
Cellular

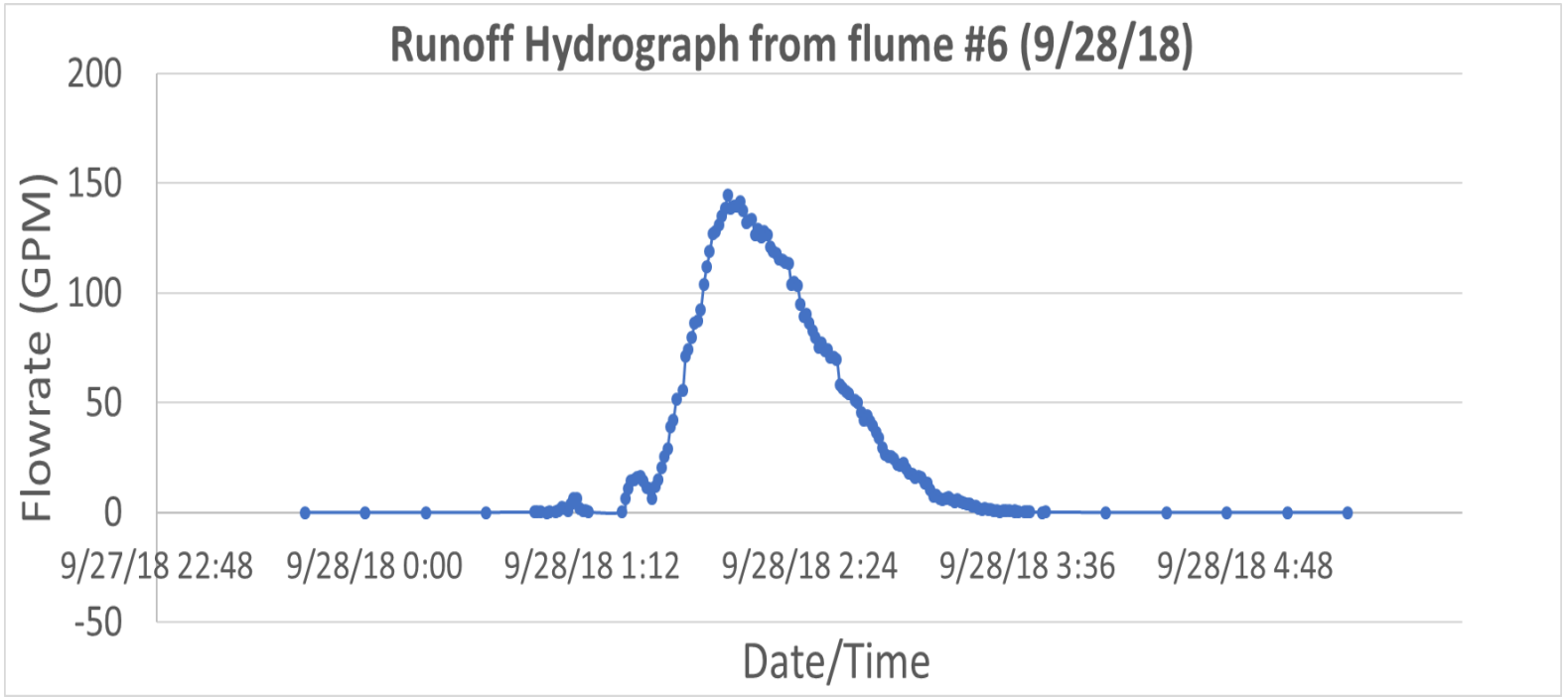
WiFi

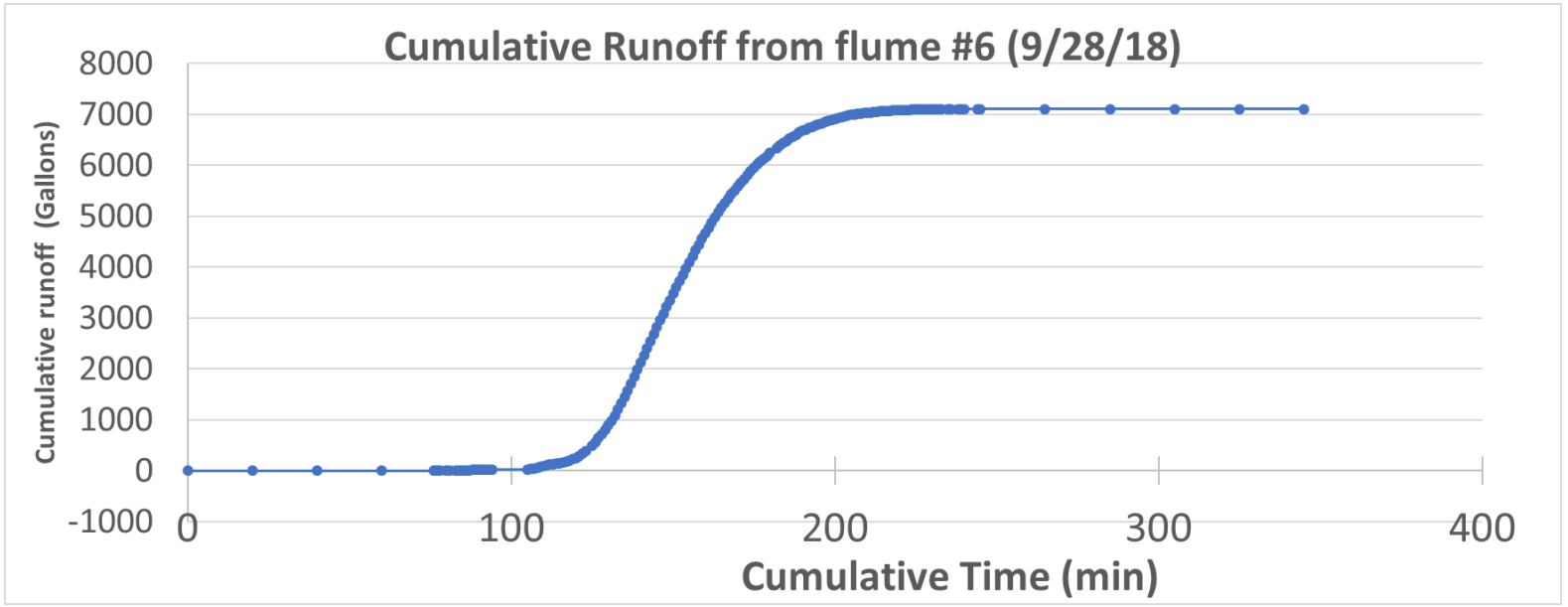


LoRa Radio

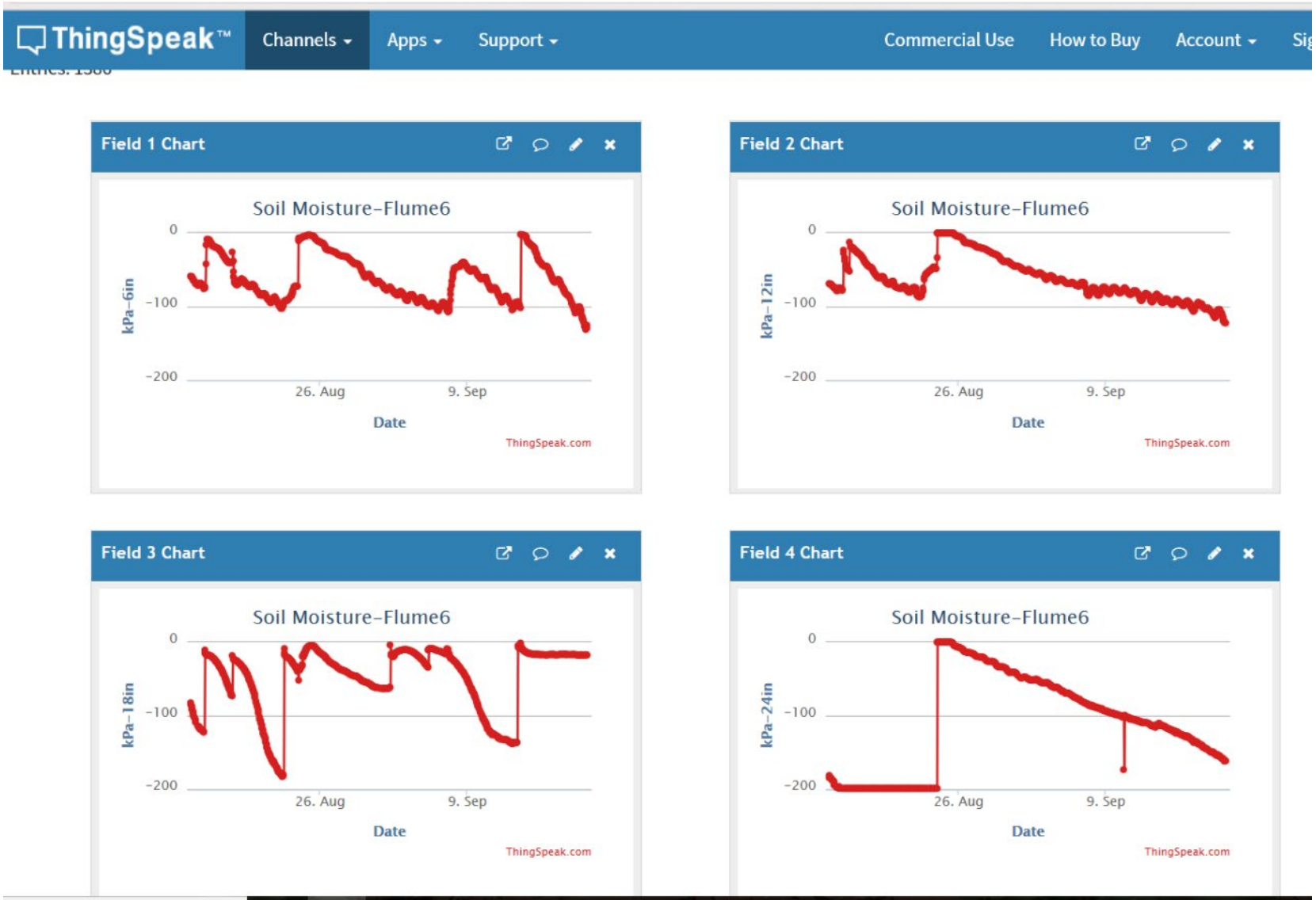
Printed Circuit Boards (PCB)




Runoff Hydrograph from flume #6 (9/28/18)
Flowrate (GPM)
200
150
100
50
0
-50
9/27/18 22:48
9/28/18 0:00
9/28/18 1:12
9/28/18 2:24
9/28/18 3:36
9/28/18 4:48
Date/Time

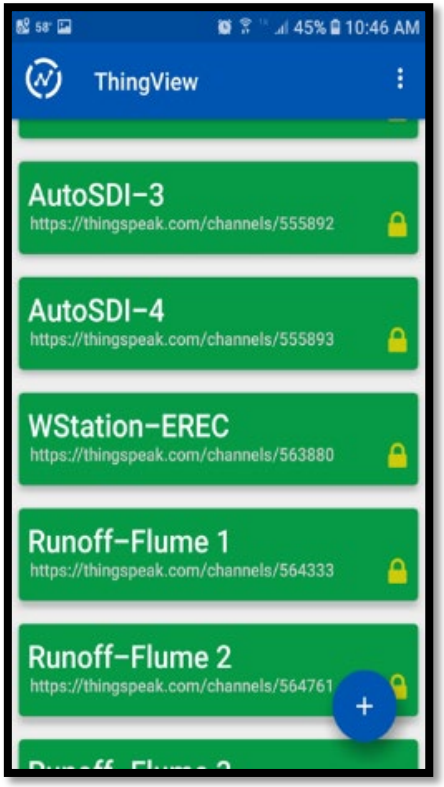

Cumulative Runoff from flume #6 (9/28/18)
Cumulative runoff (Gallons)
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
0
100
200
300
400
Cumulative Time (min)

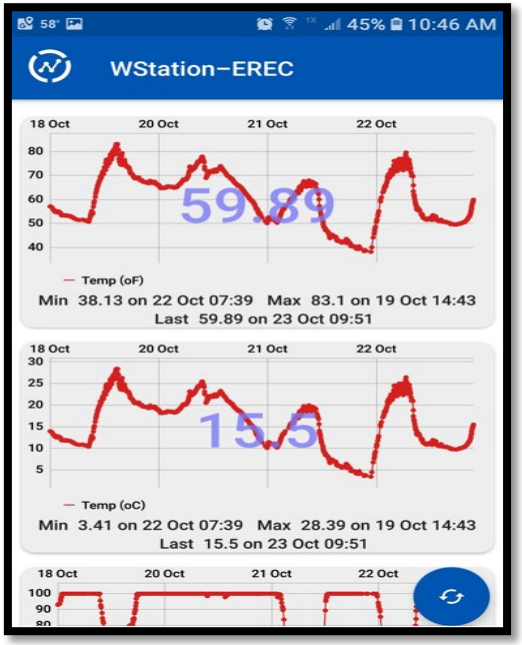
Soil Moisture data



Weather data

Mobile App (*ThingView*)





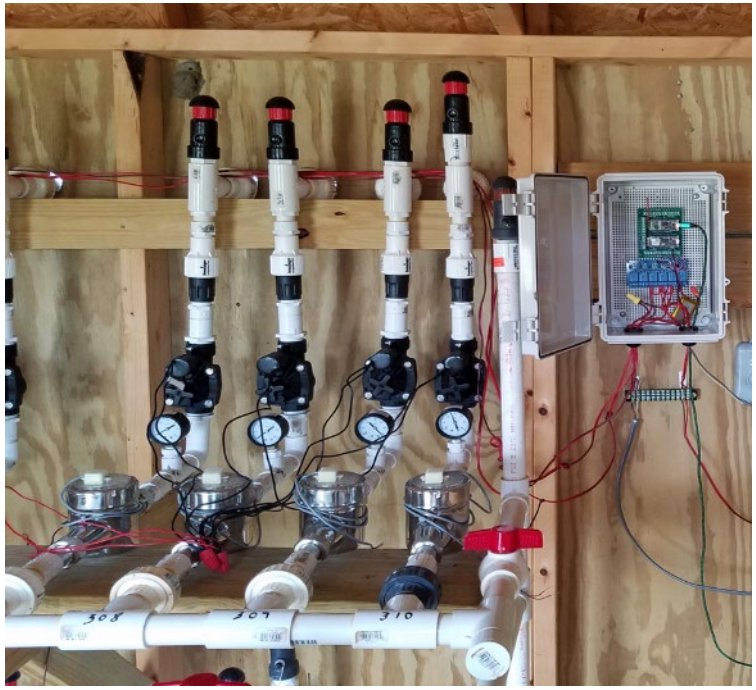
Data from weather station shown in cell phone using the ThingView app.

IoT for Irrigation Automation

End Node 1

End Node 2

Coordinator



End Node 3

End Node 4

Summary

- IoT, AI and other emerging technologies can contribute significantly in improving agricultural operations (2nd Green Revolution)
- Several working examples of agricultural applications
  - USDA/NRCS is getting involved in these technologies slowly but surely
  - Learn more, get involved, and explore the possibility of incorporating them in your work

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