# Site-Specific Management to Improve Fertilizer Use Efficiency (Adjustable Rate Fertigation)

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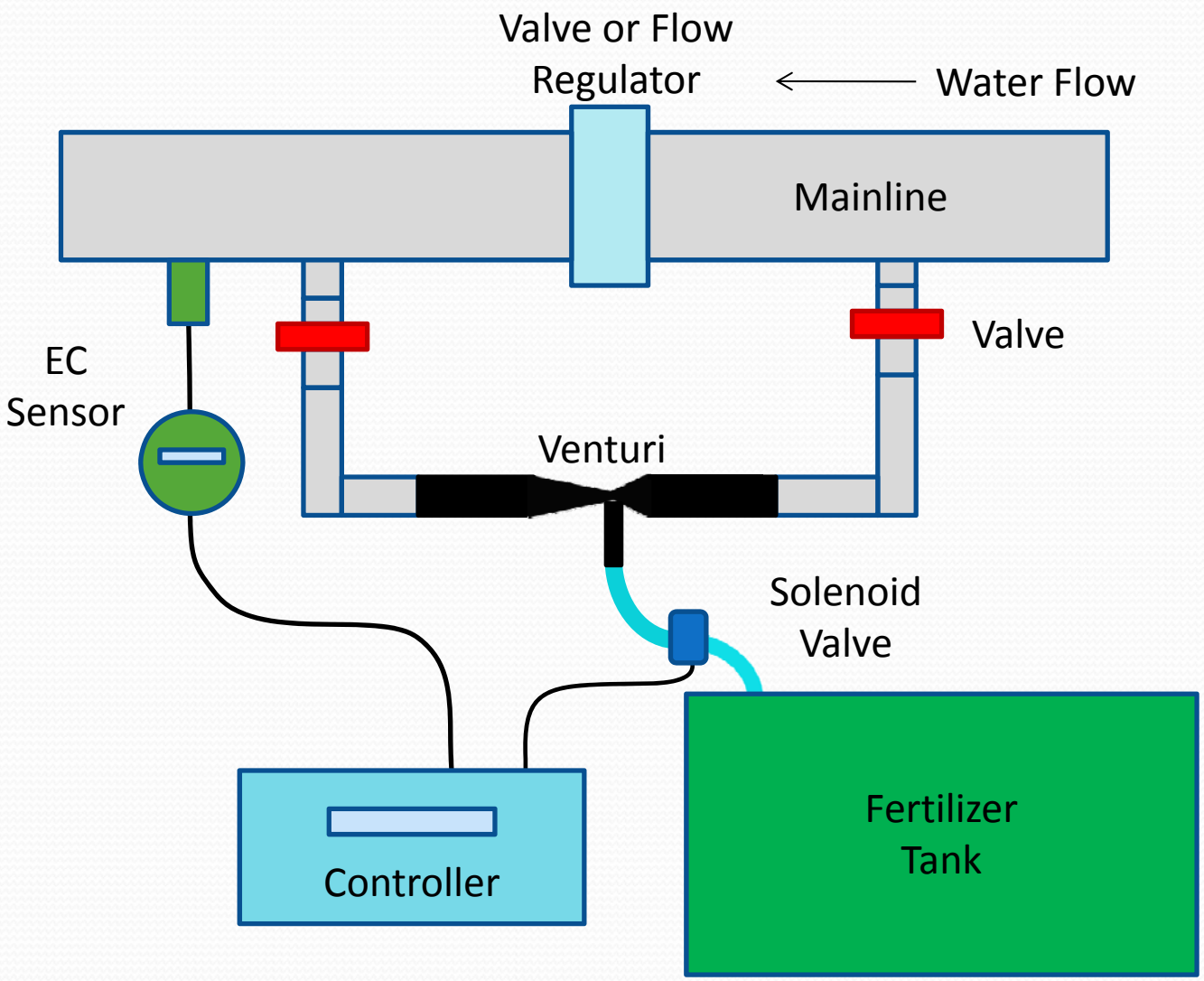
# Example Application - Container Nurseries

- Irrigate on fixed schedules
  - timers or manual control
  - under-irrigation causes plant loss
  - over-irrigation causes runoff and waste
- Injected fertilizer typically controlled at pump station
  - same rate used for each hydro-zone

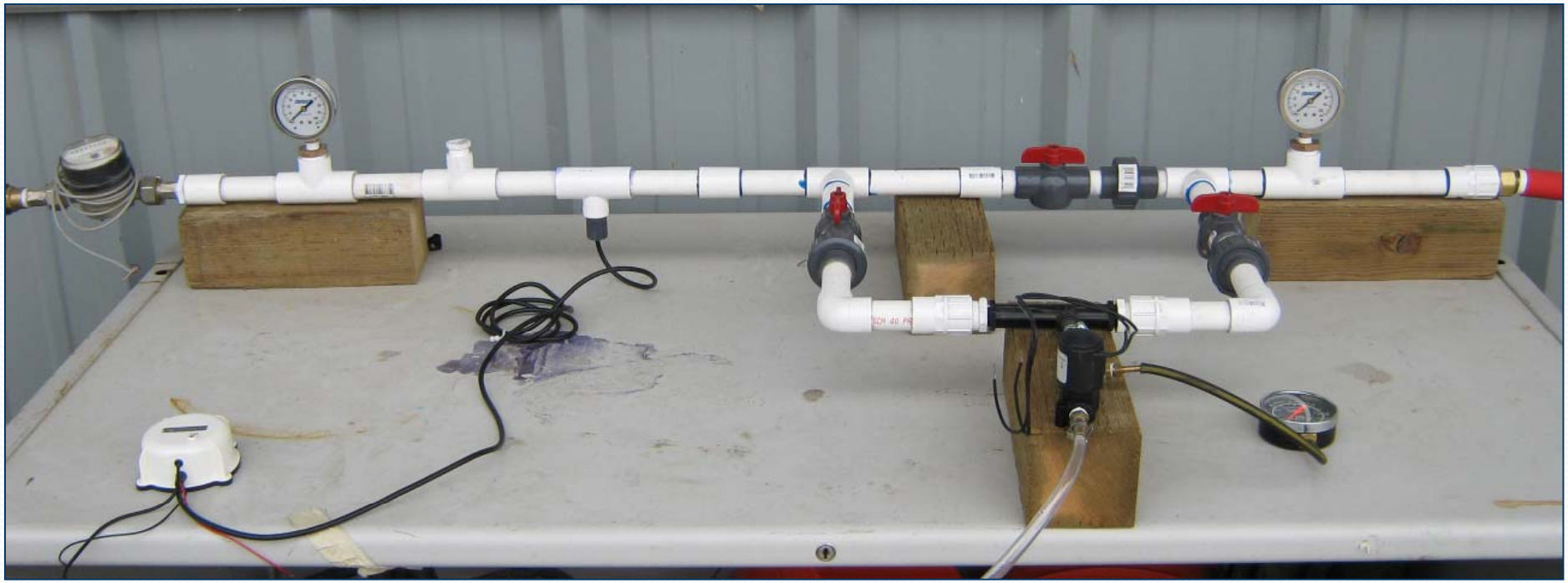
# Proposed Solutions

- Develop a simple fertilizer injection system to give adjustable-rate fertigation.
  - multiple injectors or mobile injector
  - computer controlled injection rate
- Integrate the injector with a wireless irrigation control system to give automated, adjustable-rate fertigation.
  - automated control
  - valves can be added without control wires

# Fertilizer Injector Concept



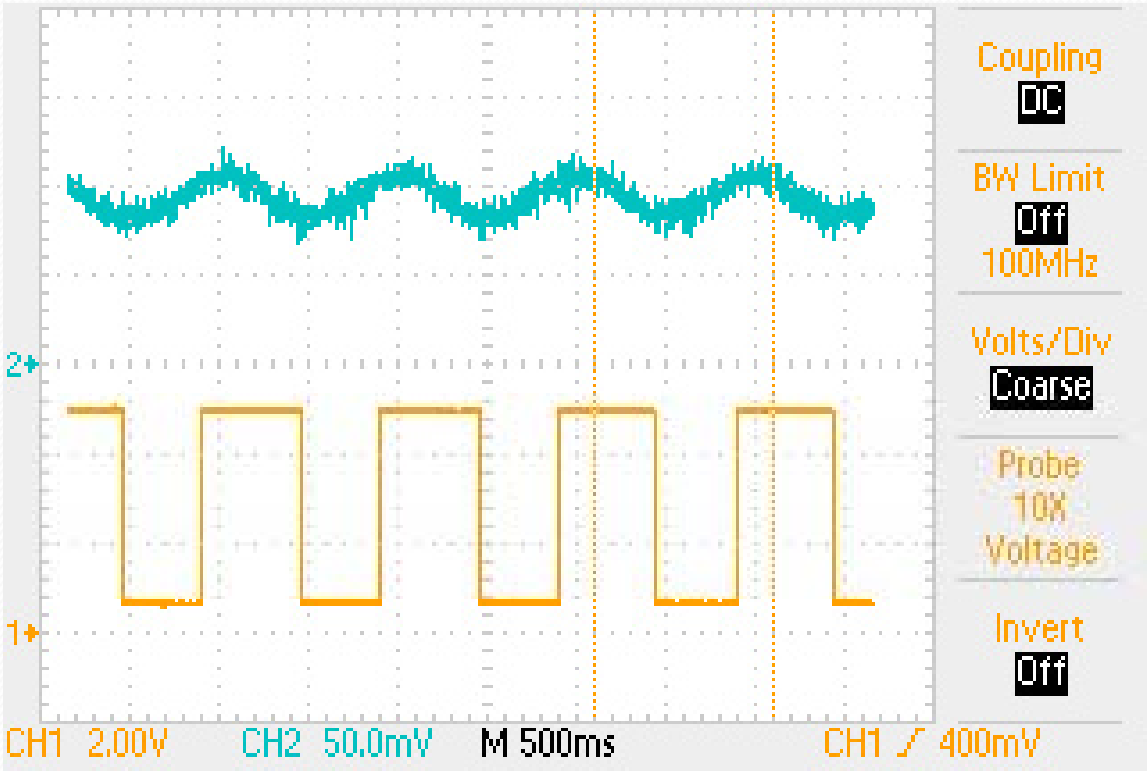
# Uncontrolled Injector Tests

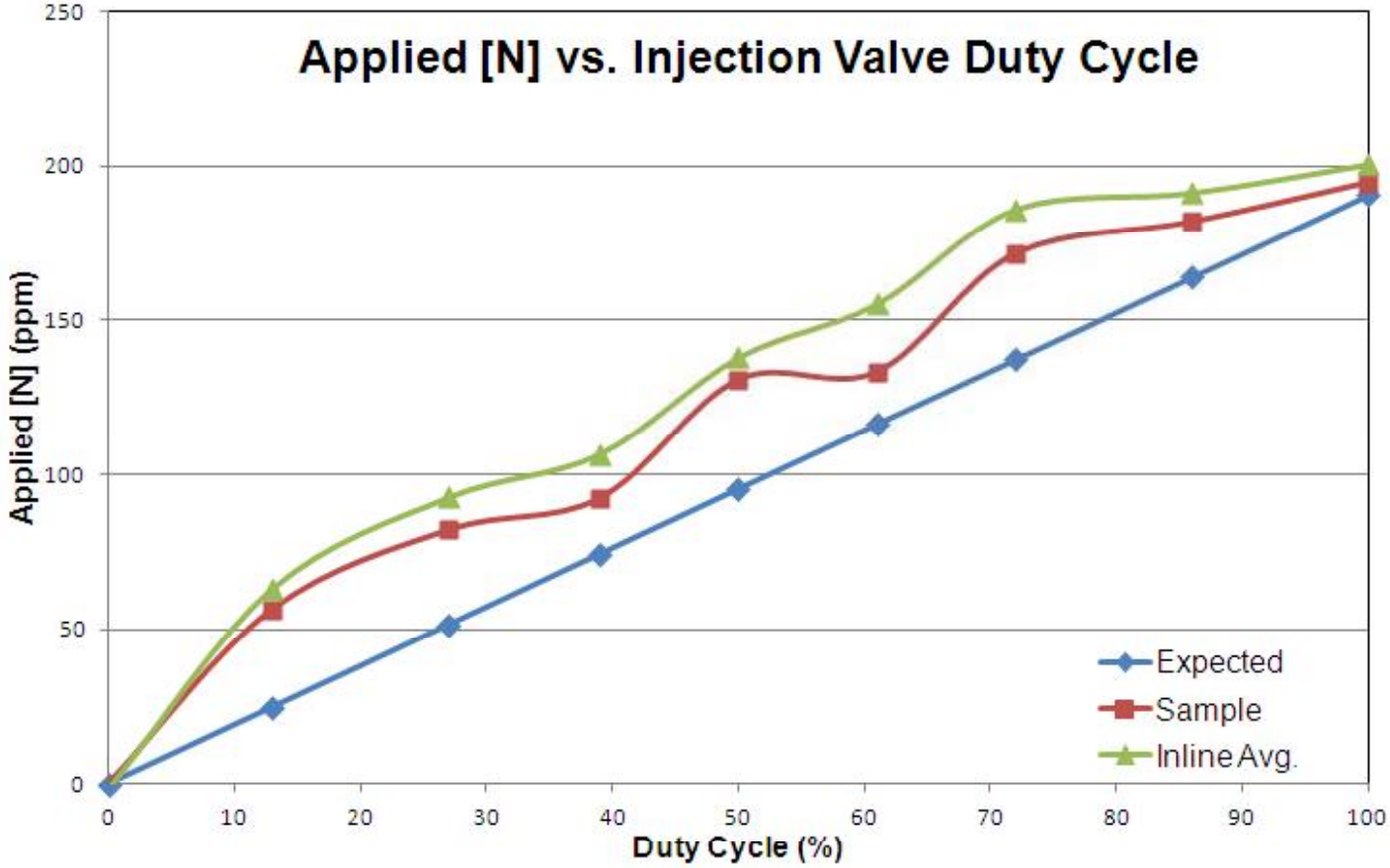


- In-line EC probe
  - 0.00 to 9.99 mS/cm
  - 0 to 2000 ppm nitrogen (N) for 20-20-20
  - [N] = (EC – background EC)/0.0039
- Solenoid valve
  - normally-closed valve
  - pulsed at 1 Hz
  - duty cycle = 0, 13, 27, 39, 50, 61, 72, 86, and 100%

EC sensor signal

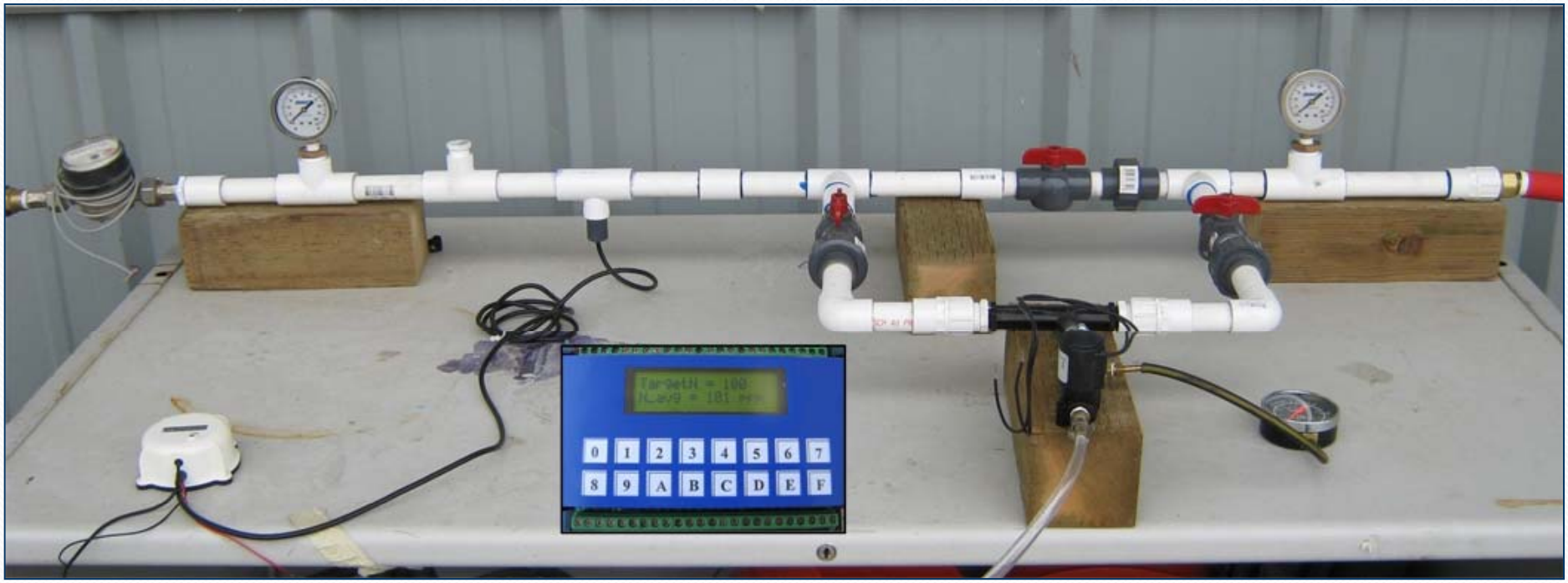
Suction valve signal



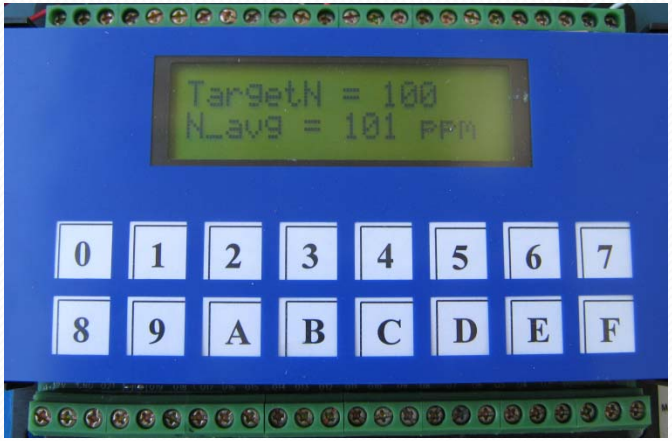


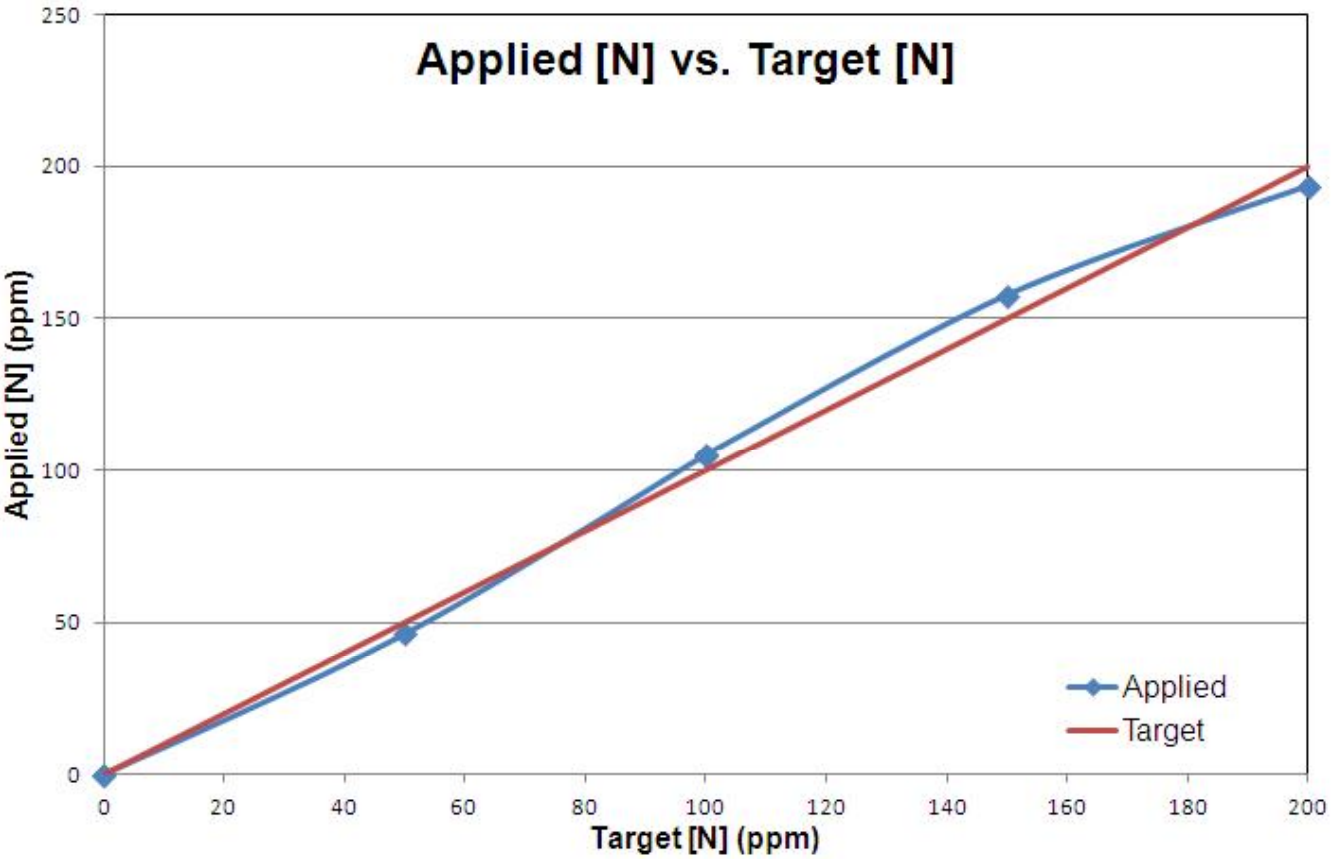

- Measured (sample) concentration greater than expected
- Estimate from in-line EC sensor closer to sample concentration than to expected concentration

# Controlled Injector Tests

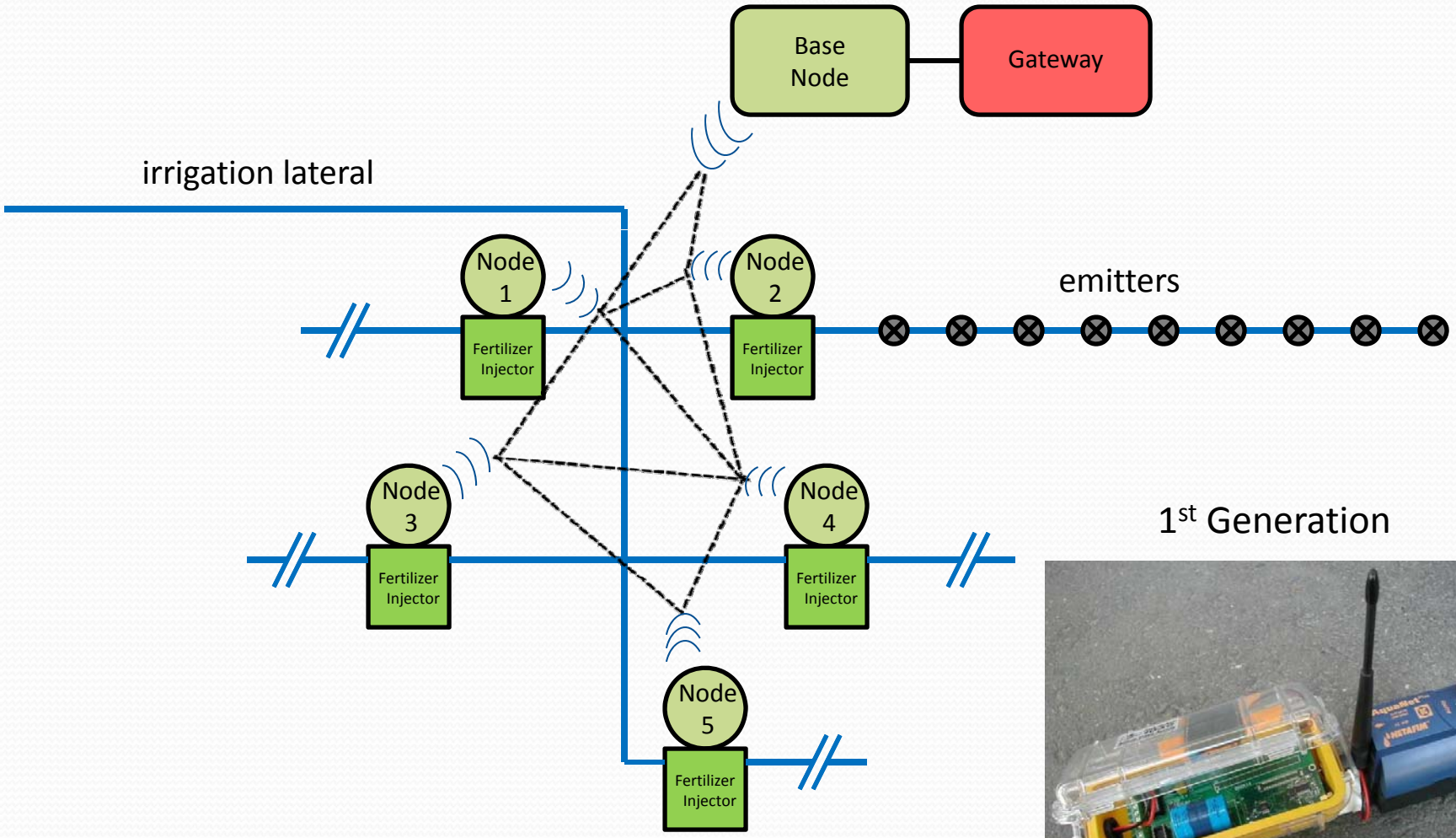


- Embedded controller
  - set target fertilizer rate, [N]
  - measure average EC over time and convert to [N]
  - control suction valve duty cycle so average [N] = target [N]




Applied [N] vs. Target [N]
Applied [N] (ppm)
Target [N] (ppm)
0
50
100
150
200
250
0
20
40
60
80
100
120
140
160
180
200
Applied
Target

# Wireless Network




1st Generation

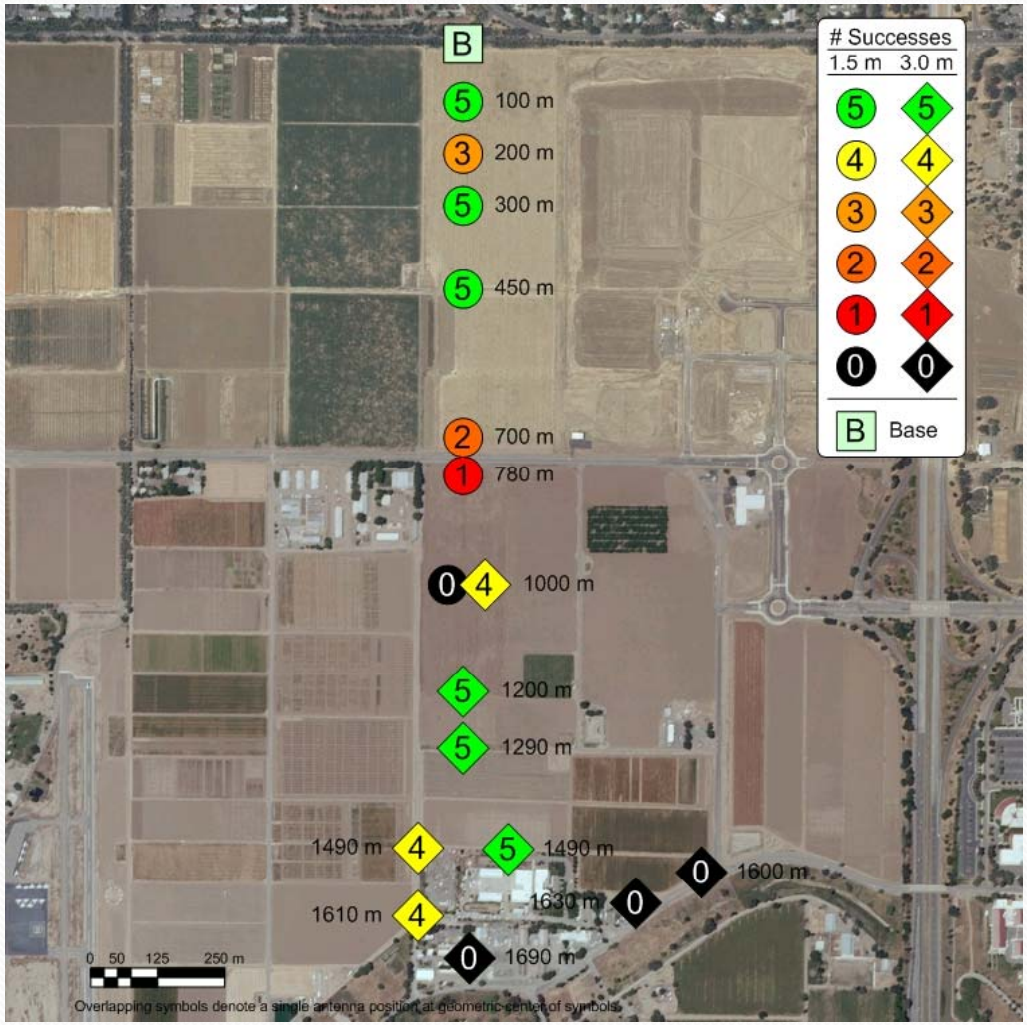
# Transition to commercial product

# Current Technology

- commercial wireless node
- mesh network, 2.4 GHz
- solar powered
- 4 ports for sensors or actuators
- 4 latching valves per actuator
- expect commercial availability of valve actuators

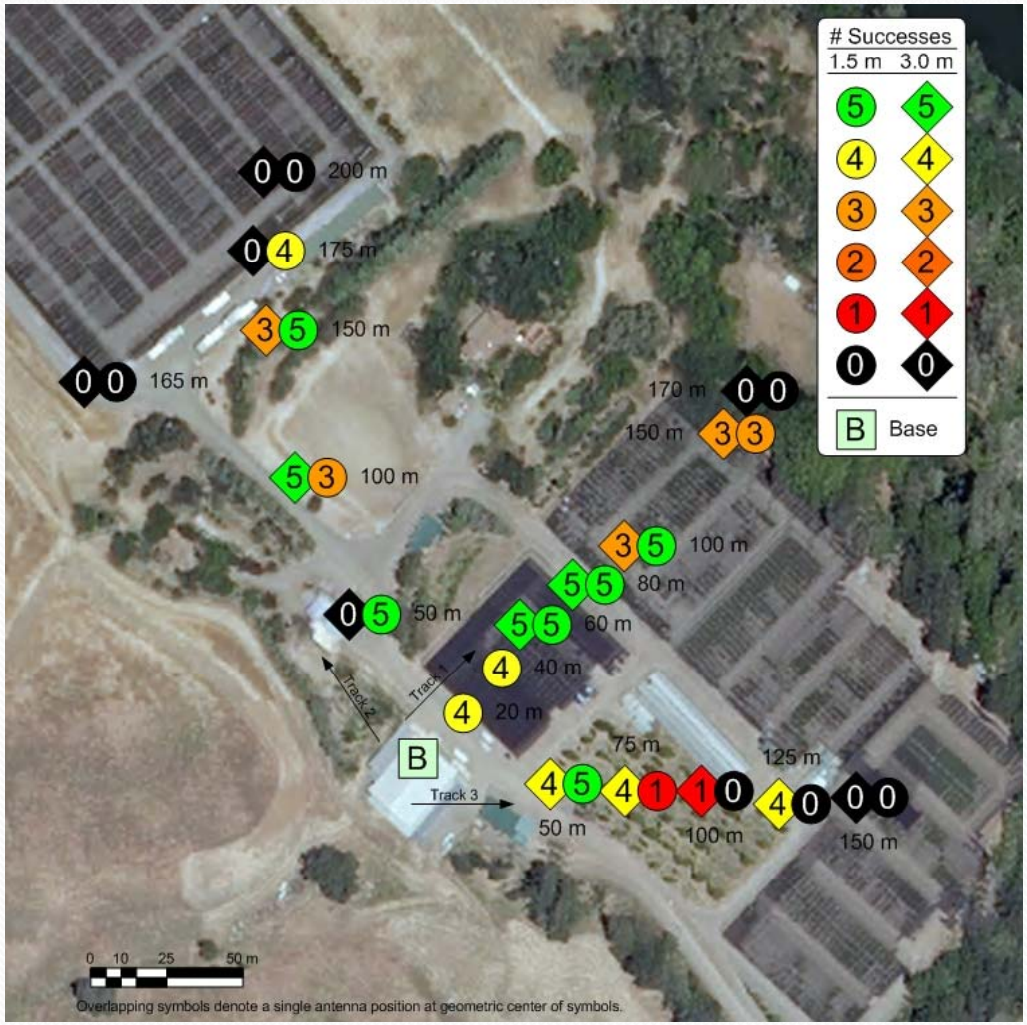
# Wireless Range in Open Fields

- Number of successful network “joins” by a node
- Visual line of sight
  - 300 m wide corridor
- Range was better with higher antenna
  - up to 1610 m

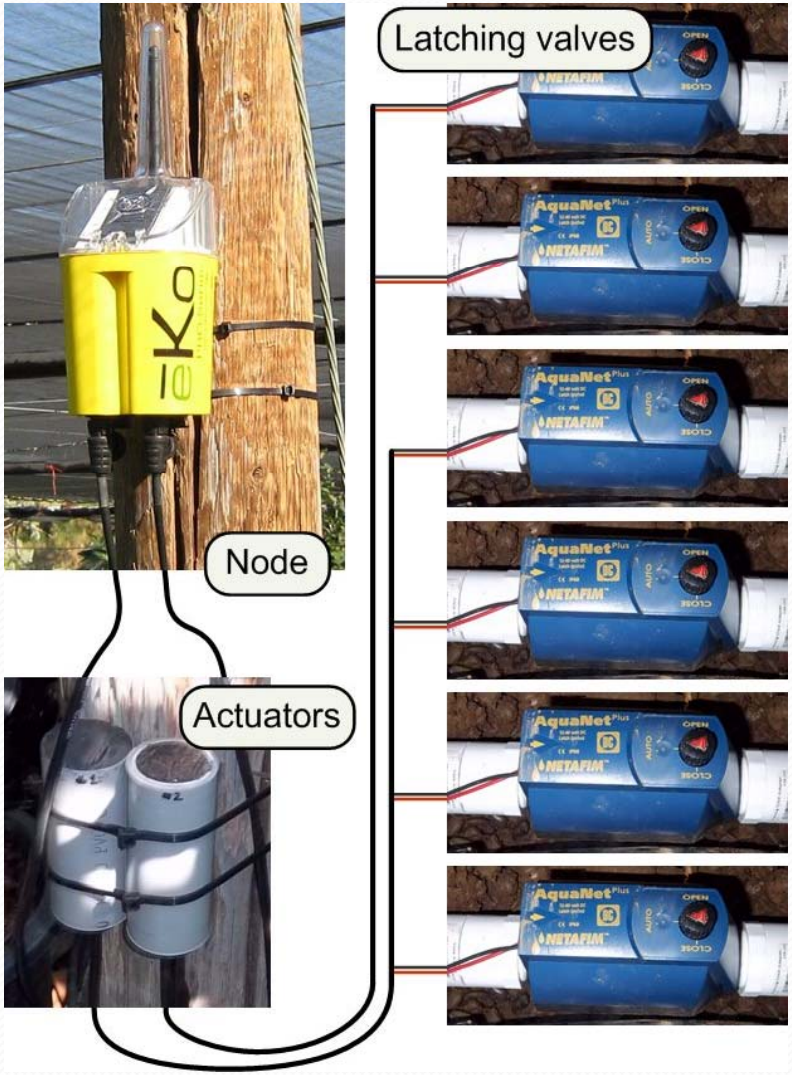


# Wireless Node Range in Nurseries

- Obstructions
  - buildings, trees, shade houses, plants
- Range varied with obstruction type and node elevation
  - up to 170 m
- Mesh network extends range



# Nursery Irrigation Tests - 2012



# Nursery 1

- container citrus

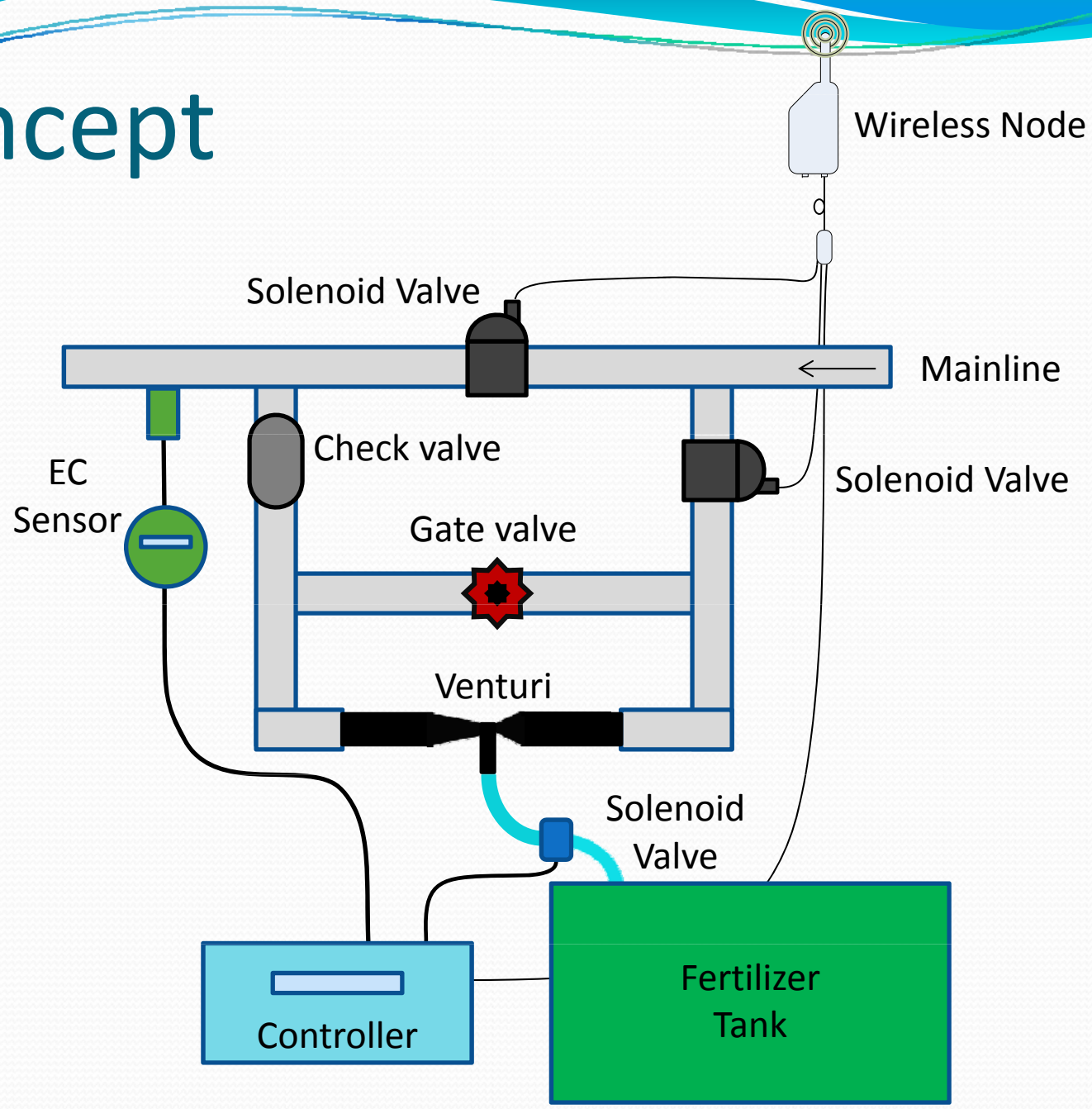
# Nursery 2

- container vines

# Next Step

- Integrate injector with wireless network
- Test multiple injector control system

# Concept


Wireless Node
Solenoid Valve
Mainline
Check valve
EC
Sensor
Solenoid Valve
Gate valve
Venturi
Solenoid
Valve
Controller
Fertilizer
Tank

# Conclusions

- Controlled injector using a venturi, EC sensor, and embedded controller was developed
- Injector tested from 0 to 200 ppm [N] with 20-20-20 stock solution
- Wireless mesh network developed to provide sensing and control capability
- Wireless network will be integrated with fertilizer injector to provide automated control of multiple injectors

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