Irrigation system evaluations

Prepared by:
Tom Lockhart, Michael Cahn, UC Cooperative Extension;
And Gerry Spinelli*, RCD of Santa Cruz County
*Contact information: (831) 464 2950 Ext 14 – gspinelli@rcdsantacruz.org

Report 152

This project was a cooperative effort between the University of California Cooperative Extension and the Resource Conservation District of Santa Cruz County.

Crop Type	**Apple**
Planted Area:	**15 Acres**
Area Evaluated	**3.8 Acres**
Irrigation system type	**Micro-Sprinklers**
Design micro-sprinkler discharge rate	**11 GPH**
Average micro-sprinkler discharge rate measured	**15 GPH @ 33 psi**
Average pressure measured within field	**33 psi**
Overall Distribution Uniformity	**79.5 %**

Recommendations

1. Install a 40 psi pressure regulator at block 1 in place of the existing 30 psi, to increase the pressure at block 1 and help equalize the application rate between blocks
2. Install pressure compensating micro-sprinklers or emitters on block 2 and 3
3. Replace all plugged micro-sprinklers
4. Regularly flush the hoses, to avoid plugging
5. Clean the filters regularly to reduce plugging
6. Experiment with running more than 2 lines per set to achieve a faster turnover and irrigate the whole ranch at least 3 or 4 times per season (may need more storage capacity and higher flow form the pump)

Introduction

This project is a collaboration of cooperating growers, University of California Cooperative Extension in Monterey County and the Resource Conservation District of Santa Cruz County. The main goals of the project are to evaluate system performance and distribution uniformity (DU) of on-farm irrigation systems and to recommend improvements.

This report is designed to assist growers as well as irrigation professionals. The report summarizes data collected during the system evaluation, and includes a description of the irrigation system with a map showing where measurements were recorded. Individual measurements are presented at the end of the report. An analysis of system performance and recommendations for improvements to design and operation are also provided.

Irrigation System and Crop

The irrigation evaluation was conducted in Block 1, 2 and 3 of the Green Valley ranch in Corralitos, CA on Aug 19th, 2016. The soils were Soquel loam, Pfeiffer gravelly sandy loam and Bonny Doon loam (NRCS Web soil survey, SSURGO dataset) and the ranch had been terraced. Slopes ranged from 5% to 15%. The well, pump and filter were located between blocks 1 and 2 and fed two 5,000 gallon water tanks located near block 3, about 380 feet from the well in ground distance and 130 ft higher in elevation. The flowrate from the pump was reported to be about 8 gpm and the pump runs every day 24 hours per day during irrigation season. Thus, about 11,520 gal/day are pumped into the 10,000 gal of storage.
A 2" PVC mainline carried water from the tanks to block 1 and 2 that were irrigated by gravity, and connected to 1¼" PVC underground lines at the blocks that functioned as manifolds. Polyethylene hoses, ¾" in diameter connected to the manifolds with tees and were controlled by individual ball valves. Each hose line irrigated one tree row. Block 1 had a 30 psi fixed pressure regulator at the connection of the manifold to the mainline, while block 2 had 15 psi pressure regulators at the tees, on the southern side of each hose. Block 3 was at the same elevation of the tanks and was irrigated with an electric booster pump that pumped water from the tanks to the

block. In block 3 the irrigation hoses were also controlled with individual ball valves but there was no pressure regulation (Figure 1).
Block 1 included 8 tree rows; block 2 included 12 tree rows and block 3 included 11 tree rows. Tree spacing was 8 feet in the rows and row spacing was 16 feet. Micro-sprinkler spacing on the irrigation line was 16 ft so there was one micro-sprinkler watering every 2 trees. The micro-sprinklers were Rivulis Blue Rondo RFR dark blue pressure compensating, with a design flowrate of 11 gph. The manufacturer's recommended operating pressure range of the micro micro-sprinklers was 22 to 50 psi. The hoses were 3/4" in diameter, 60 mill thickness. The measured inside diameter was 0.82" and the outside diameter was .95".
The current irrigation management is running 2 lines (about 50 micro-sprinklers, depending on the block) for 12 hours per day. Thus, there are a total of 44 irrigation sets, each including 2 lines (about 5 sets in each of blocks 1,2,3,4,5,6 and 10 in block 7, where 4 lines are run at the time). Each head applies about 15 gph, so 50 heads in 12 hours apply 9000 gallons, which is close to the capacity of the tanks. This way it takes about one entire irrigation season to irrigate the whole ranch just once. The issue with this management is that different blocks are irrigated at very different times. A better management would imply a faster turnover, where the entire ranch gets irrigated 3 or 4 times per season, but this would require a higher flow from the pump, additional storage capacity, shorter irrigation sets and or an automated valve system.

Figure 2. Map of the field with letters showing locations of DU measurements, and numbers showing pressure measurements in psi (in purple)

Distribution Uniformity Evaluation

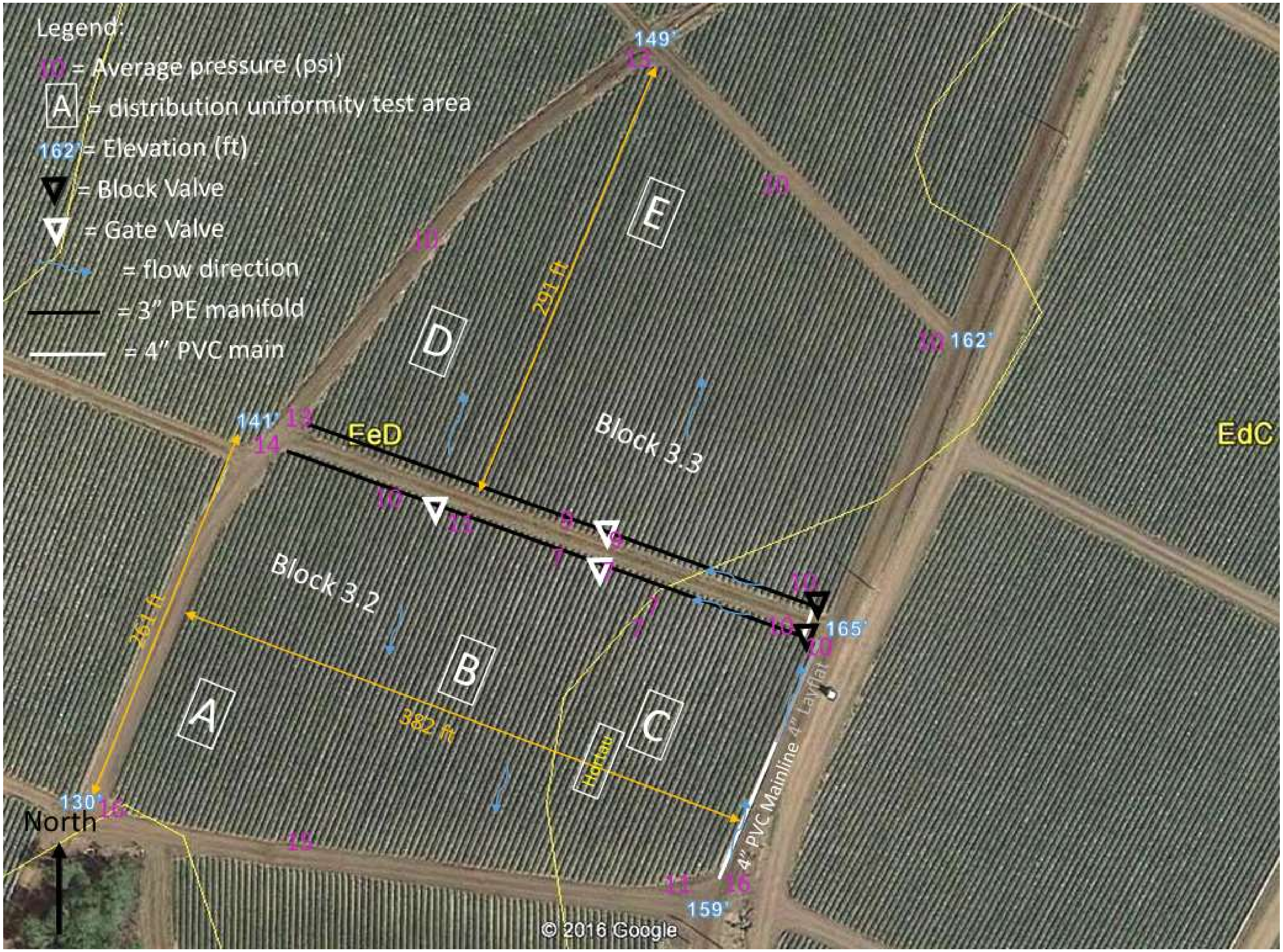
Distribution uniformity (DU) and application rate of the micro-sprinkler system were evaluated at

Table 1. Distribution Uniformity (DUlq) and flow characteristics of the irrigation system obtained from the "bucket test".

DU Area	DUlq	Sprinkler discharge rate	Line discharge rate	System flow rate	Field application rate	Average Pressure
	%	gal/hr	gpm/100 ft	gpm/acre	inch/hr	psi
A	91.4	13.23	1.38	37.5	0.08	26.5
B	73.6	11.86	1.24	33.6	0.07	27.0
All Block 1	82.0	12.54	1.31	35.58	0.08	26.8
C	86.6	15.98	1.66	45.3	0.10	26.5
D	82.2	16.51	1.73	47.1	0.10	34.8
All Block 2	84.0	16.29	1.70	46.21	0.10	30.6
E	92.2	16.66	1.74	47.3	0.10	42.0
F	88.8	16.33	1.70	46.3	0.10	42.8
All Block 3	90.0	16.50	1.72	46.78	0.10	42.4
Overall	79.5	15.11	1.57	42.9	0.09	33.3

DUlq = Distribution uniformity of the lowest quarter

Table 2 shows the results of the "cup test". The application rates ranged from 0.03 in/hr to 0.1 in/hr and were in general lower than those obtained from the bucket tests, indicating each micro-


Legend:
10 = Average pressure (psi)
A = distribution uniformity test area
162' = Elevation (ft)
= Block Valve
= Gate Valve
= flow direction
= 3" PE manifold
= 4" PVC main
149'
13
10
10
E
D
291 ft
10 162'
141' 13
14
EeD
Block 3.3
EdC
10
11
9
9
7
7
7
10
10
10
165'
Block 3.2
261 ft
382 ft
A
B
C
Hdrtau
4" PVC Mainline 4" Layflat
130' 16
North
15
11
16
159'
© 2016 Google

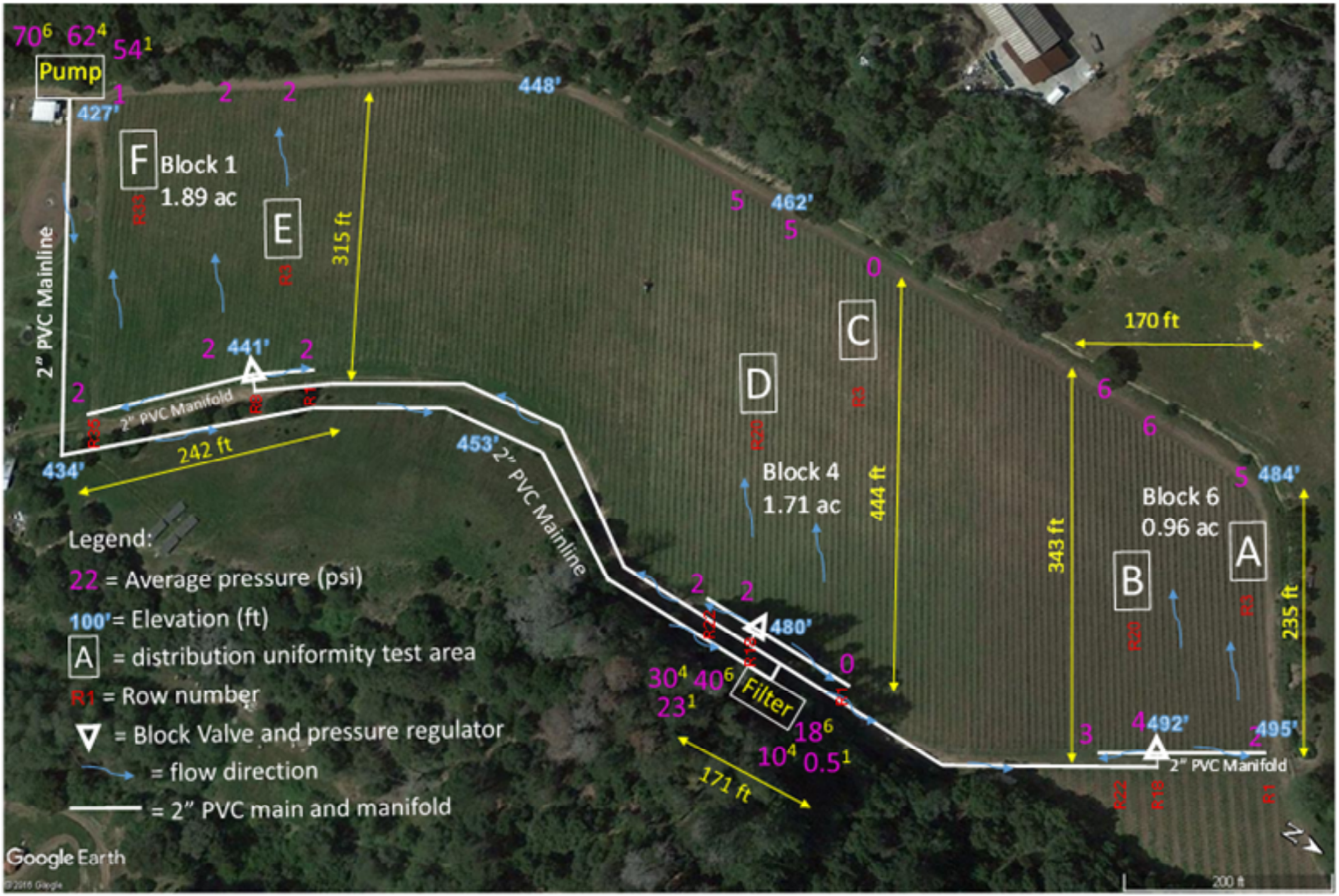

Pump
Block 1
1.89 ac
Block 4
1.71 ac
Block 6
0.96 ac
2" PVC Mainline
2" PVC Manifold
315 ft
242 ft
444 ft
343 ft
235 ft
170 ft
171 ft
Filter
448'
462'
453'
480'
484'
492'
495'
434'
441'
427'
Legend:
22 = Average pressure (psi)
100' = Elevation (ft)
A = distribution uniformity test area
R1 = Row number
= Block Valve and pressure regulator
= flow direction
= 2" PVC main and manifold
Google Earth

Table 3: Theoretical pressure loss through the system

									Pressure loss		
		Avg flowrate per drip line	**Lines open**	Flow Q	Coefficient C	Length L	Inside Diameter ID	Elevation	Due to friction Hf	Due to elevation	Total
Block		**gpm**		gpm	for PVC	feet	inch	ft	psi	psi	psi
1	Well to filter	1.32	23	30.3	140	1250	2	53.0	11.4	22.9	34
1	Filter to block	1.32	23	30.3	140	700	2	-39.0	6.4	-16.9	-11
4	Well to filter	1.54	22	33.9	140	1250	2	53.0	14.1	22.9	37
4	Filter to block	1.54	22	33.9	140	35	2	0.0	0.4	0.0	0
6	Well to filter	1.08	22	23.7	140	1250	2	53.0	7.2	22.9	30
6	Filter to block	1.08	22	23.7	140	360	2	12.0	2.1	5.2	7

Table 4: Summary of observed pressures

	Time 1	Time 2	Average	Notes
	Measured pressures (psi)			
Block 1				
pressure at well	54.0	53.0	53.5	
pressure before filter station	25.0	23.0	24.0	
pressure after filter station	1.0	0.5	0.8	
pressure **loss from pump to filter station**	29.0	30.0	**29.5**	
pressure **loss through filter station**	24.0	22.5	**23.3**	
pressure at the driphose, middle of manifold	2.5	2.0	2.3	
pressure at the driphose, end of manifold	2.0	1.5	1.8	
pressure at the tail end of the driphose	1.5	1.8	1.6	
loss from after filter to middle of manifold	-1.5	-1.5	**-1.5**	Block 1 downhill from filter
pressure **loss across manifold**	0.5	0.5	**0.5**	
pressure **loss across drip hoses**	0.5	-0.3	**0.1**	
Block 4				
pressure at well	62.0		62.0	
pressure before filter station	30.0	30.0	30.0	
pressure after filter station	10.0	10.0	10.0	
pressure **loss from pump to filter station**	32.0		**32.0**	
pressure **loss through filter station**	20.0	20.0	**20.0**	
pressure at the driphose, middle of manifold	2.0	2.0	2.0	
pressure at the driphose, end of manifold	1.0	1.0	1.0	
pressure at the tail end of the driphose	2.5	2.3	2.4	
loss from after filter to middle of manifold	8.0	8.0	**8.0**	
pressure **loss across manifold**	1.0	1.0	**1.0**	
pressure **loss across drip hoses**	-1.5	-1.3	**-1.4**	Driplines downhill
Block 6				
pressure at well	67.0	70.0	68.5	
pressure before filter station	40.0		40.0	
pressure after filter station	18.0		18.0	
pressure **loss from pump to filter station**	27.0		**27.0**	
pressure **loss through filter station**	22.0		**22.0**	
pressure at the driphose, middle of manifold	3.5	4.0	3.8	
pressure at the driphose, end of manifold	2.0	2.3	2.1	
pressure at the tail end of the driphose	5.8	5.5	5.6	
loss from after filter to middle of manifold	14.5		**14.5**	
pressure **loss across manifold**	1.5	1.8	**1.6**	
pressure **loss across drip hoses**	-3.8	-3.3	**-3.5**	Driplines downhill

Summary of Distribution Uniformity reports

Number	Date	Ranch	Farm size	Crop	Area evaluated	Irrigation method	Distribution Uniformity
			acres		acres		
137	9/23/2015		40	Strawberry	3.3	Drip tape	73%
138	10/23/2015		20	Red Beets	1.8	Sprinklers	80%
139	10/27/2015		45	Strawberry	3	Drip tape	66%
140	12/2/2015		20	Potted ornamentals	0.6	Sprinklers	68%
141	2/12/2016		10.5	Strawberry	2.6	Drip tape	88%
142	2/22/2016		50	Raspberry & Blackberry	2.3	Drip tape/hose	38%
143	3/2/2016		62	Strawberry	2.8	Drip tape	87%
144	2/26/2016		50	Strawberry	3.3	Drip tape	84%
145	3/26/2016		34	Strawberry	3.2	Drip tape	96%
146	4/26/2016		34	Organic Blackberry	1.8	Drip hose	74%
147	5/6/2016		9	Organic Blackberry	3.5	Drip hose	75%
148	5/16/2016		23	Organic Strawberry	2.5	Drip tape	77%
149	6/9/2016		10	Organic Strawberry	1.7	Drip tape	57%
151	7/28/2016		6.5	Apple	3.5	Drip hose PC	90%
152	8/19/2016		15	Apple	3.8	Micro-Sprinkler	80%
153	9/16/2016		40	Strawberry	3.8	Drip tape	83%
154	9/22/2016		100	Organic Romaine	5.7	Sprinklers	76%
155	9/30/2016		2.8	Herbs	0.83	Drip tape	92%
156	10/21/2016		6.3	Organic Strawberry	0.9	Drip tape	67%
157	11/1/2016		12	Organic Wine Grapes	4.5	Drip hose PC	72%
Total 20 evaluations		Total acres =	590	Evaluated acres =	55	Average DU =	76%

By Method

Number	Date	Farm size	Crop	Area evaluated	Irrigation method	Distribution Uniformity
		acres		acres		
151	7/28/2016	6.5	Apple	3.5	Drip hose PC	90%
157	11/1/2016	12	Organic Wine Grapes	4.5	Drip hose PC	72%
					Drip PC average	**81%**
146	4/26/2016	34	Organic Blackberry	1.8	Drip hose	74%
147	5/6/2016	9	Organic Blackberry	3.5	Drip hose	75%
137	9/23/2015	40	Strawberry	3.3	Drip tape	73%
139	10/27/2015	45	Strawberry	3	Drip tape	66%
141	2/12/2016	10.5	Strawberry	2.6	Drip tape	88%
143	3/2/2016	62	Strawberry	2.8	Drip tape	87%
144	2/26/2016	50	Strawberry	3.3	Drip tape	84%
145	3/26/2016	34	Strawberry	3.2	Drip tape	96%
148	5/16/2016	23	Organic Strawberry	2.5	Drip tape	77%
149	6/9/2016	10	Organic Strawberry	1.7	Drip tape	57%
153	9/16/2016	40	Strawberry	3.8	Drip tape	83%
155	9/30/2016	2.8	Herbs	0.83	Drip tape	92%
156	10/21/2016	6.3	Organic Strawberry	0.9	Drip tape	67%
142	2/22/2016	50	Raspberry & Blackberry	2.3	Drip tape/hose	38%
					Drip average	**78%**
138	10/23/2015	20	Red Beets	1.8	Sprinklers	80%
140	12/2/2015	20	Potted ornamentals	0.6	Sprinklers	68%
154	9/22/2016	100	Organic Romaine	5.7	Sprinklers	76%
					Sprinklers avg	**75%**
152	8/19/2016	15	Apple	3.8	Micro-Sprinkler	80%

Potential Savings

Farm size	Crop	Irrigation method	Distribution Uniformity	Target DU	Avg ETc	Potential Savings		
acres					inch/season	inch/season	AcFt/season	$/season[1]
40	Strawberry	Drip tape	73%	85%	26	5.0	16.8	4190
20	Red Beets	Sprinklers	80%	80%	18	0.0	0.0	0
45	Strawberry	Drip tape	66%	85%	26	8.8	33.0	8255
20	Potted ornamentals	Sprinklers	68%	80%	35	7.7	12.9	3217
10.5	Strawberry	Drip tape	88%	90%	26	0.7	0.6	144
50	Raspberry & Blackberry	Drip tape/hose	38%	90%	23	35.0	2.9	729
62	Strawberry	Drip tape	87%	90%	26	1.0	5.1	1287
50	Strawberry	Drip tape	84%	90%	26	2.1	8.6	2149
34	Strawberry	Drip tape	96%	96%	26	0.0	0.0	0
34	Organic Blackberry	Drip hose	74%	90%	20	4.8	13.6	3403
9	Organic Blackberry	Drip hose	75%	90%	20	4.4	3.3	833
23	Organic Strawberry	Drip tape	77%	90%	26	4.9	9.3	2337
10	Organic Strawberry	Drip tape	57%	80%	26	13.1	10.9	2732
6.5	Apple	Drip hose PC	90%	90%	8	0.0	0.0	0
15	Apple	Micro-Sprinkler	80%	85%	8	0.6	0.7	184
40	Strawberry	Drip tape	83%	85%	26	0.7	2.5	614
100	Organic Romaine	Sprinklers	76%	80%	12	0.8	6.6	1645
2.8	Herbs	Drip tape	92%	92%	24	0.0	0.0	0
6.3	Organic Strawberry	Drip tape	67%	80%	26	6.3	3.3	828
12	Organic Wine Grapes	Drip hose PC	72%	90%	8	2.2	2.2	556
590		Average DU =	76%			Tot Savings AcFt =	132.4	33103

Application Rate

Number	Crop	Irrigation method	Distribution Uniformity	Design application rate	Measured app rate	Difference
				in/hr	in/hr	%
137	Strawberry	Drip tape	73%	0.222	0.280	26%
138	Red Beets	Sprinklers	80%	0.287	0.310	8%
139	Strawberry	Drip tape	66%	0.151	0.220	46%
140	Potted ornamentals	Sprinklers	68%	0.509	0.830	63%
141	Strawberry	Drip tape	88%	0.298	0.350	18%
142	Raspberry & Blackberry	Drip tape/hose	38%	0.063	0.080	28%
143	Strawberry	Drip tape	87%	0.222	0.180	-19%
144	Strawberry	Drip tape	84%	0.222	0.150	-32%
145	Strawberry	Drip tape	96%	0.222	0.190	-14%
146	Organic Blackberry	Drip hose	74%	0.212	0.160	-24%
147	Organic Blackberry	Drip hose	75%	0.106	0.090	-15%
148	Organic Strawberry	Drip tape	77%	0.193	0.210	9%
149	Organic Strawberry	Drip tape	57%	0.289	0.230	-20%
151	Apple	Drip hose PC	90%	0.025	0.027	6%
152	Apple	Micro-Sprinkler	80%	0.069	0.094	37%
153	Strawberry	Drip tape	83%	0.151	0.174	15%
154	Organic Romaine	Sprinklers	76%	0.239	0.230	-4%
155	Herbs	Drip tape	92%	0.359	0.290	-19%
156	Organic Strawberry	Drip tape	67%	0.289	0.200	-31%
157	Organic Wine Grapes	Drip hose PC	72%	0.048	0.044	-10%

Most common recommendations:

Recommendation	Frequency
Install pressure regulators	7/20
Plugging issues, better flushing needed	7/20
Install larger oval hose	5/20
Install larger spaghetti leads	5/20
Set pressure regulators correctly	3/20
Improve orientation of rows/tapes	3/20
Fix leaks (causing ponding/runoff)	3/20
Reduce pressure (>20 psi)	3/20
Install larger layflat serving next block	3/20
Reduce irrigation set area	2/20
Mixed emitters/sprinkler heads	2/20

What Can You Do?

Pressure regulators

PRU

PRU – Ultra High Flow

Ideal for installations requiring ultra high flows and accurate zone control.

Applications: Commercial Turf, Drip, Nursery, Agricultural Solid Set, Effluent and Industrial Mining Applications.

Features

- The compact size makes it convenient for use in a valve box
- Corrosion resistant materials that can withstand harsh water conditions and chemicals
- Very low hysteresis and friction loss
- Large flow path resists plugging

~$150

Specifications | Literature | FAQ

Model #	Flow Range	Preset Operating Pressure	Maximum Inlet Pressure	Inlet Sizes	Outlet Sizes
PRU-10	20 - 100 gpm (4543 - 22713 L/hr)	10 psi (0.69 bar)	90 psi (6.20 bar)	2" F NPT, 2" F BSPT	2" F NPT, 2" F BSPT
PRU-15	20 - 100 gpm (4543 - 22713 L/hr)	15 psi (1.03 bar)	95 psi (6.55 bar)	2" F NPT, 2" F BSPT	2" F NPT, 2" F BSPT
PRU-20	20 - 100 gpm (4543 - 22713 L/hr)	20 psi (1.38 bar)	100 psi (6.89 bar)	2" F NPT, 2" F BSPT	2" F NPT, 2" F BSPT
PRU-25	20 - 100 gpm (4543 - 22713 L/hr)	25 psi (1.72 bar)	105 psi (7.24 bar)	2" F NPT, 2" F BSPT	2" F NPT, 2" F BSPT
PRU-30	20 - 100 gpm (4543 - 22713 L/hr)	30 psi (2.07 bar)	110 psi (7.58 bar)	2" F NPT, 2" F BSPT	2" F NPT, 2" F BSPT
PRU-40	20 - 100 gpm	40 psi	120 psi	2" F NPT,	2" F NPT,

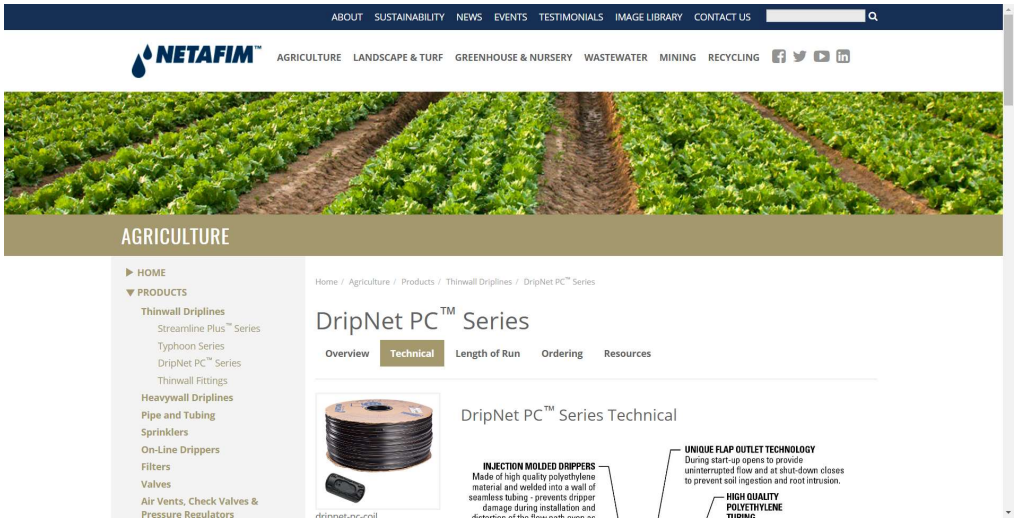
Install pressure check-points to measure pressure

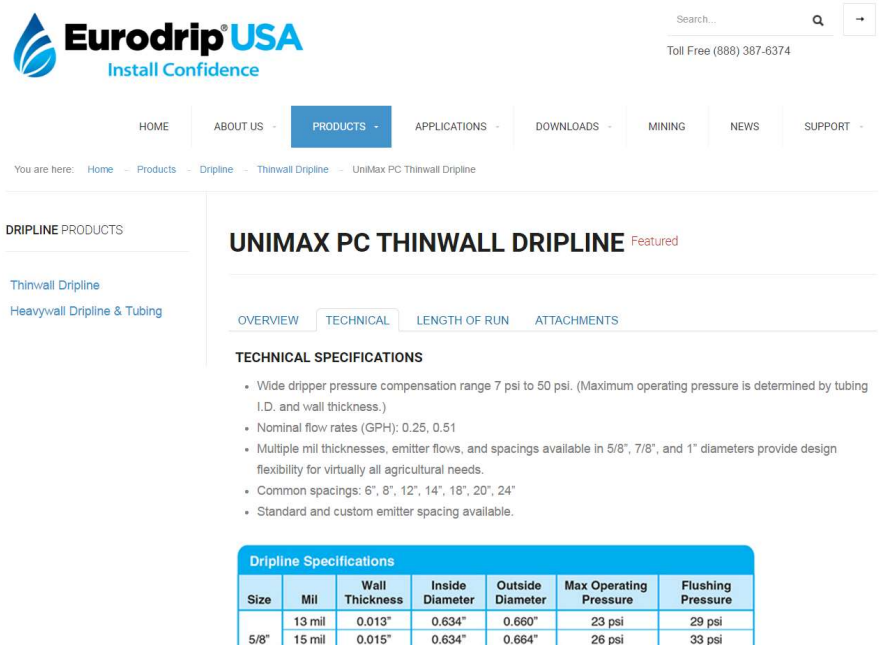
Make flushing easier

Vs


nalgene
MADE IN USA
DRIPLINE

Pressure compensating tape





5/8, 13 mil, 8” spacing, 0.625 gpm/100ft

10,000ft cost $580 (roll of 4300ft costs 250$)

Questions?

Application Rate

Number	Crop	Irrigation method	Distribution Uniformity	Design application rate	Measured app rate	Difference
				gpm/100ft	gpm/100ft	
137	Strawberry	Drip tape	73%	0.5	0.64	28%
138	Red Beets	Sprinklers	80%			
139	Strawberry	Drip tape	66%	0.34	0.49	44%
140	Potted ornamentals	Sprinklers	68%			
141	Strawberry	Drip tape	88%	0.67	0.79	18%
142	Raspberry & Blackberry	Drip tape/hose	38%	0.52	0.6	15%
143	Strawberry	Drip tape	87%	0.5	0.4	-20%
144	Strawberry	Drip tape	84%	0.5	0.34	-32%
145	Strawberry	Drip tape	96%	0.5	0.43	-14%
146	Organic Blackberry	Drip hose	74%	0.88	0.65	-26%
147	Organic Blackberry	Drip hose	75%	0.88	0.76	-14%
148	Organic Strawberry	Drip tape	77%	0.4	0.44	10%
149	Organic Strawberry	Drip tape	57%	0.65	0.52	-20%
151	Apple	Drip hose PC	90%	0.42	0.45	7%
152	Apple	Micro-Sprinkler	80%	1.14	1.57	38%
153	Strawberry	Drip tape	83%	0.34	0.42	24%
154	Organic Romaine	Sprinklers	76%			
155	Herbs	Drip tape	92%	0.67	0.53	-21%
156	Organic Strawberry	Drip tape	67%	0.65	0.45	-31%
157	Organic Wine Grapes	Drip hose PC	72%	0.35	0.32	-9%
		Average DU =	76%			