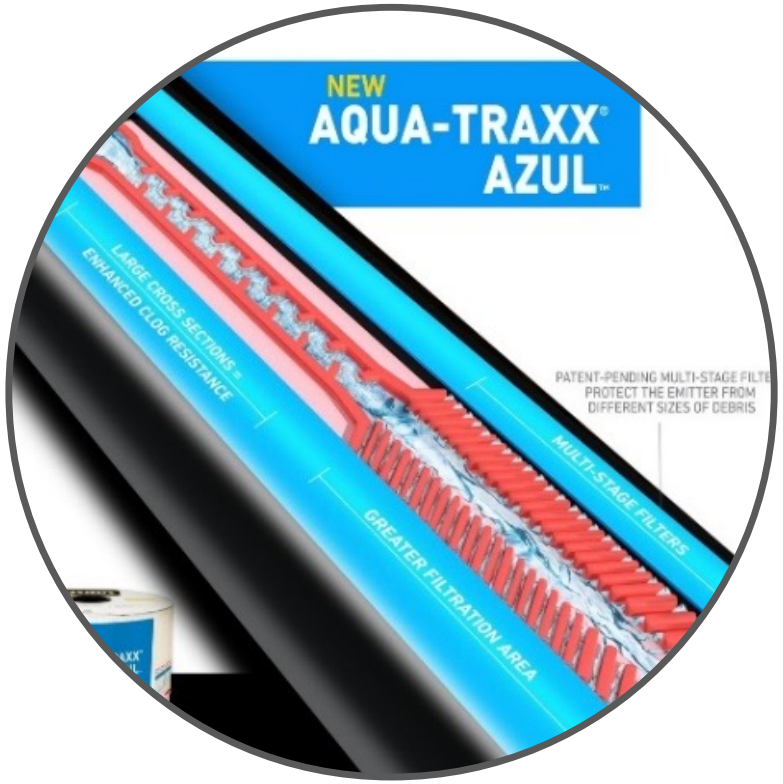
THE TORO COMPANY

Irrigation Infrastructure & Emission Devices

Anthony Tasselli

Toro Ag - Technical Sales



History of Toro Ag

- Originally built by Reed Irrigation Systems in 1972
- Acquired by James Hardie in 1978
- Acquired by Toro in 1995

- Since those acquisitions, most of our growth has come from products developed by Toro
  - *Aqua-Traxx Azul & FlowControl*
  - Blueline
  - Greenhouse products
  - Disc filters
  - Buyout relationships for allied products

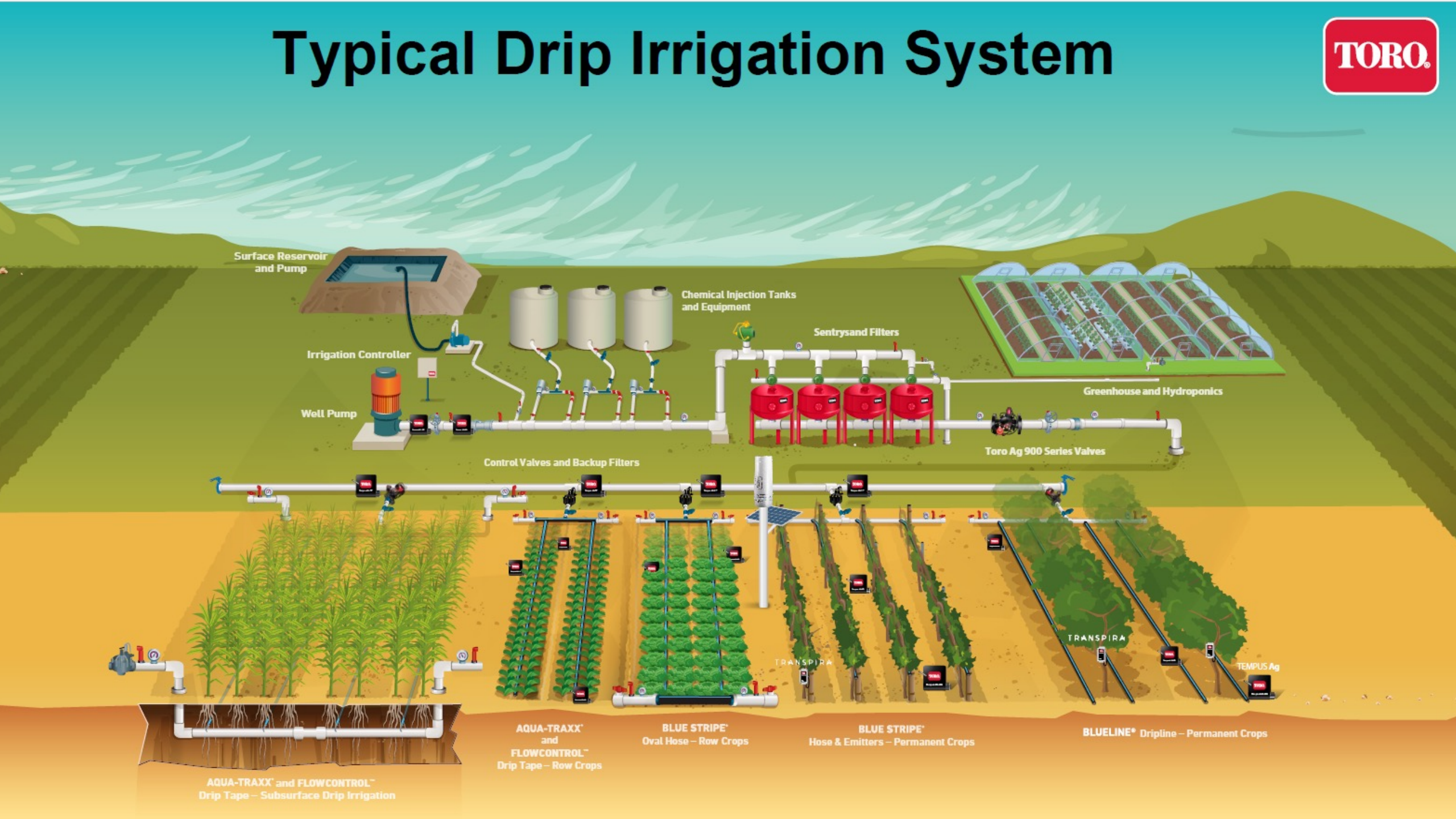
- *The Toro Company celebrated it's 100 year centennial in 2014*

- Toro Micro Irrigation changed name to Toro Ag in 2017

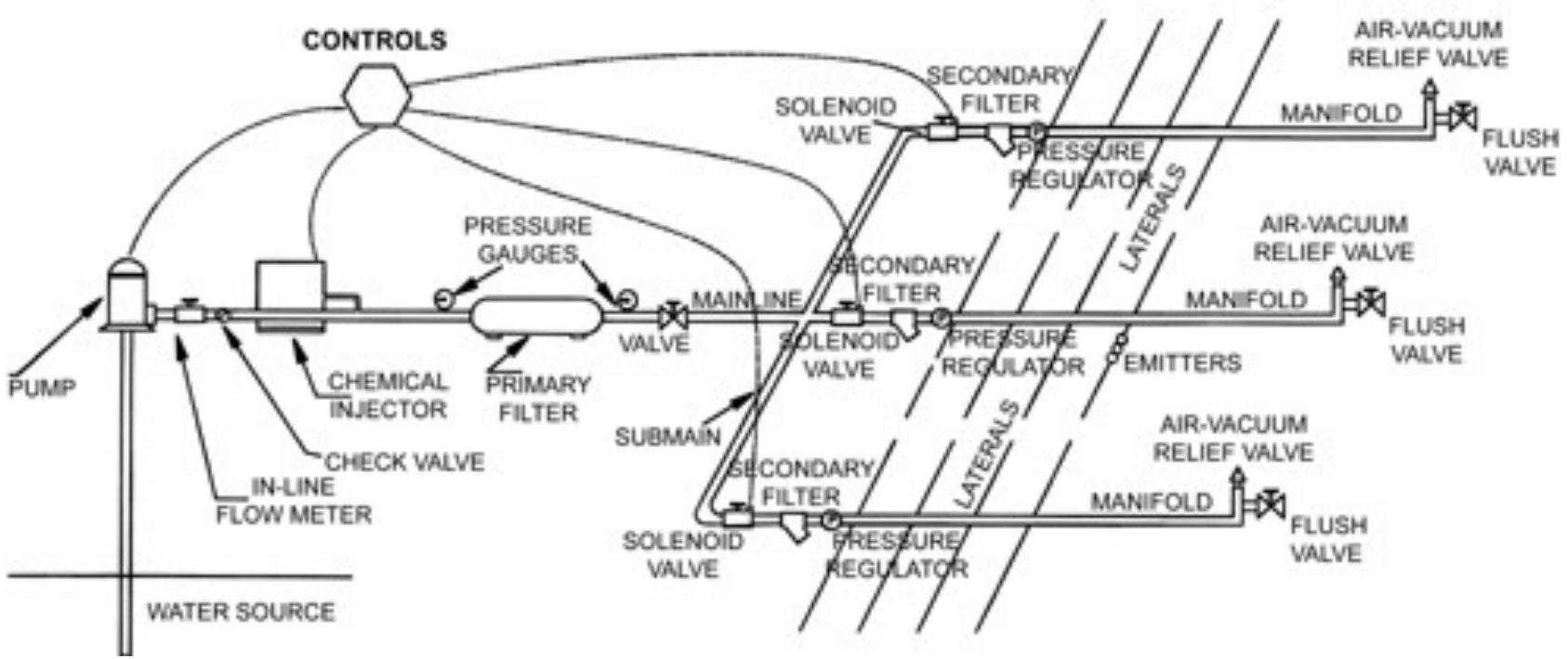
Drip Irrigation Products

- Emission Devices
  - Dripline with emitters built in
  - Drip tape
  - Drip emitters – on-line with polyethylene tubing
  - Micro-sprinklers / jets
- Water distribution tubing
  - Oval Hose
  - Lay Flat
  - Micro Tubing
- Accessories
  - Filters
  - Automation/Controllers
  - Valves
  - Fittings

Typical Drip Irrigation System



Typical Drip System Components



Essential Components

- Water source
- Pipeline
- Filter
- Control Valve
- Air/Vacuum Relief
- Emission Devices

Supplemental Components – Enhance performance & improve functionality

- Pressure Regulation
- Chemical Injection Equipment
- Flow meter(s)
- Pressure Gauges
- Solenoid Valves
- Automated control system
- Flush Valves/Flushing Manifolds

Design Considerations

A balance of properly sized components & cost saving measures

- Intended Use
  - Crop(s)
  - Life Expectancy
- Field conditions
  - Water availability
  - Soil types & characteristics
  - Crop water requirements
- Type and Size
  - Pump
  - Pipe
  - Valves
  - Filtration
  - Emission devices

Intended Use

Permanent Installations

- Emitter line
- Poly hose with external emitters
- Micro Sprinklers/ Jets/ Spray stakes
- SDI

Annual Installations

- Drip Tape
- Lay Flat hose for mainlines, submains, and manifolds
- Oval Hose/Poly Hose for distribution manifolds

Mobile Infrastructure

- Trailer-mounted pumps
- Trailer-mounted filters
- Skid-mount injection sleds
- Lay-flat mainline/manifolds
- Aluminum mainline

Permanent Infrastructure

- Wells
  - -Wet-well / Sumps
  - - Canned Subs
  - - Line shaft turbines
- Reservoir- Surface Pump
- Filter Stations
- Chemigation Sheds
- Buried Mainlines

Permanent Installations

Annual Installations

- Strawberries
- Tomatoes
- Peppers
- Lettuce
- Corn
- Onions
- Potatoes
- Cucumbers
- Squash
- Melons
- Sweet Corn
- Carrots
- Herbs

Row Crop – SDI – Permanent Installation

Permanent Infrastructure

In-field headworks – 4 zone control valves & reliefs

Primary Headworks - 48”x2” Sand Media Filter & Zone Valves

Valve manifold at primary head works

Engine driven Line Shaft Turbine

PVC Mainline, submain and manifold – shared trench

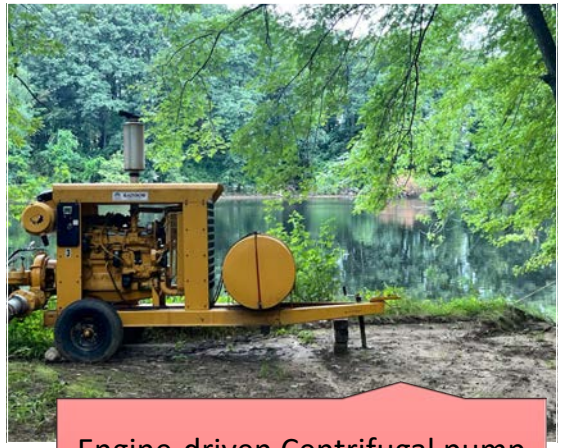
Primary Headworks - 8” Automatic Screen filter at turbine discharge

Mobile Infrastructure

Skid-mount Sand Media Filter

2-Zone Head Works

Layflat Supply to Oval hose manifolds



Engine-driven Centrifugal pump

Riverbank pump site

FlowControl drip tape on layflat manifold

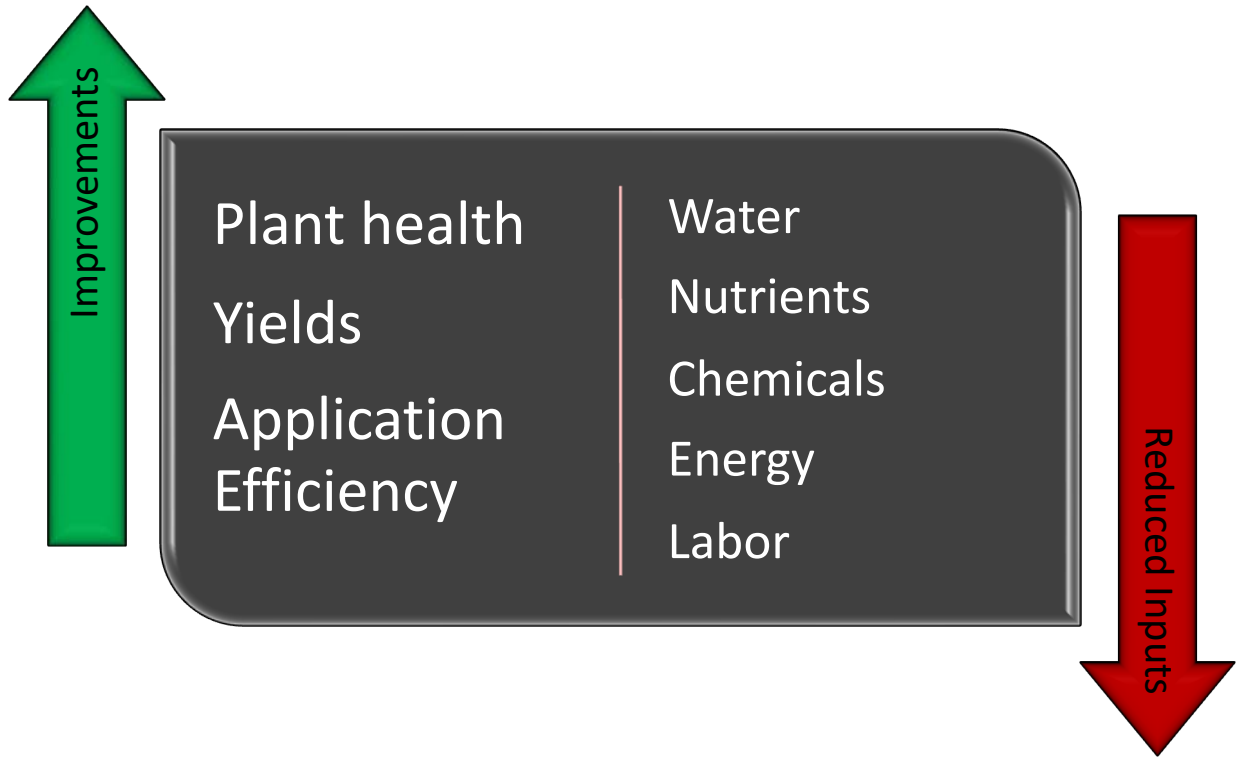
Layflat Supply & layflat manifold;

2 tapes per bed

Trailer-mounted Pump, filter, and fertilizer injection

Successful Micro-Irrigation systems should…

- Increase yield, crop quality, and income
- Reduce inputs - water, fertilizer, labor, tillage
- Distribute content uniformly and efficiently

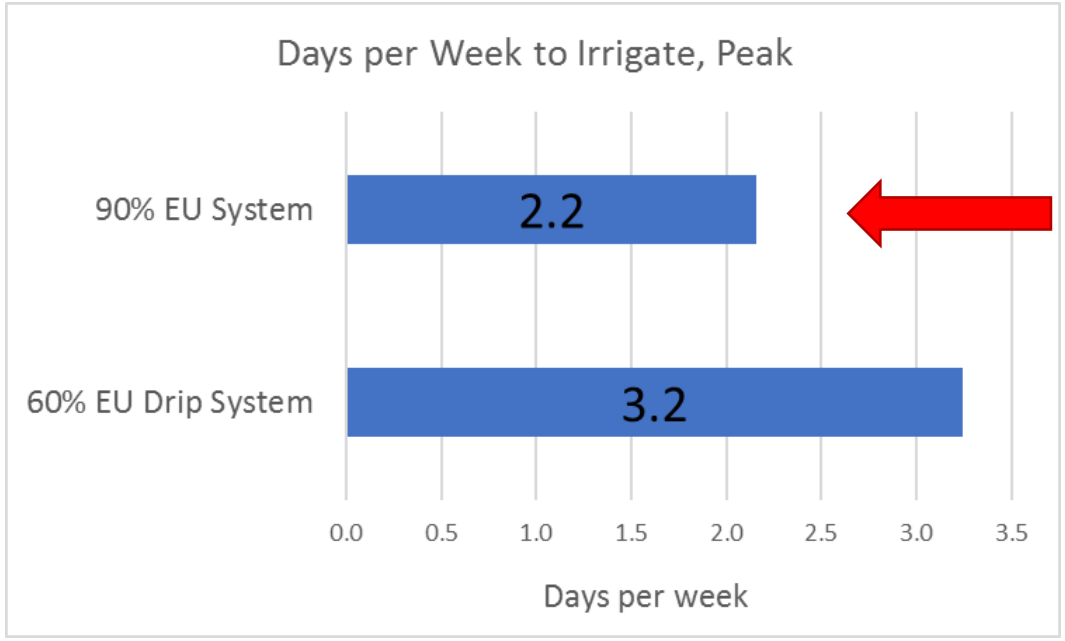


Irrigation Uniformity (EU)

- Uniform application of water and nutrients
- Efficient resource use
- Uniform crops

Irrigation Uniformity (EU) –What does it mean?

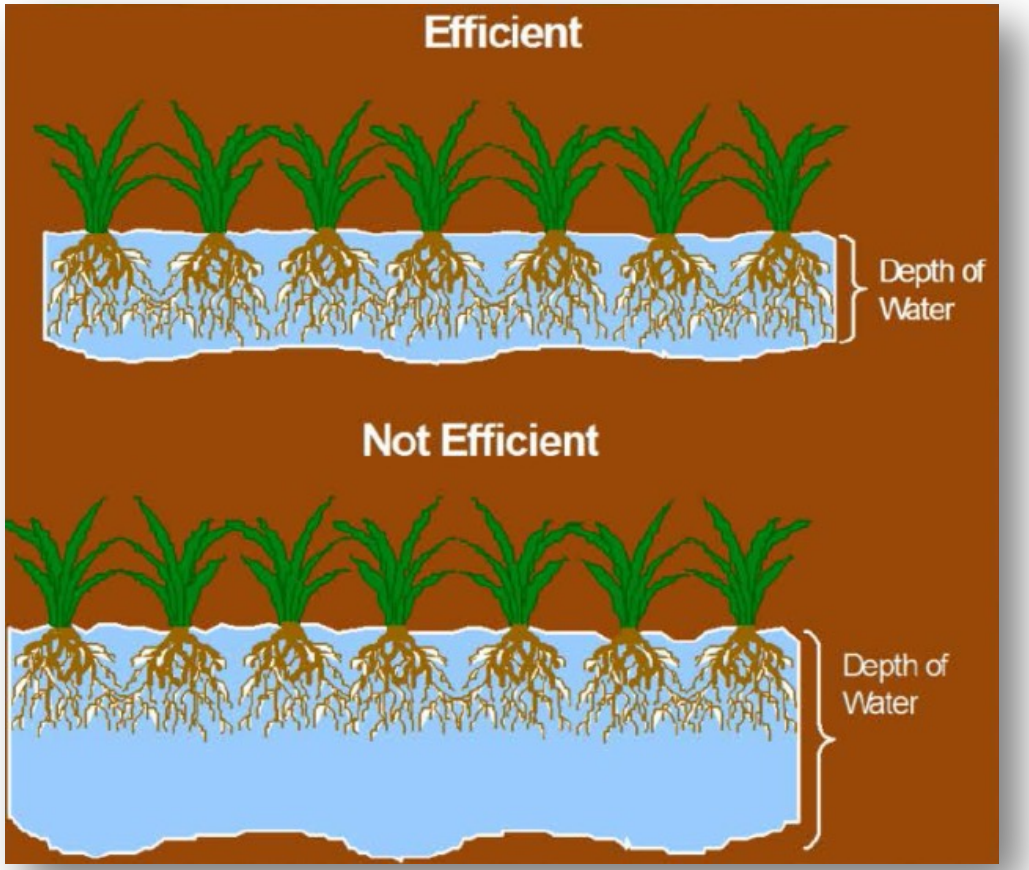
Crop Water Use at Peak ET, Inches per Week*	Drip gross application rate, inches/day**	90% EU Drip net application rate inches/day	Days per week to irrigate	Gross application rate, inches/day	60% EU Net application rate, inches/day	Days per week to irrigate
2.8	**1.44**	**1.30**	**2.2**	**1.44**	**0.86**	**3.2**
* Assuming peak ET = .40"/day x 7 days/week = 2.8"/week						
**System Details: 0.06"/hr gross application rate x 24 hrs/day = 1.44 inches/day						



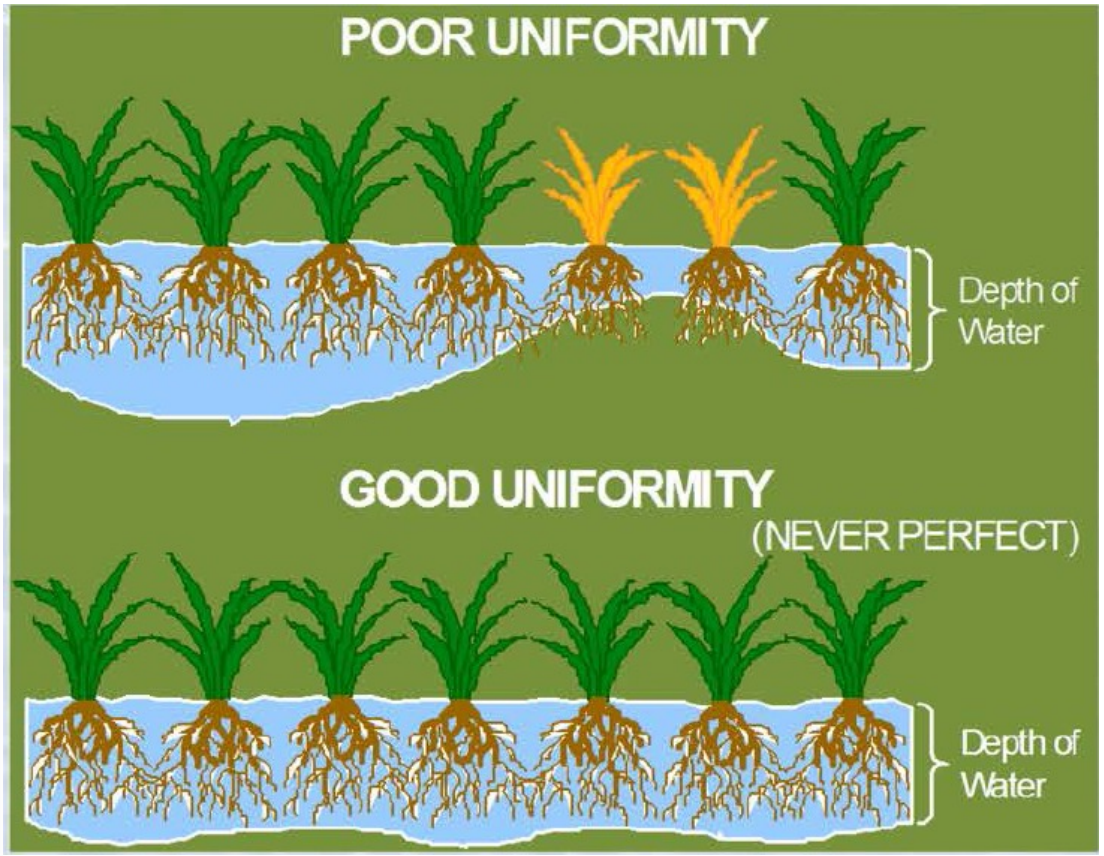
30% less run time with high EU!

Challenges to Optimize Uniformity (EU)

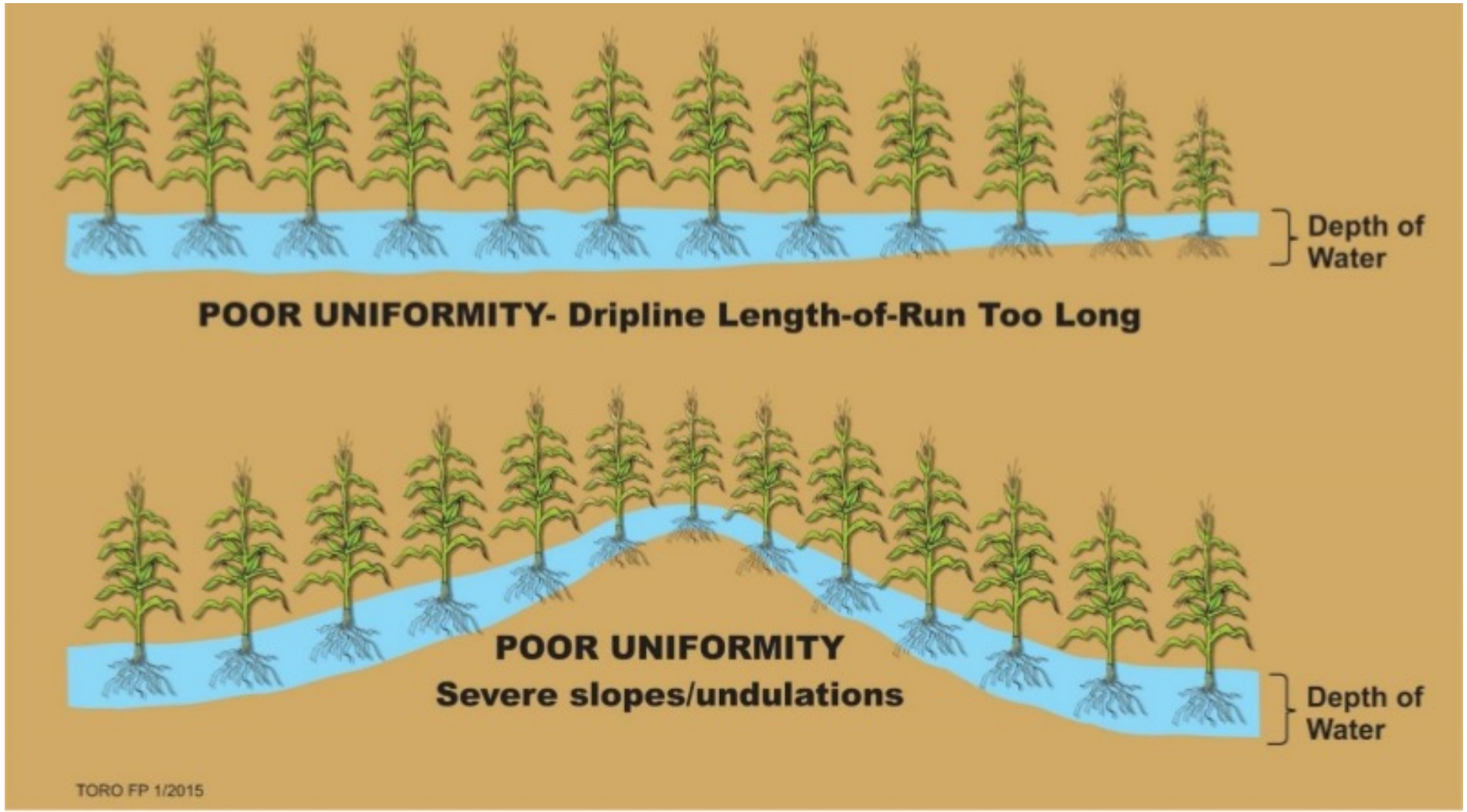
Management / Scheduling



Equipment Malfunction



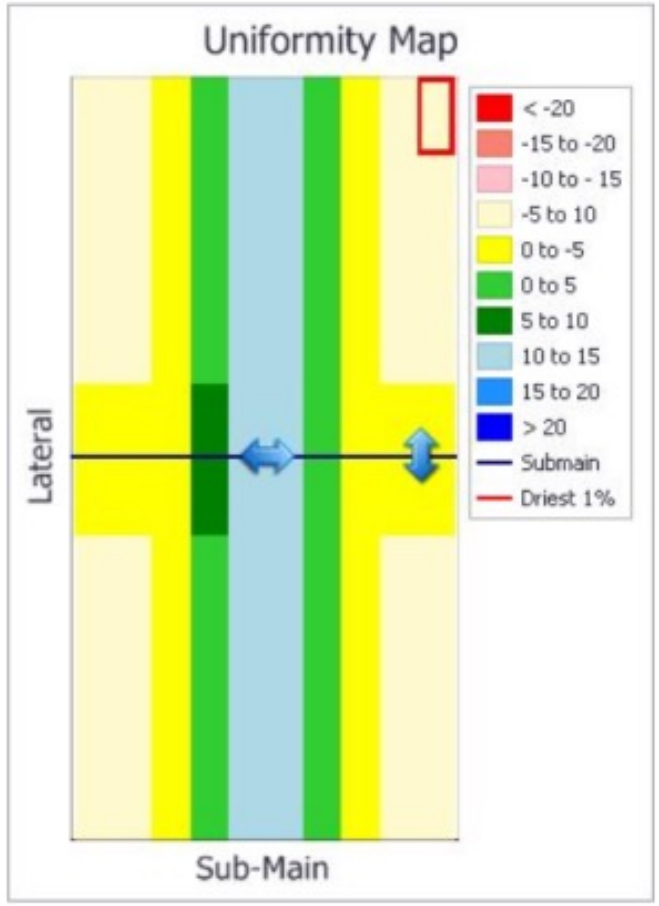
Challenges to Optimize Uniformity (EU)



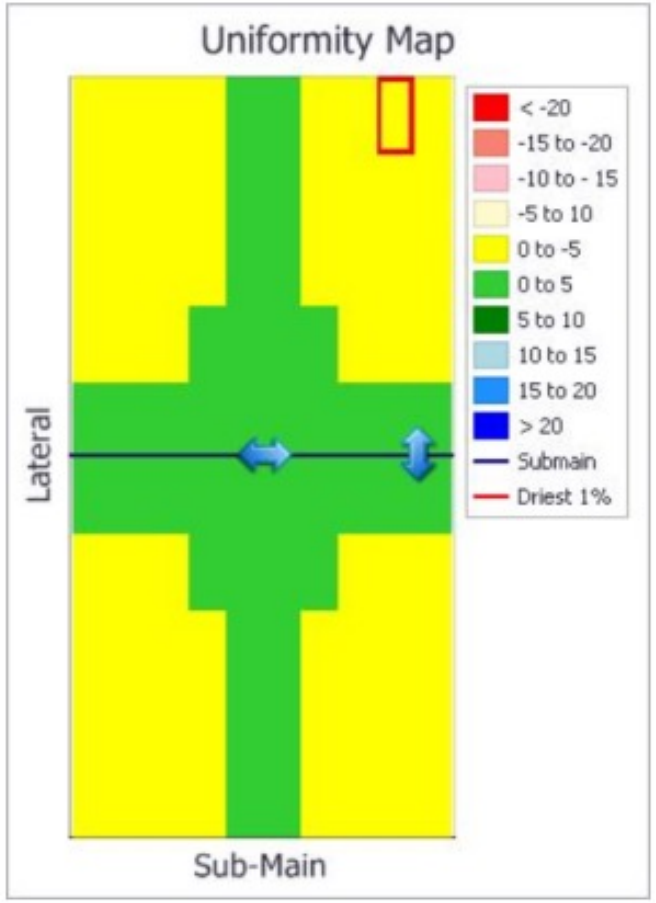
Challenges to Optimize Uniformity (EU)

Design (Terrain, Layout, Pipe Sizing)

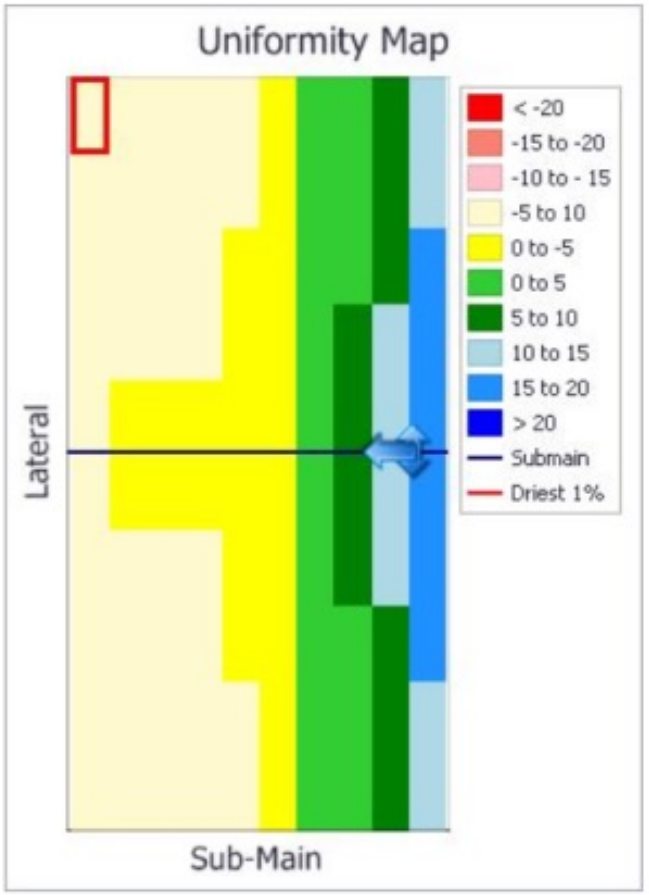
2” manifold, middle feed
89% EU



3” manifold, middle feed
94% EU



3” manifold, end feed
89% EU



Designing for Uniformity

- Terrain, layout, pipe-sizing
- **Emission Device Selection**

Types of Micro-Irrigation Emission Devices

Micro-Sprinklers

On-line Emitters

Heavy Wall Dripline

Flow Control Tape

Tape

Drip Tape Considerations

Not all drip tape is created equal

Tubing Construction	Emitter Type	Filtration Requirement	Published Flow Information	Other Differentiators	Product Traceability
• Seamless • Seamed – Cast • Seamed - Blown	• Flowpath • Discrete Emitter	• 100 mesh • 120 mesh • 155 mesh	• GPH @ 8 psi • GPH @ 10 psi • Q/100 – GPM per 100ft	• Emitter Exponent • Emitter spacing • Minimum order quantities	• Laser Etched • Printed • NA

Emitter Discharge Exponent

The Discharge Exponent (X) of an emitter determines the sensitivity of that emitter's flow rate to differences in pressure.

$$Q = K \times P^{X}$$

- ***Q*** = flow rate, gph (L/H)
- ***P*** = operating pressure, psi (kPA)
- ***K*** = flow coefficient
- ***X*** = flow exponent

X = 1.0 Fully laminar

X = 0.0 Fully pressure-compensating

Exponents Through the Years

Product Positioning	x Value	Emitter Type
Pressure Compensating BlueLine PC, Drip In PC, Dripnet PC, Inbar, Olympos	0.0	Pressure Compensating
	0.1	
	0.2	
	0.3	
Turbulent Flow Aqua-Traxx, Neptune, T-Tape, Streamline, Chapin, Irriway, Eolos, etc.	0.4	Vortex Emitters
	0.5	Orifice Flow or Tortuous-Path
	0.6	
1970's	0.7	Long or Spiral Path
	0.8	
1960's	0.9	Microtube
	1.0	Capillary Flow

Product Category Segmentation

Advantages vs. PC:

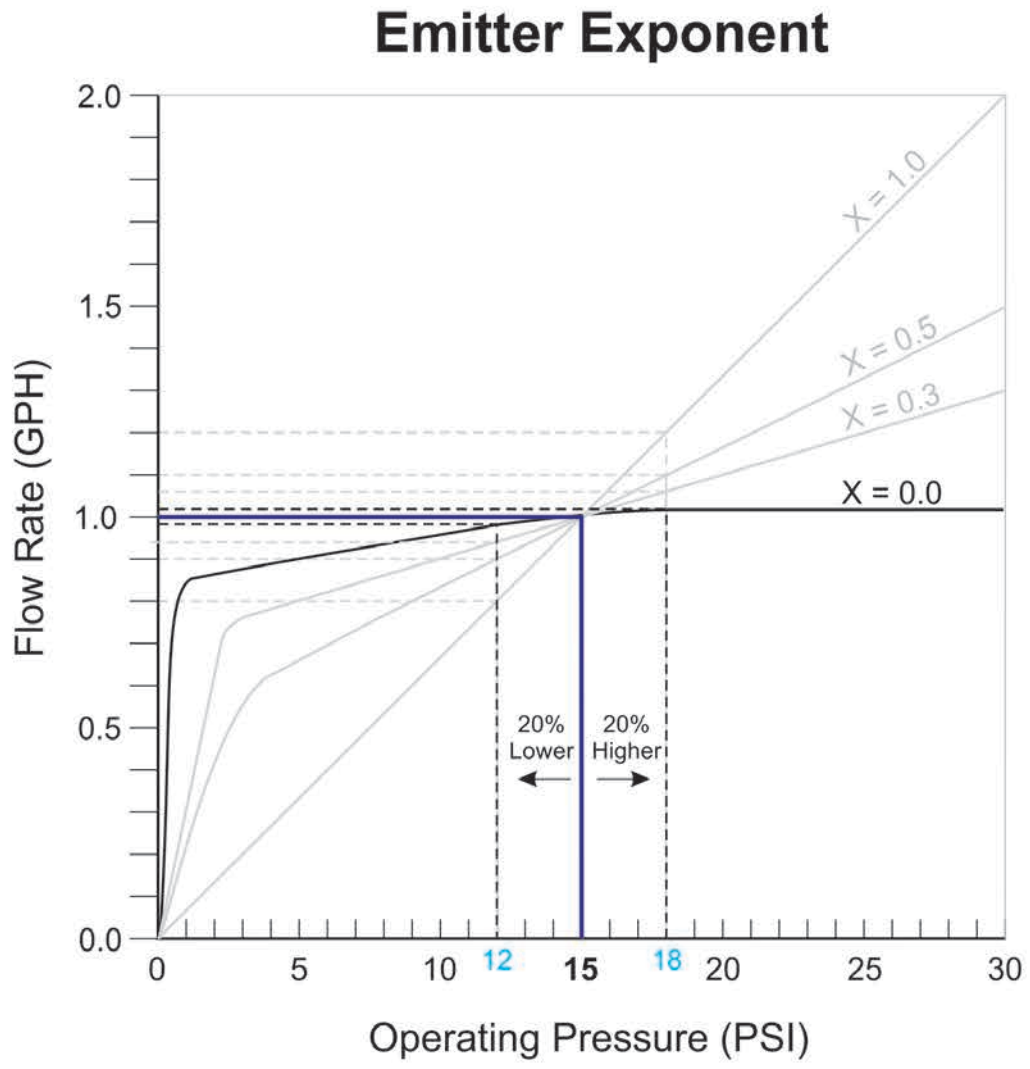
- Flexibility to increase system flow if needed
- Greater control over watering decisions
- Available in thinner walled options
- Closer emitter spacing

Advantages vs. Turbulent Flow

- Improved uniformity on:
  - Longer runs
  - Undulating terrain
- Better Performance

Product Positioning	x Value	Emitter Type
Pressure Compensating BlueLine PC, Drip In PC, Dripnet PC, Inbar, Olympos, Ram, Amnon	0.0	Pressure Compensating
	0.1	
	0.2	
FLOWCONTROL™	0.3	**Flow Control**
Turbulent Flow Aqua-Traxx AZUL, T-Tape, Streamline, Chapin, Irriway, Eolos, etc.	0.4	Vortex Emitters
	0.5	Orifice Flow or Tortuous-Path
	0.6	
1970's	0.7	Long or Spiral Path
	0.8	
1960's	0.9	Microtube
	1.0	Capillary Flow

How Emitter Exponents Relate



Design Flow: 1.0 GPH
Operating Pressure: 15 PSI
Pressure Variation: ±3 PSI

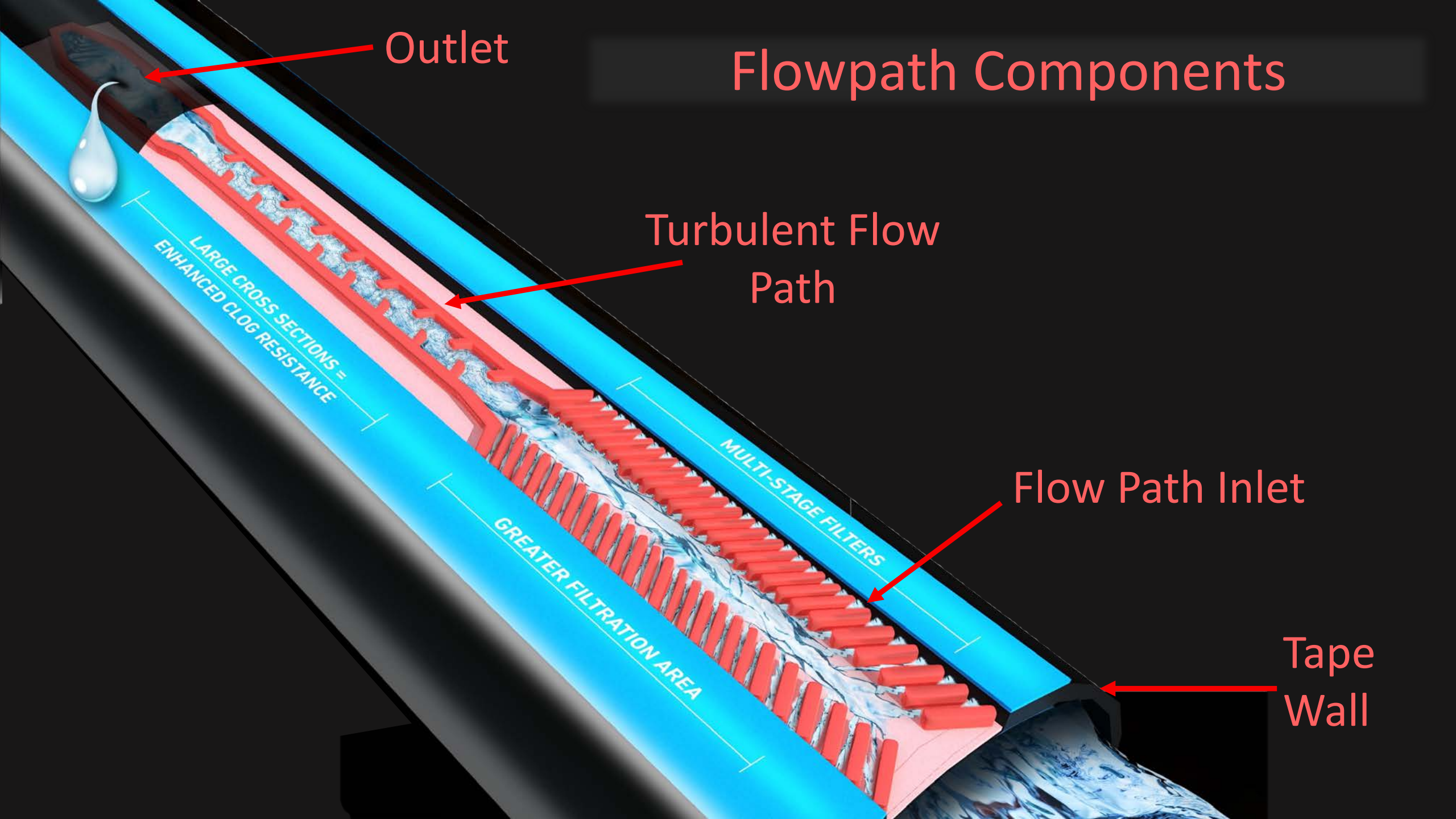
At 15 PSI Operating Pressure

1.0 = Laminar Flow (Flow Variation: ±0.2 GPH)

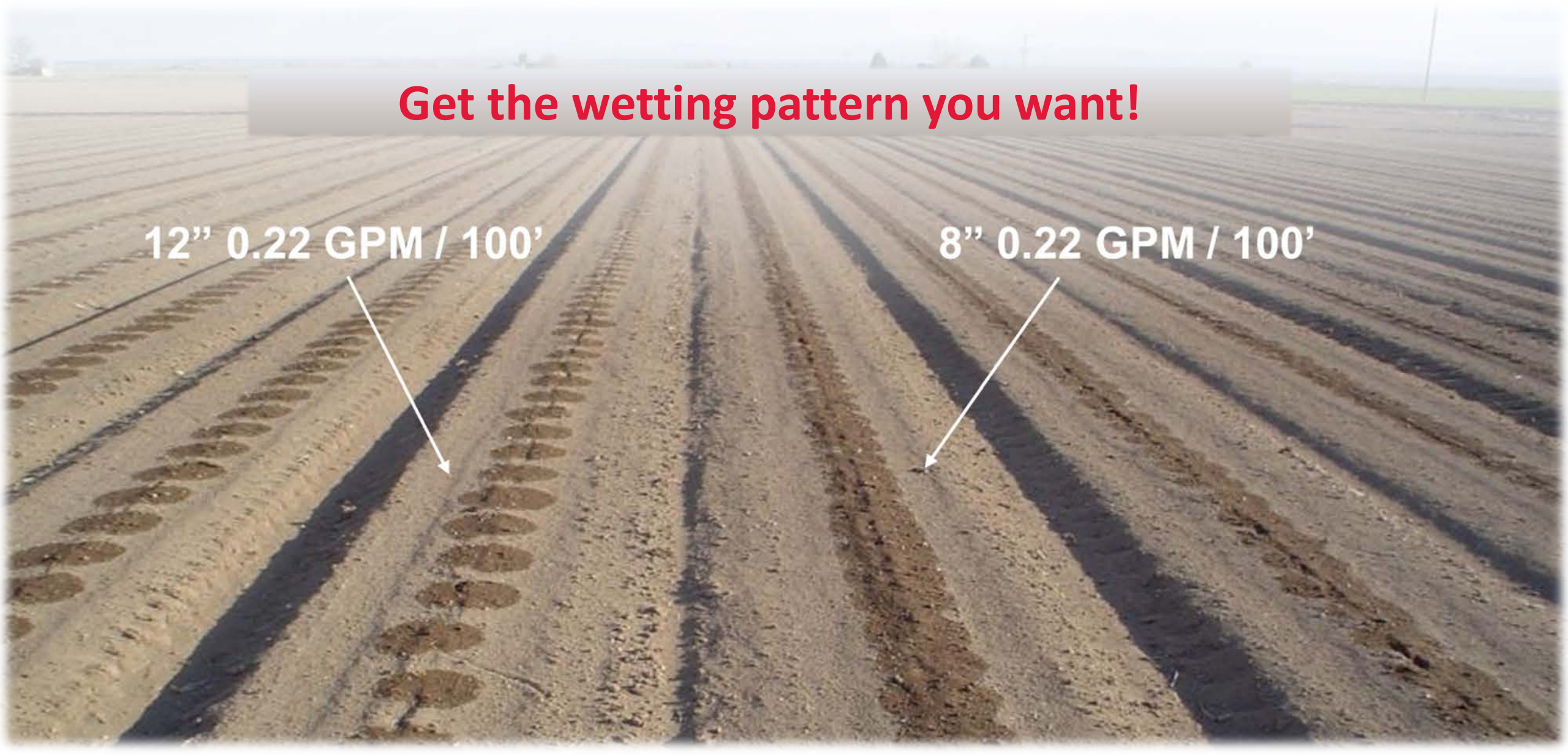
0.5 = Turbulent Flow (Flow Variation: ±0.1 GPH)

0.3 = Flow Control (Flow Variation: ±0.06 GPH)

0.0 = Full Pressure Compensation (Flow Variation: ±0 GPH)


Flowpath Components
Outlet
Turbulent Flow Path
Flow Path Inlet
Tape Wall
LARGE CROSS SECTIONS = ENHANCED CLOG RESISTANCE
GREATER FILTRATION AREA
MULTI-STAGE FILTERS

Design Flexibility



Design Flexibility

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Ultra-Low Flow

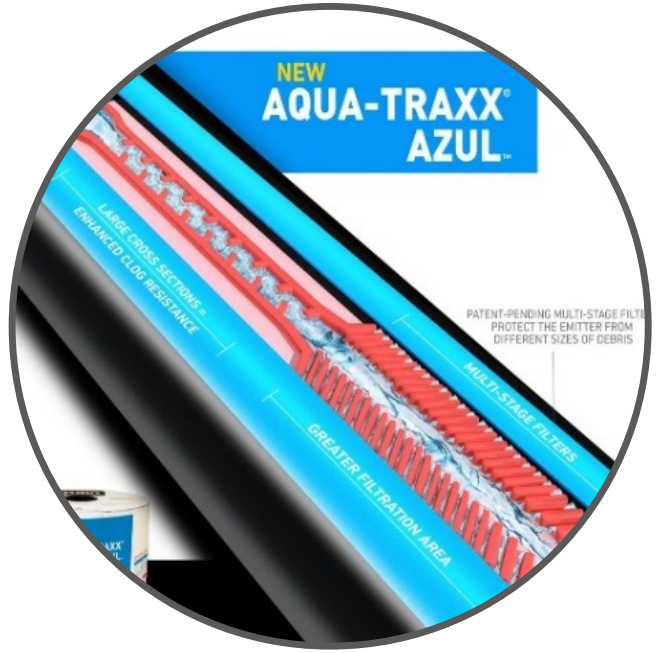
Emitter Flow Part Number	Outlet Spacing		Emitter Flow Rate				Q-100				Emitter Exponent	Filtration Requirement
			gph		lph		gpm/100 ft		lph/1 meter			
	in	cm	@ 8 psi	@ 10 psi	@ 0.55 bar	@ 0.7 bar	@ 8 psi	@ 10 psi	@ 0.55 bar	@ 0.7 bar		mesh (micron)
0.07 gph emitter												
EAXxx0817	8	20	0.07	0.08	0.26	0.30	0.17	0.20	1.30	1.47	0.55	140 (105)
EAXxx1609	16	40	0.07	0.08	0.26	0.30	0.09	0.10	0.65	0.74		
0.09 gph emitter												
EAXxx0822	8	20	0.09	0.10	0.34	0.38	0.22	0.25	1.66	1.88	0.53	120 (125)
EAXxx1611	16	40	0.09	0.10	0.34	0.38	0.11	0.13	0.83	0.94		
0.10 gph emitter												
EAXxx0825	8	20	0.10	0.11	0.38	0.43	0.25	0.28	1.86	2.11	0.50	120 (125)
EAXxx1613	16	40	0.10	0.11	0.38	0.43	0.13	0.14	0.93	1.05		
0.13 gph emitter												
EAXxx0467	4	10	0.13	0.15	0.51	0.57	0.67	0.75	4.99	5.58	0.50	120 (125)[1]
EAXxx0644	6	15	0.13	0.15	0.51	0.57	0.44	0.50	3.33	3.72		
EAXxx0834	8	20	0.13	0.15	0.51	0.57	0.34	0.37	2.50	2.79		
EAXxx1222	12	30	0.13	0.15	0.51	0.57	0.22	0.25	1.66	1.86		100 (149)[2]
EAXxx1617	16	40	0.13	0.15	0.51	0.57	0.17	0.19	1.25	1.40		
EAXxx1814	18	45	0.13	0.15	0.51	0.57	0.14	0.17	1.11	1.24		
EAXxx2411	24	60	0.13	0.15	0.51	0.57	0.11	0.12	0.83	0.93		
0.15 gph emitter												
EAXxx0650	6	15	0.15	0.17	0.57	0.63	0.50	0.56	3.73	4.17		
EAXxx1225	12	30	0.15	0.17	0.57	0.6						100 (149)[2]
EAXxx1817	18	45	0.15	0.17	0.57	0.						
0.20 gph emitter												
EAXxx04100	4	10	0.20	0.22	0.76	0.						
EAXxx0667	6	15	0.20	0.22	0.76	0.						
EAXxx0850	8	20	0.20	0.22	0.76	0.8						

9 Flow rates (0.07 – 0.53 gph)
7 Wall thicknesses (4 – 15 mil)
5 Tubing diameters (5/8” – 1 3/8”)
Emitter spacing options (4 to 36 inches)

Drip Tape

Aqua-Traxx® Azul

- Available in ultra-low emitter flow rates (0.07, 0.09 and 0.10 gph) as well as low, medium and high emitter flow rates (0.13, 0.15, 0.20, 0.27, 0.34 and 0.53 gph)
- Enhanced clog resistance with filtration requirements as low as 100 mesh - lowest for any drip tape in the industry! (0.13, 0.15, 0.20, 0.27 gph)
- Greater filtration area with patent-pending Multi-Stage filters
- Optimized flow passages further resist clogging
- One price for any emitter spacing from 6 – 24 inches

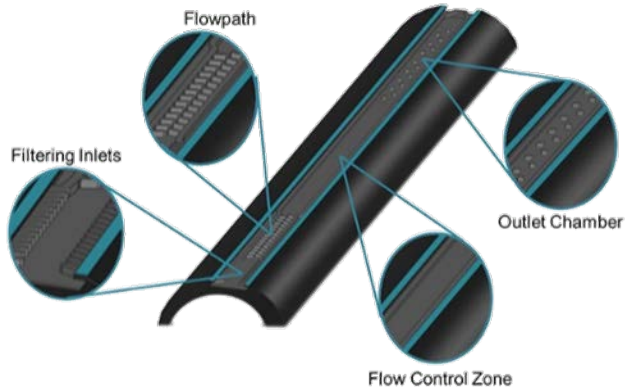


Aqua-Traxx® Azul Sweet Spot™

- Longer runs and better uniformity than 5/8” ID drip tape
- Lower system costs resulting from less hose, layflat, connections and labor
- Less expensive than 7/8” ID drip tape
- More environmentally friendly than 7/8” ID drip tape, plus more water savings due to less runoff

FlowControl®

- High uniformity on longer runs and hilly terrain
- Retain flexibility to increase or decrease application rate for greater control over watering and scheduling decisions
- Available in a wider range of thicknesses including more affordable 5/8in 6mil and 7/8in 8mil



Dripline/Emitterline

BlueLine® Pressure Compensating

- The Latest Technology – the exclusive Toro flow path technology is the result of 30 years of emitter design in combination with the latest in computer aided design.
- More Resistant to Plugging – With unique raised inlets, the amount of debris is dramatically reduced at emitter inlet.
- Unmatched Uniformity – The Toro flow path technology uses a shark tooth design providing a fully turbulent flow path that is independent from the wall of the tubing providing unmatched uniformity.
- Self-flushing Diaphragm – patented new design flushes during operation and shutdown further resisting clogging providing longer life for your system.

BlueLine® Classic

- Efficient Emitter Design - The unique "shark tooth" emitter flow path design allows uniform application of water and nutrients in demanding field applications, including long lengths of run or undulating terrain
- Accurate Flow Rate Between 5 and 60 psi - A wide operating window means less waste and uniform application
- Low Profile Emitter Design - Reduced friction loss saves energy and helps ensure uniform application
- Uniform Manufacturing Platform - State of the art injection molding technology yields an "industry best"

Poly Hoses

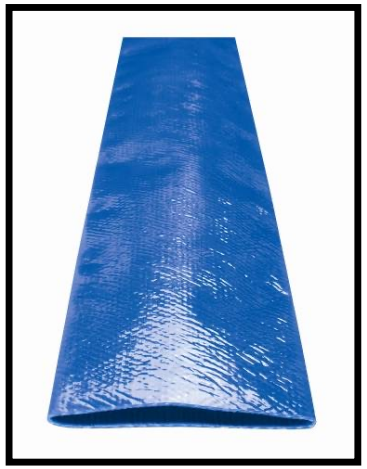
Blue Stripe® Oval and Round Hose

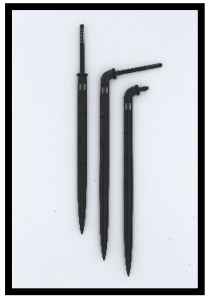
- Large diameter sizes for submain and mainline applications as a cost-effective alternative to PVC
- Smaller diameters can be used in lateral run applications on permanent crops
- When pressurized Oval Hose becomes round just like standard Blue Stripe round hose – offers freight savings of up to 50%
- The unique Oval configuration allows you to reduce storage space
- Available in a wide range of diameters, wall thicknesses, coil lengths and working pressures.
- Minimum 2% carbon black added for protection
- Also available in white, ideal for nursery and greenhouse irrigation systems

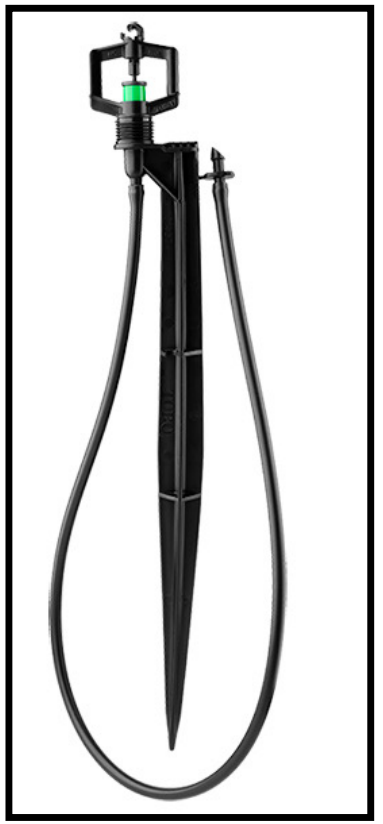
Blue Stripe® Round Hose

- Available in a wide range of diameters, wall thicknesses, coil lengths and working pressures.
- Minimum 2% carbon black added for protection
- Also available in white, ideal for nursery and greenhouse irrigation systems

Supporting Products







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