Simplifying Micro-Irrigation System Design with AquaFlow 3.2 Design Assist Software

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***Abstract*.** Micro-Irrigation system design can be an iterative, time-consuming process since multiple input variables must be evaluated in terms of the resulting irrigation conditions, as well as the flushing conditions. AquaFlow 3.2, a new micro-irrigation design program, uses a dynamic "dashboard" approach that allows the designer to easily and instantly view, on one screen, the results of all input choices including product selection, inlet pressure, slope, sub-main size and location, flushing velocity, and block dimensions. As the designer makes choices, both calculated and graphed output parameters are instantly updated along with a unique color-coded block map that visually depicts system uniformity. With this new software tool, designers can also compare the results of using one particular model of tape or dripline against another, and multiple slopes may be entered for the lateral, sub-main and mainline, as well. In this presentation, AquaFlow 3.2 will first be introduced and then demonstrated live.

Keywords. *Drip Irrigation, Micro-Irrigation, SDI, Irrigation Design, Emission Uniformity, Flushing.*

Introduction

Micro-Irrigation, also commonly called drip irrigation, is the fastest growing irrigation technology in the Unites States. It was commercially introduced over four decades ago, and its usage has since spread to 3.5 million acres of diversified farmland throughout the US as of 2008 (USDA, 2008). Farmers adopt drip irrigation because their crops respond well to the spoon feeding of water and nutrients directly to the crop's rootzone, and because valuable resources are conserved and/or optimized. These benefits improve farm income and reduce farm costs enough to pay for the investment quickly. In addition, runoff, wind drift and deep percolation of irrigation water is minimized, and access to the field is improved compared to other irrigation methods. Figure 1 graphically describes these benefits (Corcos, 2012).

Drip irrigation differs from gravity and sprinkler irrigation in a number of ways. A drip system consists of a network of plastic pipes and emission devices that deliver pressurized water directly to the soil at a low pressure and low flow rate. It is typically operated at frequent intervals, and the duration of operation may be adjusted to accomplish numerous changing objectives. Source water is filtered to prevent clogging of drip system emission devices, and chemical injection systems are used to apply fertilizers, crop protection materials and drip system maintenance chemicals. (Stetson, 2011). Figure 2 shows a Typical Drip System Layout for field crops (corn), row/vegetable crops (lettuce), vineyards (grape vines) and orchards (almond trees). (Toro, 2012)

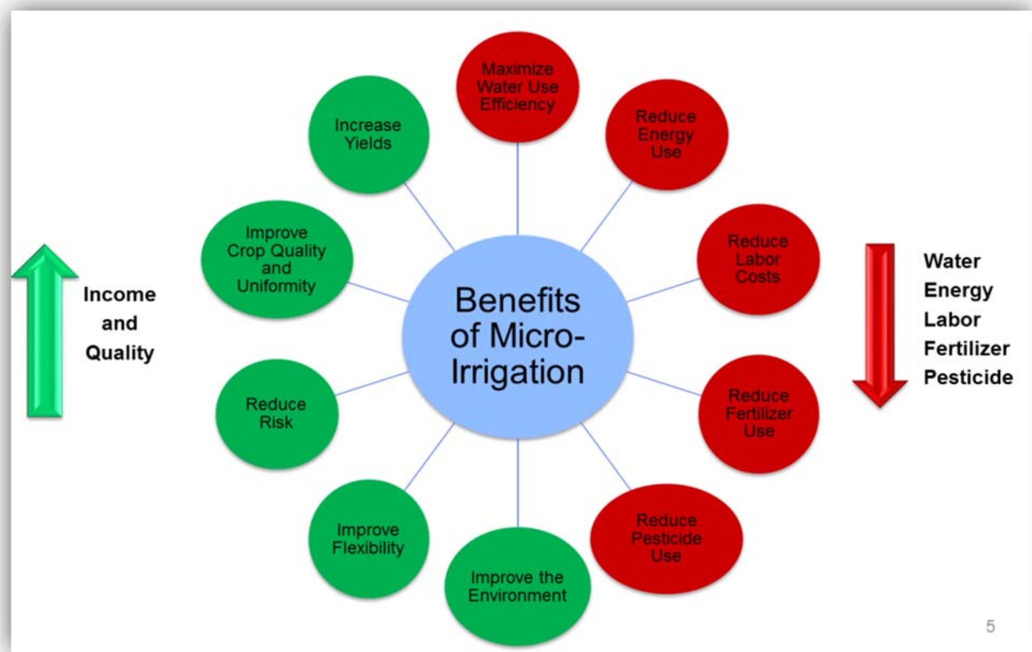


Figure 1 - Benefits of Micro-Irrigation

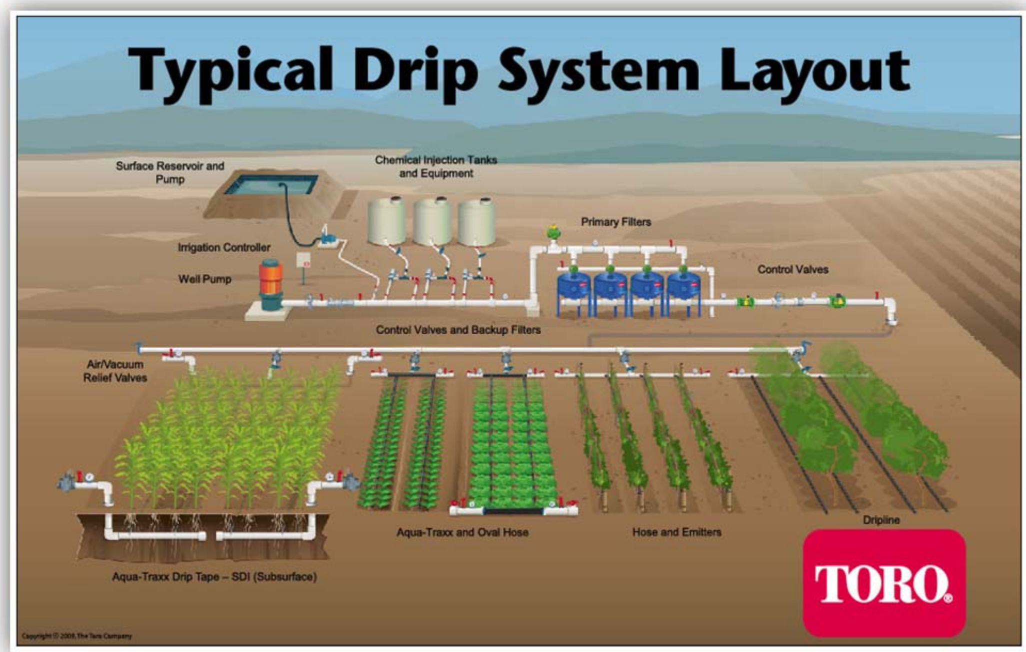


Figure 2 - Typical Drip System Layout

Although all irrigation system types share some basic hydraulic principles and equipment such as pumps and delivery pipe, there are also differences that require specialized knowledge for design, installation, operation and maintenance of the systems. The primary job of a drip irrigation system designer is to choose the right types and sizes of system components to ensure that the system applies water uniformly to each plant, and so that the system may be flushed and maintained to ensure a long life. Prior to the availability of software, designers manually calculated friction loss and flow uniformity, or used charts and nomographs developed for this specific purpose. With the introduction of consumer computers, early versions of drip irrigation design software automated many of these tasks and allowed a higher level of accuracy to be achieved.

Today, drip irrigation design has never been easier or more accurate. AquaFlow 3.2 takes advantage of recent advancements in computer processing, programming techniques and display screen technology to optimize drip irrigation design. Designers can now evaluate more selection options more quickly and more accurately than ever before, thus improving the decision making process in selecting drip irrigation system components. This will result in better, more cost effective drip irrigation system performance, and thus improved return on the investment for the farmer.

AquaFlow 3.2 Design Assist Software Platform

AquaFlow 3.2 is a new software program available for free download from Toro's website at toro.com upon approved registration. It currently supports Toro's Aqua-Traxx and Aqua-Traxx PC premium drip tape, as well as BlueLine PC and BlueLine Classic dripline. AquaFlow 3.0 features a unique "dashboard" which allows users the ability to view changes to inputs instantaneously, on one screen. This is in contrast to other design programs which require toggling between screens to view this type of information. The following is a full list of AquaFlow 3.2 features:

- A unique "dashboard" format that instantly shows the following as a result of Inputs:
    - Lateral and Sub-Main Irrigation Outputs
    - Lateral and Sub-Main Flushing Outputs
    - Tiled graphs of system parameters that may be viewed simultaneously or individually
    - A color-coded Uniformity Map that depicts block uniformity
- Easy comparison of two different lateral selections
- Pull-down menus for easy viewing
- Multiple slopes in the lateral, sub-main and mainline programs
- Choice of multiple sub-main and mainline pipe types and sizes
- Customizable reports that may be saved in multiple formats
- English and Spanish language support
- Standard English or Metric Units

The “Dashboard”

The dashboard is organized into eight areas:

1. Pull Down Menus
2. Toolbar Icons
3. Block Design Description and Project Selection
4. Lateral: Input and Output
5. Sub-Main: Input and Output
6. Flushing: Input and Output according to a) Inlet Pressure and b) Flushing Velocity
7. Color-coded Uniformity Map illustrating percent flow deviation from average
8. Tiled graphs showing pressure, flow, elevation and velocity information vs. lateral or sub-main length of run.

Figure 3 is a screen capture of the dashboard that appears right after launching the program from the desktop icon, and after selecting the Chart Tile function.

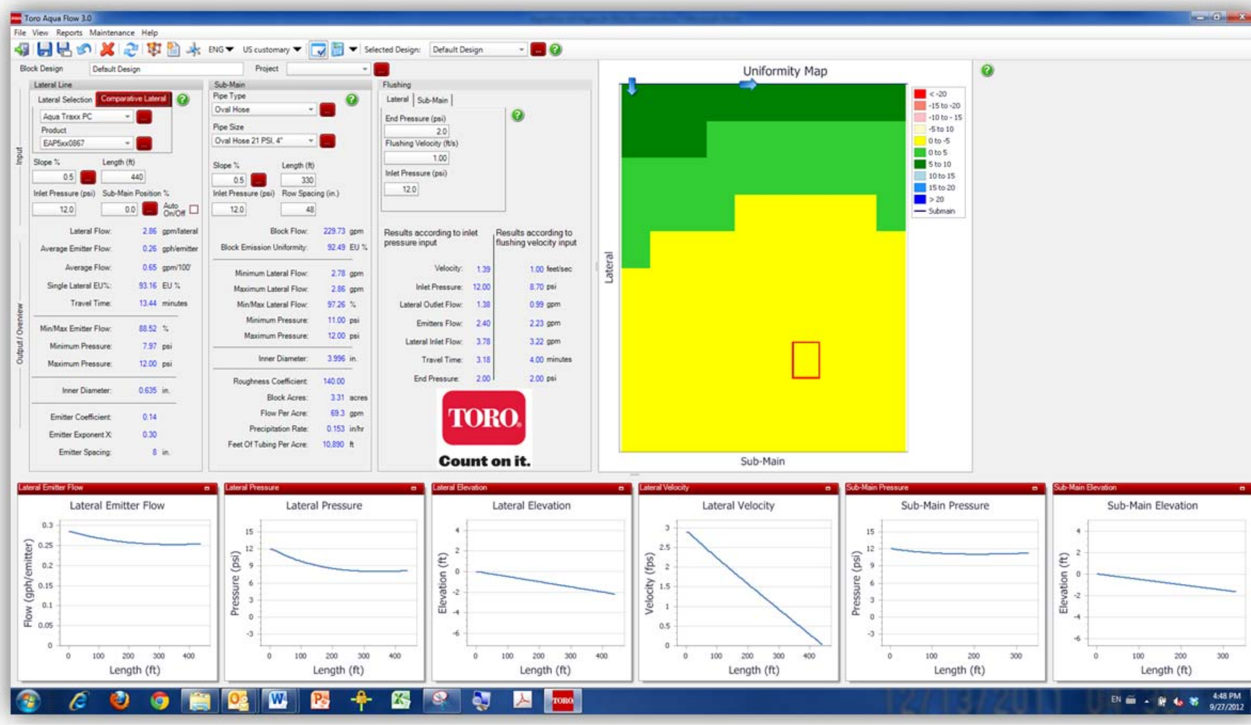


Figure 3 - AquaFlow 3.2 Dashboard

The Lateral, Sub-Main, and Flushing areas of the dashboard require input from the designer. Once data is entered, all output data, including the Uniformity Map and the Tiled Graphs, are instantly updated with the results of the new calculations. An overview of what the designer may view and use on the dashboard follows.

- Lateral:
    - Input: Product Model, Slopes, Length, Inlet Pressure, Sub-Main Position
    - Output: Lateral flow, Emitter Flow, Average Flow, Single Lateral Emission Uniformity, Travel Time, Min/Max Emitter Flow, Minimum Pressure, Maximum Pressure, Inner Diameter, Emitter Coefficient, Emitter Exponent X, Emitter Spacing.
- Sub-Main:
    - Input: Pipe Type, Pipe Size(s), Slope(s), Length, Inlet Pressure, Row Spacing.
    - Output: Block Flow, Block Emission Uniformity, Minimum Lateral Flow, Maximum Lateral Flow, Min/Max Lateral Flow, Minimum Pressure , Maximum Pressure, Inner Diameter, Roughness Coefficient, Block Size, Precipitation Rate, Length of Tubing and Flow.
- Flushing: Lateral and Sub-Main
    - Input: End Pressure, Flushing Velocity, Inlet Pressure
    - Output: Velocity, Inlet Pressure, Lateral Outlet Flow, Emitter Flow, Travel Time, End Pressure

Figure 4 shows the Lateral, Sub-Main, and Flushing areas of the Dashboard in more detail:

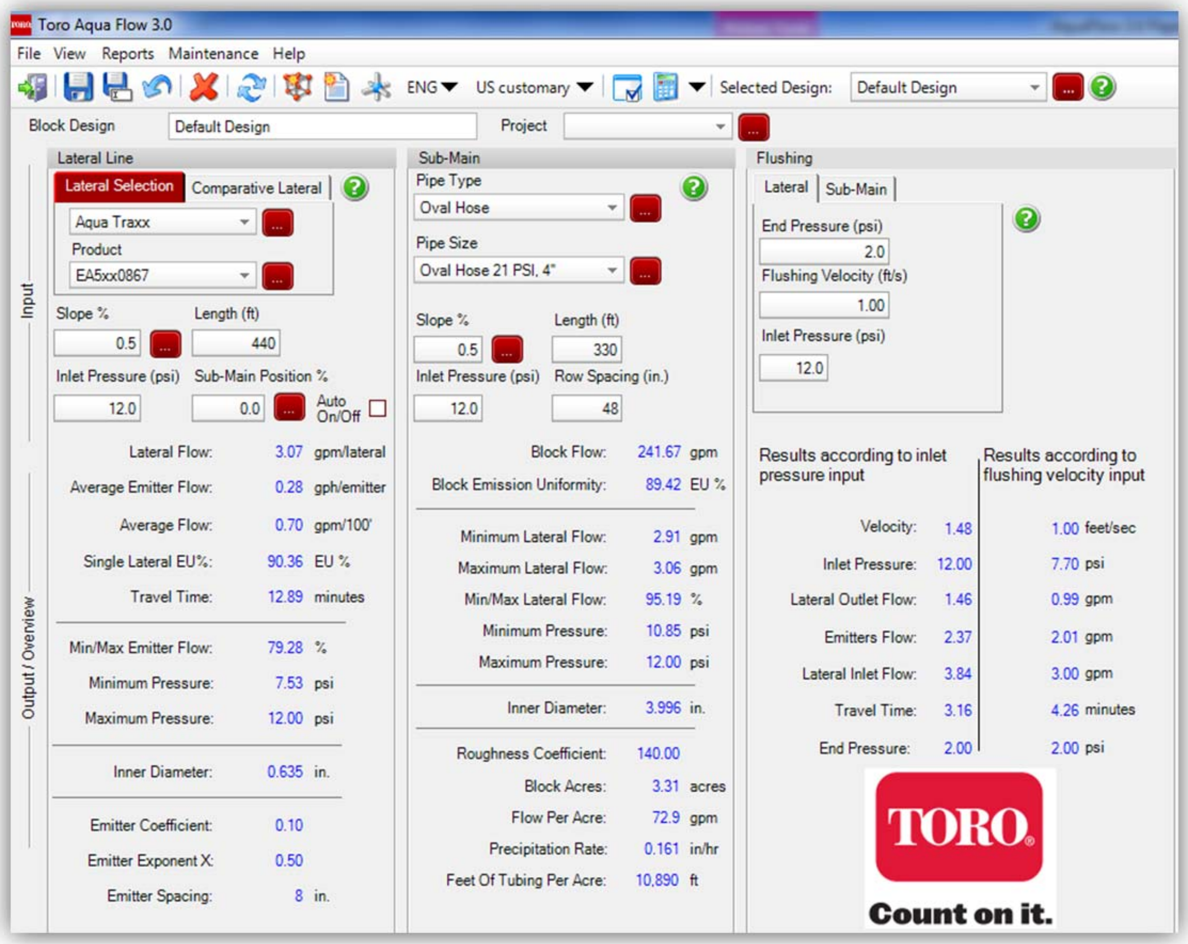


Figure 4 - Lateral, Sub-Main, and Flushing areas of the dashboard.

Another key feature of the dashboard is the Chart Tile area, which plots six drip system operating parameters vs. length of run. The default view minimizes the Chart Tiles at the bottom of the dashboard as shown in Figure 5:

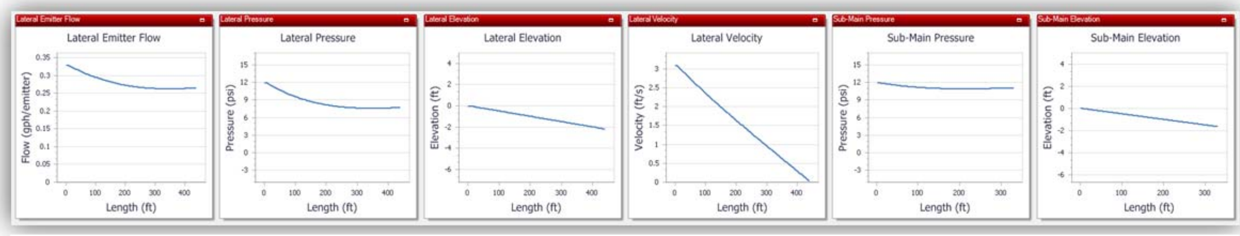


Figure 5 – Chart Tiles appear in minimized format at the bottom of the dashboard.

Alternatively, by clicking on the Chart Tile icon in the toolbar, each chart may be viewed individually in an expanded format, or with two, three, or four charts shown at a time, as shown in Figure 6:

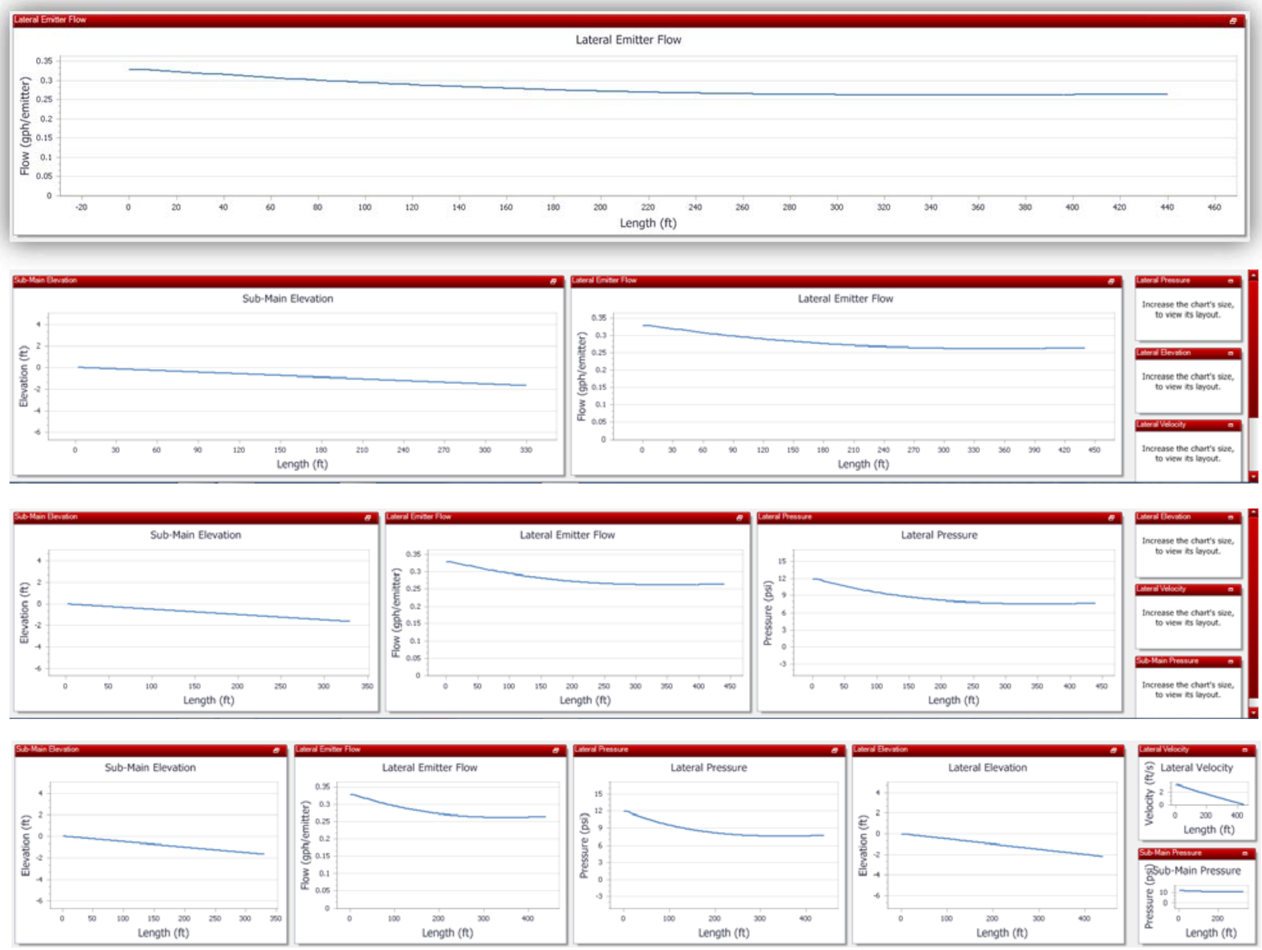


Figure 6 – Chart Tiles may appear individually or with two, three or four charts shown at a time.

The other key feature of the dashboard is the color-coded Uniformity Map which illustrates the percent flow deviation from average flow for each of the block designs. For example, a block design with high uniformity will have fewer colors than a block, design with poor uniformity. Figure 7 compares the uniformity map from a design using classic drip tape on the left with the uniformity map of a design using pressure compensating drip tape on the right. The design on the right is more desirable because it exhibits less flow variation, or less color variation, than the map on the left.

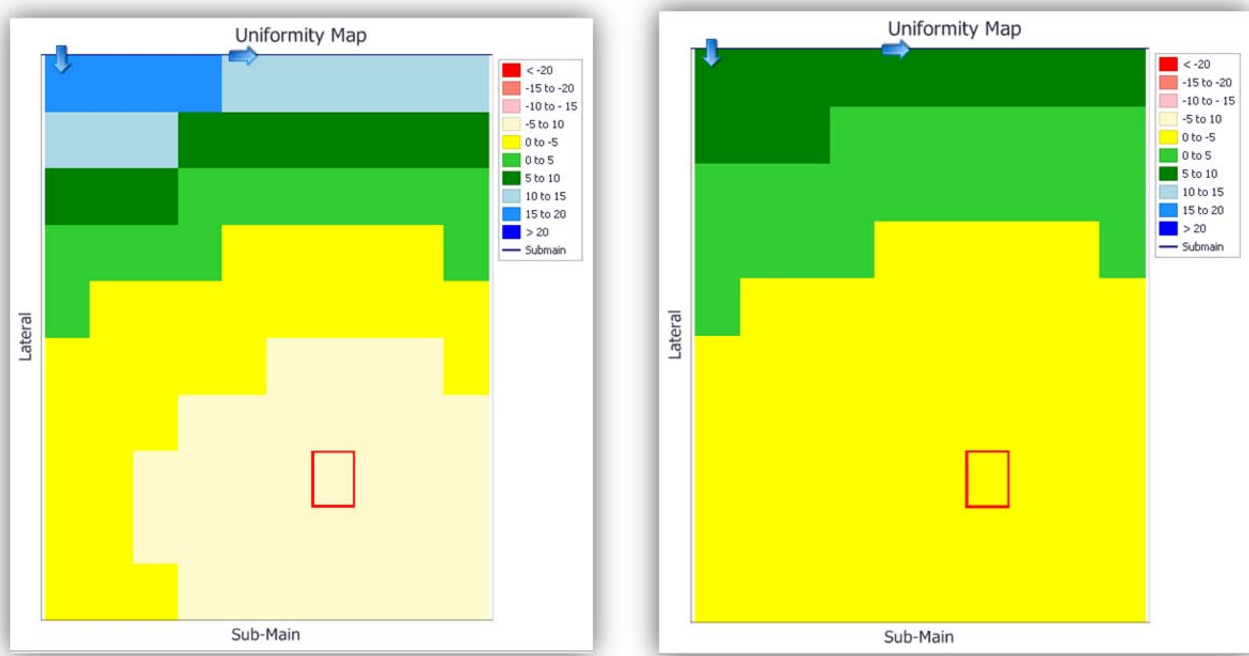


Figure 7 - Uniformity Maps for two different tape designs. The design on the left uses Aqua-Traxx Classic drip tape, the design on the right uses Aqua-Traxx PC drip tape.

In summary, the major advantage of using AquaFlow 3.2 software is that all lateral, sub-main and flushing outputs are instantly updated as inputs are changed by the designer. This includes the Output Overview, the Uniformity Map and the Chart Tiles. Thus, there is no need to toggle from one screen to another to view the results of user data input changes to length, slope, inlet pressure, manifold location, product selection, etc. This saves the designer time, and/or allows the designer to evaluate more options than ever before in an efficient manner. Now, let's compare two designs.

Default Block Design

When AquaFlow 3.2 launches, a default design appears on the screen with inputs selected and outputs displayed.

- The Lateral Selection uses Aqua-Traxx Classic drip tape part number EA5xx0867 on a .5% down slope, 440 foot length of run, 12 psi inlet pressure and the sub-main positioned at the top of the field. The Sub-Main is 4" Oval Hose, the sub-main runs along a .5% downhill slope, the sub-main length of run is 330 feet, the sub-main inlet pressure is 12 psi and the lateral row spacing is 48 inches apart.

  - The resulting Emission Uniformity (EU) for a single lateral line is 90.36%, and the EU for the entire block is 89.42%. All other Output data may be viewed beneath the Input data.
  - The Uniformity Map illustrates percent flow deviation from average for the block using color (yellow, green, and blue, in this case).
  - Select output data also appears in tiled graphs at the bottom of the page. To view any one to four of these in a larger format, select the "Chart Tiles" icon to the left of the Calculator in the Toolbar, and then click on the upper right hand corner of up to four tiles to enlarge them. Click on the "Chart Tiles" icon again to return to normal view.
- The Comparison lateral uses Aqua-Traxx PC drip tape part number EAP5xx0867 instead of Aqua-Traxx Classic – all other inputs remain the same. Note that the EU for a single lateral is now 93.16%, and the EU for the entire block is now 92.49%. Also, note that the Uniformity Map has improved and shows less color variation.

In this case, using a pressure compensating device helps the designer achieve a uniformity of 93.16% instead of 90.42%, a 3% difference.

- The Lateral and Sub-main flushing parameters may be viewed by toggling between the two choices. Note that the flushing velocity of the lateral is 1.48 feet per second (fps) when the inlet pressure is 12 psi, but that only 7.7 psi is required to achieve a flushing velocity of 1.0 fps.
- As noted above, select output data also appears in tiled graphs at the bottom of the page. To view any one to four of these in a larger format, select the "Chart Tiles" icon to the left of the Calculator in the Toolbar, and then click on the upper right hand corner of up to four tiles to enlarge them. Click on the "Chart Tiles" icon again to return to normal view.

Customers, Projects, Block Designs and Mainline Design

AquaFlow 3.2 may be used to create individual Block Designs as previously shown, but may also be used to design Mainlines that service multiple blocks. In this case, a Customer and Project must be created by the designer, and then multiple block designs assigned to that Project. A Mainline can then be associated with the project and designed to service the block with multiple segments.

- First, a Customer is created by choosing "Customer" from the Maintenance pull-down menu. This information will appear prior to the block and mainline designs when a Project is printed. Enter the required information and then click on Save and Close.
- Next a Project is created by choosing "Project" from the Maintenance pull-down menu. Create a Project name, and then choose the Customer that the Project is associated with. Now click on Save and Close.

- Now, a new Block Designs may be created. Choose “New Design” from the File pull-down menu or from the Toolbar. Name the design, enter the required information, and then click on Save & Close to view the results.
- For the next block, choose New Design again and repeat the previous procedure.
- When all blocks have been designed, a mainline may be designed to service each of the blocks. Choose “Mainline” from the Maintenance pull-down menu, or from the Mainline Icon on the toolbar. Then choose “New,” provide a name for the mainline design, and then associate it with a project so that it may be printed along with the block designs when Print Project is chosen. Now enter the elevation, flow, length, pressure, pipe type and pipe size information required for each mainline segment, beginning with the block furthest from the pump. The mainline report may then be printed and/or it may be saved. Figure 8 shows the data input screen for a two segment mainline that has been sized to supply water to the two blocks used in the previous examples as reported in Figures 11 and 12. In this example, the pump station is located 100 feet from the 2nd block.

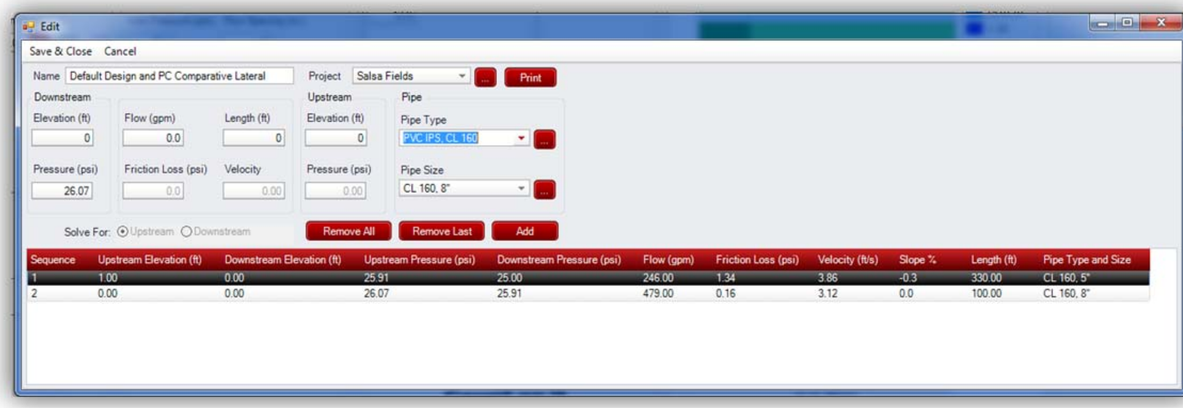


Figure 8 - Mainline Data Input Screen and Results

Printing Designs and Projects

Now any individual block design, or the entire project, may be printed, exported or emailed in pdf, html, mht, rtf, xls, xlsx, csv, text, or image file formats. From the pull-down menu, choose “Print Design” to print the Lateral Selection block design, the Comparison Lateral block design, or both, that are currently selected on the dashboard. Or, choose “Print Project” to print all the blocks and the mainline that is associated with the Project currently selected on the Dashboard. The report may then be customized with color and watermarks. Figure 9 shows the Design Report Options and the Watermark customization feature, and Figure 10 shows the report for the mainline associated with this project.

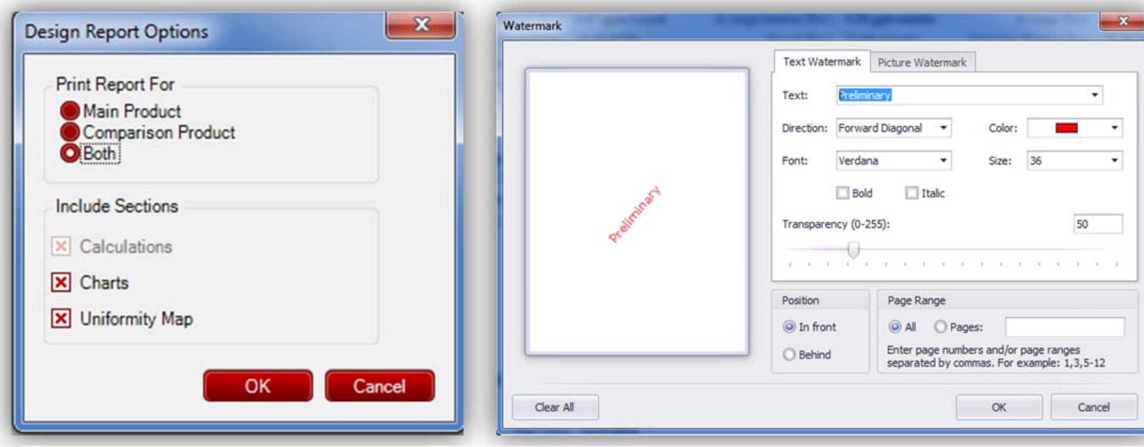
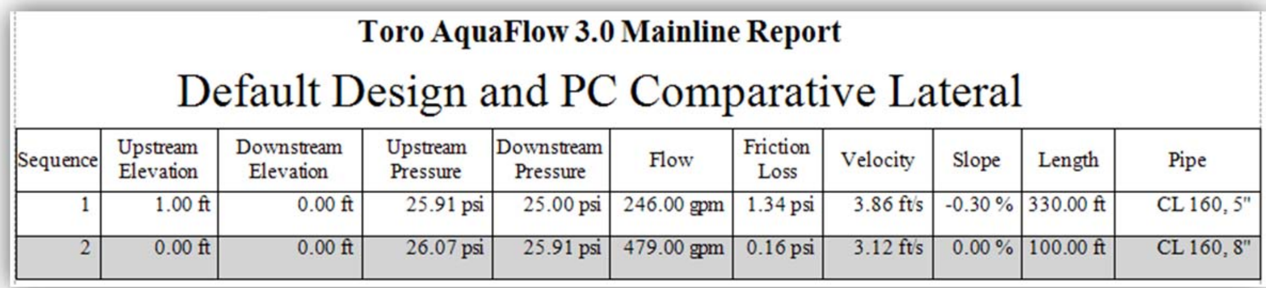


Figure 9 - Design Report Options and Watermark Options



Toro AquaFlow 3.0 Mainline Report

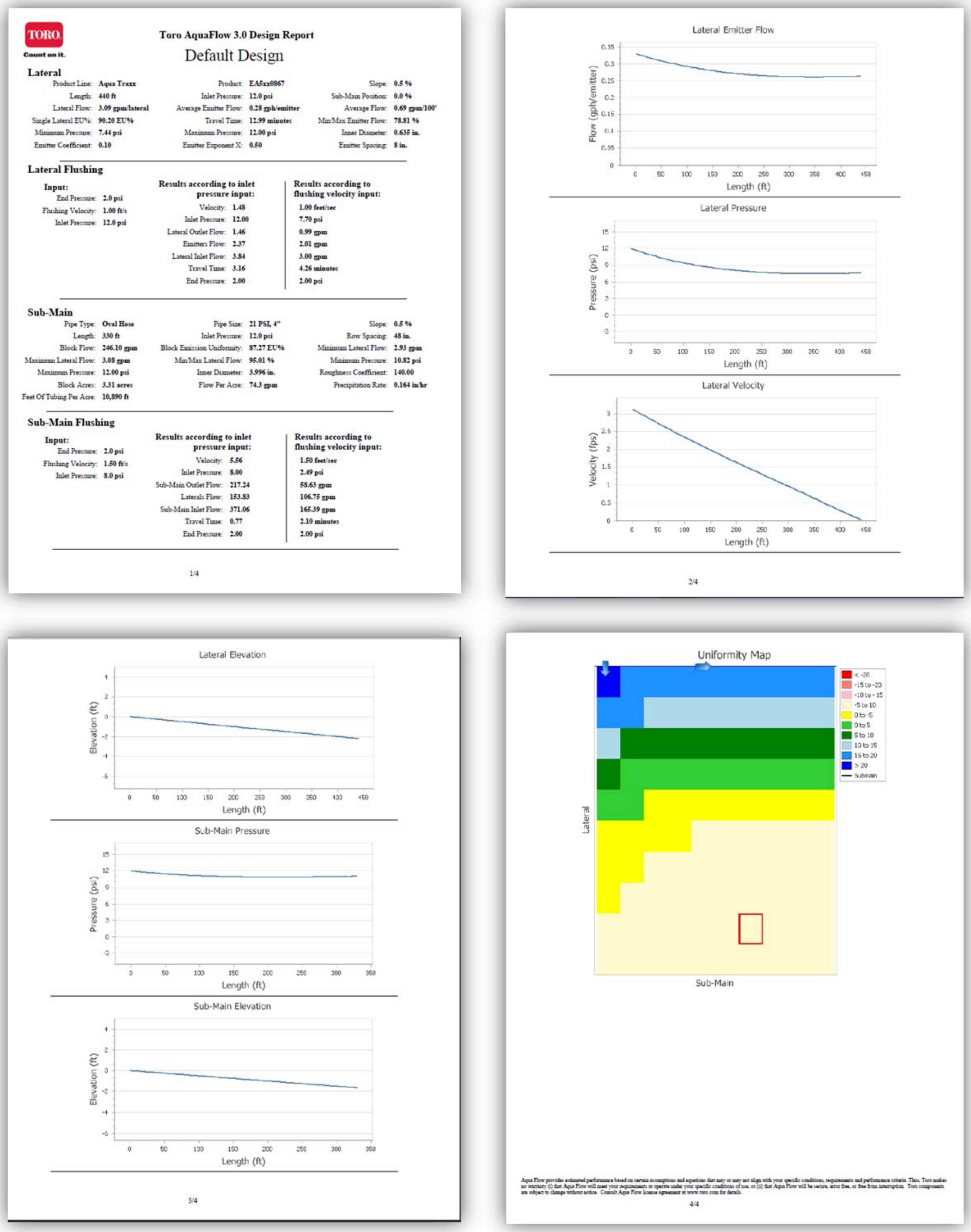
Default Design and PC Comparative Lateral

Sequence	Upstream Elevation	Downstream Elevation	Upstream Pressure	Downstream Pressure	Flow	Friction Loss	Velocity	Slope	Length	Pipe
1	1.00 ft	0.00 ft	25.91 psi	25.00 psi	246.00 gpm	1.34 psi	3.86 ft/s	-0.30 %	330.00 ft	CL 160, 5"
2	0.00 ft	0.00 ft	26.07 psi	25.91 psi	479.00 gpm	0.16 psi	3.12 ft/s	0.00 %	100.00 ft	CL 160, 8"

Figure 10 - Mainline Report

Finall7, Figure 11 shows the Lateral Selection Design Report output, and Figure 12 shows the Comparative Lateral Design Report output. All of these reports may be generated by choosing the “Print Project” option.

Lateral Selection Design Report using Aqua-Traxx Classic Drip Tape



TORO. Count on it.

Toro AquaFlow 3.0 Design Report

Default Design

Lateral

Product Line:	Aqua Traxx	Product:	EA5xx0867	Slope:	0.5 %
Length:	440 ft	Inlet Pressure:	12.0 psi	Sub-Main Position:	0.0 %
Lateral Flow:	3.09 gpm/lateral	Average Emitter Flow:	0.28 gph/emitter	Average Flow:	0.69 gpm/100'
Single Lateral EU%:	90.20 EU%	Travel Time:	12.99 minutes	Min/Max Emitter Flow:	78.81 %
Minimum Pressure:	7.44 psi	Maximum Pressure:	12.00 psi	Inner Diameter:	0.635 in.
Emitter Coefficient:	0.10	Emitter Exponent X:	0.50	Emitter Spacing:	8 in.

Lateral Flushing

Input:		Results according to inlet pressure input:		Results according to flushing velocity input:
End Pressure:	2.0 psi	Velocity:	1.48	1.00 feet/sec
Flushing Velocity:	1.00 ft/s	Inlet Pressure:	12.00	7.70 psi
Inlet Pressure:	12.0 psi	Lateral Outlet Flow:	1.46	0.99 gpm
		Emitters Flow:	2.37	2.01 gpm
		Lateral Inlet Flow:	3.84	3.00 gpm
		Travel Time:	3.16	4.26 minutes
		End Pressure:	2.00	2.00 psi

Sub-Main

Pipe Type:	Oval Hose	Pipe Size:	21 PSI, 4"	Slope:	0.5 %
Length:	330 ft	Inlet Pressure:	12.0 psi	Row Spacing:	48 in.
Block Flow:	246.10 gpm	Block Emission Uniformity:	87.27 EU%	Minimum Lateral Flow:	2.93 gpm
Maximum Lateral Flow:	3.08 gpm	Min/Max Lateral Flow:	95.01 %	Minimum Pressure:	10.82 psi
Maximum Pressure:	12.00 psi	Inner Diameter:	3.996 in.	Roughness Coefficient:	140.00
Block Acres:	3.31 acres	Flow Per Acre:	74.3 gpm	Precipitation Rate:	0.164 in/hr
Feet Of Tubing Per Acre:	10,890 ft				

Sub-Main Flushing

Input:		Results according to inlet pressure input:		Results according to flushing velocity input:
End Pressure:	2.0 psi	Velocity:	5.56	1.50 feet/sec
Flushing Velocity:	1.50 ft/s	Inlet Pressure:	8.00	2.49 psi
Inlet Pressure:	8.0 psi	Sub-Main Outlet Flow:	217.24	58.63 gpm
		Laterals Flow:	153.83	106.75 gpm
		Sub-Main Inlet Flow:	371.06	165.39 gpm
		Travel Time:	0.77	2.10 minutes
		End Pressure:	2.00	2.00 psi

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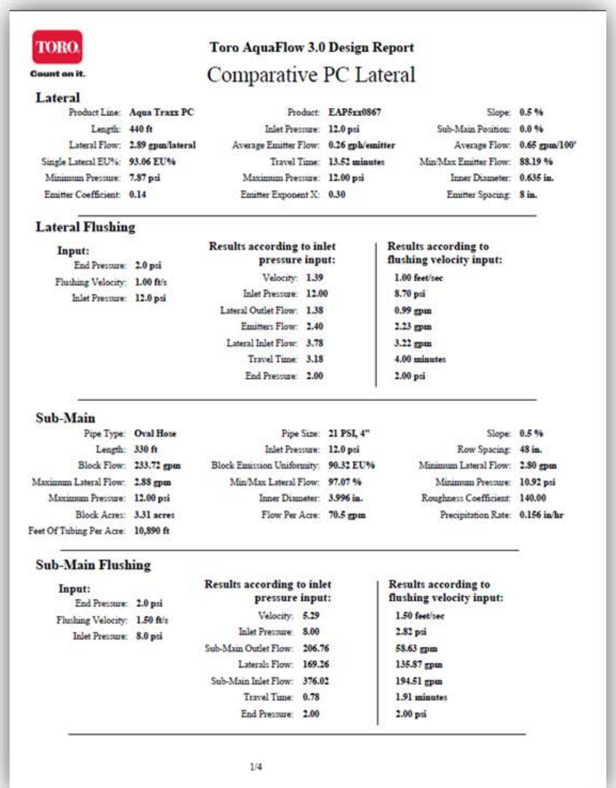
Figure 11 - Lateral Design Report Output

Comparative Lateral Design Report using Aqua-Traxx PC Drip Tape



Toro AquaFlow 3.0 Design Report

Comparative PC Lateral

Lateral

Product Line:	Aqua Traxx PC	Product:	EAP5xx0867	Slope:	0.5 %
Length:	440 ft	Inlet Pressure:	12.0 psi	Sub-Main Position:	0.0 %
Lateral Flow:	2.89 gpm/lateral	Average Emitter Flow:	0.26 gph/emitter	Average Flow:	0.65 gpm/100'
Single Lateral EU%:	93.06 EU%	Travel Time:	13.52 minutes	Min/Max Emitter Flow:	88.19 %
Minimum Pressure:	7.87 psi	Maximum Pressure:	12.00 psi	Inner Diameter:	0.635 in.
Emitter Coefficient:	0.14	Emitter Exponent X:	0.30	Emitter Spacing:	8 in.

Lateral Flushing

Input:		Results according to inlet pressure input:		Results according to flushing velocity input:
End Pressure:	2.0 psi	Velocity:	1.39	1.00 feet/sec
Flushing Velocity:	1.00 ft/s	Inlet Pressure:	12.00	8.70 psi
Inlet Pressure:	12.0 psi	Lateral Outlet Flow:	1.38	0.99 gpm
		Emitters Flow:	2.40	2.23 gpm
		Lateral Inlet Flow:	3.78	3.22 gpm
		Travel Time:	3.18	4.00 minutes
		End Pressure:	2.00	2.00 psi

Sub-Main

Pipe Type:	Oval Hose	Pipe Size:	21 PSI, 4"	Slope:	0.5 %
Length:	330 ft	Inlet Pressure:	12.0 psi	Row Spacing:	48 in.
Block Flow:	233.72 gpm	Block Emission Uniformity:	90.32 EU%	Minimum Lateral Flow:	2.80 gpm
Maximum Lateral Flow:	2.88 gpm	Min/Max Lateral Flow:	97.07 %	Minimum Pressure:	10.92 psi
Maximum Pressure:	12.00 psi	Inner Diameter:	3.996 in.	Roughness Coefficient:	140.00
Block Acres:	3.31 acres	Flow Per Acre:	70.5 gpm	Precipitation Rate:	0.156 in/hr
Feet Of Tubing Per Acre:	10,890 ft				

Sub-Main Flushing

Input:		Results according to inlet pressure input:		Results according to flushing velocity input:
End Pressure:	2.0 psi	Velocity:	5.29	1.50 feet/sec
Flushing Velocity:	1.50 ft/s	Inlet Pressure:	8.00	2.82 psi
Inlet Pressure:	8.0 psi	Sub-Main Outlet Flow:	206.76	58.63 gpm
		Laterals Flow:	169.26	135.87 gpm
		Sub-Main Inlet Flow:	376.02	194.51 gpm
		Travel Time:	0.78	1.91 minutes
		End Pressure:	2.00	2.00 psi

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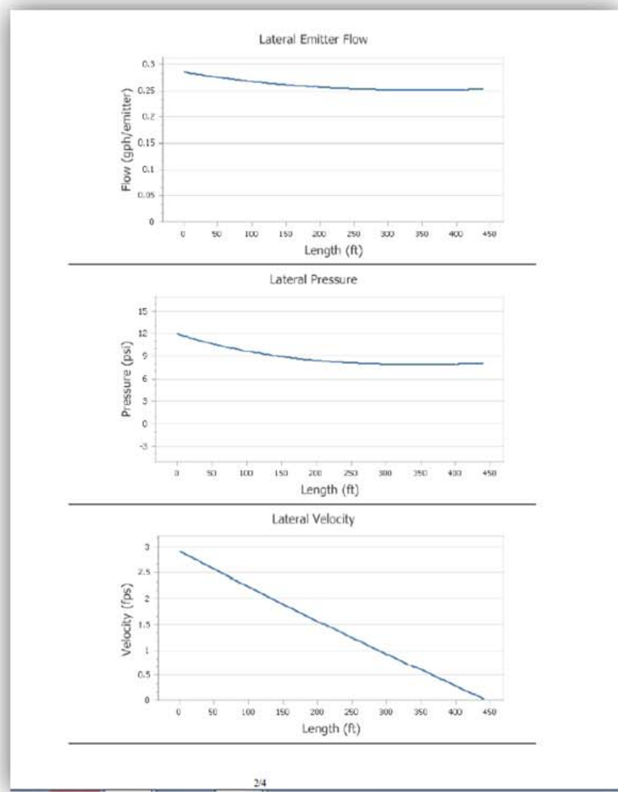

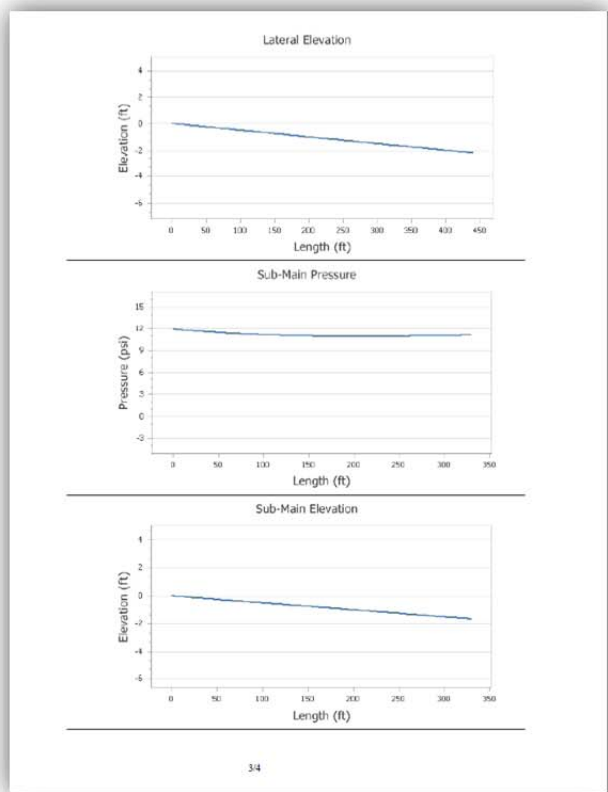

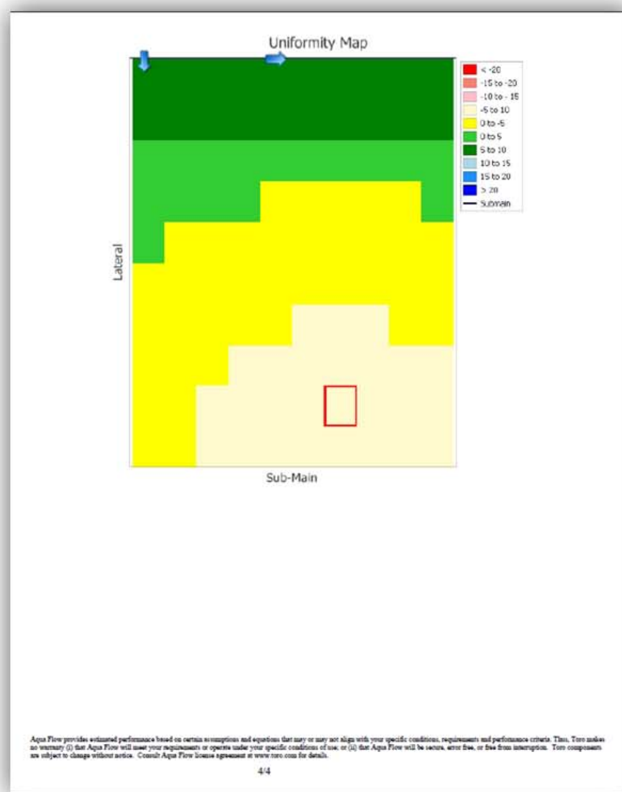

Figure 12 - Comparative Lateral Design Report

Conclusion

Making the right choices in drip irrigation design can be a tedious process. This is because the designer must choose the right inlet pressure, length of run and lateral, sub-main and mainline components, and then compare these numerous choices against one another for both irrigation uniformity performance and flushing performance. Previous drip irrigation design programs required toggling between screens to view the results of design choices.

Today, Toro's new AquaFlow 3.2 design assist software uses a unique dashboard approach that allows the designer to view both input and output data on one screen, and thus largely eliminates the need for toggling to other screens to evaluate choices. AquaFlow 3.2 also provides a color coded Uniformity Map and Chart Tiles of various operating parameters that instantly help the designer evaluate the results of input choices. Once a design is completed, it can then be saved and exported using various user-friendly file formats. By improving the efficiency and accuracy of drip irrigation design using AquaFlow 3.2, drip irrigation system field performance is improved as well.

AquaFlow 3.2 design assist software is available for free download upon approved registration at toro.com.

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