NLP Controller

Controller User Manual

Tucor, Inc.

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1 Introduction

The NLP controller is comprised of a local touchscreen display and remote access NLPNet software that are displayed in the same way. This manual describes the basic functionality of the web-based user interface to the Tucor NLP Controller.

Content related to other topics such as the controller, or the developers API, will be found in other manuals.

As the software is constantly being improved, some functions may change, other functions might have corrections or improved content.

If you receive software updates, be sure to contact your Tucor representative for the latest guide or manual updates. And be sure your Interface software version matches the guide or manual version printed on the cover page.

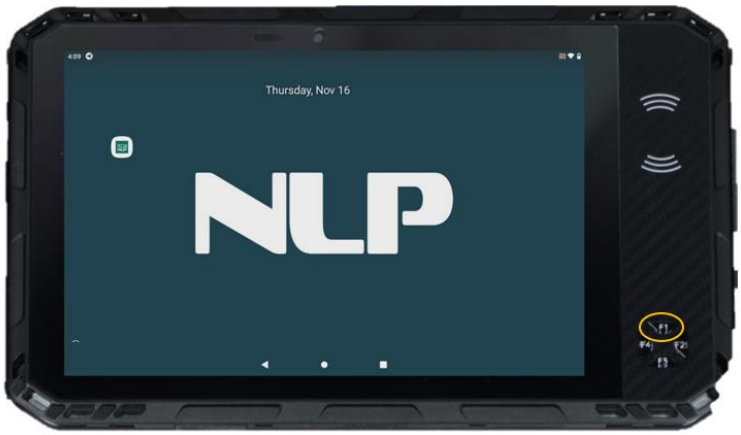
1.1 Local Use

The touchscreen provided with the NLP controller allows for local interaction with the controller's web interface. It is a static device requiring constant power, meaning that is to remain mounted inside the controller enclosure. The touchscreen is connected to the NLP locally via the built-in Wi-Fi router, allowing access to the controller in the event of an internet outage.

1.2 Powering On

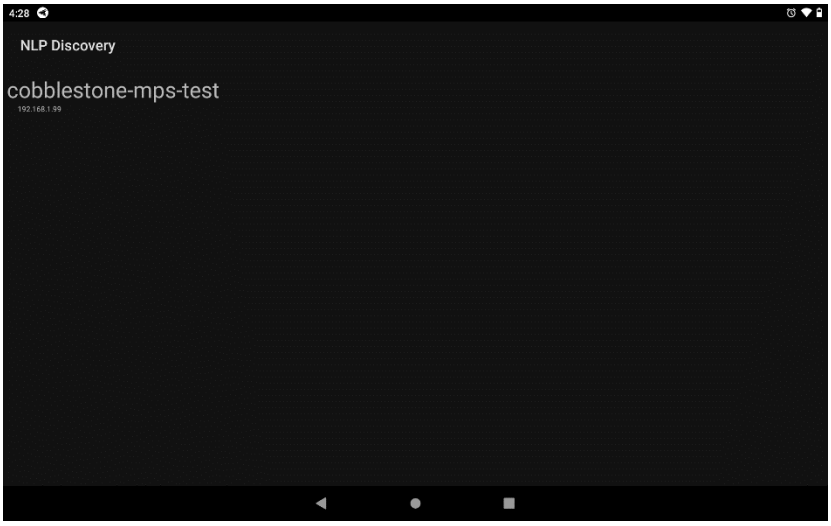
To power the touchscreen on, first toggle on the circuit breaker located in the electrical sub-enclosure. To open the electrical sub-enclosure, press down on the door clasp and swing the door upward.

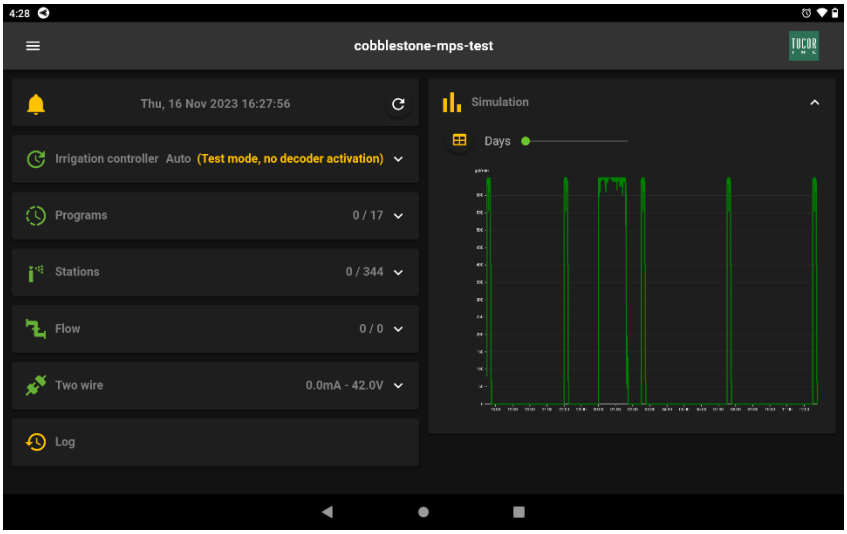
Once the controller assembly has power, press and hold the F1 button located on the lower-right corner of the touchscreen to power the touchscreen on.

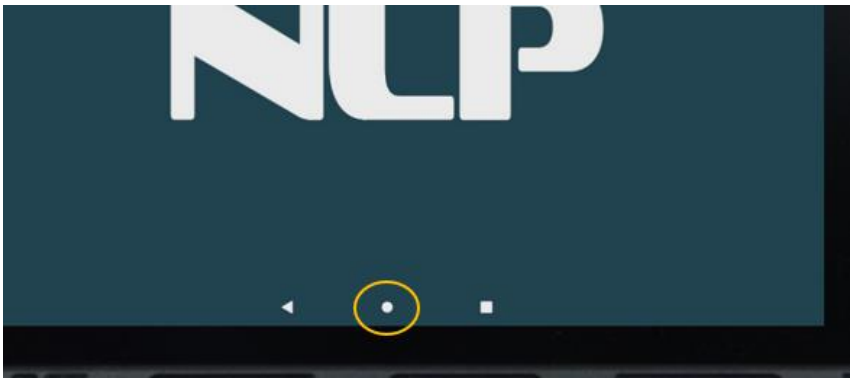


1.3 Launching the NLP

When the touchscreen powers on, the “NLP Discovery” app will automatically launch. The NLP Discovery app searches the local network for any connected NLPs and lists them by hostname & IP address. Tapping on the name will open the NLP’s web interface, where you can view and modify the controller’s current status, programs, stations, sensors, etc. If at any time you need to return to the list of controllers, press the home button (circle icon) in the navigation bar.







If no devices are appearing, confirm that Wi-Fi is enabled and connected to a network. To enable & disable Wi-Fi, pull down the notifications bar and tap on the Wi-Fi icon. To access the Wi-Fi settings, pull down the notifications bar and long-press the Wi-Fi icon.

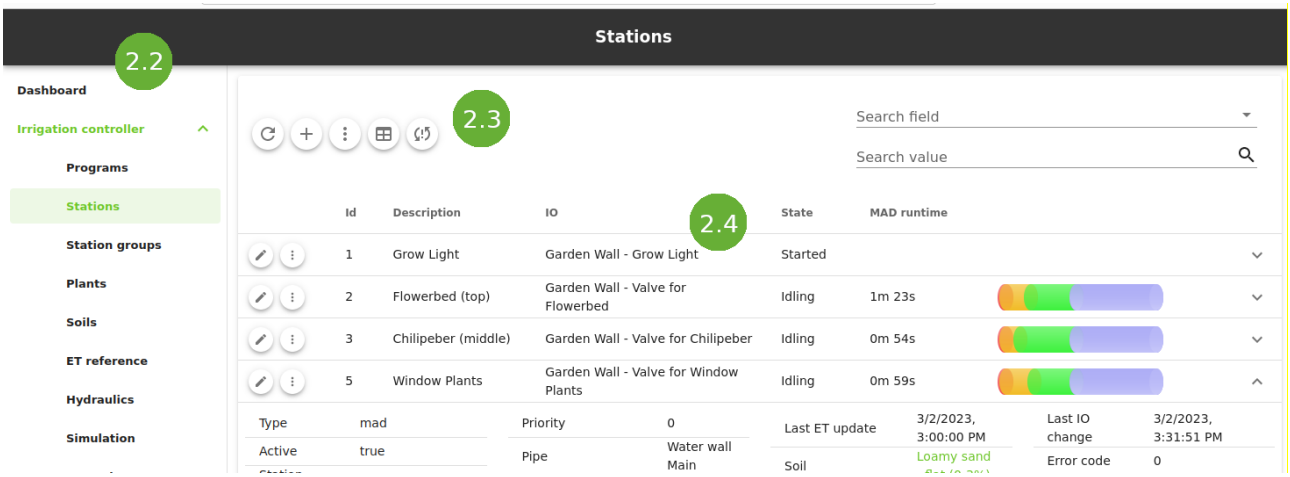
The display will shut off after 5 minutes of inactivity. Simply press the F1 button to turn the screen back on. To adjust the brightness of the display, pull down the notifications bar, pull down again to expand, and use the slider to increase or decrease the brightness.

2 Web interface overview

This section provides a general introduction to using the web interface, and performing the basic operations such as adding, editing, deleting, sorting, and searching.

2.1 Screen layout

To allow use on both desktop screens and mobile phones the web interface layout is responsive. Depending on screen resolution and orientation, up to three panels may be displayed simultaneously as you drill down through information. On smaller screens where only one or two can be displayed, only the most recently opened panel is visible.



2.2 Main Menu Navigation

If space allows, a main menu is visible on the left side of the screen. If not, you can access the menu by pressing the 'burger' button located in the upper left-hand corner.

Pressing an entry displaying a down arrow takes you to a sub-menu:

You can always go to the menu for navigation. If you have gone through several layers of selections, you may appreciate the 'back' button which allows you to trace back through the screens that led you to where you are instead of starting over.

2.3 List/Form controls

Along the top of each List or Form displayed to the right of the Main Menu (see below for more info on each), you may see a series of buttons that allow you to control some basic interface functionality or modify content on that page.

2.3.1 Refreshing content

Screen content is not automatically updated. To retrieve fresh data, press the Refresh button found in the upper left-hand corner of most pages.

The exception is the Dashboard, which updates automatically every 20 seconds.

2.3.2 Add content

To add new data, select the Add button. In nearly all cases, a blank form related to the list will appear where you can add new data.

Fill in the required fields and press the 'save' button at the bottom. You will be returned to the last list view and the new entry should appear in that list.

2.3.3 Edit content

To edit content , look for the Pencil button at the beginning of the row, entry, or record that you wish to edit and click it once. A form, like the one you see when adding content, will appear with the data for that record filled into each of the fields displayed in the list.

When done, press the 'save' button at the bottom of the form. You will be returned to the last list view and should see that data for that entry has been updated.

Some forms may only let you edit data in a sub-section of that form. A 'pencil' icon will be next to that sub-section instead of at the top of the form.

2.3.4 Actions

Actions allow you to perform immediate things to the system, such as running a station for only 25 seconds, or verifying flow. Clicking on the Action button displays a small form where you can choose which station and what action, from drop-down lists.

Click 'save' to execute the action.

2.3.5 Change view

Most of the sections in the Web Interface contain only one 'view', or list, of data related to their section. But there are a few sections, such as Stations, that have multiple views. Press the 'table button' to cycle through all of the available views.

2.3.6 Reset Errors

When available, you can reset errors that you have acknowledged or fixed in another section by pressing the reset button. Errors and/or warnings displayed should disappear within about 20 seconds.

2.3.7 Delete content

To delete content, first edit it. In the upper right-hand corner of the resulting form you should see a 'trashcan' icon for deleting the entry. Confirm to proceed with the deletion.

2.4 Lists

Lists provide a quick overview of structured data that can be sorted, searched, or modified.

2.4.1 Sorting

Pressing a column header sorts the lines on said column. Press again to sort in reverse order. Press a third time to cancel sorting. The sorting direction is shown with an arrow next to the column heading.

You may apply sorting on as many columns as you need.

2.4.2 Searching

You may search for values by selecting a field from the drop-down in the screen upper right-hand corner, and then typing a value.

If you do not choose a search field, a free-text search is performed.

2.4.3 Viewing Related Content

Some lists may contain extra buttons in each row that allow you to view related content such as listing programs or stations related to a station group.

To return to your previous content, use the back button at the top of the interface.

2.4.4 Adding sub elements to a list

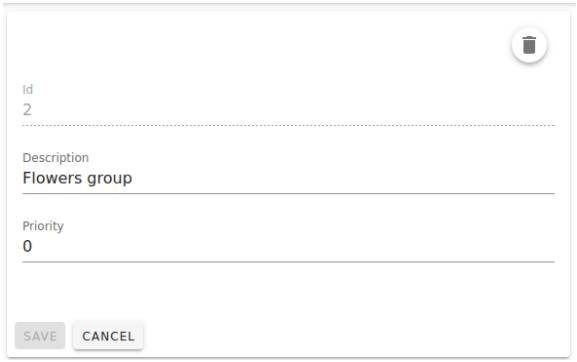
When viewing sub-elements of a list via the down-arrow (chevron) often displayed at either end of a list row, entry, or record, you may also find a plus icon that will allow you to add sub items to the list.

2.5 Forms

Adding or changing data via the web interface is done through a form. Forms share a similar layout: zero or more icons to perform various operations like refresh, edit, or delete will appear at the top of the form followed by an id that is auto generated by the interface. Below that, form fields are displayed where data is added or edited. At the bottom is a ‘create’ or ‘save’ button followed by a ‘cancel’ button.

Some forms that are to be edited may require that they are unlocked first. This is done by pressing the pencil button at the top of the form. When unlocked, the pencil icon has a slash across it, and the color of the form text becomes darker and accessible.

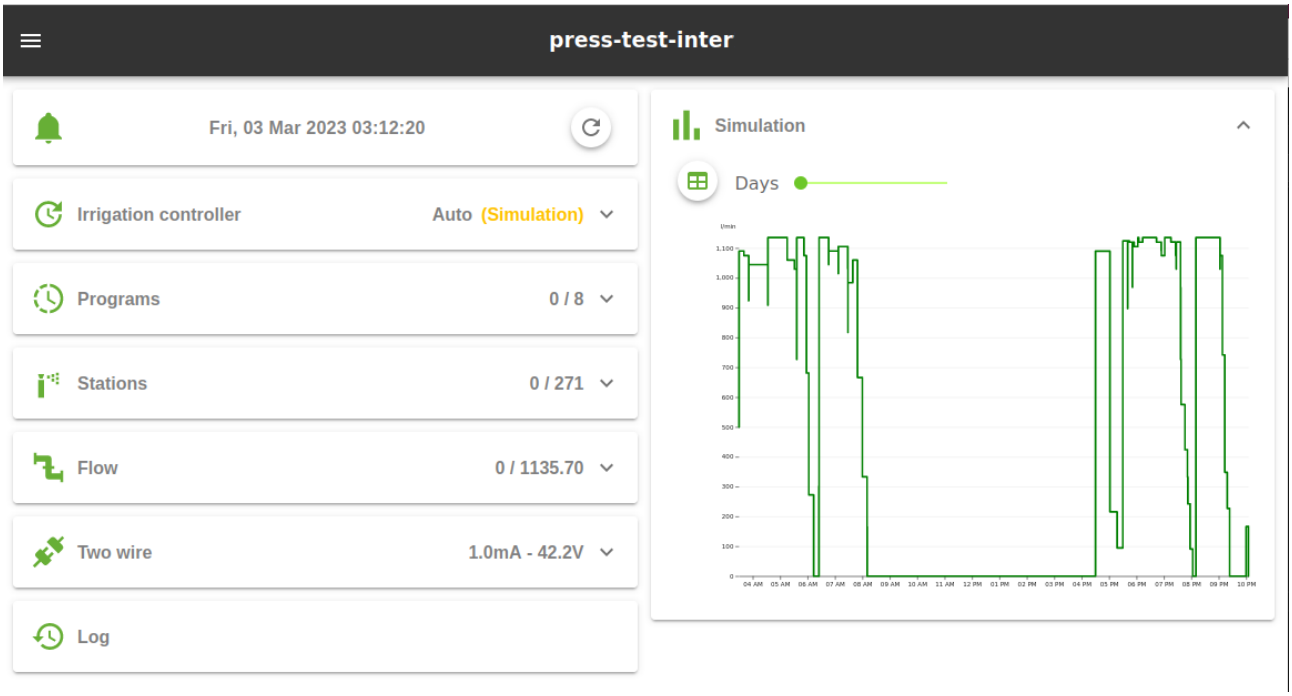
When a field is required its header or description text will turn red and the word ‘Required’ will appear below it. You will not be able to create or save the entry until all required fields are filled in.



3 Dashboard

The Dashboard shows the last known status or state information for the irrigation controller. It is broken into five main sections, 'Status', 'Irrigation controller', 'Two-wire', 'Flow', and 'Programs'. Each provides a quick look at the general health of the controller and the state of its resources.

The dashboard is automatically updated every 20 seconds. If you wish to trigger a manual update, click on the Refresh button in the Status section.



3.1 Status / Interface Clock

The top-most section provides a color-coded warning notification icon and a simple date-time stamp. The color key for the warnings is: red = 2 or more notifications, yellow = 1 notifications, green = no notifications.

The Dashboard automatically updates every 20 seconds. For more frequent updates, you can use the manual refresh on the right side of the panel.

3.2 Irrigation controller

The Irrigation Controller Dashboard section shows the state of the controller, including if the controller is in 'Test mode' where no decoders will activate (note that this is different than Simulation).

Pressing the down-arrow chevron on the right will expand the section to display a drop-down where you can set the controller mode (Auto, Manual, Paused).

Below the dropdown is a Water Budget slider. By default, it is set to 100%, meaning all programs run at a 1:1 with their settings for irrigation.

By moving the slider, you can globally adjust the amount of irrigation performed. The global Water Budget only affects Programs that have correction set to 'Water Budget' and only affects steps defined in hour or amount. Programs with None or 'Weather' in correction and steps in MAD are not affected.

3.3 Programs

Collapsed, the header shows the number of programs currently running.

Expanding the section shows the list of the programs on that controller, each with a start/stop button so that you can start/stop programs manually.

The right-most column displays either that a program is currently running or a date-time stamp when the program is next expected to start.

3.4 Stations

Collapsed, the header shows the number of stations that are currently running against the total number of stations available, expressed as a fraction (ex. 2/4 means 2 stations out of 4 are active).

Expanding the section displays a three-tabbed list where you can control various aspects of Stations.

3.4.1 Running

Under Running is a list of running and active programs with a stop button available so that you can stop stations manually from the Dashboard. The stop button at the top of the left-most column will stop *all* stations.

3.4.2 Error

The Error tab shows those stations which are experiencing an error. The error code is displayed in the last column. Error codes are explained in the Appendix.

You can clear, or reset, the error state for a station by clicking the reset button in the left column. Clicking on the reset at the top of the column will reset *all* stations that have errors.

3.4.3 All

This last tab shows all stations that are available and their current state.

In the left-most column, there are two buttons.

The Play/Stop button allows you to start and stop stations of any station type manually from the dashboard. Clicking on the Play/Stop button at the top of the column will Start/Stop all stations.

The Action button allows you to perform an action on a station. Clicking on the Action button at the top of the column will allow you to choose actions for all stations or a group of stations.

3.5 Flow

In its collapsed state, the Flow section displays expected flow and maximum system capacity for the overall hydraulics/pipe system. When expanded, you are shown the expected and measured flow rates, the number of Master Valves (MV) or Pumps and the state of each pipe section.

3.6 Two-wire

Collapsed, the Two-wire section shows the last known Two-wire current in milliamperes and its DC line voltage.

When expanded, the section is divided into two parts. The upper section shows the Two-wire system state ('operational', 'on', 'charging', etc.) as well as providing a fault code. Faults are recorded in the Log.

Selecting the Two-Wire mode brings you to a sub-menu where you can put the controller in a Short Finding mode.

The lower section displays two virtual gauges showing the last known Two-wire current in milliamperes and its DC line voltage. These are colored visual and numerical representations of the data. The radial gauges will change color when values are above or below important thresholds.

3.7 Log

This section is a direct link to the Log section described later in this manual.

3.8 Simulation

The Simulation section defaults to an expanded state and shows a line chart simulation of irrigation over the next 24 hours. You can hover over the line chart to pick out individual dates and times where irrigation state changes. By clicking on the graph when a date appears, you will get a pop-up showing the stations and programs and flow that would be active at that time, along with a projected Total Flow up to that point.

Clicking on the little calendar icon will switch to a data table containing more detailed info related to the programs and stations that would be running in the simulated time period.

The slider can be used to change the numbers of days to simulate, i.e., look ahead into the future, how the irrigation system will perform. Currently the slider can provide up to 14 days look ahead.

4 Irrigation controller

The NLP has flexible scheduling that can be corrected with Weather adjustments. Advanced MAD-based watering is also available.

Clicking on 'Irrigation Controller' in the main menu will show a submenu of components. Each component / submenu is described in the following sections, starting with 'Programs'.

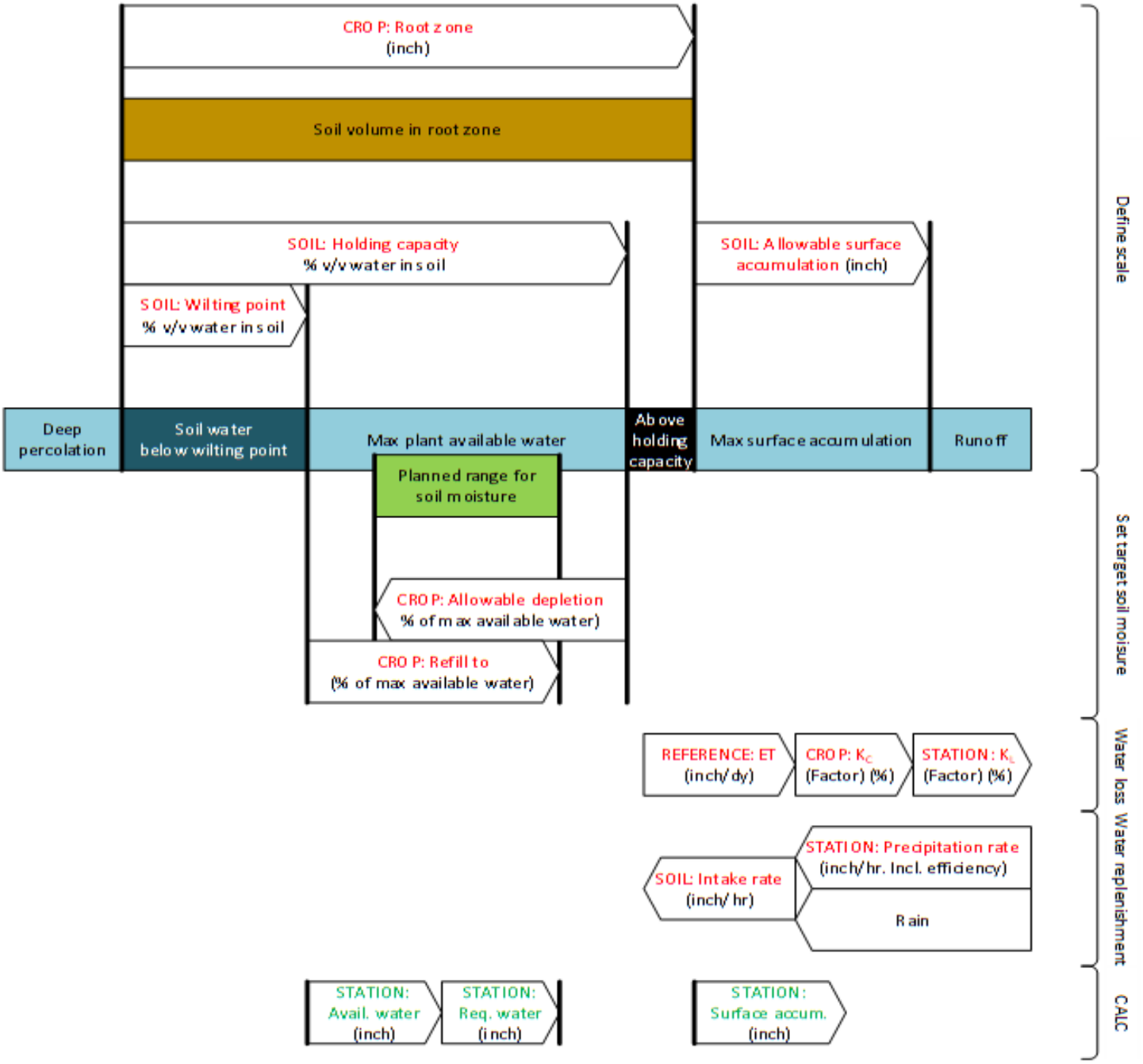
! **Note** Some objects and settings rely on others, so for your initial setup see our suggested sequence in the Appendix 'Setting up your first irrigation controller'.

4.1 Irrigation Principles

4.1.1 MAD-based irrigation (Management Allowed Depletion)

MAD-based irrigation tracks moisture at each station and strives to keep within set depletion and refill parameters. To do so, it needs input on soil, plant, station, timing, hydraulics and more.

4.1.1.1 Parameters for MAD-based irrigation



The diagram above summarizes some of the parameters involved in MAD-based irrigation. Moving from top to bottom:

- A scale for soil water is set up:
  - In the crop (plant) object is set a root zone (depth). It becomes the absolute depth to which we will apply water. Notice that the topmost box tells you both the object (CROP), the related setting (Root zone) and that it is an absolute value (inches in this case).

    - In the soil object are set a holding capacity and a wilting point. This creates a range of plant available water from the minimum useful for the plant to a maximum amount of water available.
    - In the soil object is also set the allowable surface accumulation. It will be a property of the soil and its slope.
    - A scale is now available for water content in different sections shown as the blue vertical bar.
    - Applied water beyond allowable surface accumulation is lost as runoff.
    - Water may lay on the surface, up to the allowable surface accumulation.
    - Water content may temporarily be higher than holding capacity, but this is not considered a relevant parameter.
    - Water from wilting point to soil capacity is the useful range. This becomes a scale from 0% available to 100% available.
    - Water below the wilting point is not available to the plant.
    - Water below the root zone is lost to deep percolation.
- A target range for irrigation is set up:
    - In the crop object, Management Allowed Depletion (MAD) is set as a percentage of the plant available water.
    - In the crop object, the refill percentage defines at what level of plant available water irrigation should stop.
    - The target range for soil moisture is now available shown as a green bar. The controller will keep plant available water within this range when set to irrigate by MAD.
- Water loss is modeled by:
    - In the reference object is a table of historic ET values, or a reference to an on-line source of current value.
    - In the crop object a crop factor is set. This applies a general plant specific correction to ET.
    - In the station object a landscape factor is set. This applies a station specific correction to ET.
    - ET corrected for plant and landscape is updated hourly.
- Water replenishment is specified by:
    - In the station objects, each stations' precipitation rate is set.
    - In the Irrigation controller object, a rain sensor is set.
    - In the soil object, an intake rate is set.
- Calculations done by the irrigation engine:
    - In the station object, plant available water is updated according to lost water.
    - When, in the station object, plant available water reaches MAD, the controller schedules irrigation.
    - The amount of water to reach 'refill to' is calculated and inserted in the station object as 'water required.'
    - Stations with a non-zero value for required water are turned on when allowed by other rules.
    - While irrigating, the value for 'required water' is decreased, while 'plant available water' is increased.

- Irrigation stops when 'water required' becomes zero.
- If 'intake rate' < 'precipitation rate' a fraction of the precipitation increases the value of the 'surface accumulation' at the station.
- If the surface accumulation reaches the maximum allowed, the station is stopped to allow the water to soak in.
- When the surface accumulation becomes zero, irrigation may commence by turning on the station.

4.1.2 Schedule-based irrigation

Schedule-based means that you can set up a more traditional time-controlled irrigation by instructing when exactly irrigation should be applied.

Irrigation can be scheduled on an hourly- and/or daily-basis. You can choose odd/even watering, repeated watering, station-level cycle & soak, and calendar days of exclusion.

4.2 Executing Programs

The irrigation controller runs on a second basis and executes all programs which are due to run. Programs due to run are determined by the start time setup of calendar period, water days, exclusion(s), and start time. More programs can be set to run at the same time. The hydraulics and flow management determines the final execution of stations.

The strategy on a program determines how the execution of steps in the program is performed:

- In strategy **'Auto' the NLP sets all steps due to run and leaves it to the flow management to control the order.**
- In strategy **'Sequential' it starts stations in the order of the defined steps.** It can start more steps if the hydraulics permits, but it will never move on to the next step if not all stations in the previous step have been activated.

Each program may be divided into groups called "steps" to allow for different irrigation methods to be applied within the same program.

If a step is defined with 'Wait completion' it breaks the execution into pieces. In principle steps after the step with 'Wait completion' will look like they were stacked to run right after the 'Wait completion' step. This is useful for e.g., a golf course if you want to complete hole 1 before you more on to hole 2. "Wait completion" can be applied selectively or, if a program that mimics "sequential" irrigation is desired, may be added to every step. See section ***Steps*** for more information.

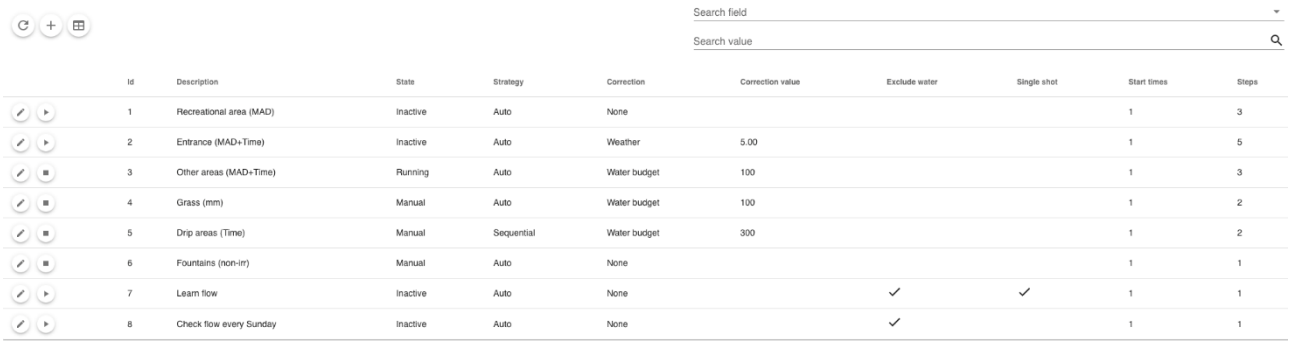
If stations and/or station groups are defined with priorities, then these will impact the order of a station run. The stations which are set due to run by the principles above will be executed by priority from highest number to lowest. A station's effective priority is determined by the group priority * 255 + the station priority.

In general, using strategy 'Auto' with no 'Wait completion' and no priority will utilize the hydraulics and flow management most efficiently. Please see the chapter on hydraulics.

4.3 Programs

A Program is a collection of 'start times' and 'steps' that define what you can control in your irrigation system and when. Clicking on 'Programs' from the main menu will display the current list of programs.

Up to 50 programs may be defined.



	Id	Description	State	Strategy	Correction	Correction value	Exclude water	Single shot	Start times	Steps
	1	Recreational area (MAD)	Inactive	Auto	None				1	3
	2	Entrance (MAD+Time)	Inactive	Auto	Weather	5.00			1	5
	3	Other areas (MAD+Time)	Running	Auto	Water budget	100			1	3
	4	Grass (mm)	Manual	Auto	Water budget	100			1	2
	5	Drip areas (Time)	Manual	Sequential	Water budget	300			1	2
	6	Fountains (non-irr)	Manual	Auto	None				1	1
	7	Learn flow	Inactive	Auto	None		✓	✓	1	1
	8	Check flow every Sunday	Inactive	Auto	None		✓		1	1

4.3.1 Views

The Views section comprises of three lists – a main program list, an irrigation control list, and a time slot list. Pressing on the table icon (or clock-schedule icon) at the top left switches between these views.

4.3.1.1 Program List – Main

This view allows you to edit a program by pressing the pencil icon for the program you want or start/stop a program manually when pressing the play/stop icon. The rest of the view displays information about the programs:

4.3.1.1.1 Id

Unique identifier for that program. This number is automatically generated and assigned when you create a new program.

Note if you delete one or more programs, those Ids become available for new programs again. The next time you add a new program the interface will use the lowest available next number in sequence. For example, if you have programs numbered 1 to 4, and you delete Program 3, the next time you add a program it will be given the Id of 3, not 5 as you might expect.

4.3.1.1.2 Description

Short text describing the program. Maximum character length: 31.

4.3.1.1.3 Strategy

‘Auto’ is the default. Determines how the program is executed. Choose between either ‘Auto’ or ‘Sequential’. ‘Sequential’-based programming will run steps in order

4.3.1.1.4 Correction

Default is ‘None’. Determines what external resources, such as a water budget, are used to modify the program’s operation. Choose an option from the dropdown menu as necessary.

4.3.1.1.5 Exclude Water (MAD-Only)

‘Off’ (greyed button) is default. Exclude water is, for example, used to overspray MAD irrigated plants in hot periods without the extra irrigation amounts being included in the MAD calculations. Exclude Water is relevant for MAD-based stations only. This option is active when the toggle is green.

4.3.1.1.6 Single Shot

Allows the program to run once then terminate, overriding schedule settings ‘Off’ (greyed button) is default.

4.3.1.1.7 Start times

The number of Start times registered for this program. Up to 100 start times may be defined (system wide.)

4.3.1.1.8 Steps

The number of steps registered for this program.

4.3.1.2 Program List – Irrigation control

This shorter list displays each program and how it's controlled – via scheduled start times, a water amount, or by MAD calculations. In the case of schedule-based, the next start time is displayed. Water amount displays the measurement used for that program in mm or inches.

Id	Description	State	Strategy	Correction	Correction value	Exclude water	Single shot	Start times	Steps
43	RED/WH	Idling	Auto	Water budget	100			1	48
44	TULIP	Idling	Auto	Water budget	100			1	22
45	ISLAND 3	Idling	Auto	Water budget	100			1	20
46	RIGHT SI	Idling	Auto	Water budget	100			1	74
47	LEFT SI	Idling	Auto	Water budget	100			1	46
48	MIDDLE	Idling	Auto	Water budget	100			1	38
49	PNY/LILY	Idling	Auto	Water budget	100			1	23

4.3.1.3 Program List – Time slots

By clicking on the clock-schedule icon at the top, you will be presented with a start times / time slot list for all programs. You may also edit entries from this view. For more info on defining start times, or time slots, look at the 'Start Times' section below.

Search field

Search value

Program	Active	Week days	Odd / even	Time interval	Rule applies	Repeat	Minimum repeat interval (min)
RED/WH	✓	M-W-FS-	Any	17:30 - 00:00 Included	Jan 01 - Dec 31	0	0
TULIP	✓	M-W-FS-	Any	20:10 - 00:00 Included	Jan 01 - Dec 31	0	0
ISLAND 3	✓	MTWTFS-	Any	16:30 - 00:00 Included	Jan 01 - Dec 31	0	0
RIGHT SI	✓	M-W-F--	Any	00:00 - 08:30 Included	Jan 01 - Dec 31	0	0
LEFT SI	✓	M------	Any	21:30 - 00:00 Included	Jan 01 - Dec 31	0	0
MIDDLE	✓	M-W-F--	Any	03:30 - 08:30 Included	Jan 01 - Dec 31	0	0
PNY/LILY	✓	--W-F--	Any	06:25 - 08:30 Included	Jan 01 - Dec 31	0	0

Next 15 changes

From Date 2023-04-03

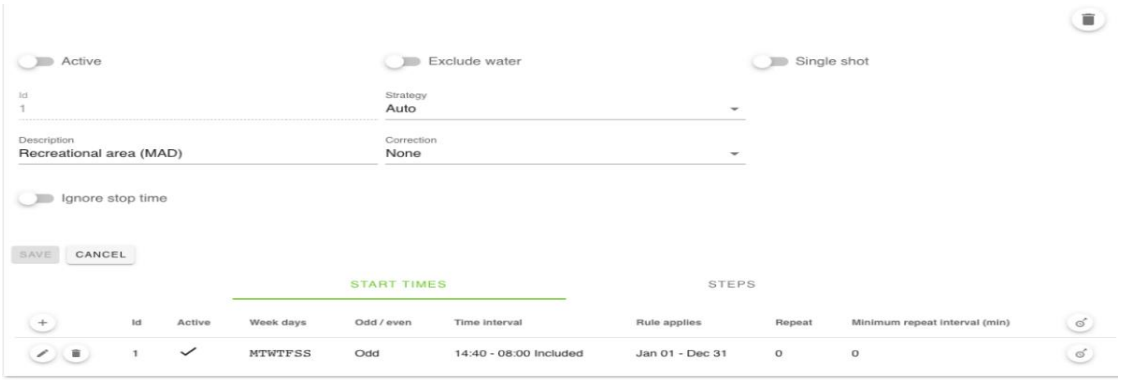
State	Next state change	Timeslot
waiting	Mon, 03 Apr 2023 00:00:00	
inRange	Mon, 03 Apr 2023 08:30:00	4
waiting	Mon, 03 Apr 2023 16:30:00	
inRange	Tue, 04 Apr 2023 00:00:00	2
waiting	Tue, 04 Apr 2023 16:30:00	
inRange	Wed, 05 Apr 2023 08:30:00	4
waiting	Wed, 05 Apr 2023 16:30:00	
inRange	Thu, 06 Apr 2023 00:00:00	2
waiting	Thu, 06 Apr 2023 16:30:00	
inRange	Fri, 07 Apr 2023 08:30:00	4
waiting	Fri, 07 Apr 2023 16:30:00	
inRange	Sat, 08 Apr 2023 00:00:00	2
waiting	Sat, 08 Apr 2023 16:30:00	
inRange	Sun, 09 Apr 2023 00:00:00	2
waiting	Sun, 09 Apr 2023 03:30:00	

4.3.2 Creating/Editing a Program

To add a program, click the plus icon.

To edit a program, click the pencil icon next to the entry you wish to edit.

When adding or editing a program, a form will appear with the fields detailed previously, with two additional sections – Start Times and Steps, with their own add/edit functionality - below the form. All three sections should be filled out for the Program to run successfully.



4.3.3 Program setup

4.3.3.1 Active

Defines whether the program is active. Only active programs will run by dates and times. A programs not designated as Active can only be run manually. An Active program can also be run manually.

4.3.3.2 Exclude water

As above

4.3.3.3 Single shot

As above

4.3.3.4 Strategy

As above

4.3.3.5 Correction

Choose a correction as:

None: This is the default. The program will be defined with MAD, time or amount for each step.

Water budget: This applies to all steps defined in time or amount, but not MAD. The actual water budget is defined in an additional field between 1 and 300%.

Weather: This applies to all steps defined in time or amount, but not MAD. The base ET is defined in an additional field. Base ET refers to the daily amount the step run times correspond to. The ET reference defines the ET settings used as reference. The ET reference is defined later in this guide. The run of the steps will be adjusted ET reference compared to the ET base. This can be used for automatic seasonal adjust.

4.3.3.6 Ignore stop time

Ignore stop time allows programs to run beyond the end time defined in the time slots (see below) and even run for days.

4.3.4 Start Times

Start Times provides a 'window' of time, or schedule, where a Program has the possibility to start and run, depending on resources. Here you define hours, days, and months for this scheduling and whether the program repeats or not.

This section displays a list of up to 100 start times (system wide).

Adding content (via the plus icon) or editing content (via the pencil icon) will bring up form to fill in or change the relevant data, described below:

4.3.4.1 Active
Determines if that schedule is active.

4.3.4.2 Included
This determines that the setup is included, i.e., the program will run on the specified days and start time.

If not included, it means the specified days and time intervals are excluded from whatever the included timeslots define.

4.3.4.3 From/to Month/day
Defines the month/day range of a program. This is useful for scheduling 'seasonal' irrigation. To schedule all year use 1/1 – 12/31.

4.3.4.4 Weekdays
Defines the days of the week a program can run. Toggle the days you want. Greyed out days are not included in the program schedule.

4.3.4.5 Odd/Even
Defines odd or even dates of the month. Example usage: If you define a month range of 3 months, then select Odd from the drop-down menu, only the odd dates (1st, 3rd, 5th, etc.) of each month are available to the program.

Note: The weekdays pattern above is also applied to odd or even dates, meaning it could be set-up to run odd dates excluding Wednesdays.

4.3.4.6 From/to Hour/minute
The from time is where the program will be set due to run. Hydraulics settings might postpone the run.

The end time defines a hard stop for the program regardless of whether it has finished or not. If there is no need for a non-irrigation window, then set end = start.

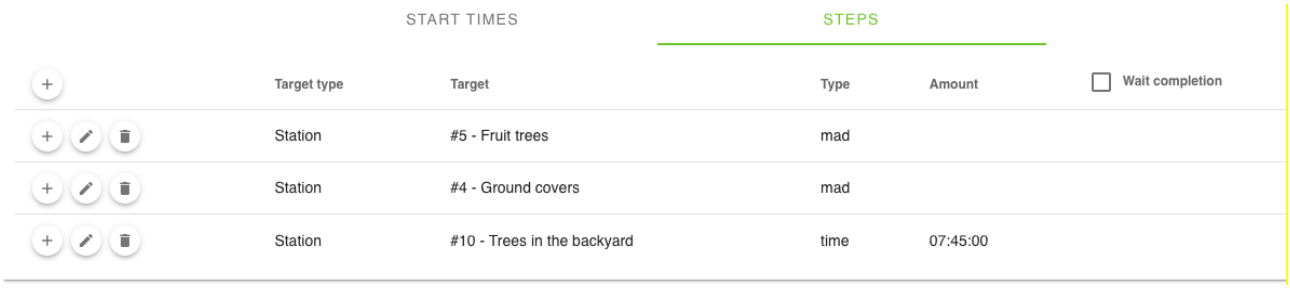
Uses 24-hour clock model (f. ex.'17:00' is 5 PM)

4.3.4.7 Repeat
Defines a number of repeats. They must be within the defined window. Otherwise, they will terminate at the end time and not finish all repeats.

4.3.4.8 Minimum repeat interval
The minimum time between repeats calculated from the previous start of a run. If each run is longer than the minimum, then the repeats will stack as they can't run in parallel with each other.

4.3.5 Steps
The Steps section defines what runs during the program schedule. This can either be a Station, a Group, or all devices.

Up to 500 steps can be defined per program.



Adding content (via the plus icon) or editing content (via the pencil icon) will bring up form to fill in or change the relevant data, described below:

4.3.5.1 Target type

Choose from the drop-down menu the correct target for this step. Target is either a station, a station group, or all stations.

4.3.5.2 Station/Group

4.3.5.3 Depending on what you choose above, this drop-down will contain either a list of Stations or a list of Groups to choose from.

4.3.5.4 Type

Specifies the type of step. The fields below this drop-down will change depending on the choice made.

4.3.5.5 Time

The amount of irrigation time in hours, minutes, and seconds for that step.

4.3.5.6 mm/in

The amount of irrigation (inches) that the step should perform.

4.3.5.7 MAD

This will cause the program to use MAD algorithms based on various resources, such as water availability, to determine how long to irrigate during this step. A station must be set to “MAD” type to run a “MAD” program.

4.3.5.8 Learn flow

Performs the ‘Learn Flow’ operation during this step.

4.3.5.9 Verify flow

Performs the ‘Verify Flow’ operation during this step.

4.3.5.10 Wait completion

This toggle will Instruct the controller to wait for this step to complete before starting the next step.

4.4 Stations

Stations are the physical points of an irrigation system. They may be pumps, valves, or any other piece of hardware that is connected to the interface via decoders, or 'line units', which are configured in the Two-Wire Section of the interface. Up to 500 stations may be defined.

Select 'Station' from the Irrigation controller sub-menu.

To add a station, click the plus icon.

To edit a station, click the pencil icon next to the entry you wish to edit.

From the Station list, information is divided into 3 views. Press the chart / table view button (fourth from the left) to toggle/rotate between each view:

The Station List view (default), Setup view, and Hydraulics view icons

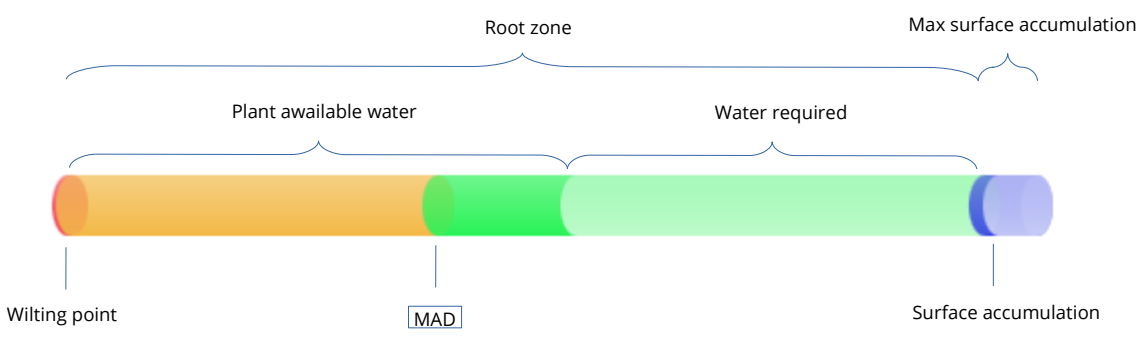
4.4.1 Views

4.4.1.1 Station List - Overview

Without toggling the view button, the first view shows an overview of the Stations that are set up, displaying the name of a station, it's current state of operation, Management Allowed Depletion (MAD) runtime, Wilting Point (WP) runtime, and Runtime Day override.

Id	Description	IO	State	MAD runtime
1	Trees in the front	ST1	Idling	423m 20s
2	Flowers @ entrance	ST3	Wait schedule	213m 13s
3	Playground	ST5	Wait schedule	211m 40s
4	Ground covers	ST2	Started	82m 31s
5	Fruit trees	ST4	Idling	651m 00s
6	Shrubs @ entrance	ST6	Wait schedule	381m 00s
7	Shrubs @ pool bar area	ST7	Idling	163m 17s
8	Shrubs @ tennis area	ST8	Idling	843m 55s
9	Drip area 1	ST9	Idling	
10	Trees in the backyard	ST10	Idling	
11	Cool season grass	ST11	Idling	
12	Warm season grass	ST12	Idling	
13	Fountain @ pool area	ST13	Started	
14	Drip area 2	ST14	Idling	
15	Shrubs in front yard	ST15	Idling	

For stations controlled by MAD calculations, the water parameters relevant for the plants root zone and possible surface accumulated water are visualized in a color-coded graphical bar at the end of the station row. When 'Plant available water' falls below MAD, the system will schedule irrigation at the next available time slot. Irrigation will continue – possibly interrupted due to scheduling – until 'Water required' reaches 0.



4.4.1.2 Id
An auto-generated system assigned read-only identifier.

4.4.1.3 Description
Standard ASCII text describing the station. Maximum character length: 31.

4.4.1.4 IO
A reference to the decoder and output port associated with this station.

In the interface webpage it is shown as a decoder IO name. Internally this is looked up from the decoder address and port number.

4.4.1.5 State
The current or last known state of this station. Possible values are listed below:

4.4.1.5.1 Inactive
A toggle to show if this station is active or not.

4.4.1.5.2 Idling
The station does not require water if in this state or is not due to run for a certain time or amount of irrigation.

4.4.1.5.3 Wait Schedule
The station requires water (non-zero ‘water required) but cannot irrigate now due to a scheduler rule.

4.4.1.5.4 Wait Start
The station is waiting to start. Causes for waiting may be other stations having higher priority, limits on number of active decoders, limits on water capacity etc.

4.4.1.5.5 Started
The station is actively irrigating.

4.4.1.5.6 Wait Stop
The station is waiting to stop but has not yet received and/or acknowledged the command to do so.

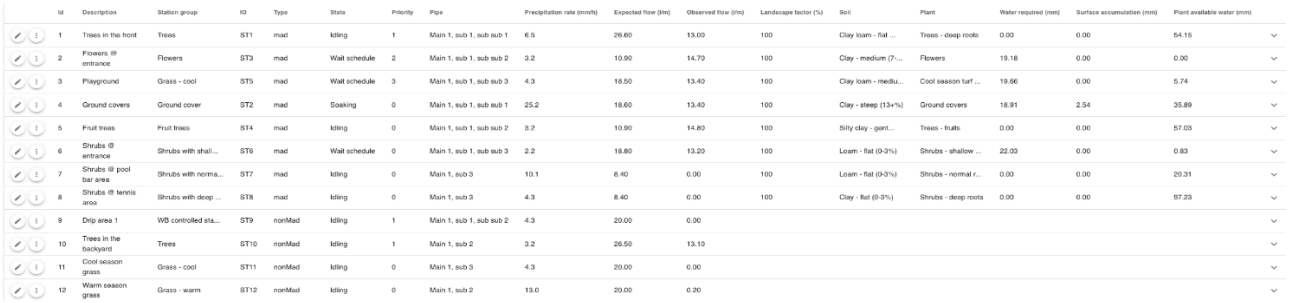
4.4.1.5.7 Soaking
The station is temporarily stopped due to allowed surface accumulation having been reached. Awaits water to soak in according to intake rate setting.

4.4.1.5.8 Error
The station has experienced an error. The error code can be found in the Station list dropdown section for that Station.

4.4.1.5.9 Rain Soaking
The state is usually triggered by a sensor such as a tipping bucket to let the system know when to enter a soaking state caused by rainfall.

4.4.1.5.10 MAD runtime
The normal time to go from replenished to MAD. Divide by ‘ET Runtime day’ to get average number of days between irrigation events.

4.4.1.6 Station List - Setup
Second view shows the setup for this station:



	Id	Description	Station group	IO	Type	State	Priority	Pipe	Precipitation rate (mm/h)	Expected flow (l/m)	Observed flow (l/m)	Landscape factor (%)	Soil	Plant	Water required (mm)	Surface accumulation (mm)	Plant available water (mm)	
	1	Trees in the front	Trees	ST1	mad	Idling	1	Main 1, sub 1, sub sub 1	6.5	26.60	13.00	100	Clay loam - flat ...	Trees - deep roots	0.00	0.00	54.15	
	2	Flowers @ entrance	Flowers	ST3	mad	Wait schedule	2	Main 1, sub 1, sub sub 2	3.2	10.90	14.70	100	Clay - medium (7-...	Flowers	19.18	0.00	0.00	
	3	Playground	Grass - cool	ST5	mad	Wait schedule	3	Main 1, sub 1, sub sub 3	4.3	18.50	13.40	100	Clay loam - mediu...	Cool season turf ...	19.66	0.00	5.74	
	4	Ground covers	Ground cover	ST2	mad	Soaking	0	Main 1, sub 1, sub sub 1	25.2	18.60	13.40	100	Clay - steep (13+%)	Ground covers	18.91	2.54	35.89	
	5	Fruit treas	Fruit trees	ST4	mad	Idling	0	Main 1, sub 1, sub sub 2	3.2	10.90	14.80	100	Silty clay - gent...	Trees - fruits	0.00	0.00	57.03	
	6	Shrubs @ entrance	Shrubs with shall...	ST6	mad	Wait schedule	0	Main 1, sub 1, sub sub 3	2.2	18.80	13.20	100	Loam - flat (0-3%)	Shrubs - shallow ...	22.03	0.00	0.83	
	7	Shrubs @ pool bar area	Shrubs with norma...	ST7	mad	Idling	0	Main 1, sub 3	10.1	8.40	0.00	100	Loam - flat (0-3%)	Shrubs - normal r...	0.00	0.00	20.31	
	8	Shrubs @ tennis area	Shrubs with deep ...	ST8	mad	Idling	0	Main 1, sub 3	4.3	8.40	0.00	100	Clay - flat (0-3%)	Shrubs - deep roots	0.00	0.00	97.23	
	9	Drip area 1	WB controlled sta...	ST9	nonMad	Idling	1	Main 1, sub 1, sub sub 2	4.3	20.00	0.00							
	10	Trees in the backyard	Trees	ST10	nonMad	Idling	1	Main 1, sub 2	3.2	26.50	13.10							
	11	Cool season grass	Grass - cool	ST11	nonMad	Idling	0	Main 1, sub 3	4.3	20.00	0.00							
	12	Warm season grass	Grass - warm	ST12	nonMad	Idling	0	Main 1, sub 2	13.0	20.00	0.20							

Id, Description, IO, and State were described earlier. Here are the remaining fields in this view:

4.4.1.6.1 Station Group

The group to which this station belongs.

A station group holds stations with a common setup, e.g., are in the same field and irrigate the same plant or crop.

4.4.1.6.2 Type

Refers to the type of station irrigation control: basic, non-irrigating, or MAD.

4.4.1.6.3 Priority

Stations are started in order of priority, 255→0. Stations with the same priority are turned on to make best use the flow available.

4.4.1.6.4 Pipe

The pipe to which this station is connected. The pipe resource specifies the available water flow.

4.4.1.6.5 Precipitation rate

This is the precipitation rate due to irrigation (e.g., inches/hour or mm/hour).

Set for each station according to sprinkler, area covered, flow etc.

4.4.1.6.6 Expected flow

This is the specified expected flow at this station.

Used to determine which stations can be turned on under restricted water availability.

Expected flow (EF) and Precipitation rate (PR) are related to the area (A) covered by the station by PR=EF/A.

4.4.1.6.7 Observed flow

Observed flow is the last successful result of running the ‘Learn Flow’ or ‘Verify Flow’ action on the station. If the measurement did not complete, 0 is inserted.

The observed flow may be manually typed as new expected flow, or automatically transferred for the station or a group of stations using an action.

4.4.1.6.8 Landscape factor (MAD-only)

The factor, also called efficiency, is a correction applied to the precipitation rate for stations with uneven water distribution or for which ET does not directly apply.

4.4.1.6.9 Soil (MAD-only)

The soil at this station.

The soil object specifies wilting point, holding (field) capacity and intake rate.

4.4.1.6.10 Plant (MAD-only)

The plant at this station. Plants affect MAD calculations in terms of root depth.

4.4.1.6.11 Water required (MAD-only)
Required water at station. Updated automatically by MAD algorithms every 1 second.

If ≠0, irrigation will start as soon as possible pending available resources (time, water, power). The value tells the controller to apply the required amount.

May be changed manually to force irrigation. Observe that this does not change the net irrigation at the station, - it merely changes the timing of application.

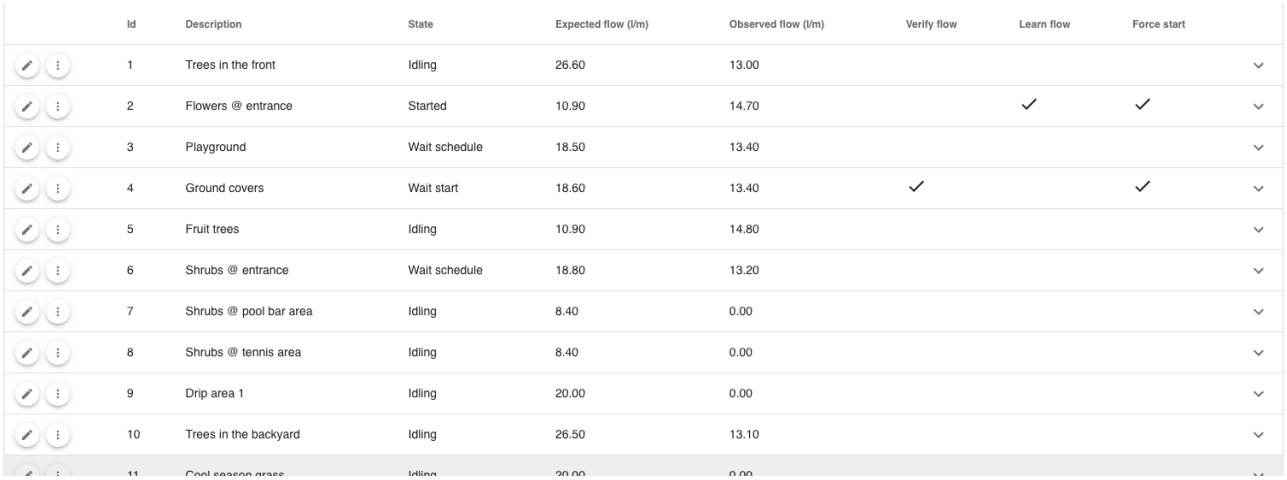
4.4.1.6.12 Surface accumulation (MAD-only)
Current layer of water on the soil surface. Recalculated every 1 sec.

When Station: Precipitation rate > Soil: Intake rate, water accumulates on the surface. Surface accumulation is the current value, (possibly) increasing during irrigation, and decreasing towards 0 during the soak phase as water is absorbed by the soil.

4.4.1.6.13 Plant available water (MAD-only)
Water available to the plant (e.g., inches or mm) in its root zone. Recalculated every 1 second.

The controller aims to keep available water between the setting for MAD (Management Allowed Depletion) and Refill To values.

4.4.2 Station List - Hydraulics
Third page shows parameters relating to hydraulics:



	Id	Description	State	Expected flow (l/m)	Observed flow (l/m)	Verify flow	Learn flow	Force start	
	1	Trees in the front	Idling	26.60	13.00				
	2	Flowers @ entrance	Started	10.90	14.70		✓	✓	
	3	Playground	Wait schedule	18.50	13.40				
	4	Ground covers	Wait start	18.60	13.40	✓		✓	
	5	Fruit trees	Idling	10.90	14.80				
	6	Shrubs @ entrance	Wait schedule	18.80	13.20				
	7	Shrubs @ pool bar area	Idling	8.40	0.00				
	8	Shrubs @ tennis area	Idling	8.40	0.00				
	9	Drip area 1	Idling	20.00	0.00				
	10	Trees in the backyard	Idling	26.50	13.10				
	11	Cool season grass	Idling	20.00	0.00				

Id, Description, State, Expected Flow and Observed Flow were explained earlier. Below are the remaining fields visible in this view:

4.4.2.1 Verify flow
A true/false flag if the flow at the station is to be verified.

4.4.2.2 Learn flow
A true/false flag if the flow at the station is to be learned.

4.4.2.3 Learn flow failed
Flag showing if Learn flow failed (1 = failed).

4.4.2.4 Force start / Override schedule and priority
Setting force start (as shown) true means the station can turn on at highest priority disregarding actual priority and schedule, i.e., allow station to respond at earliest convenience.

Force start may be specified with actions ‘run seconds’, ‘run minutes’, ‘apply amount’, ‘learn flow’ and ‘verify flow’. The flag is automatically set false when the pending operation is done, to let the station return to normal scheduling.

4.4.2.5 Station List – dropdown view

In all three views you may press the down arrow (chevron) on the desired station to view all parameters at once, plus a few more detailed below:

4.4.2.6 Active

Shows whether this station is active or not. If deactivated its state will be set as inactive.

4.4.2.7 Address

Decoder IO address of the station. In combination with the Idx (below) helps to identify specific hardware (a pump or valve for example) connected to the controller.

4.4.2.8 Idx

The 'index' of specific hardware attached to a controller via Decoders. In combination with Address (above) this value helps to identify specific hardware (a pump or valve for example) connected to the controller. A decoder many have many Idx values equal to the number of inputs or outputs for that decoder.

4.4.2.9 Last Update

Last Station update that was received by the controller.

4.4.2.10 Last ET Update

Last ET update that was received by the controller.

4.4.2.11 Last IO Change

Last known IO change received by the controller.

4.4.2.12 Program

Shows which program this station belongs to when running.

4.4.2.13 Runtime (sec)

Displays station runtime in seconds.

4.4.3 Actions

While all behavior of stations can be controlled by changing parameters of each, it is practical to do some as a direct command, applied either to a single station or a group of stations. The action for one or more is identical, except for how it is called.

Click on the vertical 3 dots icon to initiate an Action. Actions performed from the top row of buttons above the list applies to all stations or a station group, chosen from a drop-down list. Actions set from the Station list apply only to that chosen Station.

Once an action is selected the dialog expands to collect additional information. Fill in and press the Save button to initiate the action. Press the Cancel button to leave everything unchanged.

4.4.3.1 Stop

Allows you to stop a running station or station group.

4.4.3.2 Run seconds, Run minutes, Run amount

You can trigger individual stations, or groups of stations, to either run a specified time or to apply a specific amount of water.

When specifying a runtime at each station, this action uses the precipitation rate to calculate an amount of water, which is then applied in the same way as an absolute amount.

(MAD-Only) The water applied counts towards the plant's available water so net irrigation will be unchanged. Overall irrigation changes are made through ET or crop factor settings. Changes at individual stations are made by adjusting the landscape factors or the stations' water budget.

4.4.3.3 Force infiltration (MAD-only)

This action immediately transfers an amount recorded as current surface accumulation to the soil, incrementing the available water.

The command is used when surface accumulation is preventing a station from starting, e.g., during checks.

4.4.3.4 Verify flow

When verifying flow at a station, the flow rule nearest upstream is placed in 'validate flow' mode. Only the relevant station downstream from the flow rule is allowed to run. Stations connected to other pipe segments are not affected. Upon successful measurement the flow is stored as 'observed flow' for the station.

4.4.3.5 Learn flow

When learning flow at a station all flow rules back to and including a main pipe are placed in learnFlow mode, preventing all other stations from activating. Flow paths connected to other main pipes are not affected. Upon successful measurement the flow is stored as 'observed flow' for the station.

4.4.3.6 Apply observed flow

The measured flow resulting from 'Learn flow and 'Verify flow' is inserted as 'observed flow' for each station. If no flow could be determined, i.e., a stable flow was not attained, the 'observed flow' is set at 0.

You may transfer the observed flow to become a new expected flow using this action. For each applicable station having a non-zero 'observed flow' the value is copied to 'expected flow'.

4.4.3.7 Set actual soil moisture % to (MAD-only)

The controller keeps track of a calculated moisture balance at each station. You may have measured soil moisture prompting correction of the controller parameter for plant available water. The latter is an absolute value. This action sets the plant available water at each station to the entered percentage between wilting point (0) and field capacity (100%).

The action is typically used when starting the controller to set, e.g., 50% as an initial soil moisture to work from.

To correct the plant available water for an individual station, go to that stations edit page.

4.4.4 Creating/Editing a Station

Click on the plus icon to create a new Station.

To edit a station, click the pencil icon next to the entry you wish to edit.

When creating a Station, data needs to be input in the form that appears:

4.4.4.1 Id

A system assigned read-only identifier. This is auto generated.

4.4.4.2 Description

A short descriptive text. Max 31 characters.

4.4.4.3 Active

Whether this station group should be irrigated or not.

4.4.4.4 IO

A reference, by name, to the decoder and output port associated with this station.

4.4.4.5 Station group

The group to which this station belongs. In the web referenced by name, in the backend by its id.

A station group holds stations with common setup, e.g., are in the same field and irrigate the same plant or crop.

4.4.4.6 Type
Select the type of irrigation from the drop down.

4.4.4.7 MAD
Management Allowed Depletion. This irrigation method uses information on soils, plants, hydraulics, and ET references to calculate the best irrigation time and amount for that station.

4.4.4.8 Non-irrigating
The simplest station set-up type A station set to this type does not follow any water irrigation settings, i.e., does not use any hydraulic logic or cannot water via “amount”. Another use might be to control artificial lighting via a time-scheduled program.

4.4.4.9 Basic
This sets the station to follow schedule-based rules. Although utilizing the automatic cycle & soak requires the station to be defined as MAD and thus the soil type contributes to the cycle & soak calculation.

4.4.4.10 Priority
Stations are started in order of priority, 255→0. Stations with the same priority are turned on to make the best use the flow available.

4.4.4.11 Pipe
The pipe to which this station is connected. The pipe resource specifies the available water flow.

4.4.4.12 Precipitation rate
This is the precipitation rate due to irrigation (e.g., inches/hour or mm/hour).

Set for each station according to sprinkler, area covered, flow etc.

4.4.4.13 Expected flow
This is the specified expected flow at this station.

Used to determine which stations can be turned on under restricted water availability.

Expected flow (EF) and Precipitation rate (PR) are related to the area (A) covered by the station by PR=EF/A.

4.4.4.14 Landscape factor (%) (MAD-only)
A value used to offset the calculations in MAD based irrigation. A default value of 100% is recommended to start with.

4.4.4.15 Soil (MAD-only)
The soil at this station. Soils are defined in a separate section.

The soil object specifies wilting point, holding (field) capacity and intake rate.

4.4.4.16 Plant (MAD-only)
Specifies the Plant watered by this Station. Plants are defined in a separate section.

4.4.4.17 Water Required (MAD-only)
Required water at station. Updated automatically by algorithms every 1 second.

If ≠0 irrigation will start as soon as possible pending available resources (time, water, power). The value tells the controller to apply the required amount.

May be changed manually to force irrigation. Observe that this does not change the net irrigation at the station, - it merely changes the timing of application.

4.4.4.18 Surface accumulation (MAD-only)

Current layer of water on the soil surface. Recalculated every 1 sec.

When Station: Precipitation rate > Soil: Intake rate, water accumulates on the surface. Surface accumulation is the current value, (possibly) increasing during irrigation, decreasing towards 0 during the soak phase as water is absorbed by the soil.

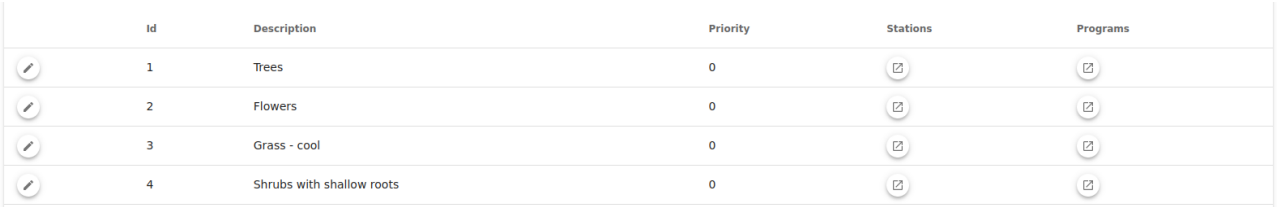
4.4.4.19 Plant available water (MAD-only)

Water available to the plant (in e.g., inches or mm) in its root zone. Recalculated every 1 second.

The controller aims to keep available water between the setting for MAD (Management Allowed Depletion) and Refill To values.

4.5 Station Groups

This section organizes stations into manageable groups that may share similar properties, such a field with the same crop and schedule or program.



	Id	Description	Priority	Stations	Programs
	1	Trees	0		
	2	Flowers	0		
	3	Grass - cool	0		
	4	Shrubs with shallow roots	0		

4.5.1 View

Station Groups contains a single list view. It shows the data below and provides links to related Stations and Programs.

4.5.1.1 Id

A system assigned read-only identifier.

4.5.1.2 Description

A short descriptive text. Max characters: 31.

4.5.1.3 Priority

Station groups are started in order of priority, 255→0, with 255 being the highest priority. Groups take precedence over Stations themselves, i.e., The highest priority group will start it's Stations in order of Station priority, then next highest priority group will start its own Stations in order of Station priority, and so on.

4.5.1.4 Stations

Press the button to view a list of stations assigned to this group. Use the back button at the top to return to the group list.

4.5.1.5 Programs

Press the button to view a list of programs referencing this group.

4.5.2 Creating/Editing a Station Group

Click on the plus icon to create a new Station Group.

To edit a Station Group, click the pencil icon next to the entry you wish to edit.

The resulting form only allows you access to the description and priority for that group.

4.6 Plants (MAD-Only)

This section allows you to define specific properties for your plants or crops.

4.6.1 View

Plants contains a single list view. It shows the data below and provides links to related Stations.

4.6.1.1 Id

A system assigned read-only identifier.

4.6.1.2 Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max character: 31.

4.6.1.3 ET reference

The ET input is used when calculating water loss for this plant. Must be specified if applying MAD irrigation. ET reference is defined in a later section of this guide.

4.6.1.4 Allowable depletion

The allowable depletion as a percentage from soil holding capacity (maximum available water, 0% depletion) to wilting point (minimum available water, 100% depletion).

A suggested starting value is 50% from which you may deviate if you know your plants' specific needs.

Plant	Suggested MAD
Rice	20 %
Lettuce	30 %
Cool season turf grass	40 %
Warm season turf grass	50 %
AVERAGE	50 %
Alfalfa	50-60 %
Cotton or potatoes	65 %

4.6.1.5 Refill to

The amount of water added from wilting point (0%) to holding capacity (100%) when MAD based irrigation applies water. Specifying up to 200% is possible, in which case water in excess of 100% will be lost to deep percolation. This may be meant to e.g., wash salts below root depth.

4.6.1.6 Root zone

The root zone in which moisture content will be maintained when using the MAD irrigation algorithm.

Enough water should be applied to wet the entire root zone and to encourage deep rooting. Deeper roots are better able to withstand periods of drought; shallow watering, on the other hand, leads to shallow roots and plants that are susceptible to drought and strongly affected by fluctuating temperatures.

Select values for moisture extraction depth of properly irrigated roots:

Examples	Rooting	Depth (inches)	Depth (mm)
Turf grass		6 (minimum 3)	150
Perennials/ Ornamental Grasses/ Shrubs 16”-24” (40-60 cm)	Shallow	12-18	300-450
Perennials/ Ornamental Grasses/ Shrubs 2’-6’ (60-200 cm)	Moderate	18-24	450-600
Shrubs >6’ (>2m) Trees	Deep	>24	>600

4.6.1.7 Plant factor

This is a correction factor applied to the ET reference. Used when ET represents a different plant, and the correction is known.

4.6.1.8 Stations

Press the button to view a list of stations referencing this plant.

4.6.2 Creating/Editing a Plant definition

Click on the plus icon to create a new Plant.

To edit a Plant, click the pencil icon next to the entry you wish to edit.

4.7 Soils (MAD-Only)

Shows a list of soils. Used in the MAD algorithm to calculate how and when to apply water. Describes common properties of a soil which may be referenced by other parts of the system.

4.7.1 View

Soils contains a single list view. It shows the data below and provides a link to related Stations.

4.7.1.1.1 Id

A system assigned read-only identifier.

4.7.1.1.2 Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max characters: 31.

4.7.1.1.3 Holding capacity

The maximum volumetric water content the soil holds against the force of gravity.

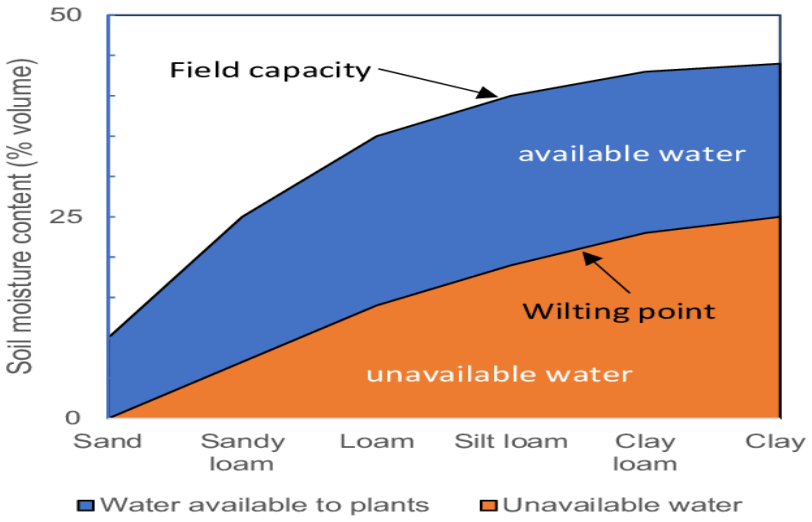
The volumetric water content is the ratio of the volume of water to the unit volume of soil. It may be expressed as percentage, ratio, or depth of water per depth of soil (i.e., inches of water per foot of soil). When the volume of water is 20 percent of the unit volume of soil containing it, the content can be reported as 20 percent, 0.20 (ratio) or 2.4 inches per foot of soil (0.2 inches/inch * 12 inches/foot).

4.7.1.1.4 Wilting point

The minimum amount of water required for plant growth.

Wilting point is considered a property of the soil, since it is differences in moisture retention of the soil, rather than differences in plant moisture uptake that determine the wilting point.

The wilting point and holding capacity are measures for how well different soil particle types hold on to water. The below figure suggests values for both (from Haqiqi, Iman & Grogan, Danielle & Hertel, Thomas & Schlenker, Wolfram. (2020). Quantifying the Impacts of Compound Extremes on Agriculture and Irrigation Water Demand. 10.5194/hess-2020-275).



4.7.1.1.5 Intake rate

The rate of water intake (infiltration) into the soil. Set a value that represents a compromise between intake into a dry soil, and intake once the surface has been wetted.

Below we have a table that shows working values.

SOIL TEXTURE	MAXIMUM PRECIPITATION RATES: INCHES PER HOUR / MILLIMETERS PER HOUR							
	0 to 5% slope		5 to 8% slope		8 to 12% slope		12%+ slope	
	cover	bare	cover	bare	cover	bare	cover	bare
Course sandy soils	2.00 51	2.00 51	2.00 51	1.50 38	1.50 38	1.00 25	1.00 25	0.50 13
Course sandy soils over compact subsoils	1.75 44	1.50 38	1.25 32	1.00 25	1.00 25	0.75 19	0.75 19	0.40 10
Light sandy loams uniform	1.75 44	1.00 25	1.25 32	0.80 20	1.00 25	0.60 15	0.75 19	0.40 10
Light sandy loams over compact subsoils	1.25 32	0.75 19	1.00 25	0.50 13	0.75 19	0.40 10	0.50 13	0.30 8
Uniform silt loams	1.00 25	0.50 13	0.80 20	0.40 10	0.60 15	0.30 8	0.40 10	0.20 5
Silt loams over compact subsoil	0.60 15	0.30 8	0.50 13	0.25 6	0.40 10	0.15 4	0.30 8	0.10 3
Heavy clay or clay loam	0.20 5	0.15 4	0.15 4	0.10 3	0.12 3	0.08 2	0.10 3	0.06 2

The maximum PR values listed above are as suggested by the United States Department of Agriculture.
The values are average and may vary with respect to actual soil condition and condition of ground cover.

4.7.1.1.6 Max surface accumulation

If the precipitation rate is higher than the intake rate, moisture will accumulate on the surface. The max surface accumulation sets a maximum acceptable accumulation. The value will be influenced by the soil, but also of the landscape, e.g., slopes will direct a lower acceptable setting, since runoff will quickly form, while flat land can accommodate a higher accumulation.

The controller calculates the accumulation, turns off irrigation when the max has been reached, and waits for the water to seep in before commencing irrigation. This is amounts to automatic cycle and soak.

A suggested starting point is to allow 0,1” to accumulate.

4.7.1.1.7 Stations

Press the button to view a list of stations referencing a soil type. Use the back button at the top to return to the Soil list.

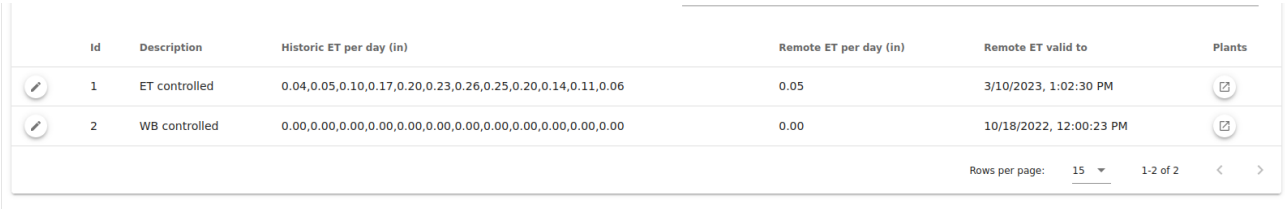
4.7.2 Creating/Editing a Soil definition

Click on the plus icon to create a new Soil definition.

To edit a Soil definition, click the pencil icon next to the entry you wish to edit.

4.8 ET reference

Water reference data is currently historic ET values for a site.



	Id	Description	Historic ET per day (in)	Remote ET per day (in)	Remote ET valid to	Plants
	1	ET controlled	0.04,0.05,0.10,0.17,0.20,0.23,0.26,0.25,0.20,0.14,0.11,0.06	0.05	3/10/2023, 1:02:30 PM	
	2	WB controlled	0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00,0.00	0.00	10/18/2022, 12:00:23 PM	

Rows per page: 15 1-2 of 2

Plants in the controller refer to a water reference for their ET values. It is possible to set up different ET tables, e.g., 20-year average, a wet year, and a dry year. You can then point a crop to the relevant reference according to how a season develops.

4.8.1 View

ET Reference contains a single list view. It shows the data below and provide a link to related Plants.

4.8.1.1.1 Id

A system assigned read-only identifier.

4.8.1.1.2 Description

A short descriptive text. Use a meaningful description as it is used as reference elsewhere in the web interface. Max character: 31.

4.8.1.1.3 Historic ET per day

12 ET values of your choice.

4.8.1.1.4 Remote ET per day

Amount of ET per day to override Historic ET.

4.8.1.1.5 Remote ET valid to

Date the Remote ET is valid to.

4.8.1.1.6 Plants link

Press the button to view a list of plants referencing an ET Reference. Use the back button at the top to return to the ET Reference list.

4.8.2 Creating/Editing an ET reference

Click on the plus icon to create a new ET definition.

To edit an ET definition, click the pencil icon next to the entry you wish to edit.

4.9 Hydraulics

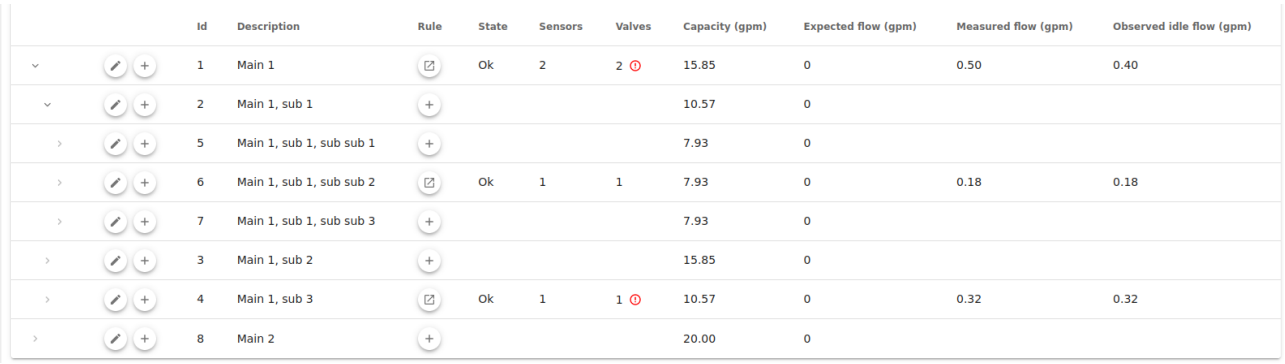
The hydraulic structure of the controller supports up to 100 independent mainlines. Each mainline is the entry point for a tree structure of pipes comprising the hydraulics. The controller can handle a total of 100 pipe sections. Each pipe section is defined by its flow capacity and the parent (a mainline has no parent).

Any pipe section can be assigned a flow rule. The controller supports up to 20 flow rules. Each flow rule consists of general settings of limits, up to 20 flow valves and up to 20 flow sensors. The NLP can support max 20 flow sensors in total for the entire hydraulics.

A Flow Valve can either be a pump, Normally Open or Normally Closed Master Valve or a booster pump. The pump, N/C MV and booster pumps behave the same way, but just gives the user the option to define what it is. A Flow Valve is optional for the flow rule.

A flow sensor can be a common or individual for the defined Flow Valve(s). If setup as individual flow sensors per Flow Valve, then the flow on the overview and dashboard represents the sum. A flow sensor is optional for the flow rule. If not present, then any flow related settings are ignored.

Stations in the controller are assigned to a pipe section. A station is controlled by/controlling the first upstream flow rule. This is also called a downstream station in relation to the flow rule.



Id	Description	Rule	State	Sensors	Valves	Capacity (gpm)	Expected flow (gpm)	Measured flow (gpm)	Observed idle flow (gpm)
1	Main 1		Ok	2	2	15.85	0	0.50	0.40
2	Main 1, sub 1					10.57	0		
5	Main 1, sub 1, sub sub 1					7.93	0		
6	Main 1, sub 1, sub sub 2		Ok	1	1	7.93	0	0.18	0.18
7	Main 1, sub 1, sub sub 3					7.93	0		
3	Main 1, sub 2					15.85	0		
4	Main 1, sub 3		Ok	1	1	10.57	0	0.32	0.32
8	Main 2					20.00	0		

Flow management
The flow management system operates on all stations which are set due to run. Whether they originate from programs with Auto or Sequential strategy, runs in time, amount, or MAD, or are manually started doesn't matter. The flow management works on each mainline as a separate individual entity and will as such be handled equally. The only common limitation is the number of active outputs set for the system. All calculation of capacity is based on expected flow for the stations.

The flow management will seek to utilize the capacity of the mainline by starting large stations and fill up with smaller stations. The NLP will traverse the hydraulic tree from the far end and upstream to the mainline when looking for stations to start. Every flow rule on the path to a given station will be considered and appropriate actions performed like turning on Flow Valves. Whenever a station stops, the hydraulics are reevaluated to find candidates to start.

If the system is set up with priorities on station group and/or stations then these will be affecting the selection of the station run in the order of highest to lowest station group priority, highest to lowest station priority and then expected flow. This gives a controlled order of the station run but can have a negative effect on the utilization of the hydraulic system.

4.9.1 Views

The Hydraulics section has only one view but toggles between showing only the main pipes or expanding to show all pipe connections with the following information.

4.9.1.1.1 Id

Available when adding or editing a pipe, Id is a system assigned read-only identifier.

4.9.1.1.2 Description

A short descriptive text. The text is referenced in the UI e.g., when assigning stations to a pipe. Maximum 31 characters.

4.9.1.1.3 Rule

The rule assigned to that pipe. Press the button to view a rule for the selected pipe, detailed below.

4.9.1.1.4 State

State of the pipe, relaying error messages generated by the system. Such as 'flow too high' or 'resource missing'. Default is 'Ok'.

4.9.1.1.5 Sensors

Number of Sensors attached to this pipe. See Flow Sensor section below for details.

4.9.1.1.6 Valves
Number of Valves attached to this pipe.

4.9.1.1.7 Capacity
The maximum flow capacity of this pipe (section).

When turning on stations it is ensured that the summed expected flow does not exceed the lowest pipe capacity of the relevant flow path. Each station is assigned to a pipe to enable such calculation.

4.9.1.1.8 Expected flow
The expected flow rate for that pipe.

4.9.1.1.9 Measured flow
The sum of flows seen by sensors connected to the rule.

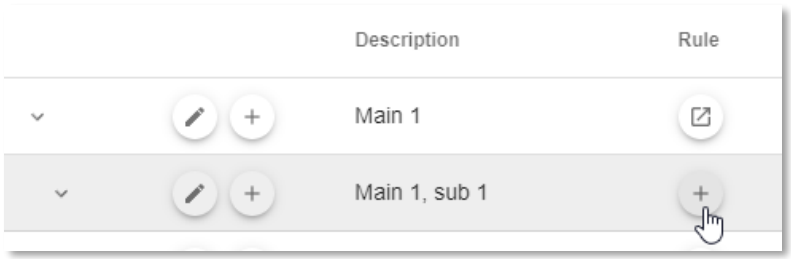
4.9.1.1.10 Observed idle flow
When a zero flow is expected and the rules for considering a flow stable are met, the measured flow is stored as 'observed idle flow'. The value may be used when determining a useful value for 'allow idle flow'.

4.9.2 Rules
A flow rule defines how to monitor and/or control the flow in a specific pipe. Up to 20 rules may be expressed.

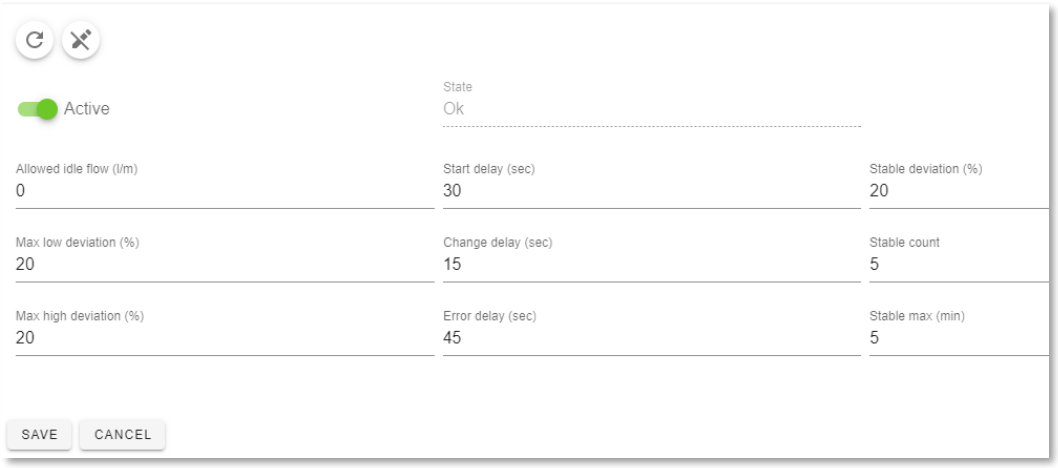
- Flow monitoring is by means of one or more sensors associated to the rule and thus the relevant pipe.
- System continuously monitors the flow rule and triggers actions.
    - Evaluation of the rule is suspended for 'start delay' or 'change delay' when applicable.
- Control is by means of one or more valves or pumps.

Add a rule to a pipe by pressing 'plus' icon in the Rule column:

Edit a rule by pressing the 'window pop out' button in the Rule column:



A form to add or edit the rule is shown:



Parameters ‘start delay’ and ‘change delay’ control an initial time for flows to stabilize before applying the rule. ‘Measured flow’ is then compared to an expected flow calculated as the sum of relevant stations expected flows, the acceptable deviations ‘max low deviation’ and ‘max high deviation’ and taking ‘allowed idle flow’ into account. ‘Error delay’ ensures the error is persistent before reporting.

To produce reliable measurements for ‘learned flow’, ‘validate flow’ and ‘idle flow’ the parameters ‘stable deviation’, ‘stable count’ and ‘stable max’ are applied.

The flow rule may have associated flow sensors. If so, the measured flow rule is evaluated against the expected flow.

The flow rule may have associated valves or pumps. If so, these are opened when the relevant pipe has an expected non-zero flow. The flow rule closes its associated open valves and pumps if certain error conditions are raised.

When a fault affects multiple flow rules, e.g., a leak, the downstream rule is handled first. After that, if the fault persists for ‘error delay’ at the next upstream rule, said rule is handled. This recursive handling continues until all faulted rules have been handled.

When learning flow at a station all flow rules back to and including a main pipe are placed in ‘learn flow’ mode, preventing all other stations from activating. Flow paths connected to other main pipes are not affected. Upon successful measurement the flow is stored as ‘observed flow’ for the station.

When verifying flow at a station, the flow rule nearest upstream is placed in ‘validate flow’ mode. Only the relevant station downstream from the flow rule is allowed to run. Stations connected to other pipe segments are not affected. Upon successful measurement the flow is stored as ‘observed flow’ for the station.

4.9.2.1.1 Active

This toggles the flow rule active/passive. In passive state it will still operate Flow Valves and monitor any flow, but no alarms will be generated.

4.9.2.1.2 Automatic action

This toggles whether any flow alarms will actively stop pumps (active) or just warn (passive).

4.9.2.1.3 State

The current state of the rule. Possible values are:

- **Ok** - The state when no other state is active. The flow rule is in the normal state.
- **No Flow** - The flow rule is in no-flow state meaning it has not seen a flow after start of a Flow Valve. The period it looks for a flow depends on the flow sensor assignment. If the pump has a flow sensor assigned (see Flow Valve setup below) it will use the start/change delay, otherwise it will use start/change delay plus the error delay. The Flow Valve(s) will be stopped if Automatic action is enabled.
- **Unexpected Flow** - There is a flow above the Allowed idle flow when no Flow Valves are active. A N/O MV will be activated if the Automatic action is enabled.
- **Flow Too Low** - The flow is too low. All downstream stations are marked for verify flow if the Automatic action is enabled.
- **Flow Too High** - The flow is too high. All downstream stations are marked for verify flow if the Automatic action is enabled.
- **Resource Missing** - The flow rule points to a non-existing output or input.
- **Verify Flow** - The flow rule is in a state where it verifies the expected flow for downstream stations. Only one downstream station will run at the time and on further downstream flow rules are active. The result of the verify flow is stored in the station’s observed field.
- **Learn Flow** - The flow rule is in a state where it learns the expected flow for downstream stations. Only one downstream station will run at the time and on further downstream flow rules are active. The result of the learn flow is stored in the station’s observed field.

4.9.2.1.4 Allowed idle flow (L/min)

Allows for a (background) flow unrelated to the controller.

- Prevents an error condition from being raised when zero flow cannot be attained.
- Is subtracted from measured flow when evaluating against expected flows.

4.9.2.1.5 Start delay (sec)

Defines the number of seconds the system shall wait from start of the Flow Valve(s) before checking for alarms.

4.9.2.1.6 Stable deviation (%)

Defines the maximum % deviation from previous reading before a flow reading is considered stable for learn flow and verify flow.

4.9.2.1.7 Stable count

Defines the interval in counts of 5 seconds where the readings shall be within the stable deviation % for accepting the flow for learn flow and verify flow.

4.9.2.1.8 Stable max (min)

Defines the maximum minutes to find a stable flow before it gives up finding a stable flow for learn flow or verify flow. The result will be set to 0 for the station.

A stable flow is required to:

- record an observed flow when learning or verifying flow. May be copied as new 'expected flow'.
- record an observed idle flow when zero flow is expected. May be copied to 'allowed idle flow'.

The flow is considered stable when:

- 'Start delay' has elapsed, and
- 'Stable count' consecutive values, taken at 5 sec intervals,
- are within 'stable deviation' percent of the first value,
- realized before 'stable max' minutes has elapsed.

The requirement for a stable flow does not apply under normal operation where, instead, after the 'start delay' or 'change delay' the momentary measurements are used.

4.9.2.1.9 Max low deviation (%)

The maximum low deviation in % of the expected flow for the active downstream stations.

4.9.2.1.10 Max high deviation (%)

The maximum high deviation in % of the expected flow for the active downstream stations.

4.9.2.1.11 Change delay (sec)

Define the number of seconds the system shall wait from a change in running downstream stations before checking for alarms.

4.9.2.1.12 Error delay (sec)

Defines the number of seconds an alarm shall be observed before it triggers the alarm.

4.9.2.1.13 Stable max (min)

Number of minutes to wait for a stable maximum flow.

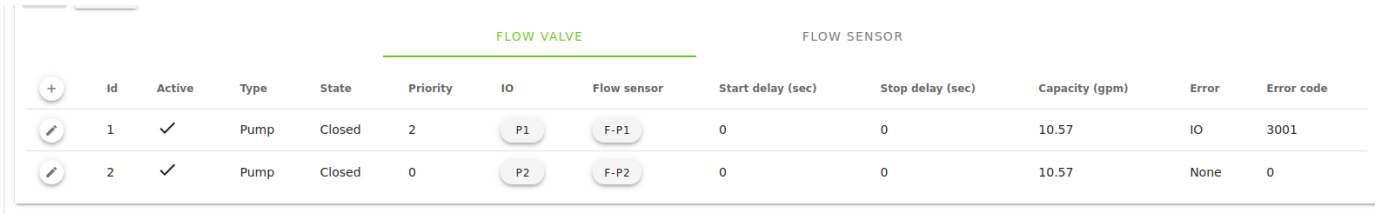
4.9.3 Flow valve – Master Valve or Pump

This sub-panel appears at the bottom of the Rule edit page.

Zero or more valves or pumps may be associated with a flow rule. In the web interface these valves are found in the Hydraulics menu, under the relevant pipe and flow rule.

- They are activated when the expected flow through the associated pipe is non-zero.

- The valve(s) are assumed to be placed at the beginning of the pipe so that they control all flow into the pipe, which leaves the pipe either to stations or to downstream pipes.
- These are activated when flow through the pipe is called for.
- These are deactivated in case the rule does not evaluate ok.
- The system ensures that the flow capacity of a pump or valve is never exceeded.



4.9.3.1.1 Id
A system assigned read-only identifier.

4.9.3.1.2 Active
This toggles the Flow Valve active or passive. In passive state it will be ignored.

4.9.3.1.3 Type
This is either Pump, Normally Open Master Valve, Normally Closed Master Valve or Booster pump. The pump, N/C MV and booster pump are activated when there is a need, whereas the N/O MV is activated in case of an alarm to close the water stream.

A pump or valve can be categorized as one of several types. Choose the one you want from the drop down:

4.9.3.1.4 State (not in edit form)
The state of the Flow Valve. The state can be:

- Open:The Flow Valve is active.
- Closed: The Flow Valve is passive.

4.9.3.1.5 Priority
Defines the priority of the Flow Valve. This is a number from 0 to 255. The higher the number is the higher priority it has. The controller starts Flow Valves from highest to lowest priority until it has achieved the needed capacity. Flow Valves with the same priority will be started cyclic to obtain equal usage.

4.9.3.1.6 IO
A reference to the decoder output controlling the pump or Master Valve.

4.9.3.1.7 Flow sensor
A reference to a sensor decoder input for a flow meter assigned to the Flow Valve. This is optional but reduces the reaction time on no flow.

4.9.3.1.8 Start delay
A delay in start from the first downstream station starts until the pump or MV is activated.

4.9.3.1.9 Stop delay
A delay in stop from the last downstream station stops until the pump or MV is activated.

4.9.3.1.10 Capacity
The flow capacity of the valve or pump. The system will not allow stations to turn on if it cannot open valves or start pumps to supply the expected water flow.

4.9.3.1.11 Error/ Error code

Errors related to the hydraulics system. Possible Error State values:

- None: This is the normal state.
- IO: There is an issue with the IO. See Error code.
- No Flow: There is no flow for the Flow Valve.

Error codes, refer to the general error codes.

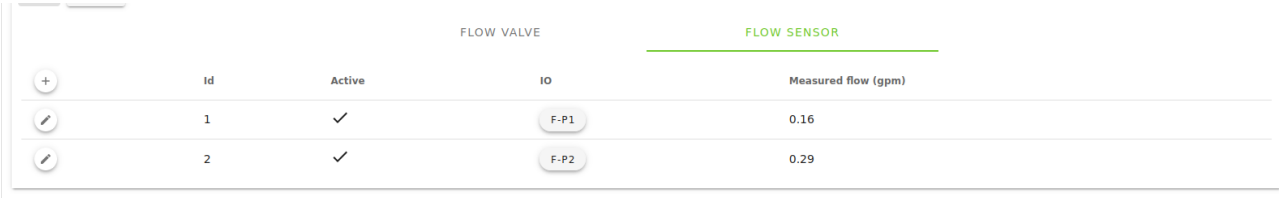
4.9.4 Flow sensor

This sub-panel appears at the bottom of the Rule edit page.

Zero or more flow sensors may be associated with a flow rule. 'Measured flow' of the rule is the sum of 'measured flow' from its active sensors.

- The sensors provide 'measured flow' input to the rule.
- The sensor(s) are assumed to be placed at the beginning of the pipe so that it measures all flow into the pipe, which leaves the pipe either to stations or to downstream pipes.

In the web interface flow sensors are found under the rule to which they refer



4.9.4.1.1 Id

A system assigned read-only identifier.

4.9.4.1.2 Active

Whether this sensor should be ignored or not.

4.9.4.1.3 IO

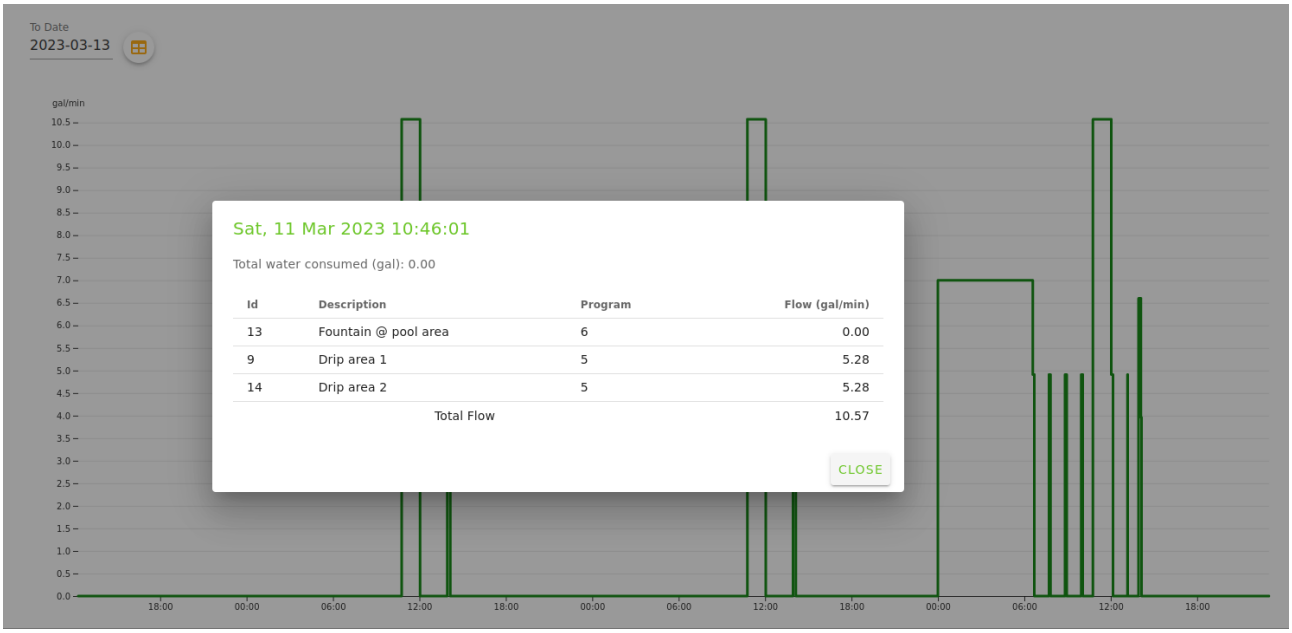
The Two-wire decoder from where input is acquired. Observe that the IO object contains settings for update frequency and conversion of actual sensor input to a volumetric flow.

4.9.4.1.4 Measured flow

The last known measured flow.

4.10 Simulation

Simulation allows you to use current interface settings to give a view of how programs and stations are expected to perform in the future. The outcome is expressed in a simple line chart where you can choose points along the line to see what programs are running and the expected flow at that point in time.



It runs the controller code fast forward showing what will happen months or even years into the future using the current controller settings. To better support it being used for decision making, you can make adjustments to the system while the controller is in simulation mode, then just re-run the simulation.

The Simulation runs a copy of the controller code inside your browser as a WebAssembly executable program to generate the fastest results.

4.10.1 Views

4.10.1.1.1 Simulation Graph

The simulation starts from today. Click on the date field to choose the 'end date' for the simulation, weeks, months, or even years in advance. Once the end date is selected the Simulation will run and display a chart of the expected run of programs and stations.

Hovering over the chart will display a date marker at a point closest to the mouse pointer. Clicking on the chart will switch the date marker to a small table showing you the station running, the program related to it, and the flow measured at that time.

4.10.1.1.2 Simulation Data

Clicking on the calendar icon will switch to table view of the simulated run log file, showing timestamps, the severity of the log entry, what happened (a station started, for example), and the raw data for that log event.

You can search through the log data generated using the search tools in the upper right of the section.

'Severity' filters the data based on the degree of severity of the information recorded.

'Search value' is an open search field. Enter partial or full info to narrow the search results.

4.11 Control

This section describes the general control settings for the irrigation controller.

4.11.1.1 View

The Control section goes straight into a form view containing the following data:

4.11.1.1.1 Mode

The controller can operate in different modes as shown in the dropdown list above. In addition to these it can be in simulation mode which means the controller won't send any 2-wire commands to decoders. This is useful if no decoders are installed yet and the daily operation is under setup and test in real time operation.

The mode Auto is the normal operation where all programs run according to the setup of water days and start times. In that mode programs and stations can be started manually. Likewise, programs started automatically can be stopped manually by the operator.

The mode Manual prevents any automatic start of programs. All programs and stations can be started manually in this mode. When changing mode from Auto to Manual it will stop already started programs running. When changing back to Auto it will NOT start programs which should have started while in Manual.

The mode Paused is used to pause all running programs and stations.

4.11.1.1.2 Test mode

This flag means that it won't turn on decoders, but it runs at normal speed. Useful for testing out Logic Engine programs and Water Engine Schedules.

4.11.1.1.3 Max active stations

The maximum number of stations that can be active at a given time.

4.11.1.1.4 Time Zone Offset (minutes)

Offset, in minutes (positive or negative), offset from UTC. No daylight savings handled, so must be manually updated 2x/yr.

4.11.1.1.5 Retry failed station every x hours

This dropdown determines the behavior of stations (when trying to start?). Accepted values are: No retry, Unmodified, Disable verify and use force, Disable verify, Use force.

4.11.1.1.6 Station retry rule

You can modify the retry function by choosing a modifier in the provided drop-down list.

4.11.1.1.7 Rain IO

This dropdown allows the user to select a Rain sensor to be used with this controller. The Rain sensor can either be a contact closure (constant on for the duration of the rain) or a pulse input type (Rain bucket that gives a pulse for every given amount of rain).

For the contact closure type the sensor decoder must be configured as switch input with send of interrupt on value and clear of attention.

For pulse input type the sensor decoder must be configured as counter input with send of interrupt on value and clear of the value.

4.11.1.1.8 Rain start delay (minutes)

Value, in minutes, that is used to delay start of station(s) after the contact closure type rain alarm goes off or this time has elapsed since last pulse for the pulse type of rain sensor.

4.11.1.1.9 Rain bucket size (mm)

The value of the size of the rain container used with the rain sensor of pulse input type. The value will be applied to the surface accumulator for each station on each pulse. The max surface accumulation for each station is considered for the case of any run-off. Typical value for a rain bucket is 0.01" or 0.25mm.

For the contact closure this value should be zero to avoid rain being added to the surface when the alarm goes on. In this case the ET must include a rain correction.

4.11.1.1.10 Water budget

Percentage of water to be applied by the controller.

4.11.1.2 Editing the Control section

You can directly edit the fields in this form/view.

Click Save to store your changes.

5 Logic Controller

Also known as Logic Engine and Rules Engine. A programmable automation controller capable of reading sensor decoders, doing calculations and carrying out actions, e.g., turning on or off decoders.

5.1 Variable

Variables holds a value for use in block programming. The values may refer to a value, state, or property elsewhere in the system.

Variables are stored as signed 32-bit integers.

5.1.1 View

This is a list of all variables used in the Logic Controller

5.1.1.1.1 Id

A system assigned read-only identifier.

5.1.1.1.2 Description

A short descriptive text. Max 31 characters.

5.1.1.1.3 State

State of the variable.

5.1.1.1.4 Type

The type specifies to what the variable connects to:

- local
- io value
- io attention
- tw (two-wire) state
- we engine state
- we schedule state
- we timeslot state
- we pipe flow
- we station state
- we station available water
- we station group active
- we flow state

5.1.1.1.5 Source Id, Source sub id

For types ‘io value’ and ‘io attention’ specifies the decoder and port from which the value should be obtained.

For types ‘we schedule state’, ‘we timeslot state’, ‘we water resource state’, ‘we water resource flow’, ‘we station state’, ‘we station available water’, ‘we station group active’ specifies the id of the relevant object.

The decoders should be set up to send their data using interrupts, so that the value is updated in the in-memory object.

5.1.1.1.6 Value

This is the initial value of a variable, taken when first set, or whenever the Node is restarted.

Also, this value is returned by the @<id> read

of ‘last read value’ when the value has not yet been read.

5.2 Block

Blocks are instructions carried out by the controller, enabling relatively advanced programming.

When programming you may reference variables [**Error! Reference source not found.**] as:

- $<id> : Read the variable
  - Variables are read, in memory, from the relevant objects.
  - Inputs from sensor decoders must be kept up to date by the sensor decoder sending interrupt messages.
- @<id> : Use the previously read value of the variable.
  - Will be the 'value' field of the variable definition if it has not previously been read.
- $? : The result of the previous evaluation.
  - If there is no pervious evaluation, as e.g., in the first line of an indented block, the returned value will be 0.

(<id> should be replaced with the id of the relevant variable).

Comments may be added to lines when preceded by a '#' (the 'hashtag' symbol). The maximum allowed length of a line is 47 characters. Example: `action: POST /lu/677088648/2/off # shut off valve`

Lines at the root level always start with the type 'if'. The block of lines under this are executed when the 'if' statement evaluates true, whereafter that block cannot be entered again for 2 seconds. 'if' and 'while' statements at lower levels are likewise protected against re-entry for 1 second.

The program must be saved in its entirety to take effect. Upon editing and saving lines, a button to save the program becomes selectable in the upper right-hand corner of the screen.

5.2.1 View

Following are the fields used to edit lines.

5.2.1.1.1 Id

A system assigned read-only identifier.

5.2.1.1.2 State

The state of a line specifies what it is currently doing. State is read-only. Possible values are:

- idle
- process
- pending
- waiting
- parse error
- variable not found
- unrecoverable action error

5.2.1.1.3 Type

This specifies the type of the block, and hence the interpretation of the data. Possible values are:

- Invalid:
  - Informational only. Should not be used.
- if:
  - Data contains a Boolean expression.
  - The block of lines found indented after the 'if' will only be evaluated when the 'if' statement becomes true.

    - ‘if’ statements at the root level, when evaluating ‘true’ and triggering the underlying code, are protected against re-entry for 2 seconds.
    - Other ‘if’ statements, when evaluating ‘true’ and triggering the underlying code, are protected against re-entry for 1 second.
    - Multiple consecutive ‘if’ statements at the same level may reference the same temporary return parameter $?. It is possible to build code executing like the switch or case statement of other programming systems.
- while:
    - Data contains a Boolean expression.
    - The block of lines found indented after the ‘while’ will be evaluated while the statement is true.
    - The block is entered once per second when the ‘while’ statement evaluates true.
- Sleep:
    - Data specifies the number of seconds the logic engine should pause evaluation of this block.
- calc:
    - Does a calculation.
    - The result is available as variable $? in the following line.
    - It is not necessary to set up a variable to hold the (temporary) result.
      example:
        - `calc: 1+2`
        - `action: POST /lu/$?/1/on`
    - Same as ‘set’ except uses the system return variable to return the result.
- set:
    - Sets a variable,
    - i.e., evaluates a formula and inserts the result in a variable.
      example:
        - `set: $2 = 1 + 2 * 2 + $?`
        - `action: POST /lu/$2/1/on`
    - Same as ‘calc’ except it returns the result in a variable.
- action:
    - Data contains an action to carry out,
    - written in the form of a REST statement to the controller.
    - Anything you can carry out through the REST API can be carried out as an action resulting from evaluation of blocks.
    - Actions insert their result code in the temporary variable $?.
    - A return code of 0 marks a successful action.
- log debug, info, warning, error:
    - Data is a text entered into the system log
    - Labelled according to the specified log type.
    - Log texts may include variables, e.g., ‘Variable 4 = $4, 3 = $3’

5.2.1.1.4 Data

Data is the expression or text qualifying the type of the block, e.g.,

- comparison (if/while)
    - 1 is true, 0 is false. Values different from 0 evaluate true. You may insert a variable directly, e.g., $? to check the return code of the previous line.
    - equal: ==
    - not equal: <>
    - greater than: >
    - greater than or equal: >=

    - less than: <
    - less than or equal: >=
    - or: ||
    - and: &&
    - not: !
    - Generously use parenthesis to guide the execution. E.g., '`if ($2==5) && (!($3=$4))`'
- formula (calc)
    - A mathematical expression, including variables, may be entered. Supports logarithms, power etc.
    - Variables used are integers, but the equation may include decimal values and the calculation is done using floating point. The result is converted to a signed 32-bit integer though.
    - The result of the calculation is available as $?.
- variable assignment (set)
    - Works as calc, except that the result is immediately assigned to a variable. As for calc, the result is also available in $?.
- REST statement (action)
    - Actions are written as REST statements to the Node and work the same way. E.g., '`POST /lu/$2/$3/on`' means turn on the port $3 on the decoder with address $2.
- text (log)
    - Enter the text you want to appear in the log. You can use variables.

5.3 Control

This section holds the general control for the Logic Controller.

You can directly edit the fields in this form/view.

Click Save to store your changes.

6 Two wire

Entries under the Two-wire main menu pertain to devices sitting on the Two-wire path, i.e., line units (also referred to as decoders) with their I/O ports and configurations.

6.1 Line Unit

A Line Unit is synonymous to a decoder and is described by address. For multi-station decoders, each output is assigned an address, and each address will populate individually.

6.1.1 View

The list of line units represents individual decoders and their immediate properties. Each will have IO properties according to the decoders type.

	Address	Type	Protocol	Hardware version:	Software version:	Inputs	Outputs	State	Discover state
	671088772	src mk3	mk3	0	6	0	1	Ok	Unknown
	671089576	src mk3	mk3	0	6	0	1	Ok	Unknown
	675089776	src mk3	mk3	0	6	0	4	Ok	Unknown
	676088648	src mk3	mk3	0	6	0	6	Ok	Unknown
	676088688	src mk3	mk3	0	6	0	6	Ok	Unknown

6.1.1.1.1 Address

The decoder 32-bit address. For MK2 and RKLD types it is a 16-bit address.

6.1.1.1.2 Type

The type of line unit at this address.

6.1.1.1.3 Protocol

Shows the protocol used for that decoder.

6.1.1.1.4 Hardware / Software versions

The currently installed versions for each part of the decoder.

6.1.1.1.5 Inputs / Outputs

The number of Inputs and Outputs defined or detected for the decoder.

6.1.1.1.6 State

Current state of the decoder. Can be one of several values: unknown, discovered, failed, ok.

6.1.1.1.7 Discover State

Discover state of the decoder. Can be one of several values: unknown, not seen, seen.

6.1.2 Creating/Editing a Line Unit

Click on the plus icon to create a new Line Unit.

To edit a Line Unit, click the pencil icon next to the entry you wish to edit.

6.2 IO

This section covers working with the IO ports available to the decoders.

6.2.1 View

This view details the Inputs and Outputs of a decoder.

	Description	Address	Index	Type	Configuration	Config state	Attention	Value (expr modified)	Verify sum
	ST1	671088772	1	Output	Autoswitch	Configured	0	0	1068
	ST2	671089576	1	Output	Autoswitch	Configured	0	0	516
	ST3	675089776	1	Output	Autoswitch	Configured	0	0	616
	ST4	675089776	2	Output	Autoswitch	Configured	0	0	1113
	ST5	675089776	3	Output	Autoswitch	Configured	0	0	697

6.2.1.1.1 Description

A description of the actual IO. Used as reference for setup of stations, pumps, flow etc., in the water engine.

6.2.1.1.2 Address, Index

The decoder address and I/O port number.

Check out the Appendix: API Primer on ways to manipulate data.

6.2.1.1.3 Type

Describes the type of decoder, either input or output.

6.2.1.1.4 Configuration

The actual configuration of the decoder. Read-only. Must be set under the configure sub-panel.

6.2.1.1.5 Config state

State of configuration. Must be in state “configured” to be operational.

6.2.1.1.6 Attention

If ‘1’ it indicates the IO has set the attention flag. Normally the API handles REST commands and their responses including feedback from a decoder to which the command was sent. State changes happening in decoders outside of commands have no return path. The state change gives rise to a Two-wire interrupt which is reported in the heartbeat as the attention bit.

An example of an attention is if Two-wire voltage is detected low while in hold state. This can happen any time between turning on and turning off the decoder.

6.2.1.1.7 Value

Actual value of the IO. For output it is 0 for OFF and 1 for ON. For input it is the raw value read, or an expression converted value if specified in the sensor decoder configuration.

6.2.2 Creating/Editing an IO object

Click on the plus icon to create a new IO device.

To edit an IO device, click the pencil icon next to the entry you wish to edit.

6.3 IO configuration

IO configurations are used to setup IO with similar characteristics. The system is delivered with a set of predefined configurations. These cannot be altered, but it is possible to create a copy for any necessary changes.

6.3.1 View

A list of the configurations available for your IO devices

	Id	Protocol	Type	Description
	0	rkd,mk2,mk3	output,input	Unknown
✎	1	mk2	input	Contact input SD, sourcing power
✎	2	mk2	input	Contact input, external sourcing power
✎	3	mk2	input	Pulse input, SD sourcing power, flow rate, up to 200 pulses/sec
✎	4	mk2	input	Pulse input, external sourcing power, flow rate, up to 200 pulses/sec

6.3.1.1.1 Id

A system assigned read-only identifier.

6.3.1.1.2 Protocol

Generation of Two-wire decoder product.

6.3.1.1.3 Type

Input or output

6.3.1.1.4 Description

Short text to describe the configuration. The text is used for dropdowns for assigning a configuration to a decoder.

6.3.2 Creating/Editing a IO configuration

Click on the plus icon to create a new configuration.

To edit a configuration, click the pencil icon next to the entry you wish to edit.

6.4 Control

This section holds general control settings for the Two-wire engine.

6.4.1 View

The Control section goes straight into a form view containing the following data:

6.4.1.1.1 Max Communication Protocol Speed (CPS)

The maximum setting for communications speed along the Two-wire. A value of 0 is the slowest speed and a value of 3 (about 2x as fast as CPS1) is the fastest speed. The value can be set under *System -> Two-wire.*

6.4.1.1.2 State

The state of the Two-wire can be ‘Off’, ‘On’, ‘Short Finding’ or ‘Leak Finding’ mode. The short and leak findings generate, or ‘injects’, a selectable 50- or 60-Hertz signal into the Two-wire to help technicians find various faults in the system.

The short finding toggles the Two-wire in counter phase letting the decoder be alive and draw current such that it can be read with a clamp meter.

The leak finding toggles the Two-wire in phase letting the decoders be shut down such that any leak current can be read with a clamp meter.

! When turning the Two-wire to On it will do a charging of all the decoders on the Two-wire. When it reaches the On state it will issue a broadcast stop all decoders to make sure they are all on a known OFF state.

This shows the actual communication speed. It can never be more than defined above in but might need to be lowered due to capacitive load. The value cannot be set from the GUI, but only via the API.

6.4.1.1.3 Voltage

The voltage is the lowest voltage read on the Two-wire. The voltage shall read in the range of 25V to 42V.

6.4.2 Creating/Editing the Control section

There are no separate ‘add’ or ‘edit’ functions for this section compared to other areas of the web interface. Set the Max Communications Protocol Speed and State directly via their dropdown menus and click ‘save’ when done.

7 System

The System section contains data, settings, and operations related to the controller itself.

7.1 Info

Contains relevant device information such as hardware and software versions, uptime, and ID of the product.

7.2 Hostname

The hostname uniquely identifies the controller. Under the menu *System -> Hostname* you can create or edit this value. Maximum number of characters is 31, and the name is required.

7.3 Ethernet

Here you find all the settings related to your ethernet connection. If the mode is set to ‘dynamic’, IP, netmask, gateway, and DNS server will be provided by your in-house network router (or mobile internet provider?).

If the mode is set to static, you are required to provide that information for the Irrigation Controller to connect to a network. Consult with your network administrator for the correct values.

The NTP server IP address is optional and will auto-sync the interface clock with the chosen NTP server.

7.4 Creating/Editing an Ethernet connection

There are no separate ‘add’ or ‘edit’ functions for this section compared to other areas of the web interface. Set the Mode directly via the dropdown provided and fill out the other fields in this form if necessary. Click ‘save’ when done.

7.5 IP

The IP Address of your Irrigation Controller’s ethernet interface. Either provided automatically by your network, or manually entered.

7.6 Netmask

The netmask is a 32-bit "mask" used to divide an IP address into subnets and specify the network's available hosts.

Netmask defines how "large" a network is or if you're configuring a rule that requires an IP address and a Netmask, the Netmask will signify to what range of the Network the rule will apply to.

7.7 Gateway

A gateway allows data to flow from one discrete network to another. It is defined here as an IP address of the gateway – for example between your company network and the internet. It is defined here as the IP address of the gateway itself.

7.8 DNS Server

DNS servers are responsible for translating domain names to numeric IP addresses, leading them to the correct server on the internet. This is often the job of your network’s router or internet modem and may be the same IP address as your gateway or may be a preferred DNS service out on the internet itself.

7.9 NTP Server

The IP address for this service connects to either an internal or external Network Time Protocol (NTP) Server.

It allows the Irrigation Controller to be synchronized automatically within a few milliseconds of Coordinated Universal Time (UTC). The service runs automatically in the background.

7.10 Serial

This form allows you to define the Serial connection parameters for direct access to the NLP. A standard user should not adjust these settings.

7.11 Baud

The baud rate is the speed at which information is transferred across the serial communications port. It is measured in bits-per-second. The default value for the Irrigation Controller is 115200 bps.

You may need to change this value if the device (i.e., a laptop or dedicated serial device) connecting to the controller requires a different transfer speed to communicate.

Available baud rates are listed in the dropdown provided.

7.12 Flow control

Flow control is used to describe the method in which a serial interface controls the amount of data being transmitted to itself.

Select hardware control, software control, both, or none from the dropdown provided. The default is both.

7.13 Parity

Parity is used to validate the integrity of the data as a simple means of error detection. It can be set in the controller as either ‘even’ or ‘odd’ or ‘none’. ‘None’ is the default.

Set this only if the serial device attached is sending its data with a parity bit set.

7.14 Creating/Editing a Serial connection

There are no separate ‘add’ or ‘edit’ functions for this section compared to other areas of the web interface. Set the information directly via the dropdowns provided. Click ‘save’ when done.

7.15 Log level

This determines the level of detail recorded in the Irrigation Controller’s log system. Choose a level from the dropdown provided.

7.16 Error codes

This is a list of currently generated error codes. You can also find them recorded in the log, or via the drop-down details section in the Station list of the Irrigation Controller.

7.17 Maintenance

This section provides a method of uploading firmware or configuration files, as well as restarting the Irrigation controller or provide a factory reset.

7.18 Restart

Restarts the Irrigation Controller.

7.19 Factory reset

Causes the Irrigation Controller to return to the firmware version and configuration that was set at the factory.

7.20 File

Clicking this field will cause a file-manager window to pop up, allowing you to choose a previously downloaded firmware or configuration file to be uploaded into the Irrigation Controller, over-writing the previous data in place.

Typically, this is used for updating your controller to fix known bugs or issues or provide new features.

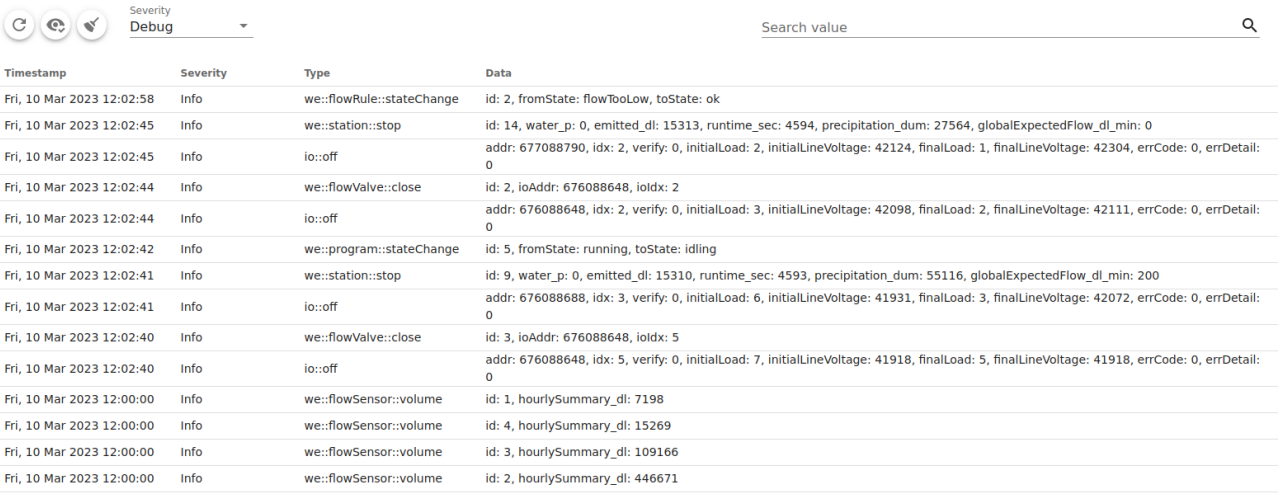
7.21 Upload

Once the file is selected, clicking the Upload button sends the file from your computer to the controller. After that procedure is complete, the controller should be restarted to load the new information.

8 Log

The logging system holds a local 1000-line circular log.

The webpage *may* show more than 1000 lines. This is because when you refresh the log page, new log lines are added to the local data store kept in your browser rather than replacing data already available.



Timestamp	Severity	Type	Data
Fri, 10 Mar 2023 12:02:58	Info	we::flowRule::stateChange	id: 2, fromState: flowTooLow, toState: ok
Fri, 10 Mar 2023 12:02:45	Info	we::station::stop	id: 14, water_p: 0, emitted_dl: 15313, runtime_sec: 4594, precipitation_dum: 27564, globalExpectedFlow_dl_min: 0
Fri, 10 Mar 2023 12:02:45	Info	io::off	addr: 677088790, idx: 2, verify: 0, initialLoad: 2, initialLineVoltage: 42124, finalLoad: 1, finalLineVoltage: 42304, errCode: 0, errDetail: 0
Fri, 10 Mar 2023 12:02:44	Info	we::flowValve::close	id: 2, ioAddr: 676088648, ioIdx: 2
Fri, 10 Mar 2023 12:02:44	Info	io::off	addr: 676088648, idx: 2, verify: 0, initialLoad: 3, initialLineVoltage: 42098, finalLoad: 2, finalLineVoltage: 42111, errCode: 0, errDetail: 0
Fri, 10 Mar 2023 12:02:42	Info	we::program::stateChange	id: 5, fromState: running, toState: idling
Fri, 10 Mar 2023 12:02:41	Info	we::station::stop	id: 9, water_p: 0, emitted_dl: 15310, runtime_sec: 4593, precipitation_dum: 55116, globalExpectedFlow_dl_min: 200
Fri, 10 Mar 2023 12:02:41	Info	io::off	addr: 676088688, idx: 3, verify: 0, initialLoad: 6, initialLineVoltage: 41931, finalLoad: 3, finalLineVoltage: 42072, errCode: 0, errDetail: 0
Fri, 10 Mar 2023 12:02:40	Info	we::flowValve::close	id: 3, ioAddr: 676088648, ioIdx: 5
Fri, 10 Mar 2023 12:02:40	Info	io::off	addr: 676088648, idx: 5, verify: 0, initialLoad: 7, initialLineVoltage: 41918, finalLoad: 5, finalLineVoltage: 41918, errCode: 0, errDetail: 0
Fri, 10 Mar 2023 12:00:00	Info	we::flowSensor::volume	id: 1, hourlySummary_dl: 7198
Fri, 10 Mar 2023 12:00:00	Info	we::flowSensor::volume	id: 4, hourlySummary_dl: 15269
Fri, 10 Mar 2023 12:00:00	Info	we::flowSensor::volume	id: 3, hourlySummary_dl: 109166
Fri, 10 Mar 2023 12:00:00	Info	we::flowSensor::volume	id: 2, hourlySummary_dl: 446671

The log details contain a timestamp, Severity level, Type of log line (info, debug, etc.), and raw data from the system.

There are some controls for the log that are along the top of the page.

8.1 Reset Log Errors

To clear out any errors displayed in the log, click the eye button to clear them.

8.2 Clean log

To clear the log, click on the broom icon.

8.3 Severity Filter

Use this dropdown to filter out what level of information is displayed.

9 Language & Units

The controller webpages support various languages and can display values in different units accordingly.

The translation and conversion are done entirely in the web client and is thus not available through the API.

10 Logout

A logout button is only available if you are accessing the interface through our SSL encrypted internet proxy. For this kind of access, a registered account is required. Logging out returns you to the login page.

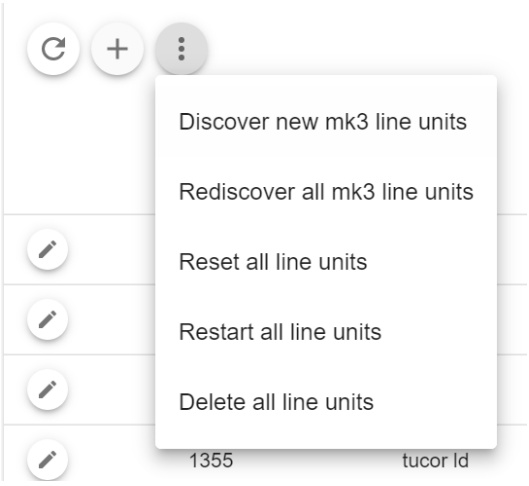
When using the interface through a local connection, such as via a direct IP address connection, there is no login or logout.

11 Appendix:

11.1 Setting up your first irrigation controller

Follow the following process to begin irrigating with your NLP. Any step listed as “Optional” has a default selection that can be modified at a later date.

1) Add your Two-wire decoder(s) under the “Line Units” Menu. This process can be skipped for MK3 decoders by selecting the “Discover new mk3 line units” button. Note: Decoders come with default switch code parameters as set in the “IO configuration” Menu. Tucor does not recommend adjusting the defaults. Adjustment may be needed for SD-110 depending upon sensor type. Please contact Tucor for assistance.
    a. Select Type:
        i. MK3= NG series or SD-110
        ii. Rk= RKLD-050- series decoders (RKD, RKD+ & LTD)
        iii. Ld= LD- series decoders (TWI)
    b. Set the decoder address by either automatic discovery of new “NG” or “SD-110” decoder units or manual addition of historical decoder units:
        i. LD-series: Add the address found on the decoder label.
        ii. RKLD-series: Generate an address for the RKLD-050 by adding “100” before the programmed station number.



    c. Set the number of outputs for a field decoder or inputs for a sensor decoder.
2) Name the decoders in the “IO” menu. Use a reference you will remember, as you’ll be pairing this to a Station later in the process.
3) Define and name a Mainline.
    a. Set its flow capacity. At a minimum, set the expected system capacity for the “Main” pipe.
    b. Optionally add rules.
    c. Optionally add valves and pumps.
    d. Optionally add flow sensors.
4) Optional: Define and name a water reference. A default of 0 ET is set.
    a. Historic ET values, and
    b. Optionally linking it to online ET via Davis WeatherLink IP. If Historic ET values are established, they serve as a back-up reference if online data is not sent.
5) Optional: Define and name additional soil types. Note, default soil types are set & can be modified. To create custom soil types, you must know:
    a. Holding capacity.
    b. Wilting point.
    c. Intake rate.
    d. Maximum surface accumulation.
6) Optional: Define and name a plant. Default plant types are established. To add a new plant type, you must
    a. Set which water reference to follow. Note, the “Default ET reference” is currently set to all plant types.
    b. Set a crop factor 100% to follow the water reference directly.
    c. Set an allowable depletion (% of scale from holding capacity to wilting point (soil properties). We recommend somewhere between 0-100% & a lower value than ‘refill to’ point.

   d. Set ‘refill to’ (% of scale from wilting point and holding capacity (soil properties). We recommend somewhere between 0-100% & a higher value than allowable depletion.
   e. Set a root zone depth.
7) Define and name a station group. At least one station group must be defined, but a station group can contain all stations.
   a. Set which schedule the group should follow.
   b. Set which plant is grown in the group.
   c. Optionally set the group priority for irrigation.
8) Add stations
   a. Match the decoder “IO” to the corresponding station. It’s done by name, so be sure to use names you will remember for IO’s.
   b. Select the type. “Non-irrigating” is the simplest station to set-up & a station can be later modified to reflect more complex types. The following settings appear based on type:
      i. Basic, MAD-type
         1. (Basic, MAD): Set a priority. 0 is the lowest.
         2. (Basic, MAD): Set to which group the station belongs. This implicitly defines a crop and an irrigation schedule.
         3. Set to which pipe section the station is connected.
         4. Set a precipitation rate for the sprinkler. Used to calculate how much water is applied.
         5. Set an expected flow for the station. Used to check water availability through pipes.
      ii. MAD-only
         1. Set a soil. Implicitly defines wilting point, holding capacity, intake rate and allowed surface accumulation at this station.
         2. Optional: Set a landscape factor to correct ET for local conditions. The default is 100%.
9) Define and name a Program.
10) Define and name rules within the Program.
   a. Set dates, weekdays, odd/even when the rule applies,
   b. Set the time interval where irrigation can (or cannot) take place on scheduled days.
11) (MAD-Only) Set an initial soil moisture at each station.
   a. (Faster) Use the ‘set actual soil moisture % to’ with e.g., 50%, to start each station with ‘plant available water’ midway between wilting point and field capacity, or
   b. (More Precise) Either edit each, setting the soil moisture directly.
12) Make sure everything is turned on.
   a. Two-wire state is ‘on’.
   b. ‘Irrigation controller’ is set active.
   c. ‘Simulation’ is off.

Your irrigation system is now live!

11.2 Error codes

This is a list of currently generated error codes viewed in the interface. For help with error codes, contact Tucor.

Error	Description	2-Wire, Controller, or Both	Detail
1001	twowire communication error	2	Communication with a decoder is disturbed. It could be bad connections which create noise.
1002	twowire not operational	2	A command has been sent to a decoder when the 2-wire was not operational. It could have been set off, it could have a short or be too heavily loaded to operate. It could also be due to power on and charging decoders.
1003	twowire load to high	2	Too many active decoders, partly short of the 2-wire, defect decoder.
2000	object not found	B	An object doesn't exist. It could e.g., be a station with a reference to a decoder, which has been deleted.
2001	object exists	B	Trying to create a duplicate.
2003	object storage full	B	Try to create more object than a certain object type accepts.
2004	object incomplete	B	Creating an object with an incomplete JSON format
2005	object wrong type	B	Creating an object with the wrong type. Patching an object with a wrong type.
2006	object in use	B	Deleting an object which is in use, e.g. an ioCfg which is used by a decoder.
2007	object active	B	Deleting an object which in use, e.g. a station which is running.
2050	sub object not found	B	Accessing a sub-object which doesn't exist, e.g. a non-existing output index on a decoder.
2051	sub object wrong type	B	Creating a sub-object with a wrong type. Patching a sub-object with a wrong type.
2100	data parse error	B	The data structure of the JSON object is incorrect. Could be because of FW version incompatibility
2101	data type error	B	Wrong data type is used, e.g. mismatch of strings and numbers.
2102	data constraint violation	B	Data outside range or invalid
2103	data field not found	B	JSON object has wrong data fields.
3000	line unit failure detected	2	The verification of a command indicates an error. The error is followed by a detailed information *)
3001	line unit non acknowledge	2	The command to a line unit is not accepted. E.g. an ON command to an output decoder already in ON.
4000	file deletion failed	B	Deletion of file during FW upgrade
4001	file write error	B	File write error during FW upgrade
5000	io config not found	B	Garbled data

5001	flow capacity too low	C	A part of the hydraulic system has too low capacity compared to the expected flow requested by a station start
6000	value too big	2	Value returned by decoder is above decoder's max for the data type, e.g. resistance too high
6001	value not measured	2	The diagnostic value is not measured in the decoder. Could be due to issues activating a solenoid
7000	flow verify timeout	I	Didn't manage to find a stable flow within the stable count and stable max minutes
7001	flow learn timeout	I	Didn't manage to find a stable flow within the stable count and stable max minutes
7002	flow too low	I	Flow is less than expected minus "Max low deviation (%)" after the start delay and change delay respectively.
7003	flow too high	I	Flow is more than expected plus "Max high deviation (%)" after the start delay and change delay respectively.

Detailed error codes related to error 3000 (2-Wire):

The error code 3000 has a detailed error code which identifies the exact error. On the WEB the error code is translated into text. See section below.

Bit	Description	Reason	Action
0	Active, the output reached an active state despite error detected, output is always turned off after an error is detected	As description	No separate action. Refer to other detail bits. This bit is system internal, is internally handled, and should never be set in API responses.
1	Inrush error, line voltage is too low	The internal decoder voltage dropped below 14V during the inrush attempt. This could be caused by: • A high 2-wire resistance (long wire run and poor splices along the 2-wire) • A low solenoid resistance (damaged solenoid, type with low resistance or more solenoids attached to the output) • A high inrush voltage • A long inrush time	Check the wire resistance. If it exceeds 48 Ohm (equals 3km wire @ 2.5mm2) then check the wire integrity. Check the solenoid resistance. Solenoids are typically in the range of 20-60 Ohm. If it is less than 20 Ohm, then check if the solenoid is damaged and replace it. If it is due to more in parallel, it is suggested to divide them into more decoders. If this is not doable then the drive parameters can be adjusted to try to make it work. By adjusting the drive parameters, it is NOT recommended to increase the holding voltage. This will not solve the problem. It is the inrush which drains the capacitor and that must be kept on a minimum. Recommendation is to reduce the inrush voltage and/or the time. Most solenoids will work with as low as 10V inrush and 30ms.
2	Hold error, line voltage is too low	The internal decoder voltage dropped too low to guarantee solenoid hold. Could be caused by: • Other decoder turned turned on (possibly using force to overrule warnings about too less voltage on the 2-wire) • High line resistance unable to supply decoder, • Too high hold voltage depleting the internal capacitor.	Lower the number of simultaneous active stations.
3	Resistance too low / high	The decoder may measure solenoid DC resistance as part of activation. This bit is set if not within 10-100 ohm, or +/-50% of a resistance determined using autoswitch. Check bits 8+9 to learn if it was too low or high. Typically reported for shorted or open solenoid. See also bit 4 as	Check the solenoid resistance. Solenoids are typically in the range of 20-60 Ohm. If it is outside that range, then check if the solenoid is damaged and replace. Parallel solenoids will lower the resistance.

Bit	Description	Reason	Action
		the same can be reported as high/low inductance.	
4	Inductance too low / high	The decoder may measure solenoid inductance as part of activation. This bit is set if not within 20-400 mH, or +/-50% of an inductance determined using autoswitch.. Check bits 10+11 to learn if it was too low or high. Typically reported for shorted or open solenoid. See also bit 3 as the same can be reported as high/low resistance.	Check the solenoid inductance. Solenoids are typically in the range of 50-200 mH. If it is outside that range, then check if the solenoid is damaged and replace it. Parallel solenoids will lower the inductance.
5	Leak too high	The decoder/solenoid connection has a leak to ground	Check the wire splices and eventually replace.
6	Hold resistance too low / high (only with verify flag)	During hold the solenoid resistance was deemed too low or high.	Check the solenoid resistance. Solenoids are typically in the range of 20-60 Ohm. If it is outside that range, then check if the solenoid is damaged and replace it. Parallel solenoids will lower the resistance.
7	Hold test failed, plunger was in passive state (only with verify flag)	With verify ON the decoder checks the plunger position after turning on, and immediately before turning off. This bit is set if the plunger was found in the OFF state, as we expected it to be ON. Possible causes: • Plunger stuck. It never moved. • Too low inrush voltage. Plunger never seated. • Too short inrush. plunger not seated. • Too high inrush voltage. The plunger bounced. • Bad plunger seating, bad magnetic contact. • Too low holding voltage • (Possibly combined with vibrations)	First, try increasing the holding voltage with about 0.3V. If that doesn't help, then an investigation of the solenoid/sprinkler is needed. Look for dirt or fertilizers and for any mechanical obstacles which prevents movement of the plunger. Note: increasing the holding voltage has a dramatically impact on the performance of the system. The power consumption from the 2-wire equals the holding voltage in the power of 2. Going from e.g. 2.4 to 5.1 holding voltage will increase the power by 4.5 meaning you can have 4.5 times less active decoders.
8	Resistance too low	See bit 3	Check the solenoid resistance. Solenoids are typically in the range of 20-60 Ohm. If it is outside that range, then check if the solenoid is damaged and replace. Parallel solenoids will lower the resistance.
9	Resistance too high	See bit 3	Check the solenoid resistance. Solenoids are typically in the range of 20-60 Ohm. If it

Bit	Description	Reason	Action
			is outside that range, then check if the solenoid is damaged and replace. Parallel solenoids will lower the resistance.
10	Inductance too low (possible reason is a short)	See bit 4	Check the solenoid inductance. Solenoids are typically in the range of 50-200 mH. If it is outside that range, then check if the solenoid is damaged and replace. Parallel solenoids will lower the inductance.
11	Inductance too high (possible reason is not connected)	See bit 4	Check the solenoid inductance. Solenoids are typically in the range of 50-200 mH. If it is outside that range, then check if the solenoid is damaged and replace. Parallel solenoids will lower the inductance.