



A CONVIRON COMPANY

Nutrient Control Programs

Reference Manual

Rev. November 2009



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NUTRIENT CONTROL PROGRAMS

Nutrient Control Programs - Reference Manual

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N U T R I E N T C O N T R O L P R O G R A M S

ABOUT THIS MANUAL

This manual describes the operation of Argus Titan nutrient control programs, specifically:

- **Nutrient Injection program (Beta)**
- **Feed Recipes program (Beta)**

It is intended as a technical reference for program configuration.

These programs are normally used in conjunction with other types of control programs to build complete nutrient control **Applications**. Within an Application, the individual control programs work in an interconnected fashion to accomplish an overall control objective.

The **Factory Screens** depicted in this manual (screens that have white backgrounds by default) are intended for the initial setup and tuning of the control programs by Argus service personnel. Only a few of the readings and settings on the Factory Screens are necessary for daily operation.

These 'operator' parameters are normally brought out to the **Operator Screens** for the application (operator screens have light blue backgrounds by default). They are then presented along with parameters from other control programs in the context of the overall control or monitoring objectives of the application.

Individual applications may also contain their own help documentation embedded in the operator screens. Operator help is specifically intended to assist system operators in the daily operation of their control systems. We recommend you start with any available operator help before consulting these control program reference manuals.



Warning: As of this publication date, both the Nutrient Injection and Feed Recipes programs are still in the BETA stage of development. By convention, Argus designates new control programs as 'BETA'. This designation remains until they have been in general use for long enough to fully prove their reliability and stability. Although we have carefully evaluated the performance of this software during development and testing, it is impossible to test for all possible failure modes. Even with mature software, it is not unusual to find the odd obscure 'bug'. As such, BETA programs should be monitored carefully with sufficient alarms and data recording to ensure they are operating as intended. Please report any anomalies to Argus so that we can quickly identify and correct any possible problems. This level of monitoring is consistent with the general level of monitoring required for nutrient control since there are many other failure modes that are not software related yet still cause the same errors.



Warning: Although you can access Factory Screens, we strongly recommend you consult Argus before making any changes. Never make any changes to program settings unless you understand the consequences. Contact Argus if you are unsure how to proceed.



Note: For nutrient dosing applications, Argus highly recommends off-line analysis of the resulting dilute fertilizer solutions during setup and commissioning and at regular intervals during normal operation to safeguard against mixing and measuring errors, incorrect control settings, and equipment malfunctions.

Alternatives

A variety of nutrient delivery control strategies can be configured on the Argus Titan system. Nutrient Injection and Feed Recipes programs are used for mixing and delivering nutrients from stock concentrates. In other situations, where pre-mixed or pre-diluted feeds are available, other control programs can be used for nutrient delivery and control.

These include injection feed programs and capabilities such as selector valve control built in to Irrigation Zones programs. In other situations, Sequencer and Equations programs can be used for custom applications. An Argus service representative can help you determine which control configuration best suits your needs.

SAFETY FIRST!

This program is intended for users who are familiar with the general principles of fertilizer chemistry and the risks and benefits that liquid feed programs have on crop production.

Mixing your own nutrients always requires care and diligence. Keep in mind that with nutrient control it is **never possible to automatically detect all conditions that could cause crop damage.**

The **Nutrient Injection** and **Feed Recipes** programs contain several management alarms for monitoring the operational status of the programs. They also contain threshold settings for EC, pH, and solution temperatures intended to halt dosing and produce alarms should any of these measurements go 'out of bounds'.

However, they cannot detect or prevent all dosing failures that might arise from broken equipment, improper settings, accidental or intentional misuse, mixing mistakes, or a variety of other malfunctions. This is because many of these failure scenarios are site-specific in nature and they must be configured individually to suit your circumstances.

To accomplish this, there is a single pointer assignment in the Nutrient Injection program can be used to halt all injection when it is triggered. This enables the logic for shutting down the nutrient injection system to be developed in other control programs. By dealing with critical conditions in this manner, it is possible to cover the widest range of possibilities and to take the appropriate actions.

Argus recommends using feedback sensors and guard sensors for monitoring critical out-of-bounds conditions. This should include monitoring:

- Flow and pressure in the both the irrigation system and nutrient injection equipment,
- EC and pH levels downstream from the Injection equipment.

Using an appropriate array of monitoring sensors for your application you can configure conditions that immediately halt injection using the **Injection Stop Input** in the Nutrient Injection program (see page 44).

Be particularly careful with trace elements. Most of the major elements have a measurable effect on EC making it relatively easy to detect a mixing mistake before any acute crop damage can occur. For example, if you accidentally mix 10 times too much potassium nitrate into a stock tank (assuming it would even dissolve) the problem is evident immediately since the resulting EC is too high in the dilute solution, triggering a dosing shutdown and alarm.

This is not the case with trace elements. At ten or even a hundred times too much boron, the effect on EC is negligible, but severe crop damage is likely. The only way to avoid this is through careful measuring and mixing practices or by using fertilizer concentrate sources with pre-blended major and minor elements (in which case you are relying on the manufacturer's quality control practices).

Be particularly careful when first configuring the Stock Tanks and Recipes. Make sure that the setting values are accurate. Before placing the system into automatic control, you should always use off-line lab analysis to confirm injection accuracy, particularly when you are mixing your own trace elements and when using recipes that blend concentrates from several stock tanks.

INTRODUCTION

Two types control programs are typically used to accomplish automatic nutrient delivery with the Argus Titan system:

- **Nutrient Injection program**

One of these programs is required to manage the injection equipment.

Main Features include:

- Up to 14 managed stock tanks plus 1 Acid/Base tank
- Full fertilizer analysis entry for each stock tank
- Concentration factor settings
- Allowances for preexisting fertilizer elements in the water supply
- Several output styles to accommodate a variety of injector types
- Complete integration with **Titan Irrigation** programs
- This program can be used with **Argus Multi-Feed** injector systems or other injection equipment
- Full support for single-tank, A/B. and single element dosing systems
- Can be used for in-line injection or dilute stock tank management
- Can produce up to 64 distinct feed recipes, each recipe defined by the user

- **Feed Recipes program**

Depending on the number of distinct feed recipes required, from one to eight of these programs can be used with each Nutrient Injection program.

Main Features include:

- Up to 8 distinct feed recipes per program
- Automatic, semi-automatic, or manual feed recipe creation
- Rules-based feed recipe creation
- Automatic parts per million tabulation for each element
- Full integration with the **Nutrient Injection** program and **Irrigation** programs

Together, these programs can mix and deliver many different feed formulations and feed concentrations to an irrigation system from a suitably equipped injector. Before use, they must be carefully configured to match the physical nutrient injection equipment in both system design and capacity.

Control Objectives

Before we discuss **how** the nutrient injection programs work, let's talk about **what** they can do. Their purpose is to prepare and deliver fertilizer recipes from liquid stock concentrates. A fertilizer recipe is like a baking recipe and the liquid concentrates are its raw ingredients.

Just as we can make many types of cakes and cookies by varying the raw ingredients and their relative proportions, we can also make many types of fertilizer recipes from relatively few ingredients.

With the large selection of fertilizer ingredients that are commercially available, you have many choices when it comes to preparing nutrient recipes:

- You can use **premixed fertilizers** where all or most of the necessary fertilizer elements have been included in a single dry concentrate mix.

With these products **you can vary the overall concentration** of the fertilizer elements in the irrigation water, **but not the relative concentration** of the individual elements.

- You can prepare **two-part or 'A/B' recipes** where the fertilizer constituents are divided between two concentrate tanks to prevent undesirable chemical reactions while in concentrate form.

With this type of strategy, **you can adjust the relative concentration of the individual elements while you are preparing the concentrates** and you **can vary the overall concentration** when the concentrates are injected for fertilizer delivery.

- You can prepare your own custom recipes using several concentrate tanks where each tank contains only one type of fertilizer material. This is sometimes called **single element dosing**.

With this type of strategy and suitable control software and hardware, **you can vary both the individual element ratios and the overall dilute solution concentration during the injection process**.

Injection flexibility increases as you move down this list, while costs increase as you add the extra injection equipment to handle the increasing number of stock solutions.

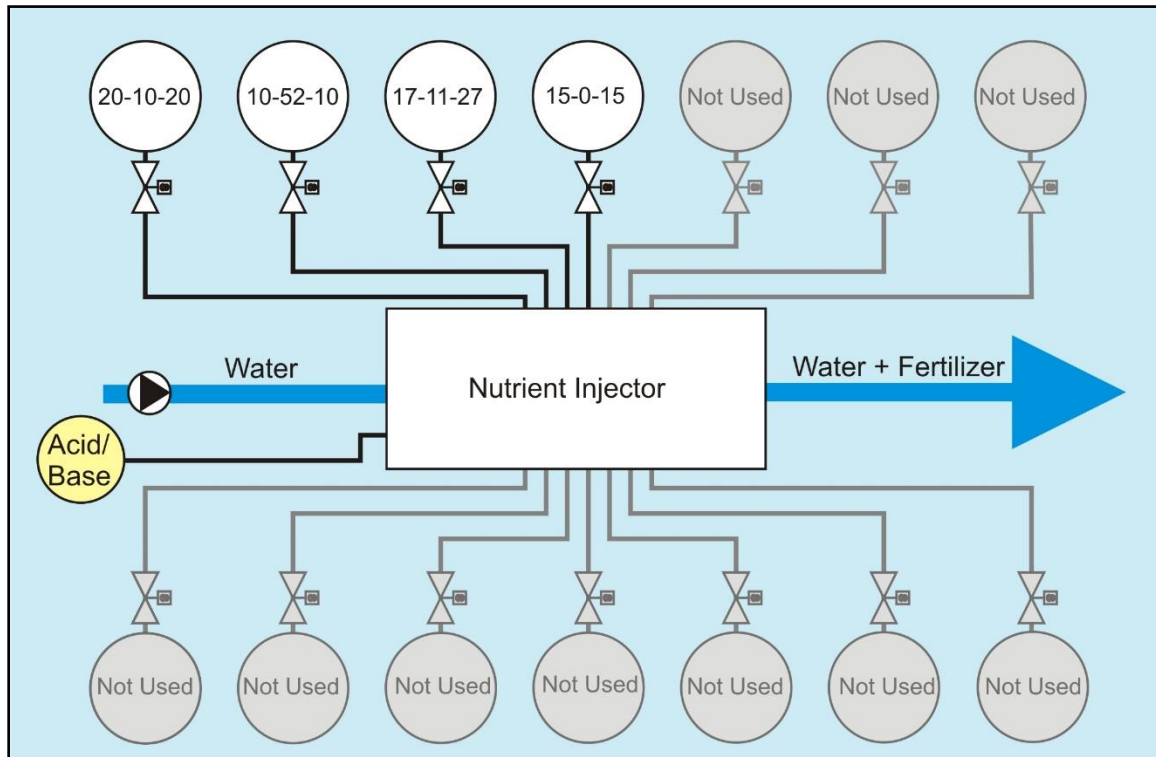
With the Titan system and the appropriate delivery equipment such as an **Argus Multi-Feed** system, you can provide all the above options.

You can even use a combination of strategies with the same injection system. The following pages illustrate examples of each type of strategy.

Pre-Mixed Fertilizers

With pre-mixed fertilizers, only one concentrate is delivered at a time since most or all of the desired nutrients have been pre-blended into a single bag. Separate pH adjustment may still be required.

The following diagram illustrates how you might use the **Nutrient Control** and **Feed Recipe** programs to deliver a variety of pre-blended or 'complete' feeds with a multi-head injector system. Note that in the illustration only 4 of the possible 14 stock tanks are being used. Your application might require more or fewer tanks.



With the above configuration, each concentrate tank contains a specific fertilizer blend. Since the nutrient control program supports up to fourteen separate concentrate tanks plus an acid/base adjusting tank, you can inject up to fourteen different feed formulations - many more than you likely ever need.

You can also vary the overall **concentration** of each formulation to suit your needs. For example, you could designate one **Fertilizer Recipe** to deliver 20-10-20 at 100 ppm nitrogen for use on young seedlings, and another recipe to deliver the same material at 200 ppm nitrogen for use on more mature plants.

With a capacity for up to 14 separate complete fertilizer concentrates and up to 64 separate recipes to adjust for concentration levels you have plenty of flexibility for using a variety of 'one-tank' fertilizer mixes on the same irrigation system.

The **Feed Recipes** program includes other features that permit you to either override or scale the fertilizer concentration based on an external control variable such as light levels. When combined with the features of the **Irrigation Schedule** programs, you can even designate more than one recipe to be applied to the same target crop.

NUTRIENT CONTROL PROGRAMS

For example, on a poinsettia crop, you could set up a rotating schedule where 20-10-20 is used for four consecutive waterings, with every fifth feeding using a high calcium source such as calcium nitrate (15-0-0-19 Ca). The Irrigation Schedules specify the feeds to be delivered, and the Nutrient Injection program prepares them on-the-fly from its stock concentrates.

To use dry fertilizer pre-mixes on your system all you need to do is dissolve the fertilizer concentrates to a designated concentration and enter this information in the **Nutrient Injection** program. **It is not necessary to enter the full elemental analysis of each tank.** You can then configure recipes that call for the specific stock tank and a specified dilution ratio to achieve the desired concentration in the dilute feed.

Notes: If you use several pre-mixed fertilizers, as in the above example, and you take the time to enter their complete analyses in the **Nutrient Control** program, it is possible to use the **Feed Recipe** program to create unique recipes by blending varying amounts from different tanks. However, in practice, if you need to create specific feed recipes on a routine basis, it is usually easier (and less expensive) to use single salt concentrates in each stock tank as described on page 12 .

A fertilizer injection system set up for pre-mix fertilizers may cost far less than one set up for single element dosing. On the other hand, the premix fertilizer material is usually more expensive. Growers with high fertilizer consumption may wish to consider A/B or single element dosing systems or to reduce the cost of fertilizer even if control flexibility is not required.

Advantages of using pre-mixed fertilizers:

- Convenience
- Requires the least complicated and least expensive injection equipment.
- Quality and chemical analysis is assured by the fertilizer manufacturer (you can't make a mistake blending the fertilizer).
- Since the chemistry is known and fixed, electrical conductivity (EC) measurements can be used to reliably predict the elemental concentrations in the dilute feeding solutions.

Disadvantages of using pre-mixed fertilizers:

- Material cost is generally higher than the basic fertilizer constituents.
- The relative ratio of the fertilizer elements is fixed.
- Some fertilizer formulations are simply not possible due to incompatible chemistry.
- Only a limited number of formulations are commercially available.

NUTRIENT CONTROL PROGRAMS

A/B Mixes

With this type of feeding strategy, two concentrated stock solutions, separated to avoid chemical precipitation at high concentrations, are used to produce a complete dilute feed solution. One tank, usually called the 'A' tank contains calcium nitrate, and sometimes other compatible materials such as half the total potassium nitrate requirement (this practice helps overcome the low solubility of potassium nitrate by 'sharing' the solubility load between both stock tanks). The 'B' tank generally contains the rest of the concentrates including phosphate and sulfate materials required to make up the complete dilute fertilizer formula (a third 'C' tank is sometimes used to boost one or more of the fertilizer constituents under certain conditions).

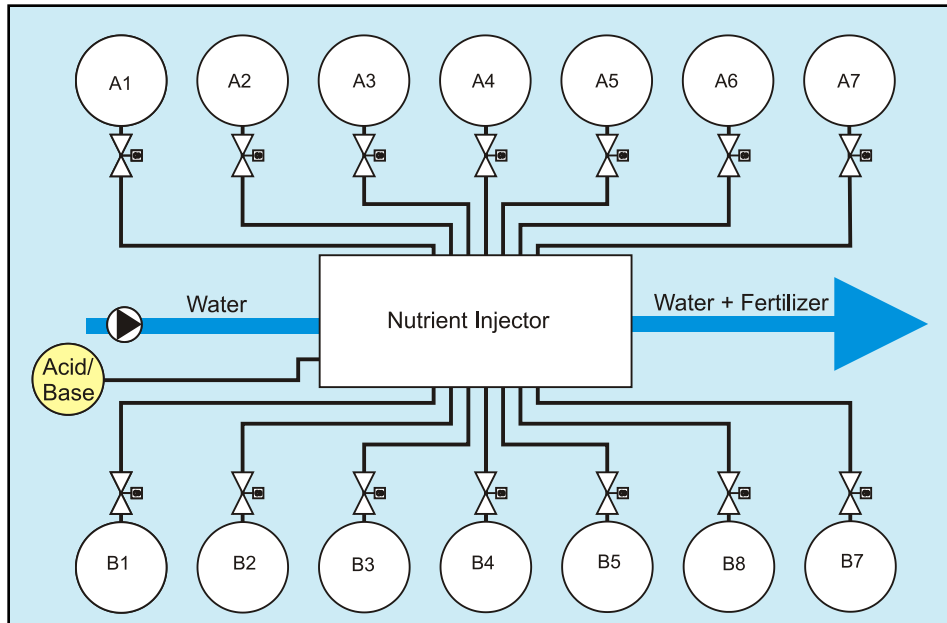
The table below illustrates typical fertilizer constituents for A and B tanks.

Tank A		Tank B	
Fertilizer	g/100 liters @200:1 concentration	Fertilizer	g/100 liters @200:1 concentration
Calcium Nitrate	14737	Potassium Nitrate (1/2 of total)	3940
Potassium Nitrate (1/2 of total)	3940	Magnesium Sulfate	7000
Iron Chelate 13%	301	Monopotassium Phosphate	3472
		Ammonium Nitrate	2059
		Manganese Sulfate	71
		Solubor	49
		Zinc Chelate	14
		Copper Sulfate	39
		Ammonium Molybdate	.36

When equal amounts from the above tanks are diluted (each at 200 times) to the final feed strength, the resulting solution has the following elemental concentrations:

Element	ppm
Nitrogen	200
Phosphorus	40
Potassium	200
Calcium	140
Magnesium	35
Sulfur	45
Iron	2.0
Manganese	1.0
Boron	.5
Copper	.5
Zinc	.1
Molybdenum	.01

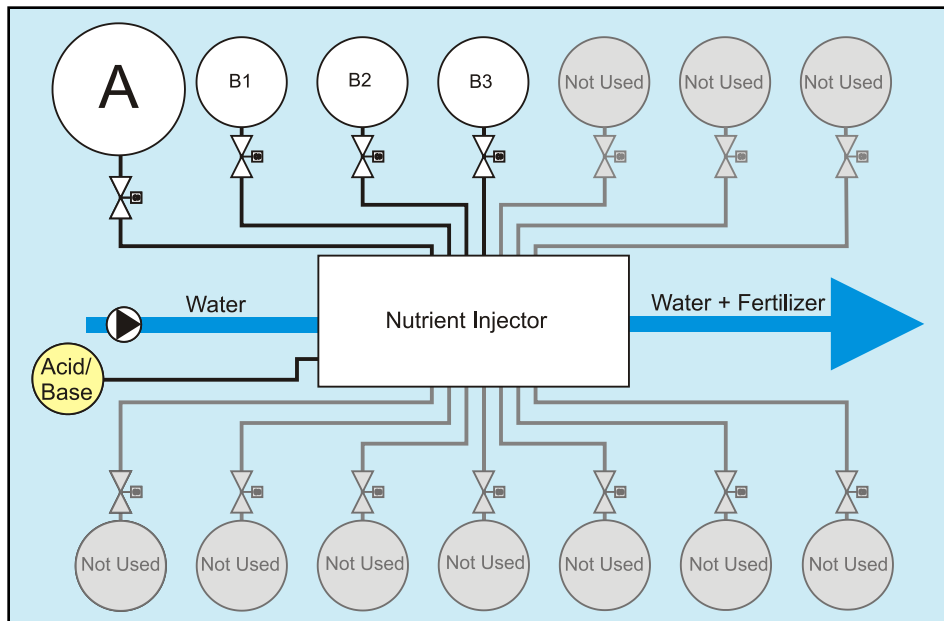
With Titan nutrient control programs you can use up to 7 pairs of A/B concentrate tanks on the same system, each with a different elemental chemistry:



'A/B' Dosing Control – Paired Tanks

The above example shows a maximum of 7 pairs of A/B tanks operated from the **Nutrient Control** program (although this is more than you ever likely need). For example, whenever a **Feed Recipe** calls for the A1/B1 pair, both are usually injected at equal rates. Using this sort of mixing strategy, A1/B1 could be a complete tomato feed, A2/B2 could be a cucumber feed, and so on.

There are many other configuration options. For example, you could use a common 'A' tank, with as many 'B' tank formulations as you require (to a maximum of 13):



'A/B' Dosing Control – Common 'A' Tank

To use these A/B concentrates on your system you need to dissolve the individual fertilizer constituents in sufficient water to produce the correct final stock solution volume for each stock tank and enter this information in the nutrient control program.

You then configure recipes that call for each tank pair, excluding all the other stock tanks. **It is not necessary to enter the elemental analysis of each tank.**

Advantages of using A/B fertilizers:

- Cost. Basic fertilizer constituents are usually less expensive than blended materials.
- Flexibility. When dissolving the materials for each stock tank refill, it is possible to alter the chemistry within each tank to suit the current conditions. You are not limited to the pre-mix formulas supplied by the fertilizer companies.
- You can vary the injection ratios between the A and B tanks at any time.

Disadvantages of A/B fertilizers:

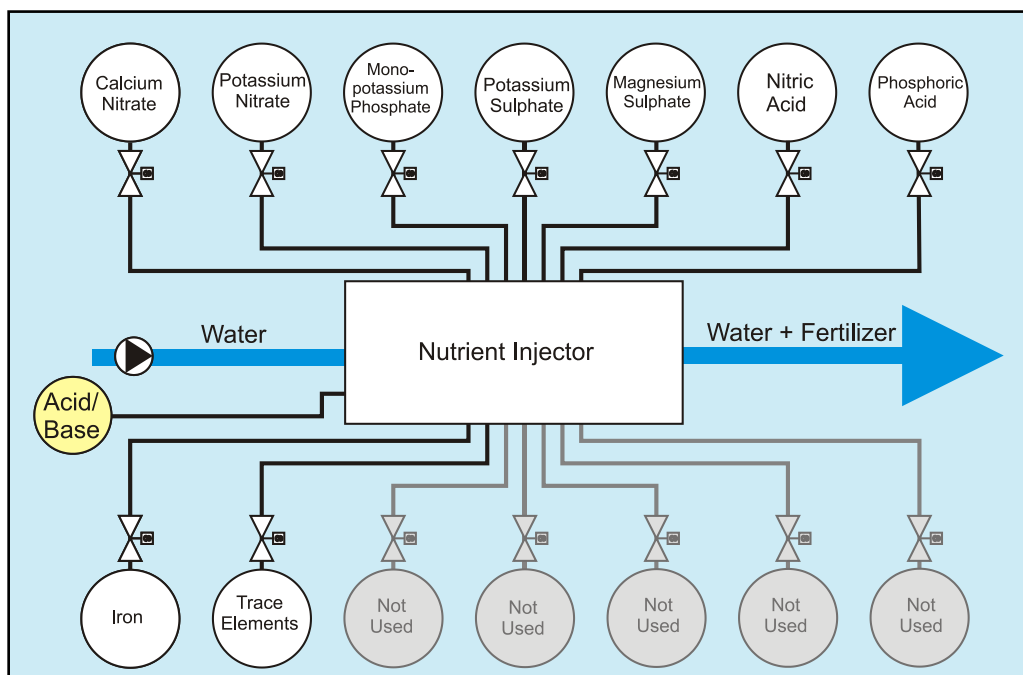
- Additional management responsibility to develop the concentrate formula.
- Human error when weighing and dissolving the fertilizer concentrates.
- The relative ratio of delivered elements is fixed from batch to batch.
- At least two output-matched fertilizer injection heads are required.
- The accuracy of electrical conductivity (EC) measurements as a means of reliably predicting the elemental concentrations in the dilute feeding solutions depends upon the accuracy of weighing and dissolving the concentrates, and the relative injection accuracy between the A and B fertilizer injection heads.

'Single Element' Dosing

Individual element control opens up the possibility for an injection system to produce almost any feed composition or concentration, **without any changes to the stock solutions**. A single system supplied with the appropriate fertilizer concentrates can produce almost any feed formulation 'on-the-fly'. The **Nutrient Injection** and **Feed Recipes** programs on the Titan system have been specifically designed to accomplish this.

Single element dosing is more appropriately called 'single salt' dosing, since many fertilizer salts contain more than one nutritional element making it impossible to deliver just one element at a time from a single source ingredient.

However, by injecting a combination of different fertilizer salts, each in its own concentrate tank, it is possible to control the relative concentrations of each element within a wide range of values.



'Single Element' Dosing Control

In the above illustration, each tank contains a fertilizer compound. Some of these compounds supply only one nutritional element, while others may supply two or more. For convenience, the trace elements are provided from a pre-blended source, and an additional iron tank has been included to boost the iron levels for certain crops.

By varying the proportions from each tank, it is possible to create a wide range of fertilizer recipes from the same stock concentrates. With up to 14 stock tanks, it is also possible to administer the trace elements separately if needed (see the note on trace elements on the following page).

Since many fertilizer salts contain two essential elements, the permutations and combinations of stock solutions that are required to achieve a given recipe can become quite complex.

The **Feed Recipes** programs contain special automatic calculation functions designed to assist you with creating recipes from the stock fertilizer concentrates on hand. As you develop each recipe, the system scans the available stock concentrate materials according to your rules to make sure a workable injection combination exists.

To achieve the desired recipes, single-element dosing control requires a larger number of stock tanks with an individual proportioning control injector for each stock solution. The Titan nutrient control program supports a maximum of 14 individually controlled injectors plus an acid/base injector for pH control. To reduce system complexity and cost, trace elements and occasionally some of the less important macro-elements can be combined into one or two tanks if individual control of these materials is not required.

Advantages of using Single-element dosing:

- Fertilizer cost: basic fertilizer constituents are less expensive than blended materials.
- Maximum flexibility: the relative ratios of the fertilizer elements can be adjusted at any time.
- Stock solution preparation is less complex as only one fertilizer source is prepared in each stock solution

Disadvantages of Single-element dosing:

- Human error when weighing and dissolving the fertilizer concentrates.
- Mechanical complexity: this is the most complex type of fertilizer dosing to manage and control. There are more opportunities for mistakes and failures.
- Uneven draw-down of the individual stock tanks can make it difficult to confirm that each fertilizer salt is being dosed in the correct proportions. This means that clogged suction lines, filters, or other operating problems are more difficult to spot and correct.
- EC measurements of the resulting dilute fertilizer solution are only useful as a gross indication of salt strength. They cannot be used to confirm that the relative chemistry is correct. **Off-line lab analysis must be used for this.**
- More expensive than A/B injection systems. Several independently controlled fertilizer injection heads are required.

Note: Trace elements are delivered in very small quantities compared to the major elements. Assuming that the injector system has been engineered with uniform injection heads, **trace elements must always be diluted in sufficient quantities of water in the stock tanks to roughly match the relative volumes that are being administered from the other tanks.** This not only increases injection accuracy but also aids in mixing safety should there be a problem with a stuck injector etc.

CONTROL OVERVIEW

Now that we know what the nutrient control programs are capable of, let's look at how they do it. This section provides an overview of the key program linkages and functions.

The diagram on the following page illustrates how the **Nutrient Control** programs (in the yellow boxes) and the **Irrigation programs** (green boxes) work together to accomplish automatic watering and nutrient injection.

The red lines indicate program linkages to and from the nutrient programs and the green lines indicate the other irrigation linkages. Linkage lines entering on the left are inputs to the programs and lines exiting on the right are outputs.

Some of these linkages are assigned individually during program setup and configuration, and others happen automatically, once the programs are assigned to an Irrigation System. All physical inputs and outputs are managed through **I/O Module** programs.

Note: These program linkages are created during system configuration and you should never need to alter them after that. The illustration is just to show how nutrient control is fully integrated with irrigation control.

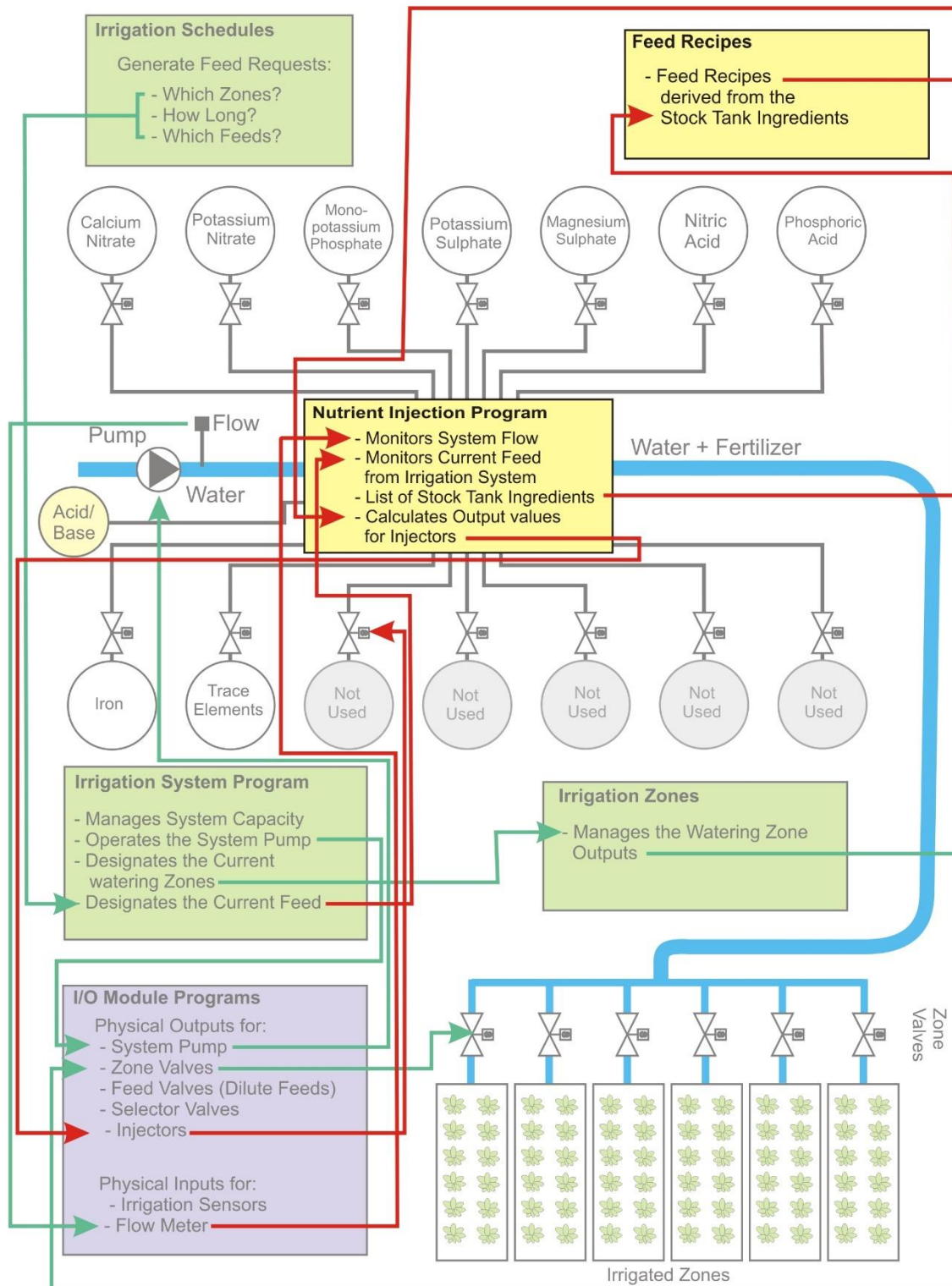
Here is a simplified sequence of the major events that occur during an irrigation watering:

1. An **Irrigation Schedule** decides it is time to water. It creates a watering request that includes the **Zones to Water**, the **Watering Duration**, and the **Feed** to be used. This request is passed on to the Irrigation system manager.
2. The **Irrigation System** program operates the system pump and processes watering requests in the order that they occur within the capacity of the system. It also separates watering requests by **Feed Type**, since only one feed can be delivered at a time. To do this it declares what the **Current Feed** is.
3. The **Nutrient Injection** program obtains the **Current Feed** information from the **Irrigation System**. It finds the recipe for this feed in the linked **Feed Recipes** program(s). This recipe contains the concentrate injection instructions to produce the correct dilute feed.
4. The **Irrigation System** turns on the irrigation pump (if it is not already on) and starts gives the signal to begin watering the designated zones.
5. An **Irrigation Zones** program then provides the signals to operate each of the requested zone valves so that water can begin flowing into the zones.
6. The **Nutrient Injection** program uses information from its **Flow Meter** to automatically adjust the nutrient injection rates to match the irrigation water flow rate.

Once configured, this entire process is automatic.

NUTRIENT CONTROL PROGRAMS

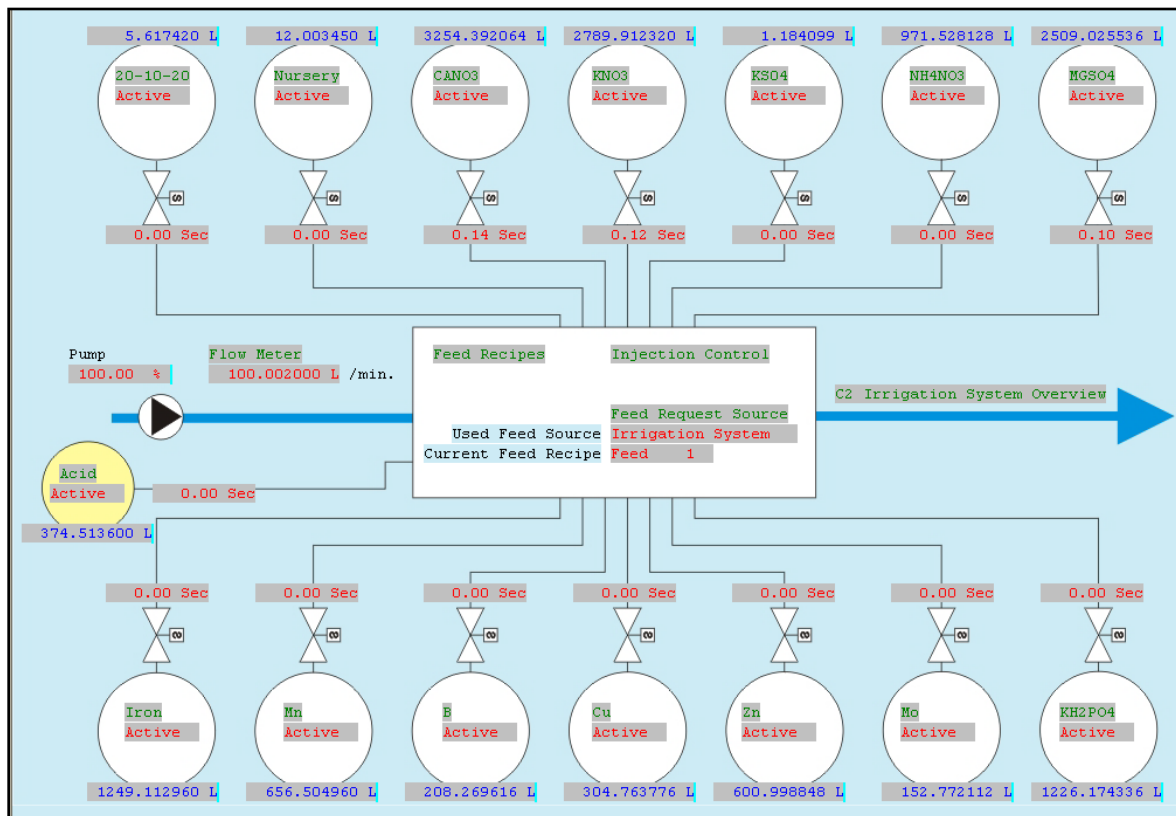
Integrated Linkages between Nutrient Control and Irrigation Programs



OPERATOR SCREENS

The **Nutrient Injection** and **Feed Recipes** programs are highly integrated, but separate programs with separate screens.

An **Operator Screen** like the one below is usually created to help display the unified elements of these separate programs. This makes operating the nutrient system easier and more understandable.



The above operator screen was created with a drawing program and imported into the Argus program as a background bitmap. Key readings and parameters from the **Feed Recipes** and **Nutrient Injection** programs were then applied as shortcuts. This screen now functions as the 'Home Screen' for the nutrient system. With a screen similar to this, you can monitor system activity and navigate to any of the underlying program screens with ease.

Note: Keep in mind that in order to demonstrate the extent of the nutrient control capabilities for this system, the above screen depicts a single-element dosing setup that uses the maximum number of stock tanks. Your system (and operator screens) may be much simpler).

NUTRIENT INJECTION PROGRAM

Nutrient Injection Overview

The Nutrient Injection program is used to manage the injection equipment. It also defines the contents of up to 14 possible stock tanks plus one acid/base tank. During operation it continuously calculates output values for each enabled injector, as well as managing injector purging, feed source selection, and flow metering.

To accomplish this, it must inject the correct proportions of fertilizer concentrates from each enabled stock tank into the irrigation stream so that the resulting dilute feed matches the current **Feed Recipe**. It must also match the overall rate of injection to the current flow rate of the system to produce the correct concentration.

The actual physical outputs (connected to the injection equipment) and inputs (sensors) are managed by **I/O Module** programs. Injector outputs can be operated as either proportional (0 to 100.00%) or as pulsed (On/Off) to properly match the control capabilities of the injectors.

Installing a Nutrient Injection Program

This program is normally installed by Argus system engineers as part of the system configuration. It is installed as a part of a preconfigured **Group** of control programs and operator screens that are custom engineered as a complete nutrient control and monitoring application.

Notes: The **Nutrient Injection** program must be installed on the same controller as the **Feed Recipes** and **Irrigation System** programs.

Nutrient Injection Main Screen

The main screen of the nutrient injection program provides an overview of the injector program and menu entries for navigating to underlying screens:

Program Type: Nutrient Injection (Beta)
Program Name **P65 Nutrient Injection (BETA)**

Alarms Current Alarm Status **Silent** Clear Latched Alarms
Injection Outputs Active

Stock Tanks <-- make a Shortcut to this from Recipe Screens

Stock Tank	Concentrate	Status
Stock Tank 1	20-10-20	Enabled
Stock Tank 2	Nurserey	Enabled
Stock Tank 3	Calcium Nitrate	Enabled
Stock Tank 4	Potassium Nitrate	Enabled
Stock Tank 5	Potassium Sulphate	Enabled
Stock Tank 6	Ammonium Nitrate	Enabled
Stock Tank 7	Magnesium Sulphate	Enabled
Stock Tank 8	Iron	Enabled
Stock Tank 9	Manganese Chelate	Enabled
Stock Tank 10	Solubor	Enabled
Stock Tank 11	Copper Chelate	Enabled
Stock Tank 12	Zinc Chelate	Enabled
Stock Tank 13	Ammonium Molybdate	Enabled
Stock Tank 14	Monopotassium Phosphate	Enabled

Acid Tank **Sulfuric Acid** Enabled

Base Tank **Calcium Hydroxide** Enabled

Acid Injection Ratio **2500 :1** **pH Modifier** Not Used

0.000400 L /L Before Feedback Correction

0.000400 L /L After Feedback Correction

Injected Amounts

Totals	This Second
0.000000 L	0.000000 L
0.000000 L	0.000000 L
2.566520 L	0.000000 L
2.070715 L	0.000000 L
0.000000 L	0.000000 L
1.102437 L	0.000000 L
1.843228 L	0.000000 L
0.752457 L	0.000000 L
0.402477 L	0.000000 L
0.128326 L	0.000000 L
0.186656 L	0.000000 L
0.367479 L	0.000000 L
0.093328 L	0.000000 L
0.915781 L	0.005833 L
0.209988 L	0.000000 L
0.000000 L	0.000000 L

Clear Injected Amounts

Water Composition Analysis

Flow Meter Flow Detected **Flow Rate** **0.083335 L / second** **5.000100 L /min**

Feed Request Source Manual Override **009 Tomatoes** **Target EC** **1.80 mS** **Target pH** **6.50 pH**

Purge Control Normal Feed Injection **Purge Valve State** **0.00 %** **Charge Valve State** **0.00 %**

Recipe Program Assignment

Synchronized Output Groups

Stabilization Delay

pH & Temperature Shutdowns

External Stop No Injection Stop Pointer

Recipe Calculation Rules

Emergency Shutdown and Restart

Program Inputs

Installation and Service

Injected Amounts – this table displays the total cumulative and instantaneous amounts being injected from each concentrate tank.

The “This Second” column displays the instantaneous volumes. These values can be used directly for data recording or in the **Equations Program Equation Counters** (accumulator mode) or the new accumulation filter (Filters Program) as the **Add** value.

The Equation Counters can then have a divisor (up to 10,000) to provide 0.01 L resolution with values up to 42,949,672.95 L.

The counters can be cleared on any basis controlled by an Equation. Accumulation rates can also be used for overdose alarm warning purposes.

The Menu Entries display screens for configuring the following settings:

Alarms - This section is used to configure management alarms. These settings are described on page 46.

Stock Tanks – there is a screen for each Stock Tank where the details of its chemical composition and overall concentrate strength are entered. These settings are described starting on page 20. The **Stock Tanks** menu entry opens a screen with a list of menu entries each Stock Tank Screen. You can place a User Shortcut to this screen in your Feed Recipes programs for quick access to the Stock tank settings.

Water Composition Analysis – This optional section is used to enter details on the chemical composition of the source water. The nutrient injection program automatically compensates for any plant nutrients already present in the source water. These settings are described on page 28.

NUTRIENT CONTROL PROGRAMS

Flow Meter – This section configures the flow meter. The nutrient injector program automatically proportions nutrient injection in proportion to the current flow rate. These settings are described on page 29.

Feed Request Source – This section links the nutrient Injection program to an irrigation system. These settings are described on page 30.

Purge Control - This section controls optional injector purging features. These settings are described on page 37.

Recipe Program Assignment - This section links **Feed Recipe** programs to this Nutrient Injection program. These settings are described on page 40.

Synchronized Output Groups - This section configures synchronized injector outputs. These settings are described on page 41.

Stabilization Delay – this section is used to define a delay time after injection first starts for the outlet EC and pH readings to stabilize.

pH & Temperature Shutdown - this section is used to define safety limits for pH and temperature deviation, beyond which, the program halts injection. These settings are described on page 41.

External Stop - This section configures an optional external stop input signal. These settings are described on page 44.

Recipe Calculation Rules - This section assists automatic recipe calculation in the Feed Recipes programs. These settings are described on page 45.

Emergency Shutdown and Restart - This section configures optional emergency shutdown and restart settings. These settings are described on page 47.

Program Inputs – This is an overview of all the external inputs that are used to set up the program. This screen is not required for daily operation.

Installation and Service – These settings are used by Argus Service technicians for program setup and service diagnostics. They are not required for everyday operation.

NUTRIENT CONTROL PROGRAMS

Stock Tank Screens

There is a stock tank screen for each concentrate tank on the system plus an acid and a base concentrate tank. The stock tank screens are identical. Up to 14 tanks can be used for fertilizer concentrates. Use as many as you need to match your injection equipment. Tank 15 is dedicated to acid addition and Tank 16 is dedicated to base addition.

Stock Tanks <-- make a Shortcut to this from Recipe Screens			Injection Outputs Active	
			Injected Amounts	
			Totals	This Second
Stock Tank 1	20-10-20	Enabled	0.000000 L	0.000000 L
Stock Tank 2	Nurserey	Enabled	0.000000 L	0.000000 L
Stock Tank 3	Calcium Nitrate	Enabled	2.683180 L	0.000000 L
Stock Tank 4	Potassium Nitrate	Enabled	2.164043 L	0.000000 L
Stock Tank 5	Potassium Sulphate	Enabled	0.000000 L	0.000000 L
Stock Tank 6	Ammonium Nitrate	Enabled	1.149101 L	0.000000 L
Stock Tank 7	Magnesium Sulphate	Enabled	1.924890 L	0.000000 L
Stock Tank 8	Iron	Enabled	0.787455 L	0.005833 L
Stock Tank 9	Manganese Chelate	Enabled	0.419976 L	0.000000 L
Stock Tank 10	Solubor	Enabled	0.134159 L	0.000000 L
Stock Tank 11	Copper Chelate	Enabled	0.192489 L	0.000000 L
Stock Tank 12	Zinc Chelate	Enabled	0.384978 L	0.000000 L
Stock Tank 13	Ammonium Molybdate	Enabled	0.093328 L	0.000000 L
Stock Tank 14	Monopotassium Phosphate	Enabled	0.956612 L	0.005833 L
Acid Tank	Sulfuric Acid	Enabled	0.221654 L	0.000000 L
Base Tank	Calcium Hydroxide	Enabled	0.000000 L	0.000000 L
Acid Injection Ratio 2500 :1 pH Modifier Not Used			Clear Injected Amounts	
0.000400 L /L Before Feedback Correction				
0.000400 L /L After Feedback Correction				

Selecting the menu entry for a stock tank opens its configuration screen:

Tank Name 20-10-20		Stock Tank Enabled		Status Enabled																																																															
Tank Composition <table> <tr> <th>Relative Composition</th> <th>Concentration:</th> </tr> <tr> <td>Nitrogen 20.0000 %</td> <td>Weight 0.200 kg</td> </tr> <tr> <td>Phosphorus 4.3649 %</td> <td>per unit Volume 1.000 L</td> </tr> <tr> <td>Potassium 16.5975 %</td> <td></td> </tr> <tr> <td>Calcium 0.0000 %</td> <td>Optional Values:</td> </tr> <tr> <td>Magnesium 0.0000 %</td> <td>Specific Gravity 0.000</td> </tr> <tr> <td>Sulphur 0.0000 %</td> <td>Molecular Weight 0.00000</td> </tr> <tr> <td>Iron 0.0000 %</td> <td></td> </tr> <tr> <td>Manganese 0.0000 %</td> <td></td> </tr> <tr> <td>Boron 0.0000 %</td> <td></td> </tr> <tr> <td>Zinc 0.0000 %</td> <td></td> </tr> <tr> <td>Copper 0.0000 %</td> <td></td> </tr> <tr> <td>Molybdenum 0.0000 %</td> <td></td> </tr> <tr> <td>Chloride 0.0000 %</td> <td></td> </tr> <tr> <td>Element A 0.0000 %</td> <td></td> </tr> <tr> <td>Element B 0.0000 %</td> <td></td> </tr> <tr> <td>Element C 0.0000 %</td> <td></td> </tr> </table> Clear Accumulator Limits Input Accumulator <table> <tr> <td>Accumulator</td> <td>0.000000 L</td> </tr> <tr> <td>Maximum Limit</td> <td>2.000000 L</td> </tr> <tr> <td>Limit Timer</td> <td>00:00:00</td> </tr> <tr> <td>Limit Counter</td> <td>0</td> </tr> <tr> <td>Alarm Priority</td> <td>Silent</td> </tr> <tr> <td>Alarm Delay</td> <td>00:00:00</td> </tr> <tr> <td>Alarm Status</td> <td>Okay</td> </tr> </table> Output Accumulator <table> <tr> <td>Accumulator</td> <td>0.000000 L</td> </tr> <tr> <td>Maximum Limit</td> <td>0.300000 L</td> </tr> <tr> <td>Limit Timer</td> <td>00:00:00</td> </tr> <tr> <td>Limit Count</td> <td>0</td> </tr> <tr> <td>Alarm Priority</td> <td>Silent</td> </tr> <tr> <td>Alarm Delay</td> <td>00:00:00</td> </tr> <tr> <td>Alarm Status</td> <td>Okay</td> </tr> </table>				Relative Composition	Concentration:	Nitrogen 20.0000 %	Weight 0.200 kg	Phosphorus 4.3649 %	per unit Volume 1.000 L	Potassium 16.5975 %		Calcium 0.0000 %	Optional Values:	Magnesium 0.0000 %	Specific Gravity 0.000	Sulphur 0.0000 %	Molecular Weight 0.00000	Iron 0.0000 %		Manganese 0.0000 %		Boron 0.0000 %		Zinc 0.0000 %		Copper 0.0000 %		Molybdenum 0.0000 %		Chloride 0.0000 %		Element A 0.0000 %		Element B 0.0000 %		Element C 0.0000 %		Accumulator	0.000000 L	Maximum Limit	2.000000 L	Limit Timer	00:00:00	Limit Counter	0	Alarm Priority	Silent	Alarm Delay	00:00:00	Alarm Status	Okay	Accumulator	0.000000 L	Maximum Limit	0.300000 L	Limit Timer	00:00:00	Limit Count	0	Alarm Priority	Silent	Alarm Delay	00:00:00	Alarm Status	Okay		
Relative Composition	Concentration:																																																																		
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Accumulator	0.000000 L																																																																		
Maximum Limit	2.000000 L																																																																		
Limit Timer	00:00:00																																																																		
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Alarm Delay	00:00:00																																																																		
Alarm Status	Okay																																																																		
Stock Tank Ready External Input Stock Ready Reading Not Used Address Logic Active when Non-Zero When Inactive Only Shutdown This Tank Enable Status No External Pointer Cross Module Request Time 89 seconds (0)																																																																			
Output Type Synchronized Pulse Group 1 Total Injection 3536.662237 L Pulse Group 1 <table> <tr> <td>Minimum Delivery</td> <td>0.005833 L</td> <td>0.10 Sec</td> <td>Calculated On Time</td> <td>0.00 Sec</td> </tr> <tr> <td>Maximum Delivery</td> <td>0.058333 L</td> <td>1.00 Sec</td> <td>Output</td> <td>Pulse Output Assignment Value</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Start Time</td> <td>0.00 Sec</td> </tr> <tr> <td></td> <td></td> <td></td> <td>End Time</td> <td>0.00 Sec</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Group Period</td> <td>1.00 Sec</td> </tr> <tr> <td></td> <td></td> <td></td> <td>Period #</td> <td>206</td> </tr> </table>						Minimum Delivery	0.005833 L	0.10 Sec	Calculated On Time	0.00 Sec	Maximum Delivery	0.058333 L	1.00 Sec	Output	Pulse Output Assignment Value				Start Time	0.00 Sec				End Time	0.00 Sec				Group Period	1.00 Sec				Period #	206																																
Minimum Delivery	0.005833 L	0.10 Sec	Calculated On Time	0.00 Sec																																																															
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			Start Time	0.00 Sec																																																															
			End Time	0.00 Sec																																																															
			Group Period	1.00 Sec																																																															
			Period #	206																																																															

Use the **Tank Name** setting to enter a descriptive name for the tank contents:

Tank Name **Calcium Nitrate**

The tank must be **[Enabled]** for the injection program to use its contents. You can use the Enable/Disable setting to temporally take the tank off line for mixing and cleaning activities.

Tank Composition

Tank Name 20-10-20		Stock Tank Enabled	
Tank Composition			
	Relative Composition	Concentration: Weight	0.200 kg
		per unit Volume	1.000 L
Nitrogen	20.0000 %		
Phosphorus	4.3649 %		
Potassium	16.5975 %		
Calcium	0.0000 %	Optional Values:	
Magnesium	0.0000 %	Specific Gravity	0.000
Sulphur	0.0000 %	Molecular Weight	0.00000
Iron	0.0000 %		
Manganese	0.0000 %		
Boron	0.0000 %		
Zinc	0.0000 %		
Copper	0.0000 %		
Molybdenum	0.0000 %		
Chloride	0.0000 %		
Element A	0.0000 %		
Element B	0.0000 %		
Element C	0.0000 %		

This section defines the elemental composition of chemicals in this tank as well as the overall concentration of dissolved materials. In this example, the tank contains only calcium nitrate, so its elemental analysis has been entered.

For the concentration settings, enter the weight of concentrate material per unit volume. In the above example, calcium nitrate has been dissolved at the rate of 0.1 Kg (100 grams) per liter of final solution. The optional values (specific gravity and molecular weight) are not used by the program at this time, so they can be left at zero.

The label on the fertilizer bag usually lists the elemental content of each fertilizer constituent as a percentage by weight. The exceptions are for P and K. By convention, phosphorus is usually expressed as P₂O₅ (phosphoric anhydride) and potassium is given as K₂O (potash). For nutrient recipes, you must first convert these two numbers to their true elemental content. Let's look at the following commercial pre-mix soluble fertilizer:

20 - 10 - 20
(N) (P₂O₅) (K₂O)

- P₂O₅ divided by 2.291 = P (elemental phosphorus content)
- K₂O divided by 1.205 = K (elemental potassium content)

Therefore, the common fertilizer 20 - 10 - 20 is actually 20 - 4.5 - 17 when expressed as elemental content.

Note: you only need to enter the complete analysis unless if your recipes are using automatic PPM calculation methods. If you intend to inject using manually entered dilution ratios you can leave the relative composition table blank (in the **Feed Recipes** program, you can set the **Injection Control** to **Manual Calculations** and enter the concentrate dilution ratio to use. See page 67 for details).

Stock Tank External Enable

Stock Tank Ready External Input		Enable Status External Active
Stock Ready Reading Non-Zero		
Address	Controller 2 - C2; I/O House 2; Tank Low Level; IN7 Compensated R	
Logic Active when Non-Zero	Cross Module Request Time	30 seconds (0)
When Inactive Only Shutdown This Tank		

This optional section is intended to halt dosing from a stock tank when it is empty or when it has some other externally defined problem.

To enable it, assign a **Stock Ready Reading** value. Typically, this is the reading from a level sensor in the tank. Use the **Logic** setting to determine how the Reading causes the external input to switch between **Active** and **Inactive** states.

When the external input is **Active**, dosing can proceed. When it becomes **Inactive**, you can select whether to shut down injection on this tank only, or all tanks.

When the Stock Ready reading is set to **[Not Used]** the **Enable Status** reads **[No Pointer Assigned]** and the External Enable is always active, effectively preventing this program section from shutting down injection.

Note: Irrigation operations continue as normal. Depending on whether just this tank or all tanks are shut down, the Injector continues to provide nutrients from other enabled stock tanks used by the current Feed Recipe, or clear water if all tanks are shut down.

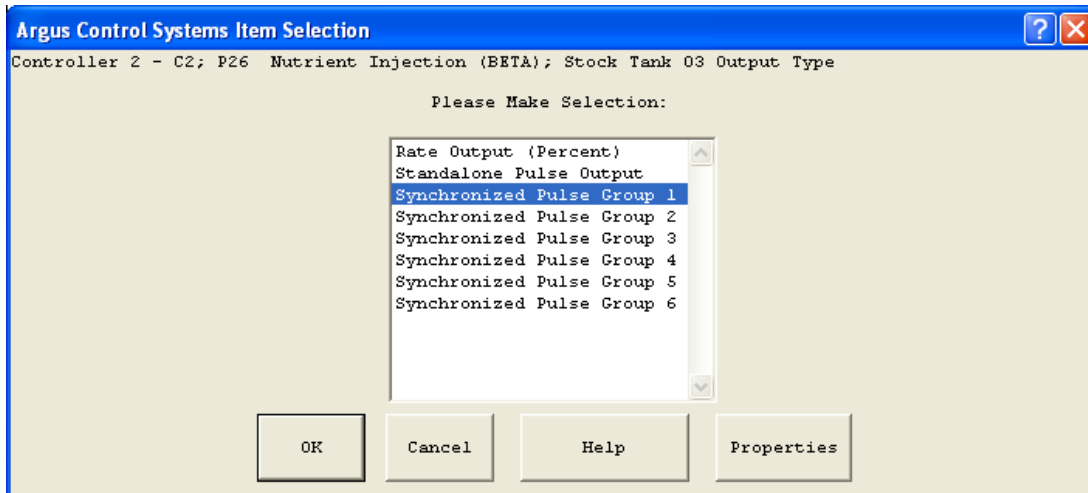
Output Configuration

Output Type Synchronized Pulse Group 1		Total Injection 1719.951232 L
Pulse Group 1		Alarm Status
Minimum Delivery	0.005833 L 0.10 Sec	Calculated On Time 0.18 Sec
Maximum Delivery	0.058333 L 1.00 Sec	Output Pulse Output Assignment Value
		Start Time 0.00 Sec
		End Time 0.18 Sec
		Group Period 1.00 Sec
		Period # 229

You can select an output style to match the injection equipment that you are using. In the above example, a synchronized output strategy is being used, where each of the enabled tanks are injected sequentially.

The **Output Type** setting is used to select the output style:

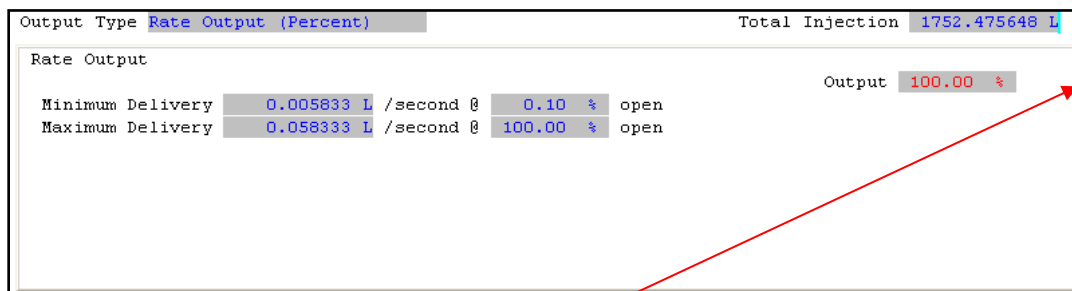
NUTRIENT CONTROL PROGRAMS



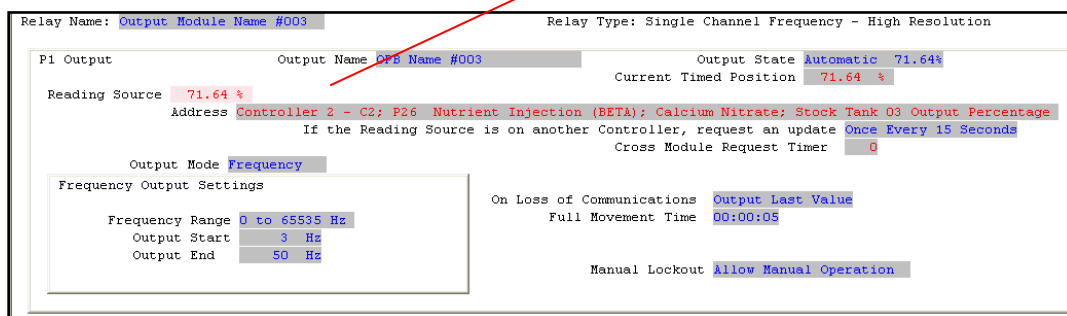
Selectable Output types are:

- **Rate Output** – outputs are expressed as instantaneous proportional percentages
- **Standalone Pulse Output** – output values are expressed as on time pulses
- **Synchronized Pulse Outputs** – all current stock outputs are operated in a controlled sequence

Rate Output (Percent)



I/O Module:



For Rate Output, the program generates a value of 0.00% to 100.00% which translates into volume delivered per second as a % of the maximum possible injector rate.

The Output value should be assigned to one of the proportional output types in the **I/O Module** program. Enter **Minimum** and **Maximum Delivery** values and corresponding percent open values for the injection device. In the above example, the valve delivers .005833 L per second at 10%, and .058333 liters per second at 100%.

This calibration information must be derived empirically or from data supplied by the injector manufacturer.

Standalone Pulse Output

Output Type	Standalone Pulse Output		Total Injection	1723.517568 L
Standalone Pulse			Alarm Status	
Minimum Delivery	0.005833 L	0.10 Sec	Calculated On Time	0.18 Sec
Maximum Delivery	0.058333 L	1.00 Sec	Pulse Period	1.00 Seconds 0.00 Sec
			Output	Pulse Output Assignment Value

I/O Module:

Output "A" High Frequency	Output Name	OPA Calcium Nitrate	Output State	Automatic 14.00%
			Current Timed Position	14.00 %
Pulse Type	Synchronized Pulses			
	Master			
Reading Source	Pulse Output Assignment Value			
Address	Controller 2 - C2; P26 Nutrient Injection (BETA); Calcium Nitrate; Stock 03 Pulse Output Value - fo			
	Watchdog	0	Request Timer	0

The **Standalone Pulse Output** provides an independent pulse output that delivers a fixed volume for each pulse or 'on' time. The **Minimum** and **Maximum** delivery time values can be set from 0.02 seconds up to 5.00 seconds in 0.02 second increments.

The **Maximum** delivery time should never exceed the set **Pulse Period** setting (from 1.00 seconds to 5.00 seconds). The **Alarm Status** indicates when there is a settings problem. This can occur if:

- 1) The Maximum Delivery Time is less than Minimum Delivery Time.
- 2) The Maximum Delivery Time is greater than Total Period.
- 3) The Maximum Delivery (volume) is equal to zero.
- 4) The Maximum Delivery (volume) is less than or equal to Minimum Delivery.
- 5) A Standalone Pulse type has no Pulse Period assigned.

This **Output** value can only be assigned to an **I/O Module D2: High Frequency Output** using a **Pulse Type** of **Synchronized Pulses**. In the linked **I/O module Output**, the Output must be set to **Master**.

Synchronized Pulses

Output Type Synchronized Pulse Group 1		Total Injection 1760.823296 L	
Pulse Group 1		Alarm Status	
Minimum Delivery	0.005833 L	0.10 Sec	Calculated On Time 0.18 Sec
Maximum Delivery	0.058333 L	1.00 Sec	Output Pulse Output Assignment Value
		Start Time	0.00 Sec
		End Time	0.18 Sec
		Group Period	1.00 Sec
		Period #	167

I/O Module:

Output "A" High Frequency	Output Name OPA Calcium Nitrate	Output State Automatic 14.00%
Pulse Type Synchronized Pulses	Current Timed Position 14.00 %	
	Master	
Reading Source Pulse Output Assignment Value		
Address Controller 2 C2: P26 Nutrient Injection (BTA); Calcium Nitrate; Stock 03 Pulse Output Value - fo		
Watchdog 0	Request Timer 0	

The **Synchronized Pulse Group 1 to 6** type output delivers a fixed volume of concentrate for a given pulse width that is synchronized with up to a total of 13 other outputs to ensure that none of the outputs is on simultaneously. This is to interleave stock solution injection to reduce the output ripple as measured by an EC sensor.

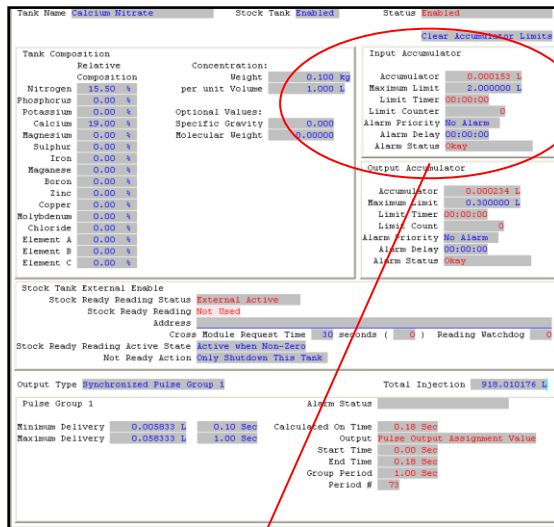
The pulse widths can be set from 0.02 seconds up to 5.00 seconds in 0.02 second increments. The pulse widths should never exceed the set **Pulse Period** from 1.00 seconds to 5.00 seconds (the pulse period is set on the **Synchronized Output Groups** screens accessed from the Main screen of the Nutrient Injection program). Otherwise, and alarm is triggered.

The **Alarm Status** indicates when there is problem with the current settings. This can occur if:

1. The **Maximum Delivery Time** is less than **Minimum Delivery Time**.
2. The **Maximum Delivery Time** is greater than **Total Period**.
3. The **Maximum Delivery** (volume) is equal to zero.
4. The **Maximum Delivery** (volume) is less than or equal to Minimum Delivery.
5. A **Standalone Pulse type** has no **Pulse Period** assigned.

This Output value can only be assigned to a **D2: High Frequency Output** using a **Pulse Type** of **Synchronized Pulses**. In the I/O module, set the **Output** as **Master** for one of the outputs within the Synchronized Group and set the other outputs in the group to Synchronize to the Master Output.

Input Accumulator



Tank Name: Calcium Nitrate		Stock Tank: Enabled	Status: Enabled
Clear Accumulator Limits			
Tank Composition Relative Composition Nitrogen 15.50 % Phosphorus 0.00 % Potassium 0.00 % Calcium 19.00 % Magnesium 0.00 % Sulphur 0.00 % Iron 0.00 % Manganese 0.00 % Boron 0.00 % Zinc 0.00 % Copper 0.00 % Molybdenum 0.00 % Chloride 0.00 % Element A 0.00 % Element B 0.00 % Element C 0.00 %		Concentration: Weight 0.100 kg per unit Volume 1.000 L Optional Values: Specific Gravity 0.000 Molecular Weight 0.00000	Input Accumulator Accumulator 0.000157 L Maximum Limit 2.000000 L Limit Timer 00:00:00 Limit Counter 0 Alarm Priority No Alarm Alarm Delay 00:05:00 Alarm Status Okay
		Output Accumulator Accumulator 0.000234 L Maximum Limit 0.300000 L Limit Timer 00:00:00 Limit Count 0 Alarm Priority No Alarm Alarm Delay 00:00:00 Alarm Status Okay	
Stock Tank External Enable Stock Ready Reading Status External Active Stock Ready Reading Not Used Address Cross Module Request Time 30 seconds (0) Reading Watchdog 0 Stock Ready Reading Active State Active When Not-Set Not Ready Action Only Shutdowns This Tank			
Output Type Synchronized Pulse Group Pulse Group 1 Minimum Delivery 0.005833 L Maximum Delivery 0.058333 L Calculated On Time 0.10 Sec Output Pulse Output Assignment Value Start Time 0.00 Sec End Time 0.10 Sec Group Period 1.00 Sec Period # 73		Total Injection 918.910176 L Alarm Status	

Input Accumulator

Accumulator	0.000106 L
Maximum Limit	2.000000 L
Limit Timer	00:00:00
Limit Counter	0
Alarm Priority	No Alarm
Alarm Delay	00:00:00
Alarm Status	Okay

The **Input Accumulator** for each stock tank accumulates the flow volume measured by the irrigation flow meter. It acts as a buffer between the inlet measurements and the actual feed injection calculations to carry forward any residual values.

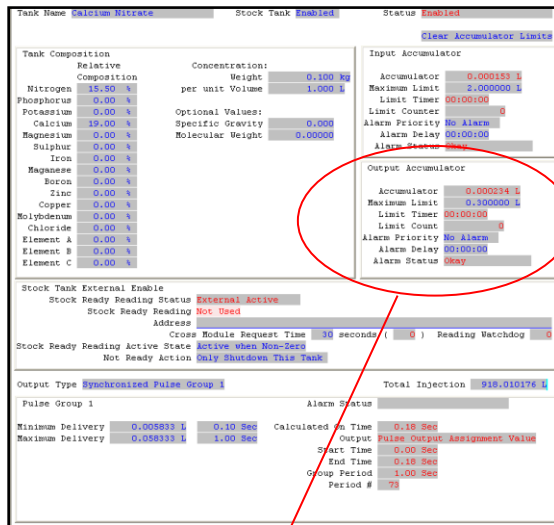
Accumulation only occurs when this stock tank is part of the current feed recipe. The **Injection** accumulation value increases in proportion to the irrigation system flow rate and the current **Feed Recipe** and it decreases as the injector completes the injection process.

The current **Accumulator** value represents the lag between the injection volume calculation and the actual injection. If the injection process lags too far behind the demand the accumulator increases until it is limited by the maximum limit setting. This limit should never be reached in normal operation.

The **Maximum Limit** setting prevents the accumulator from climbing to a dangerously high value and causing subsequent high injection when the injector 'catches up' to the flow rate. It should be set just high enough to prevent the limits from being hit. Setting too high a value causes the accumulator to carry forward uninjected remainders for too long.

The **Limit Timer** and **Limit Counter** are used to 'box score' when the **Maximum Limit** has been reached. This box score information can be useful when diagnosing injection control problems. The **Alarm** Priority and Alarm Delay settings are used to notify the operator if the **Maximum Limit** is applied for too long.

Output Accumulator



Tank Name: Calcium Nitrate		Stock Tank: Enabled	Status: Enabled
Tank Composition			
Relative Composition	Concentration:	Weight	0.100 kg
Nitrogen 15.90 %	per unit Volume		1.000 L
Phosphorus 0.00 %	Optional Values:	Specific Gravity	0.000
Potassium 0.00 %		Molecular Weight	0.00000
Calcium 19.00 %			
Magnesium 0.00 %			
Sulphur 0.00 %			
Iron 0.00 %			
Manganese 0.00 %			
Boron 0.00 %			
Zinc 0.00 %			
Copper 0.00 %			
Molybdenum 0.00 %			
Chloride 0.00 %			
Element A 0.00 %			
Element B 0.00 %			
Element C 0.00 %			
Stock Tank External Enable			
Stock Ready Reading Status		External Active	
Stock Ready Reading		Not Used	
Address			
Cross Module Request Time		30 seconds (0)	
Reading Watchdog		0	
Stock Ready Reading Active State Active when Non-Zero			
Not Ready Action Only Shutdowns This Tank			
Output Type Synchronized Pulse Group		Total Injection 918.910176 L	
Pulse Group 1		Alarm Status	
Minimum Delivery	0.005833 L	0.10 Sec	0.10 Sec
Maximum Delivery	0.058333 L	1.00 Sec	1.00 Sec
Calculated on Time		Output Pulse Output Assignment Value	
Start Time		0.00 Sec	
End Time		0.10 Sec	
Group Period		1.00 Sec	
Period #		73	

Output Accumulator

Accumulator	0.000829 L
Maximum Limit	0.300000 L
Limit Timer	00:00:00
Limit Count	0
Alarm Priority	No Alarm
Alarm Delay	00:00:00
Alarm Status	Okay

The **Output Accumulator** for each stock tank is used to sum the calculated required output volume based on the **Input Accumulator** and the **Injection Volume** calculated in the **Feed Recipe** as part of the Target ppm. Accumulation only occurs when this stock tank is part of the current feed recipe. Its purpose is to increase injection accuracy by carrying forward any calculated concentrate injection amounts that do not fit into the current pulse. This can be thought of as an uninjected remainder.

The **Injection Accumulator** value increases in proportion to the irrigation system flow rate and the current **Feed Recipe** and it decreases as the injector completes the injection process. The current **Accumulator** value represents the lag between the injection volume calculation and the actual injection.

If the injection process lags too far behind the demand the accumulator increases until it is limited by the maximum limit setting. This limit should never be reached in normal operation. It prevents the accumulator from climbing to a dangerously high value and causing subsequent high injection when the injector 'catches up' to the flow rate.

The **Maximum Limit** is used to prevent the accumulator from reaching excessively high values. It should be set just high enough to prevent the limits from being hit. A high maximum limit setting value allows the accumulator to carry forward large uninjected remainders that may cause large injection target overshoot when the injection system is able to 'catch up'.

The **Limit Timer** and **Limit Counter** are used to 'box score' when the **Maximum Limit** has been reached. The **Alarm Priority** and **Alarm Delay** settings are used to notify the operator when the **Maximum Limit** is applied for too long.

Water Composition Analysis

The Nutrient Injection program automatically compensates for the elemental concentrations in the inlet water by subtracting these amounts from the recipe before it calculates the injection volumes required to achieve the recipe targets.

From a water analysis report, enter values in ppm in the **Source Water** column and provide the overall inlet water conductivity as well.

If the current feed recipe is set to be recirculated, the program calculates the elemental composition of any recirculating nutrients by comparing the EC of the recirculated inlet water to the declared EC in the recipes program.

Note that this method does not consider any differential uptake of elements that can occur in long term, tightly closed systems. It assumes that all elements are used in proportion to the amounts that they are administered in.

For example, if the recipe EC is 2.0 ms and the returning water is 1.0 ms, the program assumes that the elemental concentration is 50% of the current recipe value.

If pH correction is used, the program adds the nutrient value of any pH correcting materials that are currently being injected from the declared elemental values of the pH correction tank.

The After/Acid/Base Addition column shows the amounts of each element that it calculates are in the inlet water. This is subtracted from the current recipe amounts before calculating the volumes of each concentrate to inject.

Water Composition Analysis

This screen is used to enter background nutrient levels in your irrigation water.
 If the current Feed Recipe in use is set to be recirculated, the elemental values are calculated based on the current Inlet Conductivity reading.
 The After Acid/Base Addition column shows the calculated effect of pH controlling substances.

Current Feed Recipe Feed 1			
	Source Water		Recirculated Feed
Nitrogen	0.000 ppm	Nitrogen	13.333 ppm
Phosphorus	0.000 ppm	Phosphorus	2.667 ppm
Potassium	0.000 ppm	Potassium	13.333 ppm
Calcium	5.000 ppm	Calcium	6.667 ppm
Magnesium	0.000 ppm	Magnesium	2.333 ppm
Sulphur	0.000 ppm	Sulphur	3.000 ppm
Iron	0.100 ppm	Iron	0.133 ppm
Manganese	0.000 ppm	Manganese	0.067 ppm
Boron	0.000 ppm	Boron	0.033 ppm
Zinc	0.000 ppm	Zinc	0.007 ppm
Copper	0.000 ppm	Copper	0.033 ppm
Molybdenum	0.000 ppm	Molybdenum	0.001 ppm
Chloride	2.000 ppm	Chlorine	1.333 ppm
Element A	0.000 ppm	Element A	0.000 ppm
Element B	0.000 ppm	Element B	0.000 ppm
Element C	0.000 ppm	Element C	0.000 ppm

	After Acid/Base Addition
Nitrogen	13.333 ppm
Phosphorus	2.667 ppm
Potassium	13.333 ppm
Calcium	6.667 ppm
Magnesium	2.333 ppm
Sulphur	3.001 ppm
Iron	0.133 ppm
Manganese	0.067 ppm
Boron	0.033 ppm
Zinc	0.007 ppm
Copper	0.033 ppm
Molybdenum	0.001 ppm
Chlorine	1.333 ppm
Element A	0.000 ppm
Element B	0.000 ppm
Element C	0.000 ppm

Conductivity 0.10 mS

Inlet Conductivity Reading
0.10 mS

Feed: Target Conductivity
1.50 mS

Flow Meter

Flow Meter	Flow Detected	Flow Rate	1.666700 L / second	100.002000 L /min
------------	---------------	-----------	---------------------	-------------------

The Nutrient Injection program automatically adjusts its injected concentrate volumes to match the current system flow rate. To accomplish this, an accurate flow meter must be correctly positioned in the main irrigation stream.

The Injection System supports two different types of Flow Meters; Pulse and Rate. **Pulse Flow Meters** use on/off or digital signals that indicate a specific volume for each pulse transition. **Rate Flow Meters** give an instantaneous voltage signal that represents a specific volume per second. Pulse type flow meters are less expensive and more accurate for this application and should always be your first choice.

Select the **Flow Meter** menu entry to open its configuration screen:

Pulse Type Flow Meter

Set the **Flow Meter Type** to [Pulse]

Current Second's Volume		1.350027 L		
Current Flow Rate		81.001616 L /min		
Reading	81			
Address	Controller 2 - C2; I/O House 2; Flow Sensor; IN8 Compensated Read			
Cross Module Request Time		30 seconds. (0)		
Flow Meter Type	Pulse			
<table border="1"> <tr> <td>Volume per Pulse</td> <td>0.016667 L</td> </tr> </table>			Volume per Pulse	0.016667 L
Volume per Pulse	0.016667 L			
No Flow Watchdog Time	5 Sec			
No Flow Watchdog Timer	0 Sec			
No Flow Flag	Flow Detected			

Enter the **Volume per Pulse in Liters** using the Flow Meter manufacturer's information for the pipe size used. Pulse type inputs are typically assigned to **I/O Module** channel A (IN8) or B (IN9). Use the **Raw Counter** reading from the **I/O Module**.

The **No Flow Watchdog** setting is used to indicate how quickly the **Input** and **Output Accumulators** should clear after no flow is detected from the flow meter. On most systems with properly sized flow meters, this setting should be set to zero. On systems with extremely low flow rates where less than one flow meter pulse is recorded over several seconds, settings of 2 to 5 seconds may be more appropriate.

Rate Type Flow Meter

Set the **Flow Meter Type** to [Rate]

Current Second's Volume		1.666700 L
Current Flow Rate		100.002000 L /min
Reading	100	
Address	Controller 2 - C2; I/O House 2; Flow Meter; IN7 Compensated Read	
Cross Module Request Time		30 seconds. (0)
Flow Meter Type	Rate	
Input Multiplier	100	
Input Divisor	100	
Conversion Factor	0.016667 L	
Debug: Last Second's Remainder	0	
No Flow Watchdog Time	0 Sec	
No Flow Watchdog Timer	0 Sec	
No Flow Flag	Flow Detected	

Use the **Input Multiplier**, **Input Divisor** and **Conversion Factor** to convert the reading into liters per second with micro liter resolution.

The **No Flow Watchdog** setting is used to indicate how quickly the **Input** and **Output Accumulators** should clear after no flow is detected from the flow meter. On most systems, with properly sized flow meters this should be set to zero. On systems with extremely low flow rates, settings of 2 to 5 seconds may be more appropriate.

Feed Request Source

This section designates which recipe the injector supplies.

Whenever the flow meter measures flow through the irrigation system, the injector system must either deliver one of the recipes chosen from a linked **Feed Recipes** program or deliver clear water (inject nothing). The injection response can be configured manually or automatically.

When manual feed selection is used, the Injector always provides the designated feed recipe (or clear water) regardless of any other requests from the irrigation system or external feed requests.

NUTRIENT CONTROL PROGRAMS

When **automatic** feed selection is used, the feed requests originate from an assigned **Irrigation System** or from an **External Feed Source**.

Feed Request Source		This screen is used to determine how the Injection Program receives Feed Requests.	
There are 2 request modes: Manual Assignment: (a specific Feed or Clear Water override)			
Automatic: (requests from the Irrigation System or the optional External Feed Source)			
Feed Selection	Automatic	(Automatic, Feed #, or Clear Water)	
Feed Source Status		Used Feed Source	Irrigation System
		Current Feed Recipe	Clear Water
		Feed: Target Conductivity	0.10 mS
		Feed: Target pH	6.50 pH
		pH Modifier	Not Used
		Feed: Ratio of Water to Acid	2500 :1
		Wanted Feed Source	Irrigation System
		Desired Feed Recipe	Clear Water
		Unrecognized Feed Requested (Clear Water Used)	Not Used
		Number Of Times Unrecognized Feed Requested	0
External Feed Source (optional)			
External Feed Reading		NOT USED	
Address			
		Cross Module Request Time	16 seconds. (0)
Default Feed Settings		Manual Override Feed Status	
Default Feed Recipe		Clear Water	
If Default Feed Isn't Available		Use Clear Water	
Default pH Target Reading		6.50 pH	
Address		GRP:NT1:P66 Feed Recipes (BETA):Recipe 1 pH Target	
		Cross Module Request Time	18 seconds. (0)
Default Water to Acid Ratio		2500 :1	
pH Modifier (Feedback) Reading		NOT USED (optional)	
Address			
		Cross Module Request Time	27 seconds. (0)
Irrigation System Settings			
Irrigation System Assignment		Main Irrigation System	
System Assignment Fault			
System: Wanted Feed		Clear Water	
System: Wanted Feed after Feed Switch		Clear Water	
System: Desired Feed		Clear Water	
System: Current Feed		Clear Water	
		System: Current Load	33 %

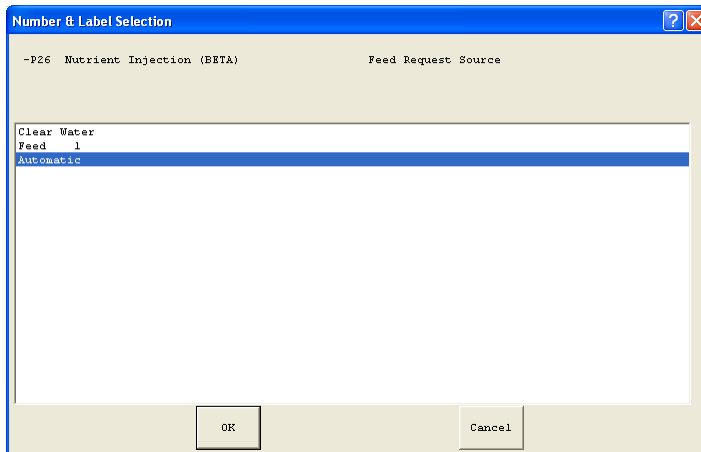
Feed Selection

Feed Selection **Automatic** {Automatic, Feed #, Clear Water}

This setting is used to choose between:

- Fully Automatic feed selection
- A manually designated Feed Recipe
- Clear Water

When **Clear Water** is selected no injection occurs except for Acid/Base injection from Tank 15. When Automatic is selected the injection program automatically injects the **Current Feed**. When Feed (x) is selected the system always injects the designated feed whenever tit detects flow.



Feed Source Status

Feed Source Status	Used Feed Source	Irrigation System
	Current Feed Recipe	Clear Water
	Feed: Target Conductivity	0.10 mS
	Feed: Target pH	6.50 pH
	pH Modifier	Not Used
	Feed: Ratio of Water to Acid	2500 :1
	Wanted Feed Source	Irrigation System
	Desired Feed Recipe	Clear Water
	Unrecognized Feed Requested (Clear Water Used)	Not Used
	Number Of Times Unrecognized Feed Requested	0

This section shows the status of current feed requests to the Nutrient Injection program. The above example indicates that a linked **Irrigation System** is providing the recipe requests and that the current recipe is Feed 1.

The **Used Feed Source** indicates the source of feed requests. Readings include:

[Irrigation System] – The system is using feed requests from the Irrigation System and there are currently no problems.

[Manual Override] - The Feed selection setting is set to Manual and the system delivers the designated feed recipe whenever there is flow.

[External Value] -The external feed source is being used to determine which recipe to feed.

[Default Feed] -The system was unable to recognize or make the requested feed so it is using the default feed.

[Clear Water] - The system is currently using Clear Water (not injecting).

[Default Clear Water] - The system is using the default feed and it is clear water.

[Bad Default Feed] - The default feed is needed but it is not available or does not exist on the system.

[Default Feed Offline] – The system cannot deliver the default feed because it is offline (not enabled)

[No Default] – The system cannot deliver the requested feed and no default feed has been assigned.

The **Current Feed Recipe** indicates the **Feed Recipe** currently in use.

The **Feed: Target Conductivity** value is calculated from settings in the current **Feed Recipe**.

The **Feed: Target pH** value is calculated from settings in the current **Feed Recipe**.

The **Feed: Ratio of Water to [Acid/Base]** [XXXXX:1] readings indicate the material (acid or base and the injection concentration currently being used for pH control.

The **Wanted Feed Source** message indicates where Feed requests are currently originating from. Sources Include: Irrigation Systems, Manual Override or and External value.

The **Desired Feed Recipe** indicates the Wanted Feed from the Wanted Feed Source.

Unrecognized Feed Request (Clear Water Used) this shows a Feed that was requested by the Irrigation Source that didn't exist on the controller. This is used to debug improperly setup Irrigation Schedules.

The associated **Number of Times Unrecognized Feed Requested** count value simply tallies the number of times this happens.

External Feed Source

External Feed Source (optional)	
External Feed Reading	0
Address	Controller 2; Tank Filler; Register 01
Cross Module Request Time	0 seconds. (0)

This option can be used as an alternative to feed requests originating from an **Irrigation System**. For example, if the Nutrient Injector is configured to fill a series of large dilute tanks which in turn are used to supply an irrigation system, there may be no need to couple the nutrient injector to the instantaneous requests from the irrigation system.

Instead, a combination of **Sequencer** and **Equations** programs could be used to keep the tanks filled, and to direct the Nutrient Injection program to supply the correct recipe when refilling each tank.

Decoupling the supply of fertilizer supply from the instantaneous demand can be beneficial in ensuring that there is a sufficient buffer of prepared nutrients as a contingency against interruptions due to breakdowns or stock tank mixing and replenishing operations.

It also permits the smaller sizing of the injection equipment to match daily needs as opposed to meeting the maximum instantaneous flow requirements.

Often these buffer tanks are already part of the irrigation system (ebb and flood benches or floors).

The External Feed reading is interpreted as follows:

- 0 = Clear Water
- 1 = Feed 1
- 2 = Feed 2 etc.

Note: When a value is assigned as an External Reading, **this section overrides all Irrigation System requests. External requests and Irrigation System requests cannot be used at the same time.** If you need to fill dilute tanks as well as managing in-line injection to irrigated zones you can do this by designating separate **Irrigation Schedules** for these tasks.

Default Feed Settings

Default Feed Settings		Manual Override Feed Status	
Default Feed Recipe	Feed 1		
If Default Feed Isn't Available	Use Clear Water		
Default pH Target Reading	6.50 pH		
Address	Controller 2; NUTGRP; P31 Feed Recipes (BETA); Recipe 1 pH Targe		
Default Water:Acid/Base Ratio	2500 :1	Cross Module Request Time	18 seconds. (0)
pH Modifier (Feedback) Reading	1.60 %	(optional)	
Address	Controller 2; NUTGRP; pH Correction PID Equations; Feed 1 pH Corr		

The **Default Feed Recipe** settings designate the default recipe to be used if the program can't deliver the requested feed. This could occur when one or more of the stock tanks that are needed to make the desired feed are either empty or off line.

The '**If the Default Feed isn't available**' setting defines an injector response if the default feed can't be made or is off-line. Normally this is set to [Use Clear Water].

Warning: It is usually best to select [Use Clear Water] so that the crop continues to be irrigated whenever there is a problem with feed delivery. If you select [Skip Watering] **he crop is not watered** when there is a problem with feed delivery.

The **Default pH Target Reading** is the pH target to be used when the Default feed is in use. Normally this is mapped to the pH setting in the default feed recipe.

The **Default Water: Acid/Base Ratio** setting is the default pH concentrate injection ratio that the system uses.

The **pH Modifier (Feedback)** reading is an optional external pointer value intended for feedback correction of the **default pH** using an external PID equations program. It is only used when the default pH is used. Each **Feed Recipe** also has an external pointer for optional external pH correction (see page 63).

The **Manual Override Feed Status** reading displays the following error message when the manual override is set to a feed number that does not exist or is not currently assigned to this nutrient system:

Manual Override Feed Status	Manual Override Feed Invalid
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Irrigation System Requests

Irrigation System Settings	
Irrigation System Assignment	Main Irrigation System
System Assignment Fault	
System: Wanted Feed	Feed 1
System: Wanted Feed after Feed Switch	Feed 1
System: Desired Feed	Feed 1
System: Current Feed	Feed 1
System: Current Load	66 %

This section is used to assign the Nutrient Injection program to an Irrigation System. An injection system cannot be 'owned' by more than one irrigation system since it can only make one feed at a time. Once assigned, Irrigation Feed recipe requests originating in the Irrigation schedules on this system are passed to this Injection program as they are processed by the Irrigation System program.

The **Irrigation System Assignment** is used to link the Nutrient Injection program to an Irrigation System program. Both programs must be running on the same controller. The **System Assignment Fault** reading indicates a problem if the assigned Irrigation System program is missing or deleted.

The four feed readings show the current status of feeds as they originate and progress through the Irrigation System:

The **Current Feed** reading shows the feed that is currently being used by the Irrigation System or the last feed that was used.

The **Desired Feed** reading shows the next feed pending on the irrigation system. To become the Desired Feed, the **Switching to Feed Delay Time** (if any) must have expired, and the Feed is now waiting for the system to move it into the Current Feed State.

The **Wanted Feed after Feed Switch** reading shows the feed that is next in line after a Feed Switch. It may still need to count off the **Switching to Feed Delay Time** before the feed is ready.

The **System Wanted Feed** reading shows the next feed to be processed from the **Irrigation Schedule** decisions.

The **System: Current Load** reading shows the current flow expressed as a % of maximum system capacity from the linked Irrigation system.

Tip: The Nutrient Injection operates based on measured flow. If it sees irrigation system flow it injects the **Current Feed** or the Default Feed that has been assigned even if there is no **System Load** (no active watering requests).

This enables injection while hand watering and it may also help to maintain proper EC in irrigation lines with slow leaks (if the flow rate is measurable). If you wish to prevent nutrient injection under 'no load' conditions, you can configure an **Equations** program to watch for measurable flow conditions when there is no system load (no active requests from the Irrigation System). The results of this equation can then be linked into the **External Stop Input** (see page 50).

For example, high flow, no load conditions might indicate a break in the line particularly if your system is externally pressurized. This situation could create lots of flow without any current irrigation requests to create the system load. You can also use the Equation logic to create appropriate alarms for alerting you should this sort of problem occur.

Purge Control

This option flushes the Injector with water during a feed change and then charge it with the next **Feed**.

Purge Control	
Injection Outputs Inactive	Current Feed Recipe Feed 1
Purge/Charge Status Normal Feed Injection	Purge/Charge Active State 0.00 %
Injector Purge Volume 20.000000 L	Purge Valve State 0.00 %
Purge Duration 00:02:00	Charge Valve State 0.00 %
Charge Duration 00:02:00	Purge Timer 00:00:00
	Charge Timer 00:00:00
When switching to CLEAR WATER Purge Before Using Clear Water	
Purge/Charge EC Reading Fault Alarm Priority No Alarm	

Purge Verification	
Purged EC Status	
Stop Control On Purge Fault ☐	
Conductivity Allowable Difference After Purging 0.25 mS	
Inlet Conductivity Reading 0.00 mS	
Conductivity After Purging 0.16 mS	
Purged Conductivity Reading 1.80 mS	Purged Conductivity Reading Watchdog 23
Address EC Readings16-bit Results 01	
Cross Module Request Time 30 seconds. (7)	

Charge Verification	
Charged EC Status	
Stop Control On Charge Fault ☐	
Conductivity Allowable Difference After Charging 0.25 mS	
Feed: Target Conductivity 1.80 mS	
Conductivity After Charging 1.80 mS	
Charged Conductivity Reading 1.80 mS	Charged Conductivity Reading Watchdog 23
Address EC ReadingsConstant 01	
Cross Module Request Time 30 seconds. (7)	

Each **Feed Recipe** can be individually set to have the Nutrient Injection program run a purging operation before the system switches to it (see page 52).

Purging produces less cross contamination between feeds in situations where this might be important. It does so at the expense of wasted fertilizer and water.

To use this feature, the irrigation system must be suitably designed.

For example, the purged volume is normally directed through a simultaneously operated purge or 'dump' valve.

The purging sequence occurs as follows:

1. **System Flush** - Upon change to a Feed that is set to **Purge Before Using This Recipe**, a purge valve is opened (using the **Purge Valve State** reading as a reading source) for the **Purge Duration**. This flushes out the previous feed solution and replace it with Clear Water.

The duration is defined by the time it takes to flush the old feed out of the system. The duration can be calculated by using the included injector system volume and the purge flow rate. The efficiency of the flush portion of the purge can be observed by observing the injector system EC (in relation to the purge water source) after the purge is completed.

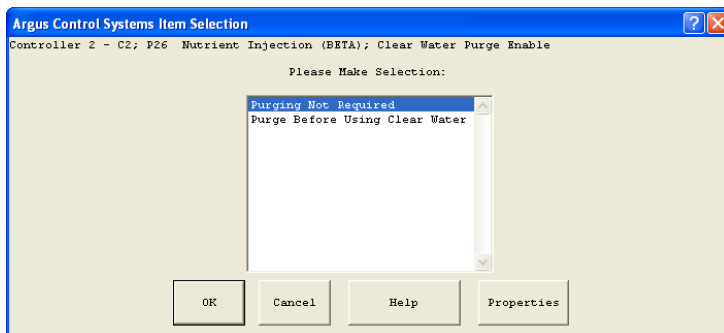
Note: the purge duration can be set to quite long purge times if a high degree of purging is required. It might take several purge volumes to completely clean out the old feed.

2. The purge valve is then closed.

- Using the declared **Injector Purge Volume**, the injection system injects enough of the new feed to bring the recirculated contents of the injector up to the new feed strength.
- Line Charging** – If required, a line changing time can be used to replenish the lines up to the point where the purge valve is located. This flushes the any remaining clear water from the line, so that the line is now filled with the new feed.
- Once the **Purge Volume** and optional **Line Charging** operations are complete, the new Feed becomes available and the Irrigation system can begin using it.

Optional **Purge Verification** and **Charge Verification** settings can be used to ensure proper functioning of the purging operations.

The **Switching to CLEAR WATER** setting is used to define injector purging behavior when switching from any **Feed** to **Clear Water**.



To operate a purge valve, the **Purge/Charge Active Valve State** reading is assigned to an On/Off relay output in the **I/O Module** program that operates the purge valve.

Use The Purge /Charge EC Reading Fault Alarm to set an alarm priority for purging faults:

Purge/Charge EC Reading Fault Alarm Priority **Level #1**

Purge Verification

Purge Verification			
Purged EC Status	☐		
Stop Control On Purge Fault	☒		
Conductivity Allowable Difference After Purging	0.25 mS		
Inlet Conductivity Reading	0.00 mS		
Conductivity After Purging	0.16 mS		
Purged Conductivity Reading	1.80 mS	Purged Conductivity Reading Watchdog	20
Address	EC Readings16-bit Results 01		
Cross Module Request Time	30 seconds.	{	10 }

This section can be used to ensure that purging operations are successful. After the Purge Duration timer has counted to zero, it compares the **Inlet Conductivity** to the **Purged Conductivity Reading**.

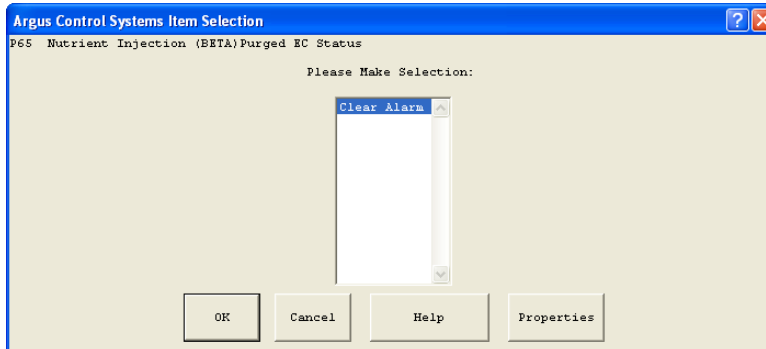
Depending on your system design, the Purged Conductivity Reading can be either the nutrient injector conductivity reading or a downstream EC sensor at the Purge Valve.

Except for the live readings, the values are only updated during an active Purge operation, so the **Conductivity After Purging** reading is the value from the most recent purge. The **Purged EC Status** parameter remains blank unless there is a Fault.

The messages are:

- **Fault: After Purging Line** – Indicates that the **Conductivity After Purging** was not with the **Conductivity Allowable Difference After Purging** setting.
- **Was Faulted: After Purging Line** – indicates that the last purge had a fault but since the **Stop Control on Purge Fault** was not enabled, the injector has continued to operate.

Select the **Purged EC Status** parameter to clear a fault:



When enabled, the **Stop Control On Purge Fault** causes the injector to stop injecting until it is manually restarted by a System Operator ☒ = Enabled ☐ = Disabled. Unless Purging operations are critical, it is best to disable the stop control function and rely on the **Purge /Charge EC Reading Fault Alarm** to alert you of purging faults without interrupting the nutrient injection operations.

The **Conductivity Allowable Difference After Purging** setting lets you set a conductivity tolerance range for the purge flushing operation.

Charge Verification

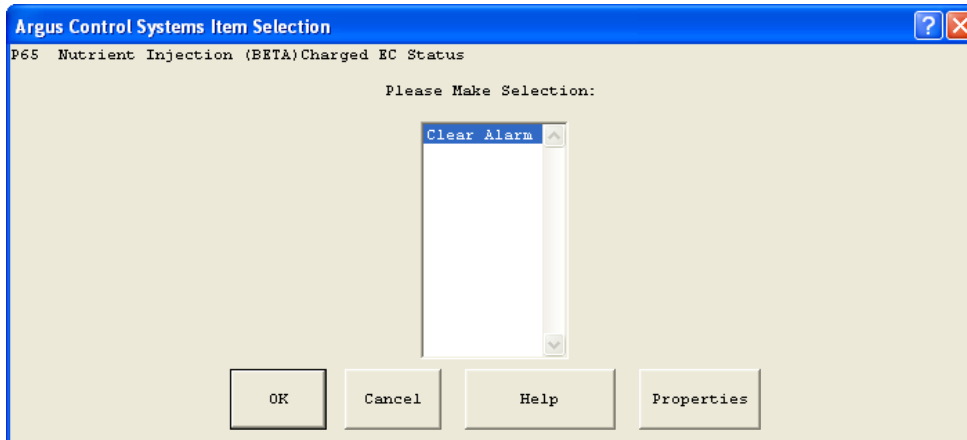
Charge Verification	
Charged EC Status	
Stop Control On Charge Fault	☒
Conductivity Allowable Difference After Charging	0.25 mS
Feed: Target Conductivity	1.80 mS
Conductivity After Charging	1.80 mS
Charged Conductivity Reading	1.80 mS
Charged Conductivity Reading Watchdog	5
Address	EC ReadingsConstant 01
Cross Module Request Time	30 seconds. (25)

This section can be used to ensure that optional Charging operations are successful. After the Charge Duration timer has counted to zero, it compares the **Feed: Target Conductivity** for the new Feed to the **Conductivity After Charging** reading. Depending on your system design, the Charged Conductivity Reading can be either the nutrient injector conductivity reading or a downstream EC sensor at the Purge Valve.

Except for the live readings, the values are only updated during an active Charge operation, so the **Conductivity After Charging** reading is the value from the most recent purge. The **Charged EC Status** parameter remains blank unless there is a Fault. The messages are:

- **Fault: After Charging Line** – Indicates that the **Conductivity After Charging** was not with the **Conductivity Allowable Difference After Charging** setting.
- **Was Faulted: After Charging Line** – indicates that the last purge had a fault but since the **Stop Control on Charge Fault** was not enabled, the injector has continued to operate.

Select the **Charged EC Status** parameter to clear a fault:



When enabled, the **Stop Control On Charge Fault** causes the injector to stop injecting until it is manually restarted by a System Operator ☐ = Enabled ☒ = Disabled. Unless Charging operations are critical, it is best to disable the stop control function and rely on the **Purge /Charge EC Reading Fault Alarm** to alert you of charging faults without interrupting the nutrient injection operations.

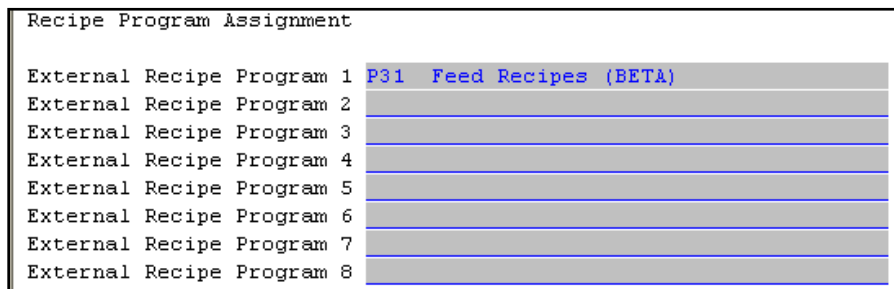
The **Conductivity Allowable Difference After Charging** setting lets you set a conductivity tolerance range for the purge flushing operation.

Recipe Program Assignment

Feed Recipe programs must to be assigned to the Injection programs before they can be used.

Recipe Program Assignment

Use the above menu entry to open the following screen:



The Nutrient Injection program can be linked to eight Feed Recipes programs for a maximum of 64 recipes per injector.

All assigned Feed Recipes programs must be located on the same controller as the Nutrient Injection program.

pH and Temperature Shutdowns

Stopped Alarm Priority	Level #1	Stop Delay Time	00:00:30
CONDUCTIVITY		Normal Operation	
NOTE: Conductivity Limits are set in each Feed Recipe			
pH Shutdown Thresholds		Status	Normal Operation
		pH Reading	7.00 pH
		Feed: Target pH	6.50 pH
		pH Guard Reading	7.00 pH
Stop If pH Below Target by	1.00 pH	00:00:00	
Stop If pH Above Target by	1.00 pH	00:00:00	
Stop If pH Deviates From Guard by	0.50 pH	00:00:00	
Resume Control when pH Reading Okay			
pH Control is Independent of Temperature			
Temperature Shutdown Thresholds		Status	
		Temperature Reading	21.67 °C
		Temperature Guard Reading	21.67 °C
Stop If Temperature Below	15.00 °C	00:00:00	
Stop If Temperature Above	40.00 °C	00:00:00	
Stop If Temperature Deviates From Guard	1.00 °C	00:00:00	
Resume Control when Temperature Reading Okay			

This section is used to define the conditions for halting dosing based on pH and temperature readings. These settings apply to all recipes, default feeds and clear water. Separate EC shutdown settings are located in the individual **Feed Recipes**.

The **Stopped Alarm Priority** setting lets you select the type of alarm priority to generate when one or more of the above STOP conditions are triggered. The **Stop Delay Time** is used to set a delay before stopping the injector. This is used to avoid nuisance shutdowns caused by temporary or transient sensor readings.

Stop Thresholds

Set the high, low, and optional guard probe deviation limits for pH and Temperature. If the measured reading exceeds these amounts the injector stops. If a **Stopped Alarm Priority** is set, an alarm is triggered after the **Stop Delay Time**.

For pH injection, once the stop condition has cleared, you can have the injector:

Resume Control when pH Reading Okay or
Remain STOPPED until Manually Cleared

You can also decide whether temperature deviations should:

STOP pH Control if STOPPED for Temperature or
pH Control is Independent of Temperature

For temperature deviations you can have the injector:

Remain STOPPED until Manually Cleared or
Resume Control when Temperature Reading Okay

Stabilization Delay

Stabilization Delay Time	00:00:30	Stabilization Status	Stabilizing
Stabilization Timer	00:00:24		Flow Detected
Stabilization Delay Status			
Stabilization Flow Watchdog Time	10 Sec		
Stabilization Flow Watchdog Timer	0 Sec		

This optional section lets you define a startup stabilization time, during which, the alarm shutdown readings and Feedback Correction values on the recipe screens are ignored. While stabilizing the alarm limits timers are not allowed to increment. This allows longer term problems to shut down the feed, but short-term stabilization issues are ignored. The **Stabilization Delay Time** setting should set long enough to avoid nuisance shutdowns, but short enough to catch serious problems.

The stabilization feature is triggered whenever there is no flow for more than the **Stabilization Flow Watchdog Time** setting. As soon as flow is detected, the stabilization Timer begins to count down.

Synchronized Output Groups

These values are usually set by Argus technicians during system setup and commissioning. They are used to set up the pulse **Output Period** when using synchronized outputs.

Synchronized outputs deliver their nutrients sequentially, one output at a time. This ensures that the injected concentrates are introduced into the water stream separately, reducing the likelihood of chemical reactions that might cause precipitate problems. Since each concentrate is injected in sequential pulses rather than continuously, a momentary 'striping' or 'ripple' effect is produced that must be compensated for in the overall system design so that by the time the nutrients reach the plants they are uniformly mixed. Generally, the smaller the output period, the smaller the ripple. However, each time an output is turned on and off the overall accuracy of injection is affected by flow disturbances that occur from opening and closing the valve. These flow disturbances are a function of the valve design and the relative volume that is being delivered.

The **Output Period** is the maximum amount of time needed to activate all of the valves in sequence. The system then uses this value to calculate on times for each of the valves. The **Total On Time** should not exceed the **Output Period**. There are specific alarms in the Alarms section of this program to monitor this. Generally, the **Output Period** should be the smallest time interval that can accommodate all of the outputs.

The **Synchronized Output Groups** are used to ensure that the members within the group do not overlap their total output pulse times.

Synchronized Output Groups				
	Output Period	Gap Interval Between Outputs	Total On Time	Output Count
Synchronization Group 1	1.00 Seconds	0.00 Sec	0.50 Sec	4
Synchronization Group 2	1.00 Seconds	0.00 Sec	0.00 Sec	0
Synchronization Group 3	1.00 Seconds	0.00 Sec	0.00 Sec	0
Synchronization Group 4	1.00 Seconds	0.00 Sec	0.00 Sec	0
Synchronization Group 5	1.00 Seconds	0.00 Sec	0.00 Sec	0
Synchronization Group 6	1.00 Seconds	0.00 Sec	0.00 Sec	0

NUTRIENT CONTROL PROGRAMS

There are 6 possible output pulse groups and each group only manages synchronization of the injectors it contains. Most injector systems that require output synchronization only needs 1 or 2 separate groups.

The menu entry for a synchronization group opens the following screen:

Synchronization Group 1	
Synchronization Group 1 Pulse Output Period	1.00 Seconds
Synchronization Group 1 Gap between Outputs	0.00 Sec
Debug: Synchronization Group 1 Injection Period Timer	0.00 Sec
Debug: Synchronization Group 1 Number Of Outputs	6
Debug: Synchronization Group 1 Last Output	0
Debug: Synchronization Group 1 Calculated Total Time	0.68 Sec
Debug: Synchronization Group 1 Period Number	239
Synchronization Group 1 Box Score: Bad Setup, Unable To Use Minimum Gap	0
Synchronization Group 1 Box Score: Bad Setup, Minimum On Times exceed Period	0

There are only 2 settings required for the Synchronization Group; the Pulse Output Period and the Gap between Outputs.

The **Output Period** value can be set to 1, 2, 3, 4 or 5 seconds.

The **Gap Between Outputs** can be set from 0.00 to 5.10 seconds in 0.02 second increments. In most cases the Gap between Outputs is not required as the Injection system automatically maximizes the time between the Outputs during each injection period. Gaps should only be set if the injection system requires a 'recovery period' between each injection to optimize injection accuracy.

Since it contributes to the **Total On Time**, the gap time should be set low enough so that the total of the minimum on times for the outputs within the group, plus the gap time, multiplied by the number of outputs within the group does not exceed the **Pulse Output Period**.

External Stop Input

This feature is used to halt injection due to externally configured conditions.

External Stop	Status	Injection Stop Not Active
Injection Stop	Non-Zero	
Address	Controller 2; H1; External Stop Logic; Final Output Position	
Active State	Active when Zero	Reading Watchdog 0 Sec

For example, a typical application may need to stop the Injection System if the Expected Conductivity differs from the Measured Conductivity for a sufficient amount of time while feeding. This is an example of an independent safety check intended to catch a multitude of possible errors or failures that could produce possibly dangerous overdosing.

Other shutdowns could result from pressure problems or high temperature problems. These external safety tests can be configured using sensors connected to the Argus system and an **Equations** program. The final result of these external tests is used as the **Injection Stop** value.

When the injection Stop is **Active**, **all nutrient injection is halted, including acid/base control**.

However, the Irrigation system continues to water! To disable this section, set the **Injection Stop** to **[Not Used]**

Note: each **Stock Tank** also contains an individual **Stock Ready External Pointer** that can be used to halt injection if there is a problem with the supply of stock solution from individual tanks.

Recipe Calculation Rules

The Recipe Calculation Rules control the element calculation order when Automatic Injection Volume Calculation routines are used in **Feed Recipes** programs. There are 4 modifiable lists and one pre-defined default list.

These rule lists are common to all Feed Recipes programs assigned to this Nutrient Injection program.

The following screen shows a specific evaluation hierarchy for rules list 1. The other three rules lists are not used in this example.

Recipe Calculation Rules				
This screen is used to specify the order in which elements are calculated.				
	Rules List 1	Rules List 2	Rules List 3	Rules List 4
1	Calcium	Not Used	Not Used	Not Used
2	Magnesium	Not Used	Not Used	Not Used
3	Phosphorus	Not Used	Not Used	Not Used
4	Potassium	Not Used	Not Used	Not Used
5	Nitrogen	Not Used	Not Used	Not Used
6	Sulphur	Not Used	Not Used	Not Used
7	Iron	Not Used	Not Used	Not Used
8	Manganese	Not Used	Not Used	Not Used
9	Boron	Not Used	Not Used	Not Used
10	Copper	Not Used	Not Used	Not Used
11	Zinc	Not Used	Not Used	Not Used
12	Molybdenum	Not Used	Not Used	Not Used
13	Chloride	Not Used	Not Used	Not Used
14	Not Used	Not Used	Not Used	Not Used
15	Not Used	Not Used	Not Used	Not Used
16	Not Used	Not Used	Not Used	Not Used

The **Default Rules** hierarchy is:

- 1 Calcium
- 2 Phosphorous
- 3 Potassium
- 4 Nitrogen
- 5 Magnesium
- 6 Sulphur
- 7 Chloride
- 8 Iron
- 9 Manganese
- 10 Boron
- 11 Copper
- 12 Zinc
- 13 Molybdenum
- 14 Element A
- 15 Element B
- 16 Element C

NUTRIENT CONTROL PROGRAMS

Alarms

Alarms

Clear Latched Alarms

Local Alarm Priorities

CRC Okay

Stock Tank Alarms

Tank	Pulse Output Setup Fault	Input Accumulator	Output Accumulator
	Alarm Priority	Status	Status
1 20-10-20	Level #1	Okay	Module
2 Nursery		Okay	Module
3 CANO3		Okay	Module
4 KNO3		Okay	Module
5 KSO4		Okay	Module
6 NH4NO3		Okay	Module
7 MGSO4		Okay	Module
8 Iron		Okay	Module
9 Mn		Okay	Module
10 B		Okay	Module
11 Cu		Okay	Module
12 Zn		Okay	Module
13 Mo		Okay	Module
14 KH2PO4		Okay	Module
Acid Acid		Okay	Module
Stock Tanks Shutdown Status			
Default Feed Status			
Requested Feed Recipe Status Okay			

pH & Temperature Shutdowns

	Low	High	Deviation from Guard	Stopped Alarm Priority	Level #1
Acidity (pH)					
Temperature					

Synchronized Outputs Alarms

Alarm Priority	Module	Setup Faults
		Unable To Use
		Minimum Gap
		Minimum On Times
		Exceed Period
Synchronization Group 1		0
Synchronization Group 2		0
Synchronization Group 3		0
Synchronization Group 4		0
Synchronization Group 5		0
Synchronization Group 6		0

The Nutrient Injection program includes management alarms for monitoring the **Stock Tank Outputs** and **Synchronized Outputs**. Alarms include:

- **Pulse Output Setup Fault**
- **Input/output Accumulator Maximum Limits**
- **pH and temperature Shutdown Alarms**
- **Stock Tank Shutdown Status**
- **Synchronized Outputs** alarms indicate when the optional **Minimum Gap** was bypassed to achieve the required output or when the **Minimum On Times** for the requested outputs in the group totaled more than the set **Output Period**.

Alarms for individual feeds, including EC shutdown alarms are in the **Feed Recipes** programs.

These alarms advise you when the normal operating capabilities of the injection system have been exceeded. In some cases, such as temperature and pH alarms, they can also cause the injector to stop dosing until the problem has been corrected.

Emergency Shutdown and Restart

The use of these shutdown and restart settings is optional. They are intended to suspend operations during power outages and to delay and shed electrical loading when power is restored by spreading the startup sequence of equipment systems over a few minutes.

If you need to configure any other conditions to halt injection use the **External Stop Input** section described on page 50.

Emergency Shutdown and Restart	
Shutdown is Active when the Reading	0.00 %
Address	Controller 2 - C2: Power Failure Sensor: Final Output Position
Cross Module Reading Request Time	30 seconds. (0)
Shutdown Threshold	Is More Than 50.00 %
If the Reading fails	Force Shutdown
When the Shutdown condition ends, wait	40 seconds before resuming program control.
Staging Delay Timer	255 seconds
Shutdown State	

This section suspends program operations while the configured shutdown condition is in effect. For example, system shutdown might be required during a power outage, when the Argus system remains running on emergency power, but control of some or all of the connected equipment may no longer be possible.

The shutdown feature suspends operations and calculations within this program without losing current values.

The **Shutdown Source** can be any numeric reading on your system. It is often assigned to a sensor channel that has been connected to a relay which is held closed by an electrical circuit. In this example, when the power fails, the circuit opens, signaling a power outage.

Whenever the **Reading** [Is More Than] or [Is Less Than] the **Threshold** setting, this section registers a [SHUTDOWN!!!] condition. If the **Shutdown Action** setting is set to [Force Shutdown], program operation is suspended. If the Shutdown Action setting is set to [Ignore Shutdown], the shutdown section is ignored (not used).

Restarting

When the Shutdown condition clears, or when the Argus controller has restarted after a power failure, it waits for the power staging delay time before allowing this control program to resume operation.

Therefore, if you enter different delay times for your controlled equipment systems you can stagger the restart timing, providing effective load management during startup, and preventing possible overload situations as all systems try to restart together.

If the **Shutdown Source Reading** fails, you can configure the system to either [Ignore Shutdown] or [Force Shutdown].

Warning: Consider the consequences of these shutdown actions carefully. If you are using emergency power generation to hold up selected equipment during power outages, these systems should be hard-wired onto backup power.

Do not use the Argus System as your sole means of load management during power outages.

Use **Alarms** and **Data Recording** to warn you of possible dangerous situations. The improper shutdown of critical equipment could have disastrous consequences if not promptly rectified.

Program Inputs

This overview screen is a summary of all of the external inputs for the nutrient program. It is used for program setup and testing. It is not required for normal operation.

Installation and Service

This section contains many parameters that are only used by Argus engineers during initial program setup and testing. It is not required for normal operation.

FEED RECIPES PROGRAM

Feed Recipes programs work with the Nutrient Injection program to accomplish automatic nutrient dosing of multiple fertilizer recipes using the same injection equipment.

Each **Feed Recipes** program can define up to eight individual nutrient recipes to be delivered by a **Nutrient Injector** program. You can use as many recipes programs as needed to define all of your recipes. Up to eight Recipes Programs can be linked to a Nutrient Injection program for a total of 64 recipes per injection system.

In **Automatic Calculation Mode**, Feed Recipes are developed using an operator entered nutrient formula. As the elemental values are entered or adjusted, the Recipes program checks the contents of the tanks in the Nutrient Injection program and calculates a mathematical injection rate achieving the desired parts per million in the dilute feed solution.

In **Manual Calculation Mode**, the operator designates the stock tanks to be used and the injection rates for each tank.

Feed Recipes Main Screen

Program Type: Feed Recipes (BETA)		Program Name: P31 Feed Recipes (BETA)	
		System Feed	
		Designation	
Feed Recipe 1	Tomatoes	Feed	1
Feed Recipe 2	20-10-20	Feed	2
Feed Recipe 3	Nursery	Feed	3
Feed Recipe 4	Feed Recipe #004	Not Used	
Feed Recipe 5	Feed Recipe #005	Not Used	
Feed Recipe 6	Feed Recipe #006	Not Used	
Feed Recipe 7	Feed Recipe #007	Not Used	
Feed Recipe 8	Feed Recipe #008	Not Used	
Alarms			
Nutrient Program Assignment Pointer			
Nutrient Injection System			
Installation and Service			

The main screen of the **Feed Recipes** program displays menu entries for the eight recipe programs as well as a menu entry for **Alarms** and **Installation and Service** screens. The system feed designation readings display the current designation for each configured recipe.

In the above example the first three recipes have been configured and each has been given a designation on the system. Once this is done, to use tomato feed, all you need to do is set an **Irrigation Decision** in an **Irrigation Schedule** program to request **Feed 1**.

The **Control Overview** section on page 14 describes how this program gets into the sequence of events for nutrient injection and watering. To see the linkages between all nutrient and irrigation control programs please refer to the diagram on page 17.

Warning: The **Nutrient Program Assignment Pointer** reading is the parameter you select from a **Nutrient Injection** program to assign the recipes in this program to that injection system. **A Feed Recipes program can only operate with one Nutrient Injection program at a time.**

If more than one Nutrient Injection program has assigned the same Feed Recipes program, a **Level 1** alarm priority is activated and the alarm label [**Assigned to Multiple Nutrient Injection Programs**] is displayed:

Alarms	Level 1
Nutrient Program Assignment Pointer	
P39 Nutrient Injection (BETA)	
Assigned to Multiple Nutrient Injection Programs	

NUTRIENT CONTROL PROGRAMS

Feed Recipes

Select a menu entry for a **Feed Recipe** to open the following screen:

Tomatoes		Enabled		System Feed Designation Feed 1	
		Purging Not Required		Recirculated Feed	
Recipe Window					
	Target ppm	Tally ppm	Tolerance	Results	Clear Latched Alarms
Nitrogen	200.000 ppm	199.985 ppm	Within +/- 5 %	Okay	
Phosphorus	40.000 ppm	39.996 ppm	Within +/- 5 %	Okay	
Potassium	200.000 ppm	199.989 ppm	Within +/- 5 %	Okay	
Calcium	100.000 ppm	99.995 ppm	Within +/- 5 %	Okay	
Magnesium	35.000 ppm	35.003 ppm	Within +/- 5 %	Okay	
Sulphur	45.000 ppm	45.472 ppm	Don't Care		
Iron	2.000 ppm	2.000 ppm	Within +/- 5 %	Okay	
Manganese	1.000 ppm	1.000 ppm	Within +/- 5 %	Okay	
Boron	0.500 ppm	0.500 ppm	Within +/- 5 %	Okay	
Zinc	0.100 ppm	0.100 ppm	Within +/- 5 %	Okay	
Copper	0.500 ppm	0.501 ppm	Within +/- 5 %	Okay	
Molybdenum	0.010 ppm	0.010 ppm	Within +/- 5 %	Okay	
Chloride	20.000 ppm	1.333 ppm	Less Than	Okay	
Element A	0.000 ppm	0.000 ppm	Don't Care		
Element B	0.000 ppm	0.000 ppm	Don't Care		
Element C	0.000 ppm	0.000 ppm	Don't Care		
CONDUCTIVITY					
Resume Control when Conductivity Reading Okay					
STOP Delay Time 00:01:00					
STOP if 0.50 mS Below Expected Conductivity 00:00:00					
STOP if 0.50 mS Above Expected Conductivity 00:00:00					
Conductivity Reading 1.40 mS					
STOP If Deviates 0.50 mS from Guard 1.40 mS 00:00:00					
Expected Conductivity 1.50 mS					
Alarm if at Correction Maximum for more than 00:30:00 00:00:00					
Conductivity Control is Independent of pH Control					
Conductivity Control is Independent of Temperature					
pH Control is Independent of Conductivity Control					
Injection Control					
Use these settings to designate which Stock Solutions to use:					
Injection Control Automatic Calculations					
Tank	Current Amount	Feedback	Correction		
1	Automatic	0.000000 L	0.000000 L	-5.00 %	
2	Automatic	0.000000 L	0.000000 L		
3	Automatic	0.004912 L	0.004666 L		
4	Automatic	0.003702 L	0.003517 L		
5	Automatic	0.000000 L	0.000000 L		
6	Automatic	0.001835 L	0.001743 L		
7	Automatic	0.003267 L	0.003104 L		
8	Automatic	0.001404 L	0.001334 L		
9	Automatic	0.000718 L	0.000682 L		
10	Automatic	0.000228 L	0.000217 L		
11	Automatic	0.000334 L	0.000317 L		
12	Automatic	0.000655 L	0.000622 L		
13	Automatic	0.000161 L	0.000153 L		
14	Automatic	0.001623 L	0.001542 L		
Correct All					
Correct None					
Calculate Using Default Rules (rules are defined in Nutrient Injection System)					

Each feed recipe consists of a **Recipe Window**, a **Conductivity Control** window, and an **Injection Control** window.

The **Recipe Window** is used to set tolerances for the desired elemental content in the final dilute solution of the recipe. The **Target PPM** menu entry is where you define the feed formula in parts per million.

Conductivity Control is used to halt injection if the measured EC deviated from the set limits.

Injection Control is used to designate the stock tanks to be used and whether automatic calculations or manually entered injection ratios are used.

Recipe Settings

Tomatoes	Enabled	System Feed Designation	Feed 1
	Purging Not Required		Non-Recirculated Feed

At the top of each recipe window you can enter a descriptive name for the recipe. A recipe must be set to **Enabled** before it can be used by the Nutrient Injection program. You should disable the recipe temporarily while making adjustments to avoid dosing errors should this feed be called while you are in the middle of making changes. If this recipe is disabled and the Irrigation System requests it, the Nutrient Injection program use its default recipe instead of this one.

Use the **Purging** setting to specify whether injector system purging is needed **when changing to this** recipe. The purging settings are in the **Nutrient Injection** program that is linked to this Feed Recipes program (see page 42 for details).

Purging flushes out the previous feed's solution with clear water and then inject this recipe's nutrients before starting irrigation. This type of purging only applies to the injection system. Purging of shared branch lines must be done using purge valves on the irrigation system.

The **System Feed Designation** setting selects a number for this feed. Recipes are referenced by their feed number in **Irrigation Schedule** programs.

Note: there is currently no automatic checking to prevent you from doubly assigning a Feed # value. **Make sure each Feed Recipe has a unique feed number.**

The **Feed Recirculation** setting is used to designate whether or not the **Nutrient Injection** program should compensate for any nutrients in the returning water when this feed is used. When set to **Recirculated Feed**, the Nutrient Injection program compares the EC of the inlet water to the **Expected EC** value for this **Feed Recipe** (see the conductivity control section page 70).

The difference is then used to offset the amounts of each element to be injected (the program assumes that all elements are used equally).

For example, if the **Expected EC** is 2.00 ms and the returning **Inlet EC** is 1.0 ms, then the program assumes there is already 50% of the concentration required. This causes it to reduce the injected amount by 50%. Therefore, if the **Nitrogen** target is 200 ppm, the program reduces the injected amount to 100 ppm. Set this value to **Non-Recirculated Feed** if you do not wish to use inlet EC compensation.

Note: this type of EC based compensation is usually sufficient for at least a few days depending on your crop and recirculation methods. However, in the longer term, it is best to use regular lab analyses when using closed or partially closed systems to ensure that the nutrient balance is kept within acceptable tolerances.

NUTRIENT CONTROL PROGRAMS

Recipe Window

Recipe Window				
	Target ppm	Tally ppm	Tolerance	Results
Nitrogen	200.000 ppm	199.997 ppm	Within +/- 5 %	Okay
Phosphorus	40.000 ppm	39.997 ppm	Within +/- 5 %	Okay
Potassium	200.000 ppm	200.012 ppm	Within +/- 5 %	Okay
Calcium	120.000 ppm	120.007 ppm	Within +/- 5 %	Okay
Magnesium	35.000 ppm	35.000 ppm	Within +/- 5 %	Okay
Sulphur	45.000 ppm	46.700 ppm	Don't Care	
Iron	2.000 ppm	2.001 ppm	Within +/- 5 %	Okay
Manganese	1.000 ppm	1.000 ppm	Within +/- 5 %	Okay
Boron	0.500 ppm	0.500 ppm	Within +/- 5 %	Okay
Zinc	0.100 ppm	0.100 ppm	Within +/- 5 %	Okay
Copper	0.500 ppm	0.500 ppm	Within +/- 5 %	Okay
Molybdenum	0.010 ppm	0.010 ppm	Within +/- 5 %	Okay
Chloride	20.000 ppm	2.000 ppm	Less Than	Okay
Element A	0.000 ppm	0.000 ppm	Don't Care	
Element B	0.000 ppm	0.000 ppm	Don't Care	
Element C	0.000 ppm	0.000 ppm	Don't Care	
Expected Conductivity				1.50 mS
Clear Latched Alarms				
Recipe Tolerance Alarm				
Okay				

Note: if you intend to use manual **Injection Control** for this feed you can ignore this section. This would be appropriate if the feed is derived from a single bag source such as a 20-10-20. In such cases you can simply direct the recipe injection program to use a fixed injection ratio from the selected stock tank. An example of this type of setup is shown on page 67.

The recipe window consists of a table of columns and a menu entry for setting elemental targets. Elements A, B, and C can be used to set targets for any other materials you wish to administer. In the above example, a recipe for feeding tomatoes has been produced from the **Target ppm** screen and the available nutrients in the **Stock Tanks** of the linked **Nutrient Injection** program.

The **Target ppm** column displays the currently calculated desired or target elemental constituent values based on settings entered in the **Target ppm** screen.

The **Tally ppm** column displays the calculated ppm values based on the Injection Volume. This is what the Nutrient Injection program can currently provide from its enabled stock tanks using the current recipe calculation rules.

The **Tolerance** column is used to set the amount of difference that is acceptable between the Target and Tally ppm values. Settable values include:

- [Don't Care]
- [Greater Than]
- [Less Than]
- [Within +/- 1 %] to [Within +/- 100%]

The **Results** column displays the results of the Tolerance check.

Displayed values are:

- [Okay]
- [Was Low] - Indicates a previous fault that has now been corrected
- [Was High] - Indicates a previous fault that has now been corrected
- [Was Hi/Lo] - Indicates that the element has been both too high and too low since the last time the result messages were cleared.
- [Fault: High] – Indicates that the current settings results in a higher injection amount for this element than specified. You may need to change the injection and tank specifications.
- [Fault: Low] – Indicates that the current settings results in a higher injection amount for this element than specified. You may need to change the injection and tank specifications.
- [Fault: Set Amount] – This fault occurs if one or more of the Tank settings in the Injection control section is set to either **Get Exactly** or **Get At Least** xxx of a specified element, and in doing so, it forces another element from the same stock tank to exceed the specified tolerances.
- [(blank)] if the Tolerance is set to [Don't Care].

Use the [Clear Latched Alarms] setting to clear all past warnings and alarms in the program.

The **Expected Conductivity** is the conductivity amount that the final diluted feed solution should read. This value is calculated using the optional Scaling and Conductivity settings values found on the **Target ppm** screen.

The **Recipe Tolerance Alarm** shows the current alarm status using the set alarm priority found on the Alarms screen.

NUTRIENT CONTROL PROGRAMS

Target PPM

Target ppm				
	External Value External Setup	Start/Low Limit/Target	End/High Limit	Target ppm
Nitrogen	Not Used	Target 200.000 ppm	Not Used 150.000 ppm	200.000 ppm
Phosphorus	Not Used	Target 40.000 ppm	Not Used 30.000 ppm	40.000 ppm
Potassium	Not Used	Target 200.000 ppm	Not Used 150.000 ppm	200.000 ppm
Calcium	Not Used	Target 100.000 ppm	Not Used 140.000 ppm	100.000 ppm
Magnesium	Not Used	Target 35.000 ppm	Not Used 30.000 ppm	35.000 ppm
Sulphur	Not Used	Target 45.000 ppm	Not Used Not Used	45.000 ppm
Iron	Not Used	Target 2.000 ppm	Not Used Not Used	2.000 ppm
Manganese	Not Used	Target 1.000 ppm	Not Used Not Used	1.000 ppm
Boron	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Zinc	Not Used	Target 0.100 ppm	Not Used Not Used	0.100 ppm
Copper	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Molybdenum	Not Used	Target 0.010 ppm	Not Used Not Used	0.010 ppm
Chloride	Not Used	Target 20.000 ppm	Not Used Not Used	20.000 ppm
Element A	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element B	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element C	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm

Conductivity & pH Targets		EC Start 1.50 mS	EC End 1.25 mS	Target EC 1.50 mS
pH Modifier (Feedback) 1.60 %				Target pH 6.50 pH
Address Controller 2; NUTGRP; pH Correction PID Equations; Feed 1 pH Corr		Ratio of Water to Acid		2500 :1

Scaling	
Reading NOT USED	No Scaling Pointer
Address	
Start NOT USED	End NOT USED

Notes:

- If an External Value is used it will override any Scaled values for that Element and the Settings become Low and High Safety Limits.
- The Optional Scaling values apply to all Elements (unless they are using an External Value).
- If you do not wish to use a range, set the End/High Limit values to NOT USED.

This is where you set the recipe targets and limits. This screen is used to develop your target values.

Note: There is no guarantee at this point that the program can prepare the required recipe to produce this feed from the available stock concentrates.

Once you have entered your targets, the program examines the contents of the enabled stock concentrate tanks and reports back in the **Results** column on the main screen for the recipe. The ability of the injector to prepare and deliver the recipe depends on the materials that are in the concentrate stock tanks and the concentrations/volumes of nutrient solution that are required.

Setpoints can be entered locally in the two settings columns or they can be obtained from external sources in the optional **External Value** column. The values entered into the settings columns have different meanings depending on the way the targets are being defined. The reading labels to the left of each settings column change according the method being used to derive each target (see below).

Conductivity and pH Targets

Conductivity and pH Targets settings are used to calculate the Target EC and pH of the final solution.

Select [[Ratio of Water to Acid](#)] or [[Ratio of Water to Base](#)] to designate either base or acid addition for this recipe. Enter an injection ratio for the designated pH concentrate. The optional **pH Modifier (Feedback)** is used for applying pH feedback correction from an external **PID Equations** program. The difference between the pH reading at the injector outlet is compared against the current target pH and a correction (if any) is applied.

This value is then used in the **Nutrient Injection** program to modify the pH injector output.

Note: The Feed Recipes program contains native PID equations for EC feedback correction (see page 80), but you must use an External PID Equation if you want to correct pH in a similar manner.

Scaling

The optional **Scaling** section is used to increase or decrease the target values over a defined Start and End range based on a selected scaling value (i.e. parts per million).

Target PPM Column

The **Target ppm** column displays the results.

There are three available methods for creating the Target ppm values:

1. Single settings
2. Scaled settings
3. External settings

These modes can be selected separately for each element.

NUTRIENT CONTROL PROGRAMS

Single (Absolute) Settings

Target ppm				
	External Value External Setup	Start/Low Limit/Target	End/High Limit	Target ppm
Nitrogen	Not Used	Target 200.000 ppm	Not Used 150.000 ppm	200.000 ppm
Phosphorus	Not Used	Target 40.000 ppm	Not Used 30.000 ppm	40.000 ppm
Potassium	Not Used	Target 200.000 ppm	Not Used 150.000 ppm	200.000 ppm
Calcium	Not Used	Target 100.000 ppm	Not Used 140.000 ppm	100.000 ppm
Magnesium	Not Used	Target 35.000 ppm	Not Used 30.000 ppm	35.000 ppm
Sulphur	Not Used	Target 45.000 ppm	Not Used Not Used	45.000 ppm
Iron	Not Used	Target 2.000 ppm	Not Used Not Used	2.000 ppm
Manganese	Not Used	Target 1.000 ppm	Not Used Not Used	1.000 ppm
Boron	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Zinc	Not Used	Target 0.100 ppm	Not Used Not Used	0.100 ppm
Copper	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Molybdenum	Not Used	Target 0.010 ppm	Not Used Not Used	0.010 ppm
Chloride	Not Used	Target 20.000 ppm	Not Used Not Used	20.000 ppm
Element A	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element B	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element C	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm

Conductivity & pH Targets		EC Start 1.50 mS	EC End 1.25 mS	Target EC 1.50 mS
pH Modifier (Feedback)	1.60 %	Target pH 6.50 pH		
Address Controller 2; NUTGRP; pH Correction PID Equations; Feed 1 pH Corr		Ratio of Water to Base/Acid 2500 :1		

Scaling	
Reading NOT USED	No Scaling Pointer
Address	
Start NOT USED	End NOT USED

Notes:

- If an External Value is used it will override any Scaled values for that Element and the Settings become Low and High Safety Limits.
- The Optional Scaling values apply to all Elements (unless they are using an External Value).
- If you do not wish to use a range, set the End/High Limit values to NOT USED.

In this mode you define an exact target value for each element that do not need automatic adjusting to compensate for changing conditions such as the available light. Set the optional **Scaling Reading** to [Not Used] and set the **External Values** to [Not Used].

This method lets you create an exact recipe with no variations due to shifting external factors such as light levels, and no allowance for variations in the raw ingredients.

All the settings in the **Start/Low Limit/ Target** window become the absolute **Targets** and any settings in the **End / High Limit Window** are ignored [Not Used] (see above).

In this mode, only the **EC Start** value is used for optional feedback control. The **EC End** value is ignored. The **Target EC Reading** shows the expected EC based on the EC Start value.

Enter a **Target pH** for this feed and the **Ratio of Water to Acid/Base** that is required to achieve it. Whenever this feed is in use, the **Nutrient Control** program uses this value to inject pH concentrates as well as for optional pH correction.

NUTRIENT CONTROL PROGRAMS

Scaled Settings

Target ppm						
	External Value External Setup	Start/Low Limit/Target		End/High Limit		Target ppm
Nitrogen	Not Used	Start	200.000 ppm	End	150.000 ppm	178.000 ppm
Phosphorus	Not Used	Start	40.000 ppm	End	30.000 ppm	35.600 ppm
Potassium	Not Used	Start	200.000 ppm	End	150.000 ppm	178.000 ppm
Calcium	Not Used	Start	100.000 ppm	End	140.000 ppm	117.600 ppm
Magnesium	Not Used	Start	35.000 ppm	End	30.000 ppm	32.800 ppm
Sulphur	Not Used	Start	45.000 ppm	End	Not Used	45.000 ppm
Iron	Not Used	Start	2.000 ppm	End	Not Used	2.000 ppm
Manganese	Not Used	Start	1.000 ppm	End	Not Used	1.000 ppm
Boron	Not Used	Start	0.500 ppm	End	Not Used	0.500 ppm
Zinc	Not Used	Start	0.100 ppm	End	Not Used	0.100 ppm
Copper	Not Used	Start	0.500 ppm	End	Not Used	0.500 ppm
Molybdenum	Not Used	Start	0.010 ppm	End	Not Used	0.010 ppm
Chloride	Not Used	Start	20.000 ppm	End	Not Used	20.000 ppm
Element A	Not Used	Start	0.000 ppm	End	Not Used	0.000 ppm
Element B	Not Used	Start	0.000 ppm	End	Not Used	0.000 ppm
Element C	Not Used	Start	0.000 ppm	End	Not Used	0.000 ppm

Conductivity & pH Targets		EC Start	1.50 mS	EC End	1.25 mS	Target EC	1.39 mS
pH Modifier (Feedback)		1.60 %				Target pH	6.50 pH
Address		Controller 2; NUTGRP; pH Correction PID Equations; Feed 1 pH Corr			Ratio of Water to Acid		
					2500 :1		

Scaling			
Reading	576 W/m ²	Using Scaling Pointer	
Address	Controller 2; Broadcast Information; Integrated Outdoor Light Ene		
	Start	400 W/m ²	End
			800 W/m ²

Notes:

- If an External Value is used it will override any Scaled values for that Element and the Settings become Low and High Safety Limits.
- The Optional Scaling values apply to all Elements (unless they are using an External Value).
- If you do not wish to use a range, set the End/High Limit values to NOT USED.

This method allows the each of the desired ppm values to be varied over a specified range in proportion to changes in a shared common **Scaling Reading**.

A typical application would be to reduce the target concentrations of certain elements as the **Outdoor Light Energy** reading increases. When a scaling reading is used, the labels in the settings windows change to indicate that they are now **Start** and **End** values.

You must enter Start and End values for all elements you wish to vary and the expected **EC Start** and **EC End** values. If you do not wish to scale certain elements, simply set their End values to [Not Used].

In the above example, the targets for Nitrogen, Phosphorus, Potassium, Calcium, and Magnesium are being reduced as light levels increase between 400 W/m² and 800 W/m². All other values remain fixed. The results column displays the calculated targets in ppm and the expected target EC.

NUTRIENT CONTROL PROGRAMS

External Setting

Target ppm			
	External Value	Start/Low Limit/Target	End/High Limit
	External Setup		
Nitrogen	Not Used	Start 200.000 ppm	End 150.000 ppm
Phosphorus	Not Used	Start 40.000 ppm	End 30.000 ppm
Potassium	Not Used	Start 200.000 ppm	End 150.000 ppm
Calcium	170.000 ppm	Low Limit 100.000 ppm	High Limit 140.000 ppm
Magnesium	Not Used	Start 35.000 ppm	End 30.000 ppm
Sulphur	Not Used	Start 45.000 ppm	End Not Used
Iron	Not Used	Start 2.000 ppm	End Not Used
Manganese	Not Used	Start 1.000 ppm	End Not Used
Boron	Not Used	Start 0.500 ppm	End Not Used
Zinc	Not Used	Start 0.100 ppm	End Not Used
Copper	Not Used	Start 0.500 ppm	End Not Used
Molybdenum	Not Used	Start 0.010 ppm	End Not Used
Chloride	Not Used	Start 20.000 ppm	End Not Used
Element A	Not Used	Start 0.000 ppm	End Not Used
Element B	Not Used	Start 0.000 ppm	End Not Used
Element C	Not Used	Start 0.000 ppm	End Not Used

Conductivity & pH Targets			
EC Start	1.50 mS	EC End	1.25 mS
Target EC	1.39 mS	Target pH	6.50 pH
pH Modifier (Feedback)	1.60 %	Ratio of Water to Acid	2500 :1
Address Controller 2; NUTGRP; pH Correction PID Equations; Feed 1 pH Corr			

Scaling			
Reading	576 W/m²	Using Scaling Pointer	
Address Controller 2; Broadcast Information; Integrated Outdoor Light Ene			
Start	400 W/m²	End	800 W/m²

Notes:

- If an External Value is used it will override any Scaled values for that Element and the Settings become Low and High Safety Limits.
- The Optional Scaling values apply to all Elements (unless they are using an External Value).
- If you do not wish to use a range, set the End/High Limit values to NOT USED.

This method allows the creation of selected individual target ppm values using external programs such as Math Modules, Equations programs, or Sequencers.

Instead of declaring a fixed concentration amount, these programs can be used to vary the concentration based on some external logic. For example, you might want to vary calcium levels based on outdoor light accumulation.

For any element where an external value is used, the two local value settings become **Low Limit** and **High Limit** setpoints to prevent the external reading from producing unsafe values. In the above example, the calcium target is being varied by an external source.

When this happens, **the Scaling Values are ignored for that element** and the labels next to each settings column display [Low Limit] and [High Limit] respectively. Notice that the External value is requesting 170 ppm, but the High Limit safety setting is holding the **Target ppm** reading to 140 ppm.

The **External Setup** menu entry opens the following screen:

External Value Pointer Details		
Nitrogen		Using Local Setting
Phosphorus		Using Local Setting
Potassium		Using Local Setting
Calcium	Controller 2 - C2; P39 Math Matrix Calcium Target; 32-bit Result	Using Pointer
Magnesium		Using Local Setting
Sulphur		Using Local Setting
Iron		Using Local Setting
Manganese		Using Local Setting
Boron		Using Local Setting
Zinc		Using Local Setting
Copper		Using Local Setting
Molybdenum		Using Local Setting
Chloride		Using Local Setting
Element A		Using Local Setting
Element B		Using Local Setting
Element C		Using Local Setting

Recipe Common Cross Module Request Time 30 seconds.

NUTRIENT CONTROL PROGRAMS

This window displays the External value status of each element. In the above example, only calcium is using an external value pointer.

The **Recipe Common Cross Module Request Time** is the amount of time to delay between requesting readings from other controllers across the System Network. This single setting is shared by all external pointers used within the recipe. It only operates if an External Value is located on another controller.

Mixed Modes

Target ppm				
	External Value	Start/Low Limit/Target	End/High Limit	Target ppm
	External Setup			
Nitrogen	Not Used	Target 200.000 ppm	Not Used 220.000 ppm	200.000 ppm
Phosphorus	Not Used	Target 40.000 ppm	Not Used 45.000 ppm	40.000 ppm
Potassium	Not Used	Target 200.000 ppm	Not Used 220.000 ppm	200.000 ppm
Calcium	Not Used	Target 100.000 ppm	Not Used 110.000 ppm	100.000 ppm
Magnesium	Not Used	Target 35.000 ppm	Not Used Not Used	35.000 ppm
Sulphur	Not Used	Target 45.000 ppm	Not Used Not Used	45.000 ppm
Iron	Not Used	Target 2.000 ppm	Not Used Not Used	2.000 ppm
Manganese	Not Used	Target 1.000 ppm	Not Used Not Used	1.000 ppm
Boron	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Zinc	Not Used	Target 0.100 ppm	Not Used Not Used	0.100 ppm
Copper	Not Used	Target 0.500 ppm	Not Used Not Used	0.500 ppm
Molybdenum	Not Used	Target 0.010 ppm	Not Used Not Used	0.010 ppm
Chloride	Not Used	Target 10.000 ppm	Not Used 60.000 ppm	10.000 ppm
Element A	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element B	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm
Element C	Not Used	Target 0.000 ppm	Not Used Not Used	0.000 ppm

Conductivity & pH Targets		EC Start 1.80 mS	EC End 2.20 mS	Target EC 1.80 mS
pH Modifier (Feedback) NOT USED		Ratio of Water to Acid		Target pH 6.50 pH
Address				

Scaling	
Reading NOT USED	No Scaling Pointer
Address	
Start NOT USED	End NOT USED

Notes:

- If an External Value is used it will override any Scaled values for that Element and the Settings become Low and High Safety Limits.
- The Optional Scaling values apply to all Elements (unless they are using an External Value).
- If you do not wish to use a range, set the End/High Limit values to NOT USED.

You can use all three element target methods together in the same recipe. In the above example, the nitrogen, phosphorus, and potassium targets are being scaled by the current Outdoor Light reading, the calcium target is **externally applied with limits**, and the rest are behaving as single setpoints because their **End/High Limits** are set to [Not Used].

Conductivity Control

CONDUCTIVITY	Resume Control when Conductivity Reading Okay		STOP Delay Time	00:01:00
STOP if	0.50 mS Below Expected Conductivity	00:00:00		
STOP if	0.50 mS Above Expected Conductivity	00:00:00	Conductivity Reading	1.40 mS
STOP If Deviates	0.50 mS from Guard	1.40 mS	Expected Conductivity	1.39 mS
Alarm if at Correction Maximum for more than	00:30:00	00:14:37		
Conductivity Control is Independent of pH Control				
Conductivity Control is Independent of Temperature pH Control is Independent of Conductivity Control				

This section is used to define threshold limits for this feed recipe that stop the injector when the measured EC reading deviates above or below the set limits or if the EC reading deviates from the optional guard sensor by more than the set limit.

Notes: Remember that stopping the injector does not stop watering unless you have specifically programmed the irrigation system to skip watering if the feed or the default feed cannot be delivered (see page 35, **Default Feed Settings**).

A conductivity or temperature shutdown is applied to each feed individually. Each feed recipe is evaluated separately for shutdown conditions. For example, Feed 1 may go into an EC shutdown but the injector can still deliver Feeds 2 and 3 since they have their own shutdown setpoints. Of course, if the shutdown condition arises from a common problem such as a sensor failure, all feeds may eventually be affected.

Once a shutdown condition occurs, select whether you want to the injector to [\[Resume Control when Conductivity Reading Okay\]](#) or [\[Remain STOPPED until Manually Cleared\]](#).

Alarm If at Correction Maximum

When using the optional **Feedback Correction** in the **Injection Control** section, you can have the program generate an alarm if the correction factor is at its maximum limit for a defined length of time. This could indicate a problem with the current settings or the concentrations in the stock tanks.

The **Stopped Alarm Priority** on the **Alarms Screen** of the Feed Recipes program lets you select the type of alarm priority to generate when one or more of the above STOP conditions are triggered (see page 70).

Stop Thresholds

Set the high, low, and optional guard probe deviation limits for Conductivity. If the measured reading exceeds these amounts, then the injector stops.

The three setting selection rules are used to define the relationship between conductivity, pH, and temperature shutdown conditions.

They define whether EC control should operate independently or whether a pH or temperature shutdown condition as defined in the Nutrient Control program (see page 41, **pH and Temperature Shutdowns**) should also result in stopping of conductivity control.

Injection Control

Injection Control
Use these settings to designate which Stock Solutions to use:
Injection Control Automatic Calculations

Tank		Current Amount		Feedback Correction	
1	Automatic	0.000000 L	*	0.000000 L	0.30 %
2	Automatic	0.000000 L	*	0.000000 L	
3	Automatic	0.007105 L	*	0.007126 L	
4	Automatic	0.003530 L	*	0.003541 L	
5	Automatic	0.000131 L	*	0.000131 L	
6	Automatic	0.000647 L	*	0.000649 L	
7	Automatic	0.003280 L	*	0.003290 L	
8	Automatic	0.001429 L	*	0.001433 L	
9	Automatic	0.000769 L	*	0.000771 L	
10	Automatic	0.000244 L	*	0.000245 L	
11	Automatic	0.000357 L	*	0.000358 L	
12	Automatic	0.000704 L	*	0.000706 L	
13	Automatic	0.000179 L	*	0.000180 L	
14	Automatic	0.001548 L	*	0.001553 L	

☒ Correct All
☐ Correct None

Calculate Using Default Rules (rules are defined in Nutrient Injection System)

The Injection Control section is used to determine a volume to be injected from the respective stock tanks that achieves the desired ppm in the dilute solution.

These volumes can be calculated dynamically by the program using either:

- [Automatic Calculations] mode.
- [Manual Calculations] mode.

Manual VS Automatic Injection Control

Manual Control mode is intended for applications where the tank contents are always mixed the same and injected at a fixed rate.

For example, if you are using an A/B type fertilizer program where both the A and B stock tanks are always injected at the same rates (i.e. 200:1) then you can select the Manual Calculations mode for this Feed to keep things simple. With manual calculations, you define the absolute injection volume of stock concentrate per liter of supply water, or the ratio of water to concentrate.

In Automatic Calculations mode, the program performs all the volumetric and ratiometric calculations **based on your targets and settings**. It decides how much to inject from each tank to achieve your recipe.

Automatic Calculations

Injection Control

Use these settings to designate which Stock Solutions to use:

Injection Control Automatic Calculations

Tank	Current Amount	Feedback Correction	0.70 %
1	Do Not Use	0.000000 L	0
2	Do Not Use	0.000000 L	0
3	Automatic	0.007105 L	0
4	Automatic	0.003530 L	0
5	Automatic	0.000131 L	0
6	Automatic	0.000647 L	0
7	Automatic	0.003280 L	0
8	Automatic	0.001429 L	0
9	Automatic	0.000769 L	0
10	Automatic	0.000244 L	0
11	Automatic	0.000357 L	0
12	Automatic	0.000704 L	0
13	Automatic	0.000179 L	0
14	Automatic	0.001548 L	0

☐ Correct All
☒ Correct None

Calculate Using Default Rules (rules are defined in Nutrient Injection System)

For **Automatic Calculations** each tank can be set to either:

- **[Automatic]** - This tank is available for use and no special preference is given to the elements in this tank during the calculations.
- **[Do Not Use]** - This tank is ignored during the calculations
- **[Get At Least xx.xx % Element]** - Adds a minimum percentage of the required ppm for a selected element. **Note:** If no other tank can provide the remaining ppm (other than a **[Use Last For: Element tank]**), the remaining ppm can be drawn from this tank.
- **[Get Exactly xx.xx% Element]** - Adds only the set percentage of the required ppm for a selected element from this tank.
- **[Use First For: Element]** - Draws from this tank before the checking any tanks that are set to **[Automatic]**, **[Get At Least]** and **[Use Last]** tanks containing the same Element. Used after any tanks designated as **[Get At Least]** and **[Get Exactly]**
- **[Use Last For: Element]** - Not used until all other sources have been tried.
- **[Ratiometric]** - Enables you to override the automatic calculations for a stock tank by entering a specific injection ratio to be used for this tank.

The above settings provide extended operator control over which stock tanks are to be used, the order that certain tanks are used, any elements of preference, and in some cases, the maximum or minimum amounts of the total element targets to be drawn from tanks.

This enables you to provide a range of declared ingredients in the stock tanks, some of which are general purpose, and others that are only to be used in certain recipes and to sort out the rules for making each specific recipe later in the feed recipes themselves.

Note: In most cases it is best to simply start with an **Automatic** setting for all the tanks you wish to draw from to create this recipe. Set the rest to **Do Not Use**. If your recipe can be achieved this way, there may be no need to use any of the other override settings to achieve your recipe specifications.

Automatic Calculation Rules

Note: This information is provided for background information only - you don't need to understand this to use the program successfully!

Due to the multi-element nature of many fertilizer compounds, for economic or horticultural reasons, it's often necessary to develop recipes by calculating the target elements in a specific order so that any preferred source ingredients are considered first.

For **Automatic Calculations** you can set and select one of the **Rules Lists** to control the order in which the elements are calculated. The Rules Lists are found in the **Nutrient Injection** program. See **Recipe Calculation Rules** page 51.

How the Recipe Program Calculates the ppm Values

To give you an idea of how automatic recipe calculation works here are the basic steps involved. You must first have completed setting up each of the stock tanks along with their element composition and concentrate strength in the **Nutrient Injection** program.

1. Go through the 14 stock tanks sequentially and calculate the volume for the set initial percentage values (Get Exactly/At Least xx.xx %) and set element.
2. Verify that the initial percentage values haven't caused any of the elements to tally up to more than the target ppm. If they have zero all the output volume values and alarm.
3. Using the element order set in the **Rules List**, go through and calculate, element by element, the following:

Step 3a: Scan through the 14 stock tanks, in order, looking for the current element and any [\[Use First For\]](#) declarations. If found, calculate the volume to produce the desired ppm for the element and add it. Tally up the ppm and determine if any of the co-constituent elements exceed their respective target ppm values, if they haven't, start on the next element, if they have, scale back the amount of volume added to accommodate all the elements in the stock tank.

Step 3b: Scan through the 14 stock tanks, in order, looking for the current element and [\[Automatic\]](#) declarations. If found, calculate the volume to produce the desired ppm for the element and add it. Tally up the ppm and determine if any of the co-constituent elements exceed their respective target ppm values, if they haven't, start on the next element, if they have, scale back the amount of volume added to accommodate all the elements in the stock tank.

Step 3c: Scan through the 14 stock tanks, in order, looking for the current element and [\[Get At Least\]](#) declarations. If found, calculate the volume to produce the desired ppm for the element and add it. Tally up the ppm and determine if any of the co-constituent elements exceed their respective target ppm values, if they haven't, start on the next element, if they have, scale back the amount of volume added to accommodate all the elements in the stock tank.

Step 3d: Scan through the 14 stock tanks, in order, looking for the current element and [\[Use Last For\]](#) declarations. If found, calculate the volume to produce the desired ppm for the element and add it. Tally up the ppm and determine if any of the co-constituent elements exceed their respective target ppm values, if they haven't, start on the next element, if they have, scale back the amount of volume added to accommodate all the elements in the stock tank.

4. Scan for elements not in the rules list, go through and calculate element by element using Steps 3a to 3d.

Notes: 1) Disabled Tanks are ignored in all calculations
 2) Elements that have tolerances declared as [Less Than xxx] do not actively add volume.

Example – Calculating for Phosphorous:

Suppose there are 3 tanks that contain phosphorus. Tank 4, tank 12, and tank 14.

They are set as follows:

- **Tank 4** [Get Exactly 25% Phosphorous]
- **Tank 12** [Use Last For Phosphorus]
- **Tank 14** [[Get at Least 50% Phosphorous]

Step 1

Suppose Stock Tank 4 is set to [Get Exactly 25% Phosphorous].

The program looks up the current ppm target for phosphorous and subtracts the entered water composition value (in the **Nutrient Injection** program) and calculates 25% of this difference:

{40 ppm – 0 ppm = 40 ppm}

{25% of 40 ppm = 10 ppm from stock tank 4}

Phosphorous is 23% (dry weight) of Monopotassium Phosphate which is mixed in tank 4 at 0.1 Kg per Liter.

Use the following formula to determine the volume to inject into a final volume of one Liter to produce the desired ppm concentration:

$$L = \frac{\text{ppm} \times 1 \text{ L}}{\frac{\text{total dry weight}}{\% \text{ element dry} \times \text{final volume}}}$$

$$L = \frac{10 \text{ ppm} \times 1 \text{ L}}{\frac{0.1 \text{ Kg}}{23\% \times 1 \text{ L}}} = 0.000435 \text{ L}$$

Step 2

Stock Tank 14 contains Phosphoric Acid and is set to [\[Get at Least 50% Phosphorous\]](#).

The program looks up the current ppm target for phosphorous and subtracts the entered water composition value (in the Nutrient Injection program) and takes 50% of this difference.

{40 ppm – 0 ppm = 40 ppm}

{50% of 40 ppm = 20 ppm from stock tank 14}

Phosphorous is 22.6% (by weight) of the Phosphoric Acid which is mixed as 0.1Kg per Liter.

$$L = \frac{20 \text{ ppm} \times 1 \text{ L}}{0.1 \text{ Kg} \times 22.6\%} = 0.000885 \text{ L}$$

Step 3

The calculation program then scans through all the tanks looking for any containing Phosphorous.

None of the tanks containing phosphorus are set to [\[Use First For\]](#) or [\[Automatic\]](#) but tank 14 is set to [\[Use At Least\]](#) so it is reprocessed and allowed to make up the remaining 10 ppm required with a final volume of 0.001327 L.

Note that Tank 12 is set to [\[Use Last for Phosphorous\]](#) but the demand is satisfied by Tank 14 before Tank 12 is scanned.

If Tank 14 were to go off-line or be disabled Tank 12 would be used to make up the required amount of Phosphorous. In other words, with the 'Use Last' setting, Tank 12 is only used if phosphorous cannot be obtained from any other tank.

Manual Calculations

Injection Control
Use these settings to designate which Stock Solutions to use:
Injection Control **Manual Calculations**

Tank	Injection Amount	Adjust	Amounts	Current Amount	Feedback	Correction
1	Ratiometric Volume 1000 :1	☐		0.001000 L	☐	0.001000 L
2	Injection Volume 0.001000 L	☐		0.001000 L	☐	0.001000 L
3	Do Not Use	☐		0.000000 L	☐	0.000000 L
4	Do Not Use	☐		0.000000 L	☐	0.000000 L
5	Do Not Use	☐		0.000000 L	☐	0.000000 L
6	Do Not Use	☐		0.000000 L	☐	0.000000 L
7	Do Not Use	☐		0.000000 L	☐	0.000000 L
8	Do Not Use	☐		0.000000 L	☐	0.000000 L
9	Do Not Use	☐		0.000000 L	☐	0.000000 L
10	Do Not Use	☐		0.000000 L	☐	0.000000 L
11	Do Not Use	☐		0.000000 L	☐	0.000000 L
12	Do Not Use	☐		0.000000 L	☐	0.000000 L
13	Do Not Use	☐		0.000000 L	☐	0.000000 L
14	Do Not Use	☐		0.000000 L	☐	0.000000 L

Conductivity For Set Amounts 1.50 mS
☐ Adjust All
☐ Adjust None
☐ Correct All
☐ Correct None
5.10 %

For Manual Calculations set each tank to either:

- **[Do Not Use]**
- **[Ratiometric Volume]** – Sets an injection ratio of inlet water to concentrate (i.e. 1000:1)
- **[Injection Volume]** – Sets the volume of concentrate to be added per liter of inlet water

Enter the **Conductivity for Set Amounts**. In **Manual Injection** mode, the Nutrient Injection program uses this value instead of the Expected EC value for shutdown alarms, optional Feedback correction, and Inlet EC compensation.

This value is the conductivity result when the manual injection settings are used. If you do not know the conductivity to enter you should perform an independent dilution of the concentrates at the Injection Amount rates and measure the resulting EC with an accurately calibrated hand held EC meter.

Note: Alternatively, you *could* let the system determine this value for you by operating the feed with clear water on the inlet (no recirculation) and no Feedback Correction amounts enabled.

If the resulting EC, seems to be within an expected range you can enter it as the Conductivity for Set Amounts value. However, Argus recommends using the independent dilution method to ensure that all settings are correct for the injector.

The **Current Amount** column displays the volume of concentrate that is injected (before any feedback correction).

NUTRIENT CONTROL PROGRAMS

When enabled, the **Adjusts Amounts** settings makes the injector compensate for any measured inlet conductivity **while this feed is being administered**.

This is reflected in the **Current Amount** reading:

Injection Control
Use these settings to designate which Stock Solutions to use:
Injection Control **Manual Calculations**

Tank	Injection Amount	Adjust	Amounts for Inlet & Target	Current Amount	Feedback	Correction
1	Do Not Use	☐		0.000000 L	☐	0.000000 L
2	Ratiometric Volume 100 :1	☒	200 :1	0.005000 L	☐	0.000000 L
3	Do Not Use	☐		0.000000 L	☐	0.000000 L
4	Do Not Use	☐		0.000000 L	☐	0.000000 L
5	Do Not Use	☐		0.000000 L	☐	0.000000 L
6	Do Not Use	☐		0.000000 L	☐	0.000000 L
7	Do Not Use	☐		0.000000 L	☐	0.000000 L
8	Do Not Use	☐		0.000000 L	☐	0.000000 L
9	Do Not Use	☐		0.000000 L	☐	0.000000 L
10	Do Not Use	☐		0.000000 L	☐	0.000000 L
11	Do Not Use	☐		0.000000 L	☐	0.000000 L
12	Do Not Use	☐		0.000000 L	☐	0.000000 L
13	Do Not Use	☐		0.000000 L	☐	0.000000 L
14	Do Not Use	☐		0.000000 L	☐	0.000000 L

Conductivity For Set Amounts 2.00 mS

Adjust All ☐ Adjust None ☒

Inlet 1.00 mS Target 2.00 mS

Feedback Correction ☐ Correct All ☒ Correct None ☐

EC Readings FAILED

Before Compensation

Enabled

After Compensation

In the above example, Tank 2 is set for a manual **Injection Amount** of 100:1 and the **Adjust Amounts** setting has been enabled. Since the current **Inlet EC** is 1.0 and the Target is 2.0, the Nutrient Injection program only needs to inject half as much concentrate to achieve the target EC for this recipe. Therefore, the actual injection ratio has been changed to 200:1 which injects half as much concentrate.

The example below shows the identical results using an **Injection Volume** type setting:

Injection Control
Use these settings to designate which Stock Solutions to use:
Injection Control **Manual Calculations**

Tank	Injection Amount	Adjust	Amounts for Inlet & Target	Current Amount	Feedback	Correction
1	Do Not Use	☐		0.000000 L	☐	0.000000 L
2	Injection Volume 0.010000 L	☒	0.005000 L	0.005000 L	☐	0.000000 L
3	Do Not Use	☐		0.000000 L	☐	0.000000 L
4	Do Not Use	☐		0.000000 L	☐	0.000000 L
5	Do Not Use	☐		0.000000 L	☐	0.000000 L
6	Do Not Use	☐		0.000000 L	☐	0.000000 L
7	Do Not Use	☐		0.000000 L	☐	0.000000 L
8	Do Not Use	☐		0.000000 L	☐	0.000000 L
9	Do Not Use	☐		0.000000 L	☐	0.000000 L
10	Do Not Use	☐		0.000000 L	☐	0.000000 L
11	Do Not Use	☐		0.000000 L	☐	0.000000 L
12	Do Not Use	☐		0.000000 L	☐	0.000000 L
13	Do Not Use	☐		0.000000 L	☐	0.000000 L
14	Do Not Use	☐		0.000000 L	☐	0.000000 L

Conductivity For Set Amounts 2.00 mS

Adjust All ☐ Adjust None ☒

Inlet 1.00 mS Target 2.00 mS

Feedback Correction ☐ Correct All ☒ Correct None ☐

EC Readings FAILED

NUTRIENT CONTROL PROGRAMS

The **Feedback Correction** enable/disable settings are used to have the program calculate a correction value for each tank based on the measured EC of the **outlet water** (see EC Feedback Correction, page 69). The feedback correction readings show the effects of any feedback corrections:

CONDUCTIVITY		Resume Control when Conductivity Reading Okay		STOP Delay Time 00:00:00	
STOP if	0.50 mS	Below Expected Conductivity	00:00:00	Shutdown Override	00:00:00
STOP if	0.50 mS	Above Expected Conductivity	00:00:00	Conductivity Reading	1.80 mS
STOP If Deviates	0.50 mS	from Guard	1.80 mS	Expected Conductivity	2.00 mS
Alarm if at Correction Maximum for more than 00:00:00					
STOP Conductivity Control if pH Control STOPPED					
STOP Conductivity Control if STOPPED for Temperature pH Control is Independent of Conductivity Control					

Injection Control					
Use these settings to designate which Stock Solutions to use:					
Injection Control Manual Calculations					

Tank	Injection Amount	Adjust	Amounts for Inlet & Target	Current Amount	Feedback Correction
1	Do Not Use	0		0.000000 L	0.000000 L
2	Injection Volume 0.010000 L	0	0.010000 L	0.010000 L	0.009000 L
3	Do Not Use	0		0.000000 L	0.000000 L
4	Do Not Use	0		0.000000 L	0.000000 L
5	Do Not Use	0		0.000000 L	0.000000 L
6	Do Not Use	0		0.000000 L	0.000000 L
7	Do Not Use	0		0.000000 L	0.000000 L
8	Do Not Use	0		0.000000 L	0.000000 L
9	Do Not Use	0		0.000000 L	0.000000 L
10	Do Not Use	0		0.000000 L	0.000000 L
11	Do Not Use	0		0.000000 L	0.000000 L
12	Do Not Use	0		0.000000 L	0.000000 L
13	Do Not Use	0		0.000000 L	0.000000 L
14	Do Not Use	0		0.000000 L	0.000000 L

Conductivity For Set Amounts	2.00 mS	Adjust All	Correct All
Inlet	0.00 mS	Adjust None	Correct None
Target	2.00 mS	Feedback Correction	-10.00 %

EC Feedback Correction

Select the Feedback Correction menu entry in the Injection Control window to open the EC Feedback Correction screen:

Feed 1 Feedback PID Calculations	Nutrient Program Current Feed	Feed 1 Flow Detected
Reset Equation	Final Output Result	0.50 %

Error Calculation		Error Reading	0.01 mS
Conductivity Reading	1.40 mS		
Conductivity Target	1.39 mS		

Proportional Calculation		
Proportional Gain Multiplier	x	Error Reading
1.00000		0.01 mS
=		Current Proportional
		0.01 mS

Derivative Calculations Disabled		Net Filtered Error	0.01 mS
Derivative Interval	00:00:01 (00:00:01)	Last Error	0.01 mS
Derivative Gain Multiplier	1.00000	Current Derivative	0.00 mS

Error Limits		These Limits are applied to the (Proportional + Derivative) and the Integral calculations.	
Lower Limit	-1.00 mS	Current Proportional + Derivative after Limits	0.01 mS
Upper Limit	1.00 mS		

Integral Calculations		Integral Limiting Status	
Integral Anti-Windup	Enabled		
Integral Gain Multiplier	2.00000	Current Integral after Limits	0.04 mS
Sample Interval	00:00:20 (00:00:13)		

Output Scaling		Net PID Error Limit Status	
		Net PID Error after Limits	0.05 mS
As the Net PID Error changes between -2.00 mS and 2.00 mS			
Proportion the output between -20.00 % and 20.00 %			
		Final Output Result	0.50 %

Warning: be extremely careful using or adjusting these settings! If in doubt please consult Argus first. Small changes in settings can result in large changes to the injected volumes, possibly forcing the injector into a shutdown condition.

Feedback correction is optional in most circumstances. Proper setup, calibration, and tuning of the system should provide good injection results without the need for feedback control. However, it can be useful for correcting small errors in stock concentration or measured flow rates. If a large amount of feedback correction is regularly needed, this is an indication that the system is improperly configured. Please call Argus for assistance.

The feedback correction routine uses the standard Argus PID (Proportional, Integral and Derivative) calculations. These are described in detail in the **PID Equations Manual**.

EC Feedback correction can be used with either manual or automatic control. An EC sensor measures the outlet conductivity of the mixed solution and the feedback correction function compares this to the target EC. If there is any measured deviation, the feedback control function adjusts the relative injection rate to bring the measured EC back in line with the current target.

EC Feedback correction can be used on some or all of the concentrate tanks. For example, you might want to only use it for the major elements, since the EC contribution of the trace elements can't be measured anyway.

Recipe Alarms

Clear Latched Alarms In This Program		Clear Latched Alarms	
Feed Recipe 1	Tomatoes	Built Recipe Tolerance Alarms Had Fault	Conductivity Low High Deviated From Guard PID Correction At Maximum Limit Warning!!
Feed Recipe 2	20-10-20		
Feed Recipe 3	Nursery		
Feed Recipe 4	Feed Recipe #004		
Feed Recipe 5	Feed Recipe #005		
Feed Recipe 6	Feed Recipe #006		
Feed Recipe 7	Feed Recipe #007		
Feed Recipe 8	Feed Recipe #008		
Tolerance Alarm Priority		Level #1	
Recipe Stopped Alarm Priority		Level #1	
Correction Maximum Warning Alarm Priority		Level #1	
Local Alarm Priorities		Level 1	

Each **Feed Recipes** program contains **Tolerance** settings and readings (see page 52) to indicate when the respective recipe is or has been unable to provide the desired ppm values within the set tolerances. This associated **Tolerance Alarm Priority** must be set to inform you of problems. Select an alarm priority in keeping with the urgency of a tolerance alarm.

The **Conductivity** alarms indicate EC shutdown conditions (see page 61). Set an appropriate **Recipe Stopped Alarm Priority** these events.

The **PID Correction at Maximum Limit** readings indicate that feedback correction has reached its maximum allowable value. It indicates that the measured EC has deviated from the expected EC enough to trigger this alarm. For a properly tuned and configured system, PID corrections should be very small. Therefore, hitting the maximum limits could be an indication of settings problems, empty concentrate tanks, or concentrate mixing and measurement errors. Set an appropriate **Correction Maximum Warning Alarm Priority** to alert you to these events.



A C O N V I R O N C O M P A N Y

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