NuLAB and NuLAB Plus
User Manual
v1.4

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1. Introduction

The NuLAB is a multi-channel, wet chemistry sensor for the automated determination of dissolved nutrient concentrations (Nitrate plus Nitrite, Nitrite, Phosphate, Ammonium and Silicate) in aqueous samples. It can be deployed outside adjacent to bays, rivers or streams inside a waterproof enclosure, in a laboratory or in an industrial plant. Data is calibrated via an On-Board Standard (OBS) that precedes one or more samples.

The NuLAB Plus extends the regular NuLAB to include a built-in touch screen controller with Green Eyes' ComScript software that allows for graphical system setup, real time data processing, daily email updates and real-time transfer of text and graphical data files to the internet. The same controller can be used with the regular NuLAB and mounted externally to the main NuLAB unit.

2. System Architecture

The NuLAB has five main elements.

1. **Reagents and Standards** are stored in IV bags that connect to the NuLAB valve.
2. A **six port rotary valve** connects the reagents, standards, detector and sample water to the syringe
3. The **syringe** collects and dispenses precise volumes of sample water, standards and reagents for flushing and mixing activities.
4. The **colorimetric detector** LED shines filtered light through flow cells (2mm low sensitivity or 10mm high sensitivity) that is quantified by a photodiode and associated electronics.
5. During analysis, the valve, syringe and detector are all controlled by **macros**, which are text files of specific instructions loaded into the memory of the NuLAB. Each chemistry has specific macros for low sensitivity and high sensitivity detectors.

The additional parts of the NuLAB plus include:

1. A Raspberry Pi Linux based computer which serves as the NuLAB Plus and regular NuLAB **controller**
2. Green Eyes' **ComScript** software provides the user interface, the **water2web** (W2W) real-time data internet displays and email alarms.
3. Commands and configuration parameters are entered into the ComScript software via the controller with a seven-inch touchscreen.
4. The **Rii, wireless mouse and keyboard** is used for screen navigation and the entry of configuration parameters. Each Rii is paired to its USB receiver connected to the USB port of the Raspberry Pi.

5. Toggle switches and computer controlled relays with NuLAB Plus (variable with selected options) are used to operate the sample delivery pump and to power the individual analytical channels.

Fig. 1: Major elements of the NuLAB Plus and NuLAB

Reagent and Standard Bags

Colorimetric Detector

Touch Screen Controller

12 Volt Power/Comms Connection

Waste Container

Syringe

Eight Port Rotary Valve
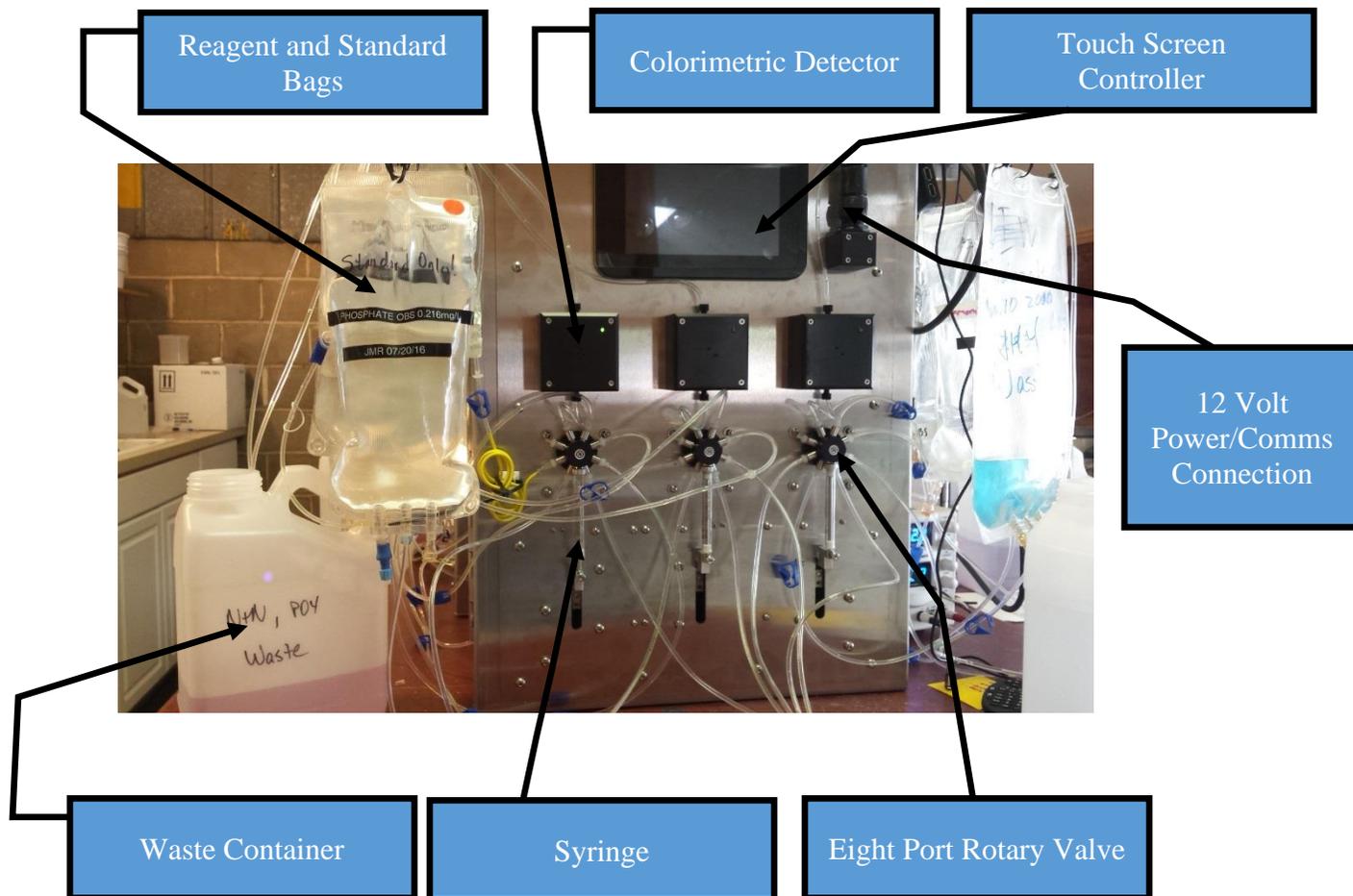
3. System Requirements

1. A 12 volt power supply for bench testing and a 12 volt battery with a 2 to 6 amp charger. Be very careful to connect the power cable leads to the correct terminals of the battery.
2. The NuLAB is not a submersible instrument so it requires a dry environment. When deployed outside, it should be fitted inside a waterproof enclosure with necessary connections for power and sample water.
3. If an existing water supply is not available, a pump (available through Green Eyes) must be used to deliver water to the sample chamber, which should remain full during both sample and OBS analysis. A mechanical check-valve or electronically operated valve placed in front of the sample chamber can be used to prevent the sample chamber from draining when the pump is turned off.
4. The Raspberry Pi Linux controller requires an internet connection to send daily emails, data files and plots to specified internet sites. The internet connection can be provided through a LAN connection, cellular modem or wifi hotspot. Note: To set up the WiFi connection, plug in the USB WiFi dongle into one of the two USB sockets on the top of the NuLAB Plus or an available usb port of the external controller. Right clicking on WiFi network icon in the upper right of the screen should show available WiFi networks. Select the correct network and enter the key/password. The controller will automatically establish a connection to the network whenever rebooted. If a key must be entered via a browser, open the web browser by clicking on the raspberry icon in the upper left of the screen. The connection page should open automatically.
5. Reagents and standards should be prepared in a proper laboratory by trained personnel. The majority of problems with the NuLAB are chemistry based and may be difficult to diagnose. While the NuLAB Plus has greatly simplified the deployment of autonomous nutrient monitors, the system still uses wet chemistry and requires **attention to details**. **Practice and patience** is necessary during initial work with the NuLAB.

4. User Control Software

The NuLAB can be controlled via a simple terminal program (Tera Term recommended) or with Green Eyes' ComScript applications running on the NuLAB controller. The controller is built-in to the NuLAB Plus and is available as an external option for the regular NuLAB. The controller uses the following three applications:

1. NuLAB_Manual – Provides manual controls for the valve, syringe and detector, and can run individual macros.
2. NuLAB_Logging – Collects and stores deployment configuration data, runs the continuous logging cycle, processes data and executes W2W functions.
3. FileTransferSetup – Collect user data for W2W file transfer to internet server during continuous operation of NuLAB_Logging.

Running NuLAB controller apps: The three apps above are opened with by clicking on respective desktop icons or by issuing text commands typed into an LX terminal window. To open the terminal, click on the computer screen icon in the upper left of the screen. When the

terminal opens, change to the ComScriptPi directory by typing the following command at the pi@raspberrypi ~ $ prompt.

pi@raspberrypi ~ $ cd ComScriptPi

then type:

pi@raspberrypi ~ /ComScriptPi $ mono ComScript.exe NuLAB_Manual

To launch the logging application type:
pi@raspberrypi ~ /ComScriptPi $ mono ComScript.exe NuLAB_Manual

Note: "_nr" which denotes no relay board, should be added to the commands for regular NuLAB (e.g. NuLAB_Manual_nr)

Text will rapidly scroll past in the LX terminal window and in a few seconds the ComScript input and output windows will open.

To open the other two apps, simply replace NuLAB_Manual with the name of the app exactly as it is listed above (e.g. mono ComScript.Mono.exe NuLAB_Logging or mono ComScript.Mono.exe NuLAB_Logging_nr for the external controller).

Helpful tip: Typing long commands such as those above on the small keyboard provided with the controller can be difficult.   Once commands are entered into the LX terminal, they are stored in the operating system's log and can be accessed easily by clicking the up and down arrow buttons of the Rii keyboard.   This way, the commands only have to be typed in correctly one time and then can be easily accessed via the arrow buttons.   Check the command log before typing any commands as they were likely stored during Green Eyes testing.

NuLAB_Manual

The NuLAB_Manual application is designed to provide a user friendly interface to test the basic functions of the valve, syringe and detector as well as to run individual macros.   After launching the app, two windows will open, NuLAB Manual Controls and NuLAB Output (Fig. 2).   Drag the NuLAB Output window to the right side of the screen so that both windows are clearly visible.

> **Note: the NuLAB windows can be resized as desired.**

NuLAB_Manual has four tabs:
> Valve:Syringe:Pump:Detector
> Macros
> Data
> Macro Upload

Fig. 2: Upper and lower views of the Valve:Syringe:Pump:Detector tab of NuLAB Manual Controls

Pump options are not included in the external controller.
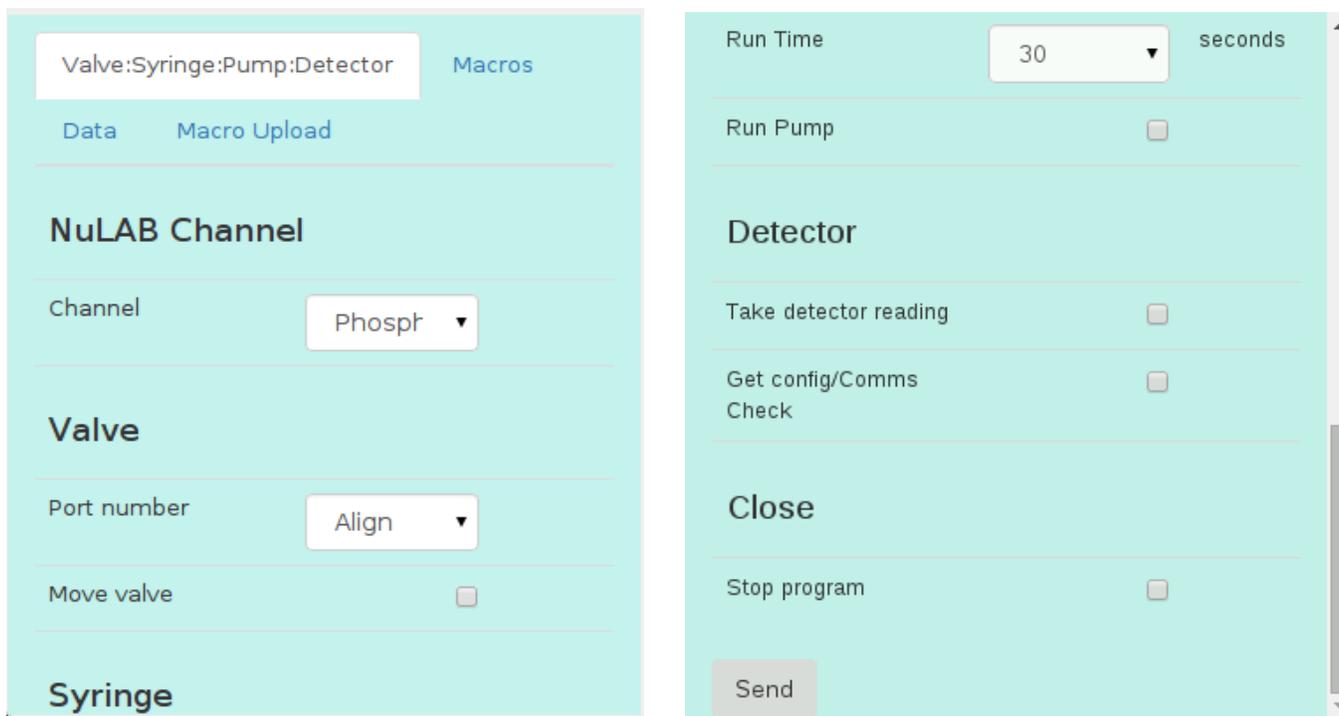
The **Valve:Syringe:Pump:Detector tab** (Fig. 2) provides basic controls of the major elements of the NuLAB. Select the desired channel and a valve, syringe or detector command then click send to have the controller issue the command to the selected NuLAB channel. A valve and syringe command can be sent at the same time with the valve command executing first. All commands begin with a communication check to the selected channel. View the System Message in the NuLAB Manual output window (Fig. 3) for feedback from the NuLAB. In addition to the System Message, detector test data and configuration information is displayed. While not necessary during automated logging operations, the

Fig. 3: NuLAB Manual input (macros tab) and output windows
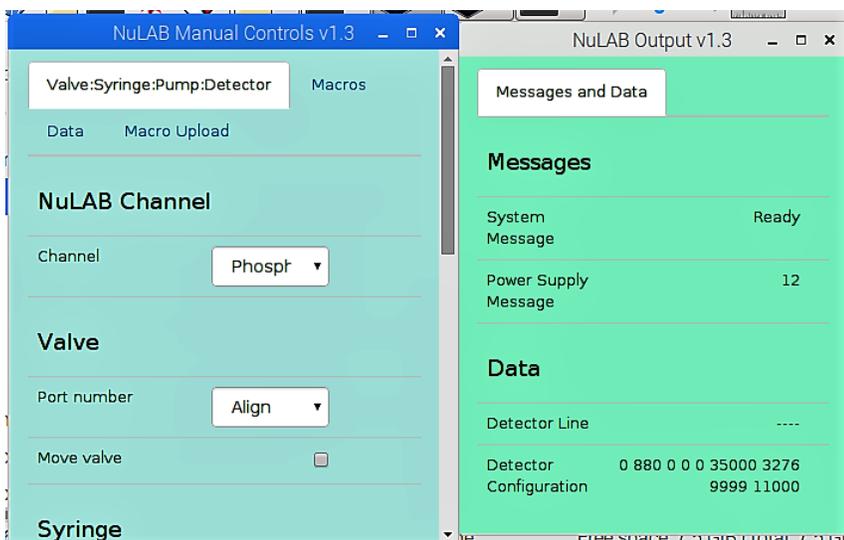
individual valve and syringe commands are useful for initial testing after setup or to flush an individual port.   This is the place to start if you are not familiar with the NuLAB.

Fig. 4: Upper and lower views of the NuLAB Manual Macros tab
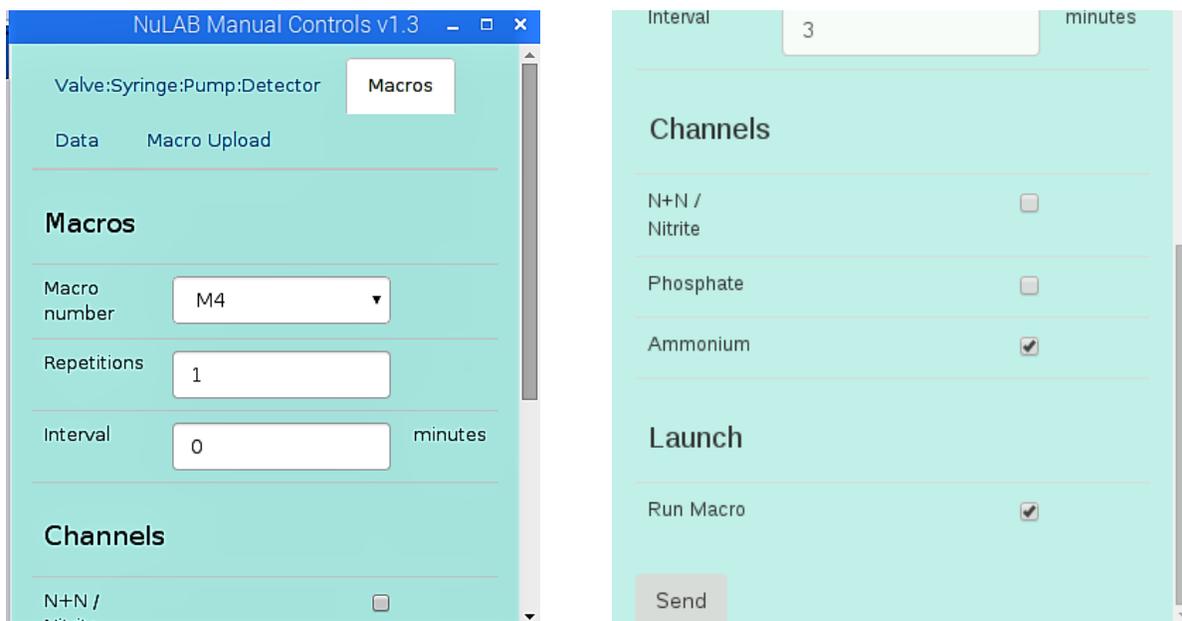
The **Macros tab** allows users to select one macro to run on up to three channels with selected interval and repetitions.   In Fig. 4, macro 3 (inlet flush) will be run two times with a three minute interval on the ammonia channel only.   Before launching a deployment in logging mode, the macros tab can be used to run reagent primes (macro 4) on all channels.   It is also necessary to run reagent blanks (macro 1 with deionized water on the inlet; macro 7 for nitrite).   The reagent blank absorbance (average of three or more replicates) can then be entered into the NuLAB_Logging app along with OBS concentration for sample concentration calculations.   It is also a convenient way to check the repeatability of the OBS, reagent blank and other standards fed through the inlet.   Green Eyes strongly recommends running a few OBS macros and insuring stable results and then running a few reagent blanks with the inlet tube connected to nutrient free water (DIW or low nutrient seawater depending on deployment water).

Data from all analysis macros can be found in the NuLAB_Manual profile directory.   To open the file browser program, click on the file manager icon in the upper left corner of the desktop.   When the browser opens, double click on the following folders and then the desired data file.

ComScriptPi >> profiles >> NuLAB_Manual (Fig. 5)

Each channel has its own data file and both N+N and Nitrite data are stored in the Nitrate_Data-M.txt file.   The files are comma separated for easy import into spreadsheet software and all raw data from the detector is included as is the calculated analysis absorbance.   Sample concentration is not calculated in the NuLAB Manual app, but can be calculated manually or in a

spread sheet if the OBS concentration, OBS absorbance and reagent blank absorbance are known.   See Green Eyes' Data Processing Guide.

The **Data tab** under NuLAB Manual is used to delete the data from each channel's MCU controller.   The MCU data buffer will be filled **after 1500 lines are collected and no new data will be stored, so it is essential that the data buffer be cleared occasionally**.   If more than 1000 lines of data are stored on the MCU, the comms check routine will write a warning to the system message in the output window that the data on the specified channel needs to be cleared which can be done easily from the data tab. In logging mode, the data buffer is cleared automatically when it exceeds 1000 lines to avoid data losses.

Fig. 5 Raspberry Pi file browser window
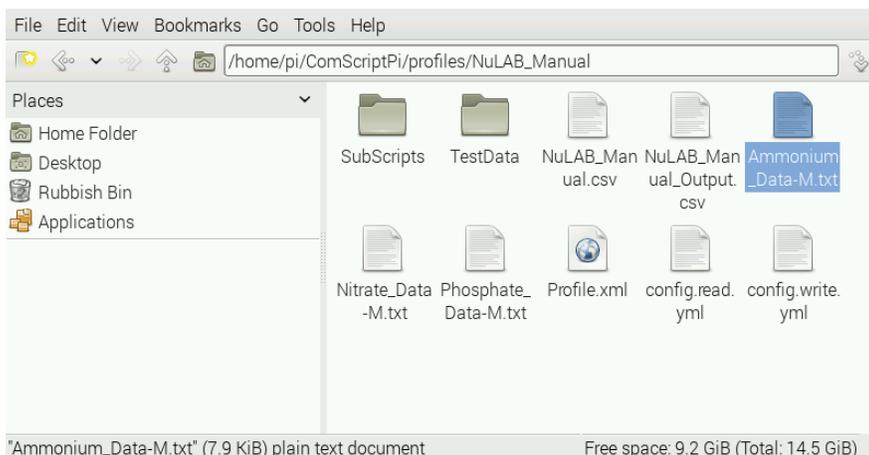
The **Macro Upload tab (Fig. 6)** allows users to upload new macros onto the MCU controller of individual NuLAB channels.   Select the macro number (1-8 see macro allocation table), the channel to upload the macro to (Nitrate, Phosphate or Ammonium) and click the Choose File button to browse to the appropriate macro text file. Macro text files are usually stored in a Macros folder under the NuLAB_Manual (NuLAB_Manual_nr) folder.   Long analysis macros may take a few minutes to upload through the relatively slow serial port.   When the macro is uploaded a "success message" will be displayed in the System Message window.

Fig. 6: Macro Upload tab
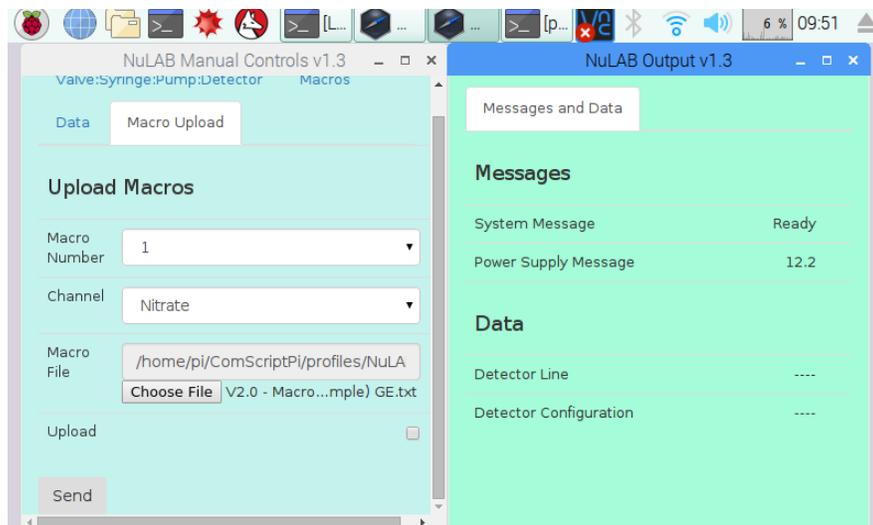
Note: The Macro Upload utility is only used to install new macros on the NuLAB and should only be used to upgrade new macros supplied by Green Eyes or to test new macros in the lab.

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NuLAB_Logging

Continuous logging setup and operation is done from the NuLAB_Logging application which, like NuLAB_Manual, has one input and output window.   The Logging app has three tabs:

> Calibration Parameters
> Alerts and File Transfer
> Logging Cycle

Reagent blank absorbance and OBS concentrations that are required to calculate sample concentration are entered in the **Calibration Parameters tab (Fig. 7)**.   The reagent blank absorbance values have no units and are collected by running DIW samples as described in the NuLAB Manual section above.   The units of the OBS concentration are selected in the calibration tab and will be written into the data file.

Fig. 7: Upper view of the Calibration Parameters tab

The **Alerts and File Transfer tab (Fig. 8)** is used to collect up to five email addresses for a daily email update that will include all text data and png plots. The email addresses must be entered without spaces or extra characters (e.g. info@gescience.com).   Under the email address text boxes in the Alerts and File Transfer tab are check boxes to turn on/off the automated file transfer (setup through the File Transfer Setup application described below) and Secure File Transfer Protocol (SFTP).

Fig. 8: Alerts and File Transfer tab

The various parameters that control how the NuLAB Plus runs the logging cycle are contained in the **Logging Cycle tab (Fig. 9)**.

Channels to Run: select individual channels (chemistries) to include in the continuous logging cycle.   Because Nitrate plus Nitrite (N+N) and Nitrite only analyses are both run on the Nitrate channel, the Nitrite specific analysis (if selected) will run after the last N+N, Phosphate, or Ammonium macro has completed.

Pump Run Time: (not included on NuLAB_Logging_nr) The number of seconds the pump will run to flush and fill the sample chamber with water.   The water travel time from the pump to the

9

sample chamber should be measured and Green Eyes recommends that the Pump Run Time be three times the measured travel time to insure proper system flushing.

Inlet Flushes per Sample: The number of times the inlet flush macro will be run to fully flush the inlet tubes, syringes and filter.   It is important to mount the sample chamber as close to the NuLAB as possible and to keep all inlet tubes as short as possible to reduce necessary inlet flushing.   Each flush routine collects 6 ml (two full syringes) from the inlet so if three channels are running the total volume pulled through the inlet filter and tubes is 18 ml.   Ideally, more than one inlet flush on each channel is not necessary, but we recommend users test required inlet flushing before commencing logging.

Fig. 9: Logging Cycle tab; upper (left), middle (center) and lower (right) views

Samples per On-Board Std.: The number of samples run after the OBS analysis (see the Logging Cycle Flow Chart in Fig. 9).   For the most accurate results, set this value to one (1) to run an OBS for each sample.

Inlet Backflush: The NuLAB can back-flush the inlet with one of the on-board reagents using a designated back-flushing macro.   This is a highly effective way to prevent clogging and bio-fouling of the filter when sampling productive or turbid water.   Check the box to enable inlet back-flushing on selected channels (checked under Channels to Run).   It is important only to enable back-flushing on one (1) channel so that chemicals are not exchanged with each other unless each channel is using its own inlet filter.   Back-flushing multiple connected inlets simultaneously will adversely affected data quality.   The nitrate channel back-flush is recommended if running nitrate analysis.   Back-flushing occurs twice daily after the 11am and 11pm analysis, and a line indicating the back-flush event including a timestamp is written into the data files.   The table below indicates the chemical used in back-flushing on each channel.

Channel	Reagent used for backflush
Nitrite	Sulfanilamide/NEDA mixed reagent
Phosphate	Molybdic Acid
Ammonium	Hypochlorite

Note: Do not enable back-flushing when sampling from a bottle or other fixed volume sample (e.g. during lab testing).

Analysis Cycle Interval: The analysis cycle interval is used to set the minutes between the start of each analysis cycle.

Samples per OBS: Set the number of sample only analysis cycles to run after the OBS and Sample analysis cycle.   If the Samples per OBS value is set at one (1), each analysis cycle will consist of one sample and one standard run within the interval.   If the Samples per OBS value is above one (1), then the analysis cycle(s) after the first will consist of only samples until the number of analysis cycles equals the Samples to OBS value.

Start Time: The controller will delay the start of logging until the specified hour and minute has arrived.   The format must be 24 hour time (military time) HH:mm (e.g. 7:30 am entered as 07:30, 2:00 pm entered as 14:00).

End Date: The numeric date when the NuLAB will stop logging.   Format must be MM/DD/YYYY (e.g. 09/08/2016 for September 8, 2016).

End Hour: The hour of the day specified in End Date to stop logging.   Format is same as start time, without the minutes (e.g. 07 for 7am).   If the End Hour arrives during an analysis cycle, the instrument will complete the cycle before stopping, so it is possible to get one data point after the End Time.

Start Logging: The "start logging" box must be checked when the send button is clicked to initiate logging.   Follow the System Messages to ensure logging has commenced or delayed as expected.

The Logging **Output Window (Fig. 10)** contains the following information:

Message: The system messages that tell you whether the commands you send are sucessfully received and executed by the instrument so that users can keep track of the instrument's operation.

Voltage (not available in all systems): The system supply voltage measured at the relay board (not present with NuLAB_Logging_nr).   **To avoid potentially catastrophic problems associated with low voltage, the controller will pause logging when the voltage drops below 11.6 and start again when it rises above 11.6.**

Latest Results: The output window also shows latest results of each chemical's On-board standard absorbance and Sample concentration.

Fig. 10: Logging Output window; upper (left), middle (center) and lower (right)
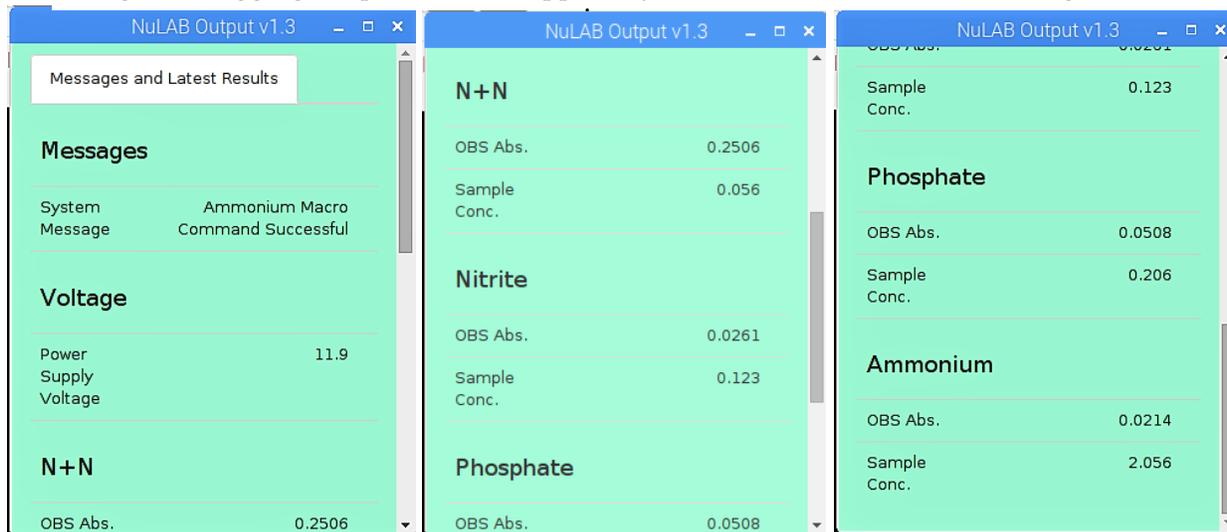
Fig. 11: NuLAB Plus logging flow chart
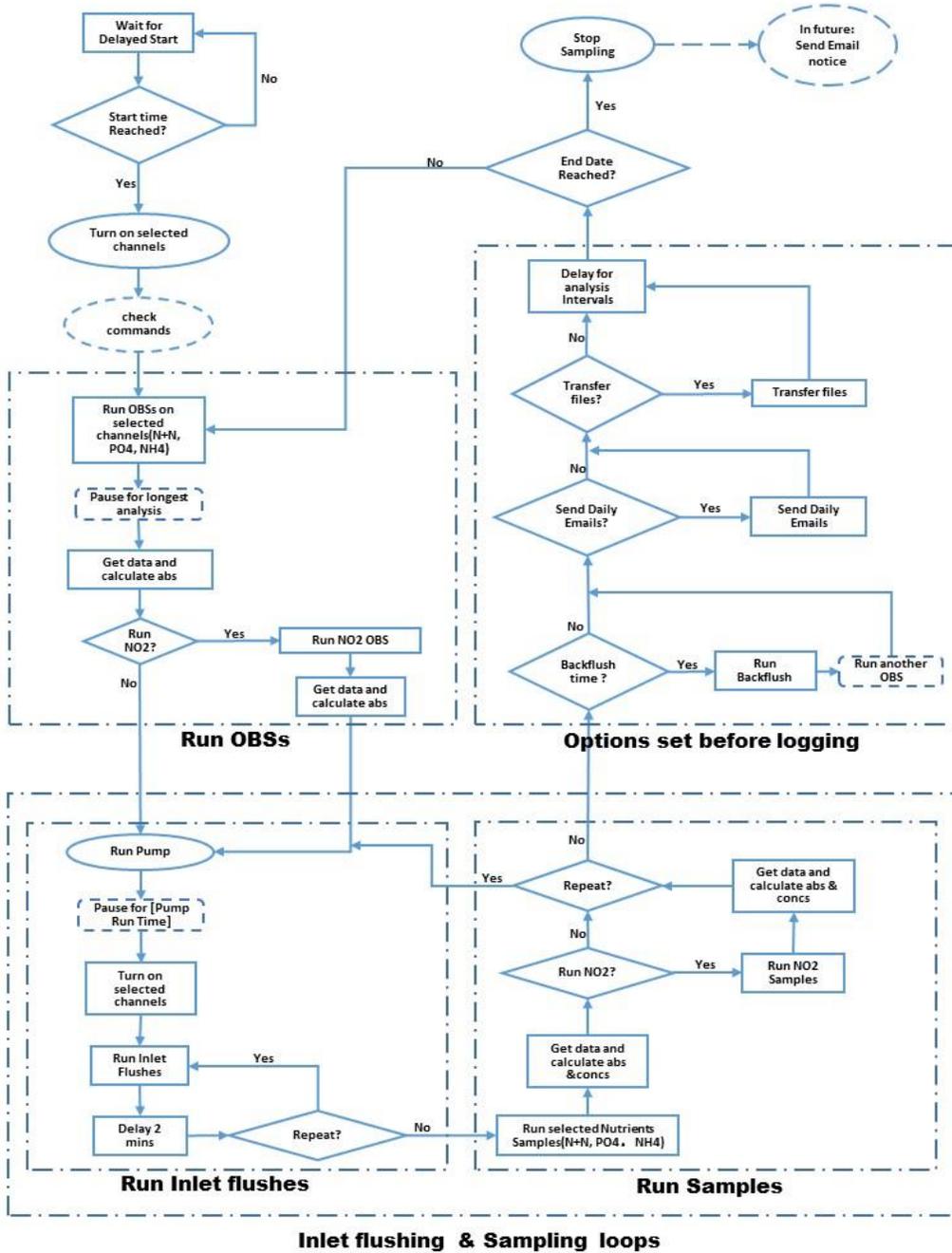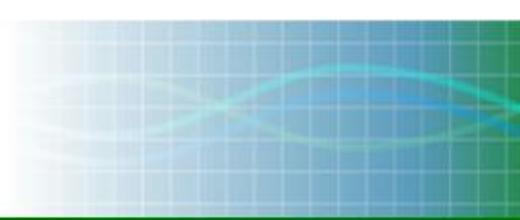
5. Terminal Connection Guide

Connecting with the **PuTTY terminal** on the Green Eyes controller:

Step 1 – Opening PuTTY: Click the home Raspberry icon and select *Internet,* then select *PuTTY.*

Step 2: Once PuTTY is open, click the serial option and change the Serial Line from "/dev/ttyS0" to "/dev/ttyUSB0" or the correct port based on the table below.

NuLAB serial port allocations

Analytical Channel	Rapsberry Pi Controller	Window Computer
Nitrate/Nitrite	USB0	Com 1 (or lowest)
Phosphate	USB1	Com 2 (or 2nd lowest)
Ammonia	USB2	Com 3 (or 3rd lowest)
Relay Board	USB3	Com 4 (or 4th lowest)
Any single Channel Unit	USB0	Com 1 (or lowest)

Step 3: Once correct address is entered into the Serial line, hit enter to open the terminal. When the NuLAB is powered, the following boot up string should be displayed in the terminal indicating a connection and communications with the NuLAB:

```
ELF-ASL V1.102(B)
NORMAL POWER UP
```
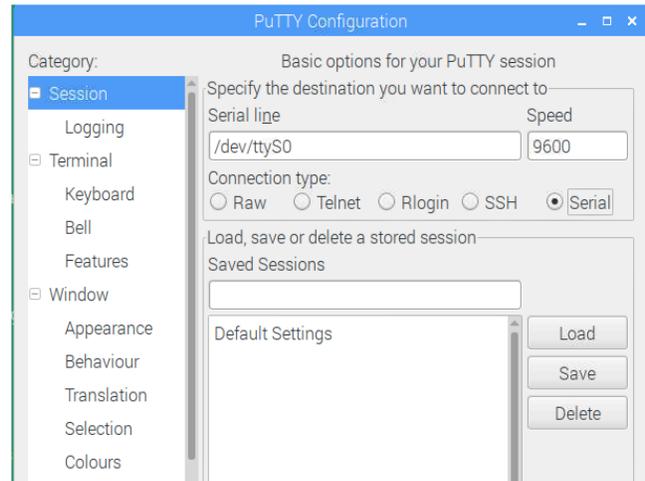
Connecting with **Tera Term** from a windows PC:

Tera Term is a free, open source, and downloadable terminal program for Windows computers. It can be downloaded at https://osdn.net/projects/ttssh2/releases/.

Step 1: Open Tera Term and select 'Serial Port' from the Setup menu at the top of the window.

Step 2: Verify that the Baud rate is 9600 and set the Transmit delay to 2 msec/char and 2 msec/line. Then choose an available Port based on the Com Port table above. As with the Putty connection above, open the Tera Term terminal with the proper connection settings and then power up the NuLAB.   The string below should be displayed indicating connection and communications.   If not, power off the NuLAB and try a different Com Port.
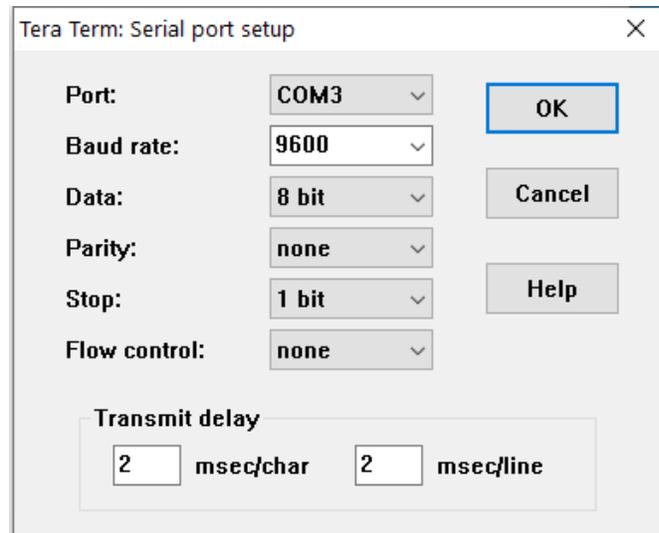
```
ELF-ASL V1.102(B)
NORMAL POWER UP
```

6. Remote Login

Remote control of the NuLAB is very convenient in the lab and can be invaluable to correct errors encountered during field deployments.   The NuLAB Raspberry Pi controller comes with VNC server, remote login software, preinstalled.   It is suggested to install Real VNC viewer software (https://www.realvnc.com/en/connect/download/viewer/) on your office computer for remote control of your NuLAB.   To login to your Pi controller within your local network, click on the VNC icon on the upper right of the Pi screen and record the IP address.   Simply type the IP address of the Pi into the address bar of VNC viewer and hit enter to connect to your controller.   Once connected, you will be prompted for the Pi's username and password which by default is **pi** and **raspberry** respectively.   It is strongly suggested to change the password on the Pi by running the configuration utility under the main Raspberry menu → Preferences → Raspberry Pi configuration.   Please use a password that you are comfortable sharing with Green Eyes so we can remotely login for tech support.

Green Eyes also installs Remote.it software on the controller for remote control when the system is deployed outside of a local network.   Please contact Green Eyes for direct assistance for Remote.it setup.

7. Macros and Reagents

Macro Allocation table

Macro #	N+N : N+N & NO2**	Phosphate	Ammonium
1	N+N sample	PO$_4$ sample	NH$_4$ sample
2	N+N OBS*	PO$_4$ OBS	NH$_4$ OBS
3	Inlet flush	Inlet flush	Inlet flush
4	Prime	Prime	Prime
5	One detector reading	One detector reading	One detector reading
6	Inlet back-flush	Inlet back-flush	Inlet back-flush
7	N+N Reagent Blank / NO2 Sample	DIW Reagent Blank	DIW Reagent Blank
8	Empty / NO2 OBS*	N/A	N/A

* Make the on-board standard for the N+N analysis (Port 6) with nitrate standard only.   The

NO$_2$ analysis is calibrated with the NO$_2$ only on-board standard (Port 4).
** (N+N) = Combined Nitrate plus Nitrite analysis : (N+N & NO2) = Combined Nitrate plus Nitrite analysis & Nitrite only

Before deploying the NuLAB for continuous sampling, be sure to perform the following steps:

1. Run macro four.   Priming the tubing gets rid of most bubbles.   If you do not prime the tubes then you will not get accurate data and you can damage the Cd column with air.   The number of primes that you perform should be determined by the length of tubing that you use to connect your reagents (longer tubing means more primes needed before running).   If you complete the M4 macro and there is still air in the tubes, then repeat as needed.
2. Run macro one.   Make the inlet is connected to DIW for reagent blanks.   This will be your base reading with a "zero concentration".   Using two known concentrations you can then use the absorbance to calculate the concentration for sample data.
3. If you are measuring nitrite by itself as well as N+N, run macro seven while the inlet is still in DIW.   This will serve the same purpose as step two for NO2 as M1 only runs a blank for N+N, PO$_4$, and NH$_4$ (The NO2 analysis is run on the Nitrate channel with N+N).
4. To access your reagent blank data go to the specific file as described under the NuLAB_Manual section above.

For every macro, be sure to set the run time to at LEAST the following run times:

Macro #	N+N : N+N & NO2	Phosphate	Ammonium
1	15 min	17 min	18 min
2	15 min	17 min	18 min
3	2 min	2 min	2 min
4	10 min	10 min	10 min
5	1 min	1 min	1 min
6	2 min	2 min	2 min
7	15 min : 8 min	17 min	18 min
8	N/A : 8 min	N/A	N/A

If running more than one channel at a time, use the longest macro time (i.e. 18 min for macro one).
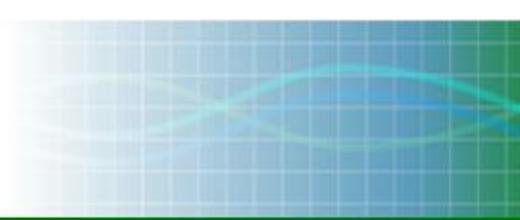
8. Valve Allocation Tables

Nitrate+Nitrite and Nitrite Valve Allocation Table
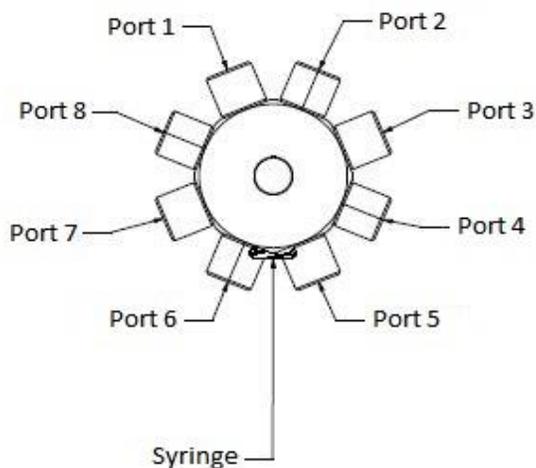
Port #	Reagent
1	Detector
2	Sulfanilamide + NEDA
3	Imidizole/DIW*
4	Nitrite (NO_2) OBS
5	Inlet
6	Nitrate (NO_3) OBS
7	Cadmium Column (other end to waste)
8	Air Intake

Note: The outlet of the detector (top on low sensitivity, long end on high sensitivity) should connect to an outside waste container.   All ports on the valve should be tightened with the provided torque wrench prior to instrument deployment and re-torqued every four to six weeks. Use only chemically resistant Tygon tubing with 1/16 inch (1.6 mm) inside diameter.   The Air intake should be connected to a bag of inert gas (e.g. Ar, He, N_2) or left open to the air. The NuLAB collects a gas bubble from the bag and passes it through the detectors immediately in front of measured solutions to sweep or scavenge micro bubbles from the detector.

* A three-way solenoid valve is now available to switch port three between imidazole and DIW.
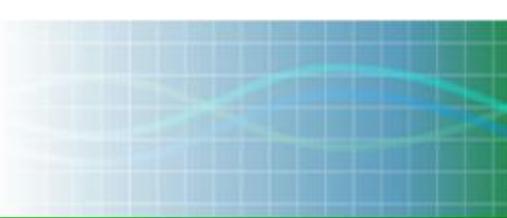
Nitrate+Nitrite (N+N only) Valve Allocation Table
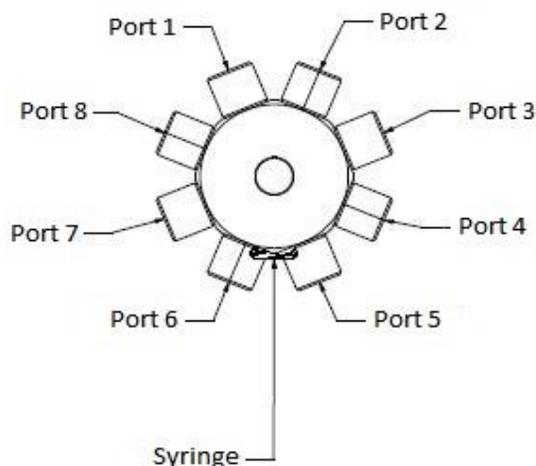
Port #	Reagent
1	Detector
2	Sulfanilamide + NEDA
3	Imidizole
4	DIW With Surfactant Wash
5	Inlet
6	Nitrate (NO_3) OBS
7	Cadmium Column (other end to waste)
8	Air Intake

Note: The outlet of the detector (top on low sensitivity, long end on high sensitivity) should connect to an outside waste container.   All ports on the valve should be tightened with the provided torque wrench prior to instrument deployment and re-torqued every four to six weeks. Use only chemically resistant Tygon tubing with 1/16 inch (1.6 mm) inside diameter.   The Air intake should be connected to a bag of inert gas (e.g. Ar, He, N_2) or left open to the air. The NuLAB collects a gas bubble from the bag and passes it through the detectors immediately in front of measured solutions to sweep or scavenge micro bubbles from the detector.

Phosphate Valve Allocation Table
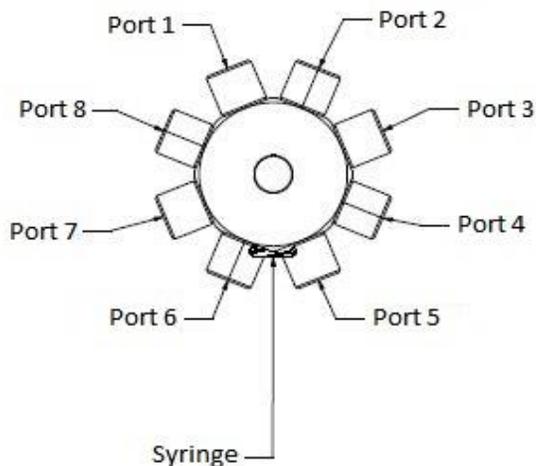
Port #	Reagent
1	Detector
2	Open Port*
3	Sodium Molybdate
4	DIW With Surfactant Wash
5	Inlet
6	Phosphate OBS
7	Ascorbic Acid*
8	Air Intake

Note: The outlet of the detector (top on low sensitivity, long end on high sensitivity) should connect to an outside waste container.   All ports on the valve should be tightened with the provided torque wrench prior to instrument deployment and re-torqued every four to six weeks. Use only chemically resistant Tygon tubing with 1/16 inch (1.6 mm) inside diameter.   The Air intake should be connected to a bag of inert gas (e.g. Ar, He, N_2) or left open to the air. The NuLAB collects a gas bubble from the bag and passes it through the detectors immediately in front of measured solutions to sweep or scavenge micro bubbles from the detector.

*For models built before 2020, Ascorbic Acid is on port 2 and the Open Port is on Port 7.
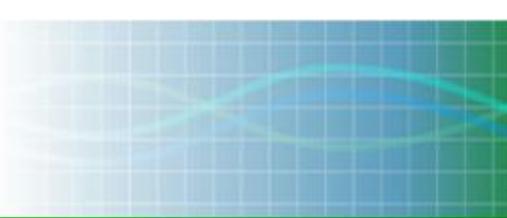
Ammonium Valve Allocation Table
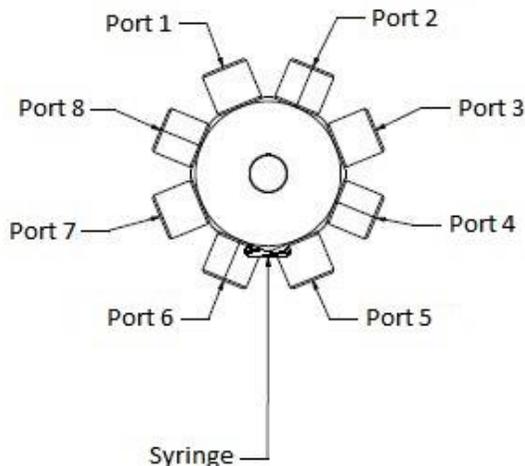
Port #	Reagent
1	Detector
2	Sodium Hypochlorite
3	Phenol
4	Complexing Reagent
5	Inlet
6	Ammonium OBS
7	DIW Wash
8	Air Intake

Note: The outlet of the detector (top on low sensitivity, long end on high sensitivity) should connect to an outside waste container.   All ports on the valve should be tightened with the provided torque wrench prior to instrument deployment and re-torqued every four to six weeks. Use only chemically resistant Tygon tubing with 1/16 inch (1.6 mm) inside diameter.   The Air intake should be connected to a bag of inert gas (e.g. Ar, He, N_2) or left open to the air. The NuLAB collects a gas bubble from the bag and passes it through the detectors immediately in front of measured solutions to sweep or scavenge micro bubbles from the detector.

Silicate Valve Allocation Table
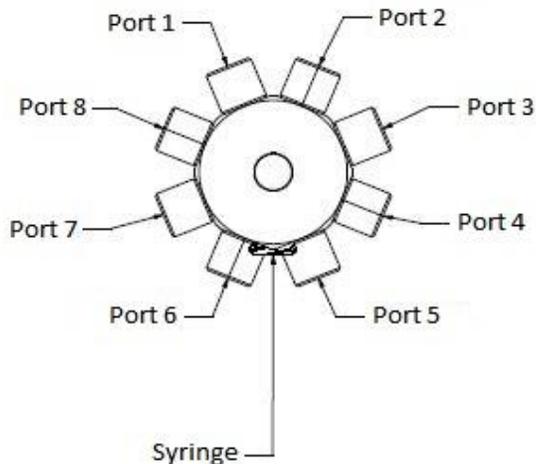
Port #	Reagent
1	Detector
2	Molybdic Acid
3	Oxalic Acid
4	Ascorbic Acid
5	Sample Inlet
6	Silicate (SiO4) OBS
7	DI Water
8	Air Intake

Reagent and OBS connections: All reagent and OBS connections should be made with 1/16"
(1.6 mm) ID tubing.   Larger diameter tubing or unnecessarily long lengths of tubing can reduce
flushing and cause noisy or inaccurate results, particularly for the OBSs.   OBS tubing should be
sterilized with isopropyl alcohol prior to connecting to reagent bags.   Detector inlet and outlet
use 3/32 inch tubing.

9.   Setup and Recovery

Reagent preparation: Follow the procedures described in Green Eyes reagent recipes to prepare
reagents and standards. Recipes other than those supplied by Green Eyes may not produce
desirable results and should be thoroughly tested before using in field deployments.

Note: For updates on reagent and other technical improvements please send Green Eyes a
request to be added to **technical updates email list**.

After preparing the reagents and standards, they should be poured into reagent bags (medical IV
bags).   The easiest method is to connect the tubing (1/16" ID) of the bag to a large funnel
securely mounted above the bag and pour the reagent into the funnel (the greater the vertical
distance between the funnel and the bag the faster the flow into the bag).   Cutting the bottom
out of a common lab squirt bottle turns it into a large funnel with small outlet to connect the bag
tubing.   Some different sizes of tubing and barbed adapters may be necessary to make
connections from the end of the squirt bottle to the 1/16" bag tubing.   It is also helpful to
remove the stem from inside the squirt bottle cap so that all the liquid is able to flow out of the
squirt bottle funnel.   When the reagent has flowed into the bag, squeeze the bag to push the air
bubbles and some liquid back into the funnel.   Allow only the liquid to flow back into the bag
and pinch the clamp before air re-enters
the bag.   While it is desirable to remove
all the air bubbles, one or two small
bubbles are of no concern. If a large
funnel is not available for bag filling, a 60
ml or larger syringe can act as a suitable
funnel.

Fig. 11: NuLAB and accessories inside external enclosure

Deployment: When deploying the
NuLAB in the field, the instrument,
reagents, battery and other accessories
should be stored in a waterproof enclosure
(Fig. 10) or building.   To reduce
temperature changes, the enclosure should
be insulated and protected from direct
sunlight or painted a reflective color.
The bottom of the enclosure should be
lined with a layer of absorbent cloth to
contain any accidental reagent leaks.
The sample delivery pump and tubing

should be secured along its path to the NuLAB and the sample chamber input and output connections should be fastened with stainless steel hose clamps to prevent leaks. The NuLAB inlet tubing is connected to the 1/16" nozzle at the bottom of the sample chamber (available as an accessory from Green Eyes or Green Eyes' sales representative). When running more than one channel, a y-connector(s) should be used to connect each channel's inlet (port five) to the sample chamber. Place the y-connectors close to the NuLAB to minimize combined inlet volume.

Connecting reagents and the OBS to the NuLAB: Follow the reagent and OBS allocations as indicated in the valve maps in section six above. Be sure all bags are pinched off before connecting them to the valve and that the end of the tubing extends past the barb on the valve nozzles or it will slip off. When removing tubing from the valve, use your fingernail to pry the tube over the barb while pulling on it. When re-connecting a tube, trim off the last cm where the tubing was previously deformed from the barb to insure a secure connection.

When using the nitrate channel, the cadmium column/tube (OTCR) should be connected so that the end of the cadmium touches or butts up against the valve nozzle. The other end of the OTCR should be connected to a waste bag (check sample, reagent and waster volume spread sheet for required bag volume).

After all connections are made and the tubing is run neatly, **check and double check that all pinch clamps are in the un-pinched position.** Place the inlet tube in a clean bottle of high quality deionized water (DIW) or low nutrient seawater (LNSW) for initial flushing and reagent blank analyses. Open the NuLAB_Manual application to the Macros tab (see running NuLAB controller apps above) and run one or two reagent prime macros (macro four). When complete, check that the reagents, OBSs and inlets are fully flushed and there are no leaks. If all lines are fully primed, run one or more OBS macros until the absorbance signal is stable, then run three or more reagent blanks (DIW or LNSW) and record the average absorbance of the reagent blanks from the data files (Fig. 5).

Note: It is very important that the DIW or LNSW be checked periodically to insure very low or below detection nutrient concentrations. It is also advisable to use the same water (DIW or LNSW) that is used for reagent blanks to make the OBSs.

Launching logging mode: Be sure to **connect the sample line to the sample chamber outlet**. Open the NuLAB_Logging application (see running NuLAB controller apps in section four above) to the Calibration Parameters tab and enter the reagent blank absorbances and OBS concentrations (the calculated sample concentrations will have the same units as the OBS concentrations). In the Logging Cycle tab, enter the desired logging cycle parameters. To maximize accuracy, Green Eyes advises to run no more than two samples per OBS (used for calibration) unless the interval is short (~20 minutes). It is also suggested to run the pump for three times longer than the water travel time from the pump inlet to the sample chamber (e.g. sample transit time equals 30 seconds, set Pump Run Time to 90 seconds). After checking "start logging" and clicking the 'Send' button, it is important to watch the message window to insure no errors are encountered and you have a successful start to the deployment. Be sure all battery, power and solar panel connections are secure and waste is flowing from the detector lines to the waste jug before closing the enclosure. **Do not be alarmed if the sample pump does not run on the first analysis, because the OBSs run before the samples.**

Deployment recovery: If the data has not already been downloaded from the internet, it can be copied onto a USB memory stick.   Place a USB drive into one of the available USB sockets and a window should automatically open to allow you to open the USB drive in a file browser. Open a second file browser and navigate to ComScriptPi >> profiles >> NuLAB_Logging and transfer the Logging data files (one for each nutrient measured and nitrate with is calculated as the difference of N+N and Nitrite and thus has no raw data) onto the USB drive.   Use the eject icon in the upper right of the screen to safely remove the USB drive or it may become corrupted.

Flush the valves: Disconnect the sample line from the sample chamber and place it into a bottle of DIW. Pinch off all reagent and OBS lines, and remove all bags and the OTCR from the instrument.   Connect the inlet and outlet of the OTCR to form a closed loop with as little air as possible.   The OTCR can be stored like this for up to one month, but it should be stored dry for longer periods of nonuse.   See the Nitrate reagent recipe for the re-activation procedure or send the column to Green Eyes for a complete reactivation.   Connect clean tubing from each valve port, except the detector, to a bottle of DIW.   Close the NuLAB_Logging app and open NuLAB_Manual to the macro tab.   Run two or more prime macros (macro 4) to flush DIW through the valve and detectors.   When flushing is complete, shut down the Raspberry Pi from the main menu (upper left of screen).   The flushing tubes can be removed (they can be reused) and the NuLAB should be stored in a secure, dry location.

Note: When simply replacing reagents and OBSs in the field, it is not necessary to flush with DIW, but to run one or more prime macros.   However, it is important to **avoid letting regent solutions dry up inside the valve** without proper flushing with DIW or crystals can form inside the valve and damage sealing surfaces.

10.   Evaluating and Maintaining Data Quality

The NuLAB is a complex wet-chemical instrument that when deployed correctly produces high quality data.   However, problems with chemistry or electro-mechanical operation can degrade data quality.   It is important for users to become familiar with the normal operation and results of the instrument to detect errors or abnormalities.

Data Quality Subjects

> **On-Board Standard (OBS)**: The OBS analysis is the single most important tool to evaluate proper function of the NuLAB.   When the OBS absorbance is stable and at an expected value for the concentration of the standard, the **instrument** is functioning correctly.   It does not by itself verify the sample data is accurate (see Sample Data below).
>
> The OBS signal can change due to **ambient temperature or reagent**

degradation, but it will not necessarily affect data quality.   The effect of temperature or reagent performance will be accounted for in the absorbance of the OBS used for sample calibration, given that the OBS is analyzed at a sufficient frequency.   OBS variability when driven by daily temperature may be positively (Nitrate) or negatively (Phosphate) correlated, but in both cases the correlation will be strong when the ambient temperature (field enclosure, lab or other deployment environment) is above the set reaction temperature.

Target Reaction Temperatures

Nutrient	Data Bits Target	Equivalent Reaction Temperature ºC
Nitrate/Nitrite	15000	31
Phosphate	15000	31
Ammonia	20000	46.5
Silicate	15000	31
Note: actual temperature is contained in data string		

OBS signals driven by reagent degradation are also not detrimental to data quality unless the decline in the signal is greater than 25%.   Such a decline is unlikely for deployments up to eight weeks when the reagents are stored in Green Eyes supplied reagent bags that are purged of air.   The reagents should also be protected from natural light, particularly NEDA/Sulf., Ascorbic Acid, and Phenol.

If the Cd column efficiency degrades from air, sulfide or extended use, the Nitrate OBS signal will decline accordingly.   If the decline in efficiency is not more than 25% and the concentration of Nitrite is low (below 0.014 mg-N/L, 1 µM), the effect to accuracy will be small.   Nonetheless, it is recommended to bring spare Cd columns to all field visits and to replace old columns with freshly activated units.   Degraded Cd columns may be sent to Green Eyes for reactivation and users are encouraged to purchase reactivation kits.

Declining OBS absorbance can also be caused by **degradation of the OBS itself.** This will result in the **sample concentrations** being inflated by approximately the percentage of the degradation of the OBS.   Thus, it is important to prepare the OBS with clean DIW and to add preservative (Green Eyes uses 1.0 ml of chloroform per liter of OBS).   After filling, all air should be purged from the new or sterilized OBS bags, clean tubing should be used and low OBS concentrations should be avoided.   When

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properly prepared, the OBSs have proven to be stable for up to eight weeks, even in high temperatures. Standard degradation will occur in the tubing before it happens in the larger volume contained in the bag. Thus, it is important to promote flushing by keeping the **lengths of tubing from the bag containing the OBS to the valve as short as possible**.

If OBS degradation is suspected, it is important to collect a sample of the OBS from the field for lab analysis (this should also be done periodically under normal circumstances). A linear correction can be applied to the data from the point the degradation (decline in the OBS absorbance) to the end of the deployment. **Comparison of the corrected NuLAB data and hand collected samples is critical to evaluating the final data quality**.

Sample Data: Stable OBS readings indicate that the instrument and reagents are functioning well but do not guarantee the sample data is accurate. Failures in the sample delivery system can result in poor flushing or an empty sample chamber. The sample pump operation should be checked before deployments and during service visits to insure proper sample delivery. Pump tubing that becomes biofouled should be cleaned or replaced and the sample chamber should be cleaned periodically. Minor biological growth in the pump tubing and sample chamber will not affect data quality.

If the instrument samples air, bubbles will get into the detector and scatter the light. This will cause very low light transmissions and the sample absorbances to shift radically including negative sample absorbances for all channels. In this instance, the NuLAB should be shut down and all "bubble" data should be discarded. Occasional bubble readings are expected, particularly in the 10mm, high sensitivity detectors, but that is not an indication of sample delivery failure. If bubbles are more frequent than normal and the pump system is functioning correctly, the valve to detector tubing should be replaced and the flow-cell cleaned with lab detergent and copious DIW.

Check Standards: One of the best ways to verify data accuracy is to feed a trusted standard into the NuLAB while in logging mode and compare the reported concentration with the calculated concentration from the NuLAB. Be sure to wipe the inlet tube before putting it in the check standard and to connect the inlet tube to the sample chamber when finished.
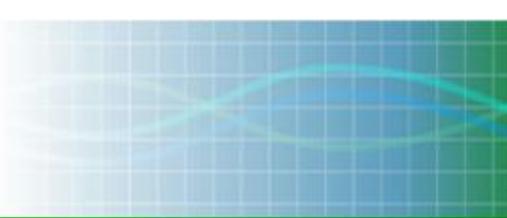
Comparison Samples: It is strongly encouraged that comparison samples are collected either by hand or by an automated sampler (e.g. ISCO) and run at a trusted lab. Samples should be preserved by freezing (best), by treating with 0.1 ml of chloroform per 100ml of sample or other established methods.

Please contact Green Eyes for assistance with data quality evaluation or correction.

11. Servicing

As a wet-chemical analyzer, the NuLAB requires attention to detail and periodic servicing. For best results and to reduce maintenance cost, users are urged to follow the servicing guidelines below.

Homing the Syringe

Step 1 – Connect to the NuLAB with a terminal: Connect a terminal to the NuLAB channel as described in the Terminal Connection Guide.

Step 2 – Align the valve and open a pipe: The initial connection to the NuLAB is to the MCU controller where most user/controller commands are processed.

Channel	Address
NO_3	/1
PO_4	/2
NH_4	/3
SiO_2	/4
Digester	/5
Relay	/6
LT	/9

Check the communication with the MCU by sending the I0 command to display the MCU configuration. All commands to the MCU must be preceded by the '/' and the address of the MCU (See table). As an example, to display the MCU configuration on a Phosphate unit:

```
/2I0[enter]
Output: @00/00/00 00:00:00,1068,880,244,244,0,40000,3276,999,15000
```

Note: No backspaces or incorrect characters are allowed. If an error is displayed, hit enter and retype the complete command.

After comms are confirmed with the IO command, send G1 to align the valve to port one.

```
./2G1[enter]
```
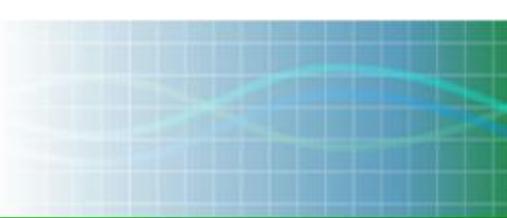
After 10 – 20 seconds, the '.' prompt will be displayed indicating that the alignment is completed.

To adjust the offset, send U2 to set the configuration to the syringe motor.   U1 is the valve motor which shares many configuration values with the syringe which if changed will cause valve motion errors.

```
>U2[enter]
```

To adjust the syringe homing routine, commands need to be "piped" from the MCU to the stepper motor controller. To open a pipe on a Phosphate channel:

```
./2P[enter]
```

After sending another return, &INV and the > prompt should be displayed:

```
&INV
>
```

Step 3 – Syringe Homing Check: Lower the syringe 3000 motor steps with the
 '-' command.   (3000 steps used for example.)   Acceptable values range from 2000-8000 motor steps.

```
>-3000[enter]
```

The syringe should be lowered approximately one inch.

Send the Homing command 'A' with the correct steps the syringe was lowered.

```
>A3000[enter]
```

The syringe will move up until the homing limit switch closure is detected by the stepper controller and then move an additional number of "syringe offset" motor steps set in the stepper configuration.

When homing is complete, the following output will be displayed, but with different values.

HOMING->COMPLETE - Step Diff = 2738,3000,-38

The last number (-38) is the homing result, which indicates the number of motor steps the syringe was overdriven during the homing procedure.   The goal when adjusting the homing is to set the offset such that the homing result is between -35 to -75, indicating

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the syringe is properly homed. If the result is too negative, the syringe will make a clunking sound from excessive overdriving when it homes and if it is positive or zero, it indicates that the syringe has not reached the fully depressed home position and the offset should be increased.

Step 4 - Adjusting the Syringe Homing Offset: If the homing result is not between -35 and -75, the Homing Offset value should be adjusted.

The configuration must then be unlocked by sending &5525 to change values.

```
>&5525[enter]
SET
```

'SET' is returned when the configuration is unlocked.

Display the list of syringe motor configs with '?l' and save it in the event configuration values are changed accidentally:

```
>?l[enter]
```

A list of values similar to those below will be displayed.

```
a:-2032
c:250
d:1
h:10
i:1000
m:1
o:250
s:2000
t:1
u:2
w:72
x:100
y:1
>
```

If the homing result from Step 3 is outside of -35 to -75, the homing offset should be changed.   As an example, if the result is -15, then the offset (o above) should be increased by 20 to 60 steps by sending o275 (an increase of 25).

```
>o275[enter]
```

Check that the new offset value is achieving a homing result between -35 and -75 by following the procedure outline in Step 3.   The procedure should be repeated a few times as the first result is not accurate because the syringe may not have started from a fully homed position.   Variability in the homing result of +/- 20 steps is normal and of no concern.

When the homing adjustment is complete send Ctrl-C to close the pipe to the MCU or just power cycle the NuLAB.

Below is a log of a typical Homing check and adjustment session:

ELF-ASL V1.102(B)
NORMAL POWER UP   - Power up string
./2I0   - Comms Check with MCU config
@00/00/00 00:00:00,1058,880,544,544,0,40000,3276,999,15000
./2G1   - Align the valve to port 1
./U2OK!   - Set commands to Unit 2 - syringe
./2P   - Open pipe to stepper controller, send additional [enter]
&INV
>-3000OK!   - Lower syringe 3000 steps
>A3000OK!   - Home the syringe with expected position -3000
HOMING->COMPLETE - Step Diff = 2699,3000,51 – Homing result positive
>-3000OK!
>A3000OK!
HOMING->COMPLETE - Step Diff = 2748,3000,2 – Repeat homing, result still positive needs adjustment
>&5525SET   - Unlock configurations
>?I
a:2
c:250
d:1
h:10
i:1000
m:1
o:250
s:2000
t:1
u:2   ←Confirms unit two (syringe) set
w:72
x:100
y:1
>o300OK!   - Set Homing offset (o) to 300
>-3000OK!
>A3000OK!   - Recheck homing
HOMING->COMPLETE - Step Diff = 2750,3000,-50
>-3000OK!

```
>A3000OK!
HOMING->COMPLETE - Step Diff = 2700,3000,0
>o335OK!   - Increase homing offset to 335
>-3000OK!
>A3000OK!   - Recheck homing
HOMING->COMPLETE - Step Diff = 2700,3000,-35
>-3000OK!
>A3000OK!
HOMING->COMPLETE - Step Diff = 2700,3000,-35
>-3000OK!
>A3000OK!
HOMING->COMPLETE - Step Diff = 2714,3000,-49 – Three checks successful, homing
set correctly
```

Valve and syringe: The valve and syringe and the moving fluidic parts of the NuLAB require inspection and some servicing during scheduled field visits (four to eight weeks) when replacing reagents and standards.

Re-tighten valve nozzles
- Pinch off and remove the reagent bags from the past deployment
- Remove the syringe from the valve by unscrewing the shoulder screw at the bottom of the plunger and then unscrewing the syringe from the valve at the top of the plunger (no tools required).
- Re-tighten all eight valve nozzles.
- If any of the nozzles were leaking, use DIW and a paper towel to remove any reagent from the surface of the valve or the faceplate. Inspect the nozzle and replace as necessary
  - The NEDA/Sulf reagent is made in 5% HCl and can slowly dissolve the aluminum body of the valve so any leaks need to be cleaned up very well or the valve will be destroyed.
- Check that the syringe plunger still moves freely and seals properly by drawing and expelling some DIW water from a beaker.   Stains on the syringe plunger shaft are an indication that the syringe has a slow leak.   This will likely not affect data quality, but the syringe will need to be replaced in the near future. Reconnect the syringe to the valve firmly with dry fingers only – do not use pliers.

Detector Tubing
- If the low sensitivity detector tubing that passed directly through the detector is significantly stained, it should be replaced.
  - Disconnect tubing from the valve to the detector tube
  - Disconnect detector waste line tubing from the top end of the detector tube
  - Unscrew the detector tubing nuts from the top and bottom of the detector
  - Pull the detector tubing out of the detector – some force may be required to pull the tubing through the bottom compression ferrule if installed

- Slide a new length of clean detector tubing (wipe the outside with a lint free wipe)
- It may be difficult to guide the tubing through the small hole in the detector.   If necessary, the cover of the detector can be removed (four screws) to guide the tubing through the small hole in the detector.
- Slide a ferrule over the top of the detector tube and down into the threaded hole in the detector block.   The ferrule may need to be opened some with a conically pointed tool or marlinspike so it will slide over the detector tubing.   **Be sure the flat side of the ferrule faces the bottom of the threaded hole and the conical end of the ferrule will be compressed by the nut when tightened**.
- Slide the tubing nuts over the detector tubing and thread nut into the detector block until finger-tight.   If the detector tube is not secure inside the detector, tighten the top nut until the tube will not move (listen for a click).

Cadmium (Cd) Column

- If the Nitrate OBS absorbance has declined it could be caused by a loss of efficiency in the Cd column.   Passing 10-20 ml of Copper Sulfate/Imidazole activation solution through the Cd column will improve reduction efficiency.   Flush the activation solution with pure imidazole.   Green Eyes offers Cd column activation kits that include a syringe and activation solution.

Tubing and Filter

- The inlet tubing and the filter should be replaced if stained or have visible biological growth.
- The OBS tubing should be replaced when new OBS bags are connected to the instrument.
- The short lengths of tubing between the valve and detectors should be replaced at every field service visit and kept to a minimum length without kinking.   Dirty tubing can cause the scavenging bubbles passed through the detector to break up and cause very noisy data.

Servicing upon storage

- Connect valve ports two through eight to DIW and run the Prime Macro (M4) two or more times so the valve is thoroughly cleaned of sample water and reagents.
- Clean any leaked reagents from the faceplate.
- Flush a lab detergent solution through the 10 mm high sensitivity detector flow cell followed by copious DIW.
- Store the NuLAB in a dry container with desiccant packs

12. Appendices

a. Specifications

Physical

> NuLAB (two channel): 39 cm x 34 cm 20 cm (H x W x D), Weight: 6 kg plus reagents
>
> NuLAB Plus (three channel): 66 cm x 64 cm 30 cm (H x W x D) including reagent
>
> hangers, Weight: 6 kg plus reagents

Analytical

> - Standard Ranges (detection limit to linear range, micro M)
>> High Sensitivity Detectors
>>> **mg/L:** N+N 0.003 to 0.70, Nitrite 0.002 to 0.5, Phosphate 0.006 to 0.8, Ammonium 0.004 to 0.3, Silicate 0.008 to 1.7
>>> **micro mol/L:** N+N 0.2 to 50, Nitrite 0.15 to 35, Phosphate 0.2 to 25, Ammonium 0.3 to 20, Silicate 0.3 to 60
>> Low Sensitivity Detectors
>>> **mg/L:** N+N 0.01 to 2.8, Nitrite 0.008 to 2.1, Phosphate 0.025 to 2.0, Ammonium 0.02 to 1.0, Silicate 0.04 to 2.8
>>> **micro mol/L:** Nitrate 0.8 - 200, Nitrite 0.6 - 150, Phosphate 1.0 - 75, Ammonium 1.5 to 75, Silicate 1.5 to 100

> - Precision (one SD @ midrange of scale): Nitrate 2%, Nitrite 2%, Phosphate 3%,
>
>   Ammonium 4%, Silicate 3%
>
> - Expanded Ranges: Up to 5 mg/l through auto-dilution
> - Accuracy: Based on the accuracy of the preserved on-board standard and sample delivery/handling procedures
> - Analyses: Typically 1000 per channel, per deployment. Controlled by reagent payload and chemistry.

> **Note:** Detection limit calculated as 3 x SD of reagent blank; linear range is variable upon
>
> detector path length and chemistry. Contact Green Eyes for specific information.

General

> - Power: voltage 10 - 15 dc, current per channel (mA) heating max. 820, motors 160-260, idle 90; add 250 mA continuous for NuLAB plus
> - Communications of each channel: RS232   9600,N,8,1
> - Not waterproof

b. Deployment Checklist

Laboratory preparation before departing to the field
- o The NuLAB has been setup and tested in the lab successfully
  - • Good precision (5% RSD or less) from the On-Board Standards (OBS) with expected absorbances
  - • No leaking valve nozzles (all properly torqued) or syringe plungers
  - • Data recording properly in appropriate files
  - • Remote login working
- o Pumping system has been successfully tested
- o The deionized water (DIW) reagent blank absorbance for all channels has been recorded and is acceptable (5% RSD or less; discard any "flyers" for average).
- o The concentrations of the OBSs have been recorded and samples of the OBSs have been collected for verification at an independent lab
  - • Green Eyes uses chloroform to preserve the OBSs. If preparing yourself, it is suggested to add 1.0 ml of chloroform to each liter of OBS prepared in DIW.
- o If the NuLAB will be transported to the field with the OBS and reagents connected to the valve, close pinch clamps and secure reagent bags for travel.   Otherwise, close all pinch clamps, disconnect all reagent bags from the valves, and insert plugs into the ends of the reagent tubes for added security during travel.   Transport the reagents in a cooler or other suitable container that will block light and contain leaks.
- o NuLAB equipment needed for field
  - • NuLAB and deck lead
  - • Controller, serial cables and USB to serial converter (if not built into NuLAB case)
  - • All reagent and OBS bags and DIW for washing
    - ▪ It is advisable to leave some extra DIW in the enclosure with the NuLAB for service visits.
  - • Sample Chamber and spare filters
- o Enclosure Supplies
  - • Enclosure
  - • Pump, tubing and connectors
  - • Solar panel or other power source
  - • 12-volt battery(s)
  - • Cell modem for controller
- o Additional Supplies
  - • Waste container(s)
  - • Spare tubing, pinch clamps and connectors
  - • NuLAB tool Kit
  - • Paper towels, waste container
  - • Cable ties, electrical tape
  - • **Safety goggles and lab gloves**
  - • **Drinking water**

Field Deployment Checklist
- o NuLAB is secured in the enclosure and the enclosure is watertight
- o Power and controller cables are secure
- o The pump is submerged and secure in the water body being sampled, and the pump hose is secured to the sample chamber inlet (bottom 3/8" connection); the outlet of sample chamber is free to discharge safely away from the enclosure and not directly back to the pump.
- o The sample chamber is secured and all the inlets (port five) are connected to the sample chamber filter (no pinch clamps)
    - o Test the sample delivery to NuLAB by running the pump to fill the sample chamber and then running the inlet flush macro (M3) on all channels.
- o Cell modem or WiFi hotspot is charging
- o System battery is maintained by solar or line power
    - o Starting voltage _____
- o Reagents and OBSs are **all connected to correct ports and no lines are pinched**
    - o Technician initials _____
- o Reagent and OBS lines have been adequately primed (no air) via one or more M4 macros
- o Run one OBS analysis with NuLAB_Manual on all channels and check for reasonable (within 10% of recent lab test) absorbances.
- o Open NuLAB_Logging and enter the correct OBS concentrations and reagent blanks for all necessary channels or verify they are correct if they were set in the lab.
    - o Technician initials _____
- o Enter additional logging settings such as Sample Interval and the Sample to OBS ratio
    - o Select at most one channel to backflush
    - o It is recommended to backflush with the N+N channel if present and the additional volume (0.8 ml/day) of the Sulf./NEDA reagent should be included in the required volume for the deployment.
- o If possible, set the deployment start date in the very near future so logging cycle start can be visually verified.
- o Be sure all the time formats are correct – incorrect formats will lead to logging start and stop errors.
- o Check the 'Start Logging' box and send the commands to ComScript to commence logging
    - o Logging commenced at _____
- o Collect one or more samples of the water adjacent to the pump for independent lab analysis and later comparison with the NuLAB data. Collect additional comparison samples during the deployment as able.
    - o Samples should be preserved immediately after collection. Methods include 1-freezing, 2-chloroform and 3-mercuric chloride. Contact Green Eyes for guidance on sample preservation.

c. Warranty and Liability

Warranty

Green Eyes LLC warrants the NuLAB electronics, detectors and enclosure against faulty materials and workmanship for a period of 12 months, and the valve and syringe for a period of six months from the date the unit originally ships from Green Eyes facility.

Faulty units will be repaired or replaced at Green Eyes option free of charge provided they are delivered to Green Eyes LLC's premises at the owners/user's expense, and providing all manufacturer's recommendations with regard to operation, servicing and storage have been followed. The warranty will not apply if the fault has been caused by misuse, attempted repair or modifications in a manner not authorized by Green Eyes LLC.

Return Address: Green Eyes LLC
                     930 Port St.
                     Easton, MD 21601 USA

Limited Liability

Green Eyes LLC disclaims all product liability risks arising from the use or servicing of this equipment. Green Eyes LLC cannot take steps to comply with laws pertaining to product liability, including laws which impose a duty to warn the user of any dangers as it has no way of controlling the use of this equipment or selecting the personnel to operate it. Acceptance of this system by the customer shall be deemed to include a covenant by the customer to defend, indemnify, and hold Green Eyes LLC harmless from all product liability claims arising from the use or servicing of this system.

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