

EcoLAB - Operating Manual

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2.0 Introduction

The EcoLAB Analyzer System is a submersible chemical analyzer for automated monitoring of dissolved chemicals in natural waters. Current analytes include nitrate plus nitrite (N+N), nitrite, orthophosphate, ammonium and silicate. Other colorimetric methods including dissolved copper and iron can be added.

The system is comprised of an analyzer module, colorimetric detectors, data logger/controller, reagent bag hanger and a protective guard.

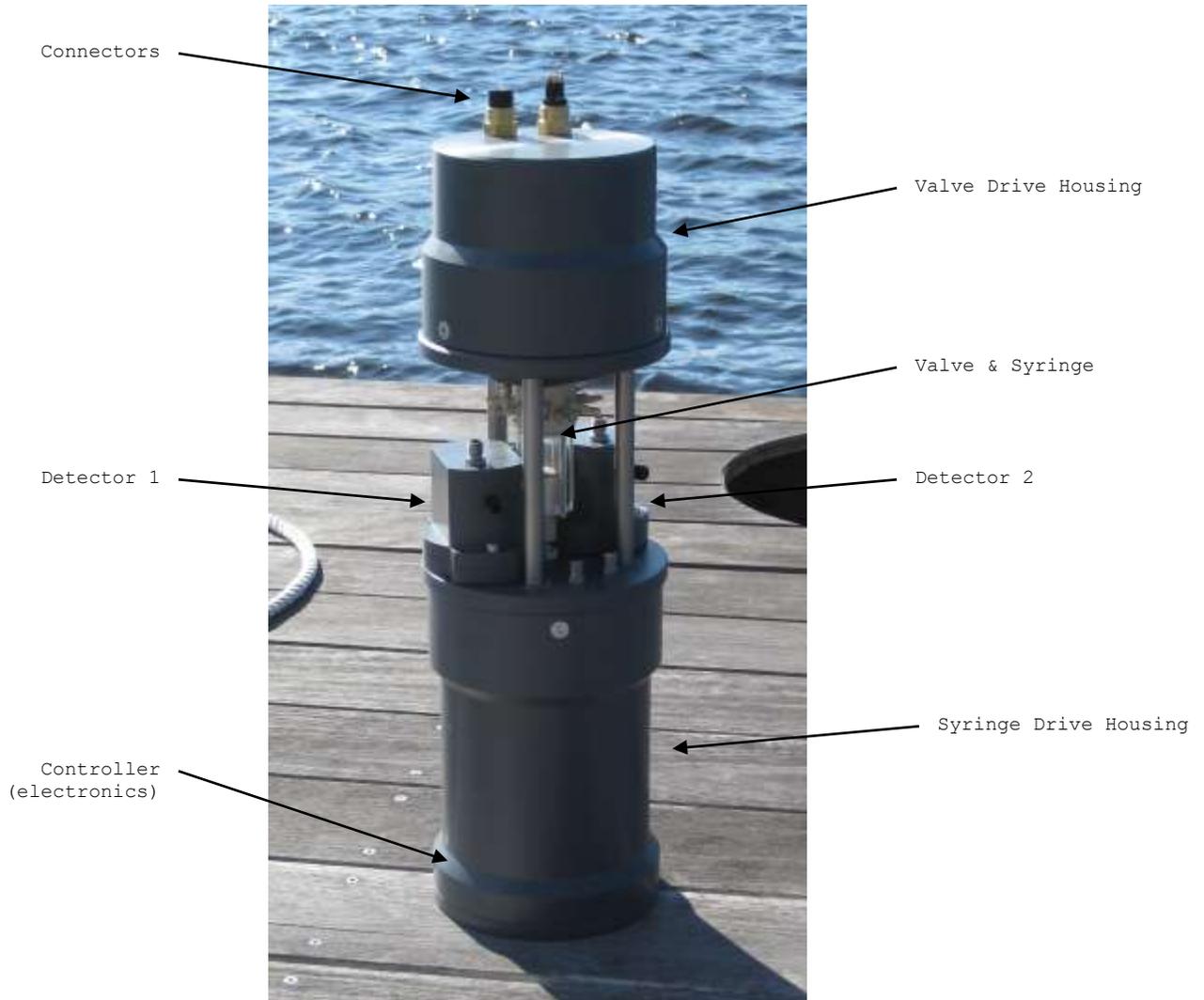


Fig 1 - EcoLAB Analyzer

The analyzer module is comprised of a 3.5 ml syringe connected to the common port of 16 port rotary valve. The syringe collects and mixes sample water or standards (OBSs) with reagents and passes these solutions into adjacent detectors for analysis. Mixing of solutions is achieved by pulsing the syringe up and down when the valve connects the

syringe to the relevant detector flow cell. During a deployment, all syringe, valve and detector functions including mixing and flushing, are controlled by text file macros that can be adapted for specific analytical goals. Unlike continuous-flow or flow-injection laboratory systems, the EcoLAB is a discrete analyzer whereby a fixed volume is mixed in the syringe, inserted into the detector and analyzed while stationary.

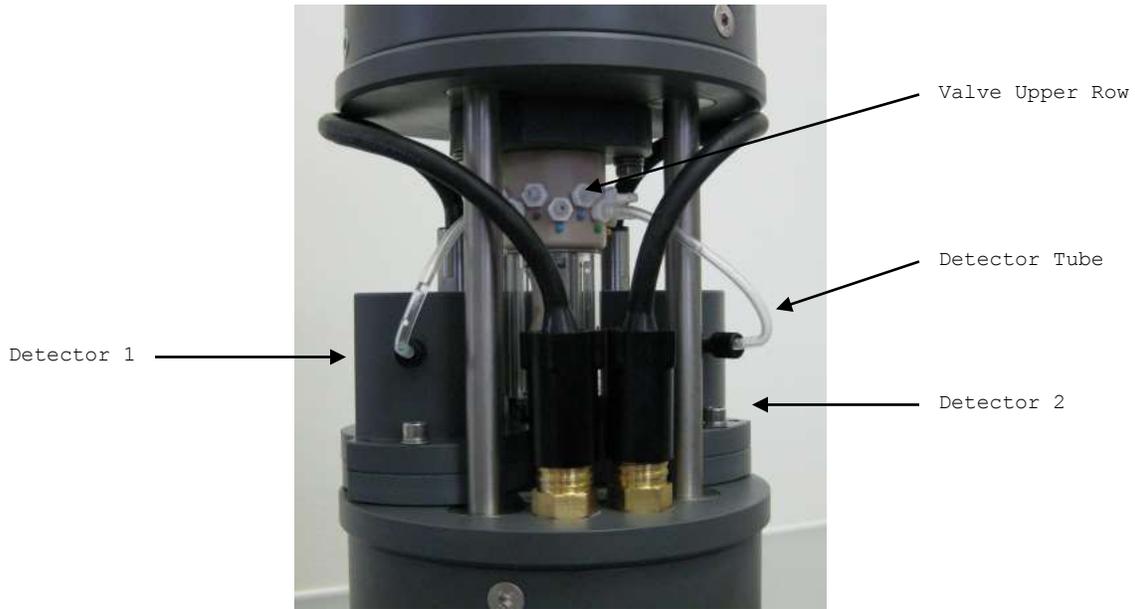


Fig 2 - EcoLAB Analyzer with two low sensitivity detectors

2.1 Detectors

Each detector incorporates one or two narrow-band colorimeter channels optimized for the peak response of the selected analyte. Miniature high-efficiency heaters are integrated into the detector block (for chemistries requiring heat) and the Beer-Lambert Law is used to convert raw light transmission data into sample concentrations.

2.2 Reagent Hanger & Guard



Fig 3 - EcoLAB with reagent hanger and high sensitivity detectors (left) and EcoLAB mounted in reagent housing with battery pack, mooring tie bar and battery pack (right).

When assembled, the analytical system is fixed in the center of the guard. Reagents and standard bags are attached to the reagent bag hanger that mounts on the top of the analyzer. Reagents and standards are delivered to the valve via 1/16" (1.6mm) ID chemically resistant tubing. Analyzer waste can be collected into waste bags usually mounted outside the reagent housing.

2.3 Important requirements

1. Power Supply: A 12 volt, 3A (minimum) power supply should be used for bench testing.
2. Valve Nozzle Torque: Valve nozzles must be tightened to 32 in-oz. of torque and should be removed and cleaned prior to each deployment.
3. Servicing: The EcoLAB syringe shaft o-ring should be replaced after every three months of operation and the syringe vari-seal should be replaced annually. All other o-rings can be replaced annually. See servicing section for more details.
4. Shock & Impact: The EcoLAB is a precise scientific instrument and should be handled gently and packed in foam for shipping.
5. Fasteners: All fasteners are either 316 stainless steel or titanium. Please contact Green Eyes or your local distributor to replace fasteners.
6. Date: The date and time can be set to US date format (MM/DD/YY) or European (DD/MM/YY) with the T1 command. The format selected when setting the time with the T1 command will be used for all EcoLAB timestamps and the delayed start wakeup time.

3.0 Methods

Green Eyes analytical routines are based on established methods referenced in the reagent manual. Other methods such as those published by US EPA can also be adapted with Green Eyes assistance. A list of currently measured analytes is given below. Please contact Green Eyes or your local Green Eyes' representative if a desired colorimetric or fluorometric method is not listed.

3.1 Analyte List

Standard Methods

- Nitrate/Nitrite
- Phosphate
- Ammonium (colorimetric or fluorometric)
- Silicate

Special Order Methods

- Urea
- Iron
- Copper

A full description of the method associated with your equipment configuration is given in the Chemical Methods Manual.

3.2 Analysis Macros

The EcoLAB utilizes sets of macros to perform analytical, flushing and reagent prime operations. Analyses types include sample, standard and reagent blanks. Macros, which are text files of letter commands and numeric arguments that control the actions of the valve, syringe and detectors, are described in detail in section 6.0

4.0 Operation

The EcoLAB can be thought of as a chemistry robot that automates traditional manual methods whereby the analyst mixes samples and standards with reagents in a test tube. The resulting colored solution is then poured into a cuvette and placed in a colorimeter to measure light transmission. With the EcoLAB, the syringe acts as a pump to collect and dispense solutions and as the test tube for mixing. The rotary valve serves as a space efficient chemical manifold connecting the syringe to various solutions and the detectors which have been miniaturized with modern electronics. Because the syringe and valve are controlled by high resolution stepper motors and a rotary encoder, dosing and mixing are very reproducible. With acute control of the optics in the detectors, the resultant precision is comparable to traditional laboratory systems.

4.1 Power

The EcoLAB system operates at a nominal 12 volts DC. The absolute range is 10 - 15 volts DC. The EcoLAB may be damaged by operating outside of this voltage range or reversing the polarity input.

Green Eyes offers a submersible battery pack that mounts to the external housing for mooring deployments or the EcoLAB can be powered from a rechargeable battery maintained via solar panel.

For bench testing, a 12 volt DC regulated power supply is most convenient. Green Eyes offers a reliable power supply with a current display, but other widely available 12 volt, regulated supplies rated for 3 Amps should power the EcoLAB properly.

4.2 Communication

The EcoLAB controller uses the following configuration:

Communication format: RS232, ASCII
Baud, Protocol: 19200, N81

A terminal emulator software (Tera Term recommended) can be used to issue commands, upload macros and download data. Green Eyes also provides a graphical ComScript application to control the EcoLAB in a more user-friendly interface that is available for free download from the EcoLAB page or the Green Eyes website (please see the separate EcoLAB ComScript manual for details; also available on the website).

4.3 Connections

Each unit has two connectors on the top as shown below.



Fig 5 - Electrical Connectors

Remove the dummy plug from the connectors. Connect and secure the communications/power lead. Connect the red and black wires on the deck lead to a suitable 12 VDC power supply. DO NOT POWER UP. Be sure that a thin layer of silicon grease is maintained on the connector pins.

Attach the female DB9 connector on the bench lead to the supplied USB to serial adapter plugged into the PC.

The instructions below use the terminal program. Please see the EcoLAB ComScript Manual for the graphical interface.

Open the terminal emulator program, select the correct COM port and configure the software for the above communications protocol. If using Term Term which is recommended, these settings are available by selecting the 'Serial port' option under the 'Setup menu'.

Turn on the power supply and check that the following sign-on message is displayed on the screen.

```
ECO-2 V2.xxx          (Firmware version)
@SD1                 (SD memory card initialized)
@NPU                 (Normal power up)
@CMD                 (Command mode)
>                   (Command / user prompt)
```

Please read the rest of this manual before continuing to operate the system.

5.0 Commands

Commands are entered after the '>' Prompt. The prompt indicates the EcoLAB is ready for next command. Commands can only be entered when the prompt is shown and the EcoLAB will not communicate while executing a command or macro. While in logging mode, the EcoLAB must be awakened from sleep with "\$\$" to resume communications at the command prompt.

All commands are in the following format:

<Cmd><Arg><CR>

Where: Cmd = Command
 Arg = Argument
 CR = Carriage return <CR> or Enter (ASCII decimal 13,
 hex 0D)

5.1 Command Set

Cmd	Arg	Description	Units	Notes
?	None	Query status		@RDY = ready @BSY = busy
\$	\$	Wake from sleep		
+	0	Zeros syringe counter		
	1 - 23000	Insert Plunger	Motor steps	1 ml = 6180
-	0	Zero syringe		
	1 - 23000	Retract Plunger	Motor steps	1 ml = 6180
/	1 or 2	Set current detector		
D	0	Download data:		
	1	All raw data		
	2	New raw data		
	3	All processed data		
E	0	Erase data file:		
	2	All raw data		
F	0	All processed data		
	password	Reset non-volatile config to default		
G	1	Align at port 1		1 - 110 seconds
H	1	Display header information		See below
I	1 - 64800	Set sample interval	Minutes	1 min to 45 days
K	1 or 2	Set detector channel		Pre-set the '/' command
L	0 - 4095	Set detector light intensity		Pre-set the '/' command
M	0	Start Logging mode		Macro details below
	1 - 20	Run analysis macro		
N	0	Reset analysis counter		0-3500 on v1.125 and earlier
	1 - 30000	Sets maximum macros		
O	1	Open detector serial bus connection		CTRL-D[Enter] to close connection
P	1 - 20	Go to port	Port	Shortest distance
S	1	Scan detector		Pre-set the '/' command Set 'K' & 'L' commands
T	1	Set time (RTC)		Format: (0)MMDDYYhhmmss (1)DDMMYYhhmmss

U	0 - 20 password	Upload Macro Clear all Macros		See below
V	0 - 20	View Macro		See below
W	1	Set wake-up time		Same format as set with T command
X	0,3,4	Report mode		See below
Y	0 or 1	Turn OFF/ON detectors	0=OFF/1=ON	
Z	0	Put EcoLAB in Sleep		Very low power mode
&	0 password	Show firmware version Load new firmware		See procedure

5.2 Messages

A list of status and diagnostic messages are given below:

@ALM - Wake-up alarm set in the past / current wake-up time
 @ABS - Absorbance readings follow
 @ARG - Incorrect argument (out of range, etc.)
 @BAD - Bad macro command
 @BOR - Brown-out reset (e.g. very low battery, faulty power supply)
 @BSY - Unit executing a command
 @CMD - Command mode
 @DET - Detector reading follows
 @END - End of action (macro / sampling / data download)
 @ERR - Error state during macro
 @FS: - File system message (e.g. @FS: FILE NOT FOUND)
 @FWU - Firmware updated
 @ID# - Unit serial or ID number
 @INV - Invalid command
 @LPC - Linear position counter (used for debugging macros)
 @MAC - Current macro
 @MAX - Max number of samples reached (system will halt & sleep)
 @MC1 - Motor 1 (valve) position invalid
 @MC2 - Motor 2 (syringe) position invalid
 @MCL - Macro line (use for macro debugging)
 @MER - Motor error = motor 1, motor 2 (e.g. no movement detected)
 @MME - Motor movement error (valve position detection error)
 @MOT - Motor positions follow
 @NPU - Normal power-up
 @OFF - All circuits powered down in sequence & going to sleep
 @OK! - Entry acknowledged
 @PWR - Last time power was removed
 @RDY - Unit ready for a command
 @REC - Recovery from failed command or reset (e.g. from a brown-out)
 @RES - Reserved command / command not available
 @RTC - Real-time clock follows
 @RST - Reset command (e.g. after command F, reset variables to default)
 @SD1 - Found Smart Data (SD) card 1
 @SD_ - SD card error
 @SD= - SD card status (e.g. not found)
 @SE2 - Serial entry from port 2 (raw detector data)
 @SMP - Sample count
 @STP - Stepper drive status (debug mode only)
 @T/O - Peripheral timed-out (e.g. detector disconnected)
 @WDT - Watch dog timer triggered (fatal time-out, hang, crash, error)
 @[O] - Serial connection open

@[C] - Serial connection closed

These messages are valuable diagnostic tools. Please capture and send error message to your local tech support agent.

5.3 Command Descriptions

password

Where required the password is: 5525

? - Query Status

When awake the system will respond to '?' with the status @RDY (ready for a command) or @BSY (busy executing a command).

\$\$ - Wake from Sleep

The string \$\$ will wake the unit from sleep to the command prompt.

+ & - Move Syringe

The + and - commands insert and retract the syringe respectively. The argument is the number of steps or increments of the stepper motor.

Syringe volume: 6180 steps = 1.00 ml
 23000 steps = 3.72 ml (MAXIMUM travel)

All syringe movements are relative to the current position. The syringe motor incorporates a "clutch" such that limited over-driving of the syringe insures that it completes macros fully depressed, and all macros incorporate some overdriving. A short "beep" from the syringe is a normal sound during overdriving.

The system continuously counts motor steps. Because the plunger is routinely over-driven the step counter will often be negative. It can be reset to zero with command +0 or -0.

/ - Set Detector

The / (forward slash) command is used to set the detector (1 - 4) that will receive subsequent detector commands. The / command must be used before the other detector commands K, L & S.

A detector address table should be provided with each EcoLAB. Contact Green Eyes if it was not provided or view the appropriate analysis macro in a text editor. The / command designating the detector address should appear near the top of the macro and the argument after the / is the address.

Single channel detector addressing is straight forward.

Nitrate = 1
Phosphate = 2
Ammonia = 3
Silicate = 4

Detector addressing can be a bit confusing with low sensitivity dual detectors, because it is actually the processor that is addressed, not the detector(s). High sensitivity detectors have one processor per

detector, but every detector has two optical channels (selected with the K command). With high sensitivity detectors, channel 2 is a reference to the "active" channel 1, that reads light transmission through air. Channel 1 reads light transmission through the flow cell connected to the valve and syringe. The l1 command adjusts the light transmission on channel 2 until the target received light (set in the detector config) is reached. The final channel 2 led brightness/current setting is then applied to channel 1 for data readings.

With low sensitivity detectors, channels 1 and 2 are controlled by one processor and both can be used as active channels that read the light transmission of solutions passed through the detector's optical tube from the syringe. Low sensitivity detectors do not have a reference channel.

As an addressing example, a low sensitivity nitrate/silicate detector is addressed as 1 (/1) where nitrate is channel 1 (K1) and silicate is channel 2 (K2).

To set the light and take a reading on the nitrate channel the following commands would be issued:

```
/1  
K1  
L3275  
S1
```

Note the use of K1 to select the channel 1 (nitrate) of the detector.

To set the light and take a reading on the silicate channel the following commands would be issued:

```
/1  
K2  
L3275  
S1
```

Note the use of K2 to select the channel 2 (silicate) of the detector.

With a high sensitivity nitrate/silicate detector, the nitrate is address 1 (/1) and silicate address 4 (/4). Both active channels are 1 (K1) and both reference channels are 2 (K2).

D - Download Data

There are two types of data files:

Raw: Time-stamped data recorded with raw light transmission and other detector data in bits (0-65535).

Processed (formerly called Real): Time-stamped raw data with calculated absorbance values.

There are two files for each type:

All - All accumulated data (see data processing guide)
New - All data collected since the previous download.

Therefore, four data files are created with any analysis macro and may be downloaded individually.

D0 - All raw
D1 - New raw
D2 - All processed
D3 - New processed

"New" data files are intended for periodic download via a telemetry system where only data accumulated since the last download is desired to limit transmission time and avoid duplication.

Note: The "new" data files are erased by downloading them with D1 and D3.

E - Erase Data

All data files can be erased with a corresponding E command (e.g. E0<CR> will erase all raw).

F - Reset Non-Volatile Variables

All header variables (H1) are reset to default values using F<password><CR>. Please review your header variables after setting them to default.

G - Align Valve

The command G1 will align the valve to port one. Depending on the starting point, aligning can take up to 1.5 minutes.

H - Header Information

H1 displays the current logging configuration, current time and other relevant information. An example and description is below:

```
>H1@OK!  
@ID#2012 I60 N0/3360 X0 U0 11.73V  
@MOT:VAL=1 SYR=-1  
@RTC:06/19/17 11:25:45  
@PWR:06/19/17 11:17:50  
@ALM:06/19/17 12:00:00
```

Line 1 = <serial/ID#><interval><macro count>/<max macros to run in logging mode><reporting mode><motor><supply voltage>
Line 2 = <valve position><syringe position>
Line 3 = <current time>
Line 4 = <previous time unit was powered-up>
Line 5 = <wake-up/start time>

Valve & Syringe Position

In line 2, @MOT the VAL= indicates the current valve port. SYR= indicates the current syringe position.

VAL=0 is invalid and means the system has lost track of the valve. This can happen by switching off power when the valve is in motion. The valve must be realigned with the G1 command.

SYR=(negative) indicates the syringe plunger is theoretically above its end-stop and this is an invalid position (over driving the syringe as discussed above will cause a negative syringe count and is not cause for concern).

I - Sample Interval

Sets the wake and sleep interval used during logging in minutes. The interval is from the start of the M0 master macro to the first Z0 sleep command and from then on, the interval sets the time between one Z0 to the next Z0 sleep commands. For reliable timing the interval should be greater than the time required for all sub-macros (M1...M20) to execute between Z0s.

Example M0 master macro:

```
#inlet flush M14
M14
#N+N OBS macro M2
M2
#inlet flush M14
M14
#N+N sample macro M1
M1
# go to sleep until interval expires
Z0
```

In the above M0 example, all the macros will execute and then the instrument will go into low power sleep until the interval expires. If the interval is set to 60, the macro will loop once per hour until max macros are reached.

Note: See Section 6 for a more detailed example of the M0 master macro.

K - Set Detector Channel

Each detector has two channels (1 & 2). This command selects the channel for subsequent detector commands. The / command to select the detector should be preset.

L - Set Detector Light

Set the light level (brightness) in the range 0 - 4095 for the current channel of the current detector. The range 0 - 4095 is equivalent to 0 to 30 mA. The / and K commands should be preset.

M - Run macro

M0: Initiates continuous logging mode of the repeating sequence of analytical, flushing or utility macros (M1 - M20) contained in M0. M0 also automatically sets the macro counter to zero.

M1-20: Commands M1 through M20 run the macro specified by the argument one time. See section 6.0 from more details.

N - Maximum number of macros

The N command sets a limit on the number of all macros (including analytical, flushing and utility) listed in M0. The macro counter and max macros value is displayed during logging mode and thus can be tracked by a data logger by polling the EcoLAB with the H1 command.

O - Open serial comms pipe with detectors

O1 opens a serial communication pipe directly with the detectors for diagnostic purposes or changing detector configuration settings. Ctrl-D[Enter] will close the pipe and put communications back to the EcoLAB controller. Communication directly with the detectors should only be done after consulting with Green Eyes or an authorized Green Eyes representative.

P - Move to Port

The P command moves the valve to ports 1 to 16 via the shortest direction. The port allocations and port numbers are given in Section 8.2.2

S - Detector Reading

S1 will take one detector reading and display it. The /, K & L commands should be preset.

T & W - Set EcoLAB Time (T) & Set Wake-up Alarm (W)

T1 asks the user for the desired format and then the current time. Current formats include MMDDYYhhmmss (option 0) and DDMMYYhhmmss (option 1) where hours (hh) is in a 24 hour format.

When entering the time, The EcoLAB will display a '[' after the desired format is entered. Enter the time values with no spaces and when the last digit of the seconds value is entered, that time will be used to set the clock.

The W1 command is used to set the wakeup time. After the M0 command is issued, the EcoLAB will sleep until the time is equal to the wakeup time and then enter logging mode. The format is the same as specified with T1. It is important that the wakeup time is a valid time, but if it's in the past and the EcoLAB will initiate logging as soon as M0 is received. Use H1 to view the current wakeup time.

Example:

```
>T1@OK!  
Enter date format 0=MM/DD/YY 1=DD/MM/YY  
>0@OK!
```

```
[061917112530]  
06/19/17 11:25:30  
>W1@OK!  
[061917120000]  
06/19/17 12:00:00  
>H1@OK!  
@ID#2012 I60 N0/3360 X0 U0 11.73V  
@MOT:VAL=1 SYR=-1  
@RTC:06/19/17 11:25:45  
@PWR:06/19/17 11:17:50  
@ALM:06/19/17 12:00:00  
>
```

Note: Highlighted text is entered by the user.

U - Upload Macros

Macros are uploaded using the U command. The argument supplied after the U designates the macro number. For example, U0 will upload the master macro and U1 macro 1.

Macros are described in detail in section 6.0.

V - View Macros

Macros can be viewed with the V command. The argument of V corresponds to the macro number. For example, V0 will display the master macro and V1 the first analysis macro. Macro comments are filtered out during uploading and thus not displayed with V.

Macros are described in detail in section 6.0.

X - Reporting Modes

Operations, data and diagnostic information may be selectively displayed by the X command setting.

Default 0: Raw data, absorbance & processed data
 3: Raw data, absorbance & processed data & macro commands
 4: All + debug

For example, option 3 when testing a new macro or trouble-shooting chemistry and option 4 for low-level functional trouble-shooting.

Debug (diagnostic) mode is very verbose and details are outside the scope of this manual. If in-depth trouble-shooting is required please contact tech support.

Y - Turn OFF/ON Detector Bus

When the system is powered-up the detectors remain off. To use them they must first be powered with the Y1 command. Conversely Y0 will turn-off the detectors and reduce power.

Z - Sleep (low power)

The Z command turns off all peripheral electronics and puts the main processor into **low power sleep**. It can only be awoken by sending \$\$.

& - New Firmware

New firmware is supplied periodically and may be loaded via the serial port. Please contact Green Eyes for specific instructions on firmware upgrades.

5.4 Command examples

Manual detector test reading

```
G1<CR>           // Align valve to inlet
-20000<CR>       // Collect inlet water
P3<CR>           // Move valve to nitrate detector
+20000<CR>       // inject inlet water into nitrate detector
Y1<CR>           // Power up detector bus
/1<CR>           // Set detector one for comms
K1               // Select channel one of selected detector
L3276<CR>        // Turn on led on selected detector and channel to
                 // 80% brightness
S1<CR>           // Collect and display one line of data from detector
```

```
Y0<CR>          // Detector data only saved when running a macro
                // Power down detector bus
```

Run a macro

```
M16<CR>         // Run M16 macro to prime phosphate and ammonia
                // reagents and OBS
M14<CR>         // Run the inlet flush macro M14
```

Note: different EcoLAB configurations will have different macro assignment

6.0 Macros

All actions of the EcoLAB syringe, valve and detectors can be executed through macros (ascii text files) comprised of letter commands and numeric arguments that are similar to the commands issued from the command prompt. The **master macro (M0)** is a repeating loop of sub-macros M1-M20.

6.1.1 Master Macro (M0) Commands

The following list contains the only commands valid with the Master Macro (M0):

Cmd	Arg	Description	Notes
#	N/A	Macro comment	Comments are not uploaded
M	1 to 20	Run a macro	
r	1-255	Repeat loop start	Arg is number of iterations
%		End of repeat loop	No arg
Z	0	Put EcoLAB to sleep	Puts EcoLAB to sleep and halts macro execution until the Interval (I) expires
;	0	End of macro	Must be placed at the end of the macro to force it to loop back to the start

Master Macro Format

<cmd><arg><CR>

1024 lines maximum

Master Macro Example

Simple M0 for N+N and PO4 OBSs and Samples

```
# Inlet flush
M14
# N+N OBS
M2
# Inlet flush
M14
# PO4 OBS
M5
# Sleep until interval expires
Z0
# Repeat five times
r5
# Inlet flush
M14
# N+N Sample
M1
# Inlet flush
M14
# PO4 Sample
M4
# Sleep until interval expires
Z0
# End repeat loop
%
```

In the M0 example above, setting N to 96 would yield four iterations (loops) of M0 with 48 total analytical macros (four each M2 and M5; 20 each M1 and M4). If the interval (command I) is set to 60, all macros between Z0 commands, including those inside the repeat loop, would execute every 60 minutes (given the run time for all the macros does not exceed 60 minutes). The EcoLAB will go into low-power sleep at Z0 until the interval expires, at which time it will begin running macros again.

Note: It is important to include all macros, not just analytical macros when setting max macros N.

6.2 Macros (M1 to M20)

There are 20 available macros that can be used for sample or OBS analyses, prime (flush all valve lines at setup), inlet flushing or utility/testing. Because each EcoLAB is customized to the user specifications, the same macro number may have different functions on different instruments. Each instrument is shipped with the macros installed to meet the user specified configuration of detector wavelengths and sensitivity.

Please refer to the configuration information for macro functions specific to your instrument. A set of example macros for a unit supplied with nitrate, phosphate, silicate and ammonia detectors is provided below. Notice that some macro numbers, such as 13, are repeated which allows users to select different reagents for back-flushing the inlet. There is also more than one Prime macro so users can match the prime macro with the chemistries being run. All five nutrients cannot be run on the EcoLAB during one deployment due to the limited number of valve ports (16). Usually, either silicate or nitrate is run, but not both on the same deployment. If the EcoLAB is fitted with all four detectors (nitrate, phosphate, ammonia, and silicate) loaded N+N macros will need to be replaced with silicate macros and vis versa.

Name	Date modified	Type	Size
 Macro 0 (N+N NO2 PO4 NH4 Analysis Cycle)	4/21/2017 11:46 AM	TXT File	1 KB
 Macro 0 (SiO4 PO4 NH4 Analysis Cycle)	4/5/2017 5:35 PM	TXT File	1 KB
 Macro 1 (N+N - Sample) V2.2 - 10mm(I1-K1) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 1 (SiO4 - Sample) V2.2 - 10mm(I1-K1) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 2 (N+N - Standard) V2.2 - 10mm(I1-K1) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 2 (SiO4 - Standard) V2.2 - 10mm(I1-K1) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 3 (N+N - Reagent Blank) V2.2 - 10mm(I1-K1) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 3 (SiO4 - Reagent Blank) V2.2 - 10mm(I1-K2) - Det 3 - Std 13 - 4-5-6	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 4 (PO4 - Sample) V2.2 - 10mm(I1-K1) - Det 12 - Std 2 - 7-8	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 5 (PO4 - Standard) V2.2 - 10mm(I1-K1) - Det 12 - Std 2 - 7-8	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 6 (PO4 - Reagent Blank) V2.2 - 10mm(I1-K1) - Det 12 - Std 2 - 7-8	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 7 (NH4 - Sample) V2.2 - 10mm(I1-K1) - Det 12 - Std 13 - 9-10-11	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 8 (NH4 - Standard) V2.2 - 10mm(I1-K1) - Det 12 - Std 13 - 9-10-11	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 9 (NH4 - Reagent Blank) V2.2 - 10mm(I1-K1) - Det 12 - Std 13 - 9-10-11	4/10/2017 5:01 PM	TXT File	3 KB
 Macro 10 (NO2 - Sample) V2.2 - 10mm(I1-K1) - Det 3 - Std 2 - 4	4/10/2017 5:01 PM	TXT File	2 KB
 Macro 11 (NO2 - Standard) V2.2 - 10mm(I1-K1) - Det 3 - Std 2 - 4	4/10/2017 5:01 PM	TXT File	2 KB
 Macro 12 (NO2 - Reagent Blank) V2.2 - 10mm(I1-K1) - Det 3 - Std 2 - 4	4/10/2017 5:01 PM	TXT File	2 KB
 Macro 13 (Inlet Backflush) V2.2 - NH4 Citrate Port 9	4/18/2017 10:04 AM	TXT File	1 KB
 Macro 13 (Inlet Backflush) V2.2 - PO4 Molybdate Port 7	3/28/2017 9:19 AM	TXT File	1 KB
 Macro 13 (Inlet Backflush) V2.2 - SiO4 Molybdate Port 6	3/28/2017 11:21 AM	TXT File	1 KB
 Macro 14 (Inlet Flush) V2.2	5/23/2017 10:07 AM	TXT File	1 KB
 Macro 15 (Prime - N+N NO2) V2.2	4/10/2017 4:16 PM	TXT File	2 KB
 Macro 15 (Prime - SiO4) V2.2	4/10/2017 4:17 PM	TXT File	2 KB
 Macro 16 (Prime - NH4) V2.2	4/18/2017 9:59 AM	TXT File	2 KB
 Macro 16 (Prime - PO4) V2.2	4/18/2017 10:01 AM	TXT File	2 KB
 Macro 16 (Prime - PO4-NH4) V2.2	4/10/2017 4:17 PM	TXT File	2 KB
 Macro 17 (N+N Test Reading) V2.2 - 10mm (I1-K1)	4/10/2017 5:01 PM	TXT File	1 KB
 Macro 17 (SiO4 Test Reading) V2.2 - 10mm (I1-K1)	4/10/2017 5:01 PM	TXT File	1 KB
 Macro 18 (NH4 Test Reading) V2.2 - 10mm (I1-K1)	4/18/2017 9:56 AM	TXT File	1 KB
 Macro 18 (PO4 Test Reading) V2.2 - 10mm (I1-K1)	4/18/2017 10:14 AM	TXT File	1 KB
 Macro 18 (PO4-NH4 Test Reading) V2.2 - 10mm (I1-K1 I1-K1)	4/10/2017 5:01 PM	TXT File	1 KB

Figure 6: Example list of EcoLAB macros

6.2.1 Macro Commands

The following list contains the commands that are valid within Macros (M1 - M20).

Note: While some macro commands are the same as the user commands, many are not. Use only macro commands in macros.

Cmd	Arg	Description	Units	Notes
#	N/A	Macro comment		Not uploaded
/	1 - 4	Set detector	See detector addressing	Set address before sending a command
+	1 - 23000	Insert syringe plunger	Motor steps	Reset to zero with arg=0
-	1 - 23000	Retract syringe plunger	Motor steps	Reset to zero with arg=0
A	1	Calculate I0 and I1 absorbance, display and store		Must be used after both I0 and I1 readings are collected. Usually the last command of an analysis macro
D	1 - 65535	Pause	Seconds	
F	0 - 999			See macro flag explanation 6.3
G	1	Align valve and move to port 1		
H	0 - 4	Heater control	0 - Both OFF 1 - Heater A ON 2 - Heater B ON 3 - Both ON 4 - Bring to set temp., turn off	
K	1 - 2	Set detector channel		Precede with: /
L	0 - 4095	Set LED current/brightness		Precede with: / and K
P	1 - 16	Go to port specified with arg via shortest route	Ports 1-16	
Q	1 - n	Go to port n - negative direction	Ports 1-16	
R	1 - n	Go to port n - positive direction	Ports 1-16	
S	1	Read/store detector data		Precede with: /, K and L or 1
Y	0 - 1	Set detectors OFF/ON	0 - off 1 - on	See note*
d	1 - 65535	Brings heaters to and holds them at set temp. for arg seconds		Target temperature is set in detector config.
i	250 - 1000	Set syringe motor step delay	µs	Consult Green Eyes

l	0 - 2	Set detector light to specified value	0 - Set Ch1 led brightness to preset value (3276, 80%) 1 - Adjust led brightness to set received light target 2 - Turn Ch1 and Ch2 leds off	Target received light is set in detector config.
p	string	Print comment	Up to 50 characters	
r	1-254	Repeat the following commands Arg times		Loop ends with %
%	None	End of repeat loop		
;	0	End of macro		

Sampling Macro Format

<cmd><arg><CR>

1024 lines maximum

Example Macro

```
# Heat      - This is a comment. It is not uploaded
H4          - Bring heater up to set temperature
G1          - Align valve
P13         - Go to port 13 (Phosphate OBS)
-10000      - Retract 10000 steps
P12         - Go to Port 12 (Phosphate and Ammonia detector)
+10000      - Insert 10000 steps
# PO4 IO    - This is a comment. It is not uploaded
F123        - Flag = Phosphate, Standard, Reference (IO)
/1          - Detector 1
K1          - Channel 1
L3276       - Light = 3276 bits
D60         - Hold until temp = threshold
H0          - Heaters off
S1          - Read light transmission
L0          - Light OFF
;0          - End of macro
```

6.3 EcoLAB Macro Data Flags

Data flags are attached to each detector reading. The flags indicate the analyte, the analysis macro and the type of reading.

Where: X = Analyte
 Y = Macro
 Z = Reading Type

The key to the data flags are given in the tables below:

Analyte	X
0	NO3 - Nitrate
1	PO4 - Phosphate
2	NH4 - Ammonium
3	SiO - Silicate
4	Reserved
5	NO2 - Nitrite
6	Reserved
7	Reserved
8	XXX

Macro	Y
1	Smp - Sample
2	Std - Standard
3	Cmb - Combo
4	Tst - Test
5	Rbl - Reagent Blank
6	Cal - Calibration
7	Fls - Flush
8	Utl - Utility
9	XXX

Reading	Z
1	I0s - Sample Reference
2	I1s - Sample Reaction
3	I0t - Standard Reference
4	I1t - Standard Reaction
5	I0r - Reagent Blank Reference
6	I1r - Reagent Blank Reaction
7	I0u - Utility Reference
8	I1u - Utility Reaction
9	Chk - Check

Example

011 = Nitrate, Sample, Sample Reference

112 = Phosphate, Sample, Sample Reaction

221 = Ammonium, Standard, Sample Reference = INVALID FLAG

6.4 Uploading Macros

Macros are pre-installed. It is not intended that the user modify or upload new macros without first seeking advice from our technical support. The macro commands are provided to aid understanding of the analysis routines provided.

6.4.1 Macro Upload Procedure

Macro files are simple ASCII text files with no control or special characters (e.g. TAB). The upload process is invoked by the "Ux<CR>" command, where x is the target macro number. When ':' is displayed upload may commence. Every macro must terminate with the ";0<CR>" command. At this point the normal command prompt will resume.

Be sure the terminal is configured with 5ms character and newline delays. If using Tera Term (recommended) the settings are available by selecting the Serial port under the Setup menu. After setting the delays, the macro file can be sent to the EcoLAB by choosing the Send file... option under the File menu. A file browser window will open allowing navigation and selection of the correct macro loaded on the PC.

7.0 Data

There are two sources for data: real-time via the serial port and downloaded (D commands).

7.1 Data Format

Each analysis macro generates two lines of timestamped colorimeter data. The first is the reference reading (I0) which is usually mixture of sample or OBS water with some reagents to replicate the baseline optical properties of the water. Color forming reagents are not added to I0 readings. The second reading is the reacted value (I1) which is the light transmission of the sample or OBS with all color forming reagents. The absorbance (signal) of the analysis is calculated from Beer's law as follows:

$$\text{Abs} = \text{Log}_{10} (I0/I1)$$

Where I0 is the light transmission of the reference reading and I1 is the light transmission of the reacted (colored) solution.

For details of data format and processing please refer to the Green Eyes data processing guide.

The ComScript application for the EcoLAB, which is available for free download on the Green Eyes' website (the application manual can also be downloaded from the website), can process all raw data into absorbance and concentration.

7.2 Raw Detector Reading Format

A single detector reading is shown with field numbers on the line beneath. Optical data (fields 9, 10 and 11) are recorded as a 16-bit integers (0-65535).

03/17/10 13:20:07,11.6,PO4,Smp,I0s,2001,880,0,51329,27957,10184

Field	Description
1	Time stamp
2	Supply voltage
3	Chemistry Type
4	Macro Type
5	Reading Type
6	Detector serial or ID#
7	Detector channel wavelength (nm)
8	Heater status
9	Light transmission
10	LED current
11	Detector temperature

Fields 3, 4 & 5 - See the Macro Flags section 6.3 for details.

Field 9 - Light transmission - is the analytical reading. This represents the amount of light able to pass across the analytical path and is used to calculate absorbance.

7.3 Calculated Data Format

No longer supported. Please refer to the Green Eyes' data processing guide and use the ComScript EcoLAB application to calculate sample concentration.

8.0 Deployment

It is strongly suggested that users familiarize themselves with the EcoLAB on the lab bench for several days before deploying the instrument on a buoy or mooring. It is also recommended that when the initial deployment setup is complete, the EcoLAB is run in the reagent housing over night before the deployment to insure everything is working correctly. It is not uncommon to connect a reagent to the wrong port or leave a pinch clamp in the pinched position during setup. **Double checking correct reagent connection, that all tubing is free and that all pinch clamps are not pinched is critical to success!**

The EcoLAB has a built-in data logger and controller and is thus able to control its sampling schedule (see 6.0 macros) in macro 0. For integration into multi-instrument systems, a data logger can be used to issue individual macro commands (M1 - M20) or by **setting max samples N to single batch of M0 analyses.**

8.1 Configuring auto-sampling

Auto-sampling mode is configured with the following steps.

1. Check the RTC is correct (read time with H1 set with T1) and that the delayed start (W1) is valid.
2. Enter the future start time for the deployment (command W) if a delayed start is desired.
3. Set the analysis interval (command I)
4. Set the total number of macros to execute (command N)
5. Record the header info with the H1 command and verify all deployment parameters above were entered correctly.
6. Start auto-sampling mode (command M0)

Auto-sampling sequence

The system will compare the RTC time and the delayed start time. If the alarm is in the future the system will enter a low power sleep mode until the start time. If the alarm is in the past the cycle will start immediately.

When the system wakes-up at the start time it will run first batch of analysis macros in the cycle until the master macro Z0 command puts the EcoLAB into sleep mode. Before running each macro, the EcoLAB will display the macro it's running the macro counter and the max macros to run. Macro print statements and data will be transmitted out the user interface as well.

Analysis interval 'I'

The analysis interval sets the time that will elapse between Z0 commands in the master macro. After waking from sleep, the interval begins to elapse and the EcoLAB begins running macros. When the next Z0 have reached, the EcoLAB will sleep for the balance of the interval.

Waking the system from sleep and exiting from auto-sampling mode

When the system is "asleep" it may be awoken with the "\$\$" command which will end logging and return the system to the command prompt. To relaunch logging, reset the max macros N and send M0.

Automatic Recovery

If the EcoLAB temporarily loses power while running M0 (auto logging), it will restart the M0 sequence at the beginning when power is returned. To stop auto logging mid-macro during bench testing while connected to a PC, turn off the power and press and hold the esc key when power is returned until the command prompt is displayed.

8.2 Preparing for Deployment

The following procedure to prepare for deployment is recommended:

1. Prepare all reagents and standards. Required volumes for specified analyses are provided in the reagent volumes spreadsheet.
2. Fill reagent/standard bags with the appropriate volume for the deployment.
3. Collect samples of the OBSs for verification.
4. Connect all the reagents, OBSs, DIW, air and waste lines as specified by the valve allocation table specific to the EcoLAB configuration.
5. Double check that all tubing is free, clamps are not pinched and connected correctly.
6. Install the EcoLAB in its reagent housing and route the inlet line outside the housing.
7. Connect DIW or low nutrient seawater to the inlet (port 1)
8. Purge air from the reagent and OBS lines using the appropriate prime macro(s). Run the prime macro(s) a second time if air bubbles remain after the first prime.
9. Download & clear old data files
10. Configure auto-sampling mode as required (section 8.1)
11. **Upload the M0 macro with the back-flushing macro commented out.**
12. Run the instrument on the lab bench overnight to insure proper function.
13. Verify the overnight test results are as expected and have stabilized.
14. **Upload the M0 macro with the back-flushing macro NOT commented out.**
15. Place the filter on the inlet line and secure it just outside of the reagent housing.
16. If the battery or user interface connectors are not fitted on the bulkhead, install a dummy plug.

8.2.1 Reagent Volumes

See Reagent and OBS volume spreadsheet.

8.2.2 Valve Port Allocations

See valve allocation table or figure specific instrument configuration.

8.3 Recovery

Immediately after recovery proceed as follows:

1. Connect your PC and download the data from EcoLAB. If the battery is drained, use an external power supply.
2. Wash the exterior of the instrument thoroughly with fresh water to avoid corrosion of stainless steel fasteners.
3. Check that some reagent and OBS remains in the bags and run one or more test sample for all nutrients and record the results.
4. Remove the cadmium column (if used), waste bags, reagents and on-board standard from the instrument. Do not allow air to enter the Cd column.
5. Freeze a sample of the OBSs for later analysis.

6. Connect all valve ports to DIW and run two or more prime macros for all channels to flush the valve and syringe.

9.0 Servicing

The EcoLAB unit, reagent housing and battery pack should be cleaned of biological growth after each deployment and the valve and syringe should be cleaned with soapy water and soaked in DIW. To remove the valve, remove the syringe coupling and the two valve mounting bolts. If the assembly will not easily slide out from the main unit, lower the syringe with the -10000 command.

After three months of continuous operation, the seals on the syringe shaft must be replaced or water could enter the pressure case and destroy electronics.

To service the syringe seals:

1. Disconnect the deck lead.
2. Remove the syringe pressure case.
3. Reconnect the deck lead and establish communications.
4. Raise the lower syringe shaft until the nut at the base of the syringe shaft is visible inside the syringe motor mounting block.
5. While holding the narrow specialty wrench on the nut just above the motor, unscrew the shaft (counter-clockwise) with the regular wrench on the nut at the top of the shaft. Both wrenches are supplied in the toolkit.
6. Carefully lift the syringe shaft from the main unit.
7. Use the slotted washer tool provided in the toolkit to unscrew the syringe shaft bushing. Avoid cracking the plastic slot on the bushing with adequate, but not excessive down force.
8. **Replace the syringe shaft bushing with a new one and be sure that the o-ring in the bottom is clean and has a light coating of silicon grease. If only replacing the o-ring, be sure it is clean and lightly greased.** Tighten the bushing until flush with the bulkhead, but do not overtighten.
9. Clean the syringe shaft with a lint free wipe and apply a very thin coating of silicon grease.
10. Carefully insert the syringe shaft back through the new bushing. The shaft will need to be pushed through the variseal and then the o-ring. Push the shaft down on to the motor lead screw and tighten it down onto the locking nut. Make sure the syringe shaft is all the way down at the base of the small threads on the lead screw and tighten the locking nut against the shaft with the wrenches. Be careful not to "round" the nut on the shaft by over-tightening.
11. Put the unit back into the syringe pressure case and verify the there are still 22000 steps of travel.

Periodically check Green Eyes website for additional technical support and service documents as well as instructional videos. If unsure how to service the EcoLAB, please contact Green Eyes or your local agent.