EcoLAB 2 – Operating Manual

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2.0 Introduction

The EcoLAB 2 Analyzer System is a submersible chemical analyzer for automated monitoring of dissolved chemicals in all natural waters. Analytes include nitrate, orthophosphate, ammonium, silicate, iron and chloride. Many other standard colorimetric methods may also be adapted.

The system comprises of an analyzer module, controller, reagent storage carousel and a protective guard.

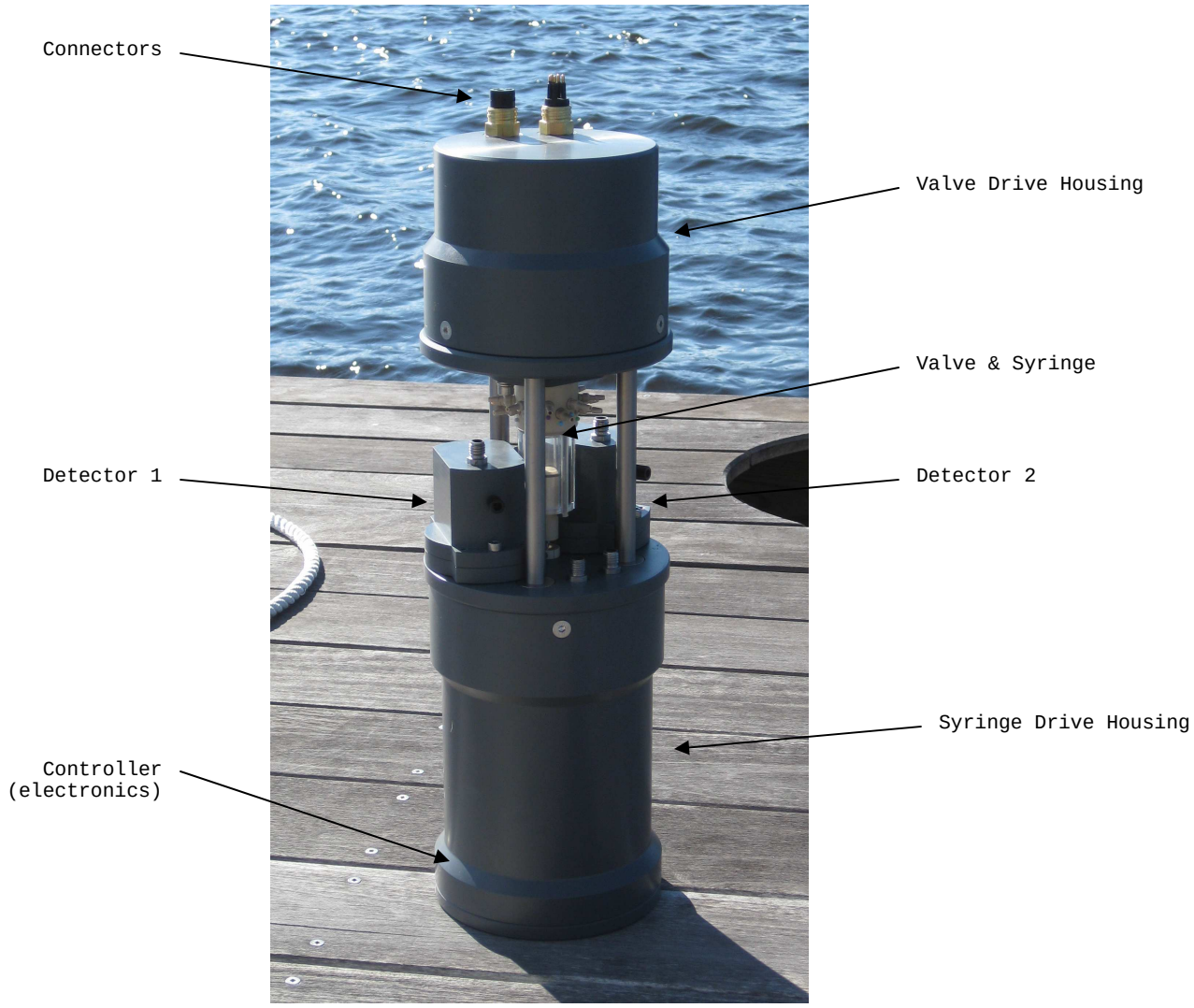


Fig 1 - EcoLAB 2 Analyzer

The analyzer module includes a fluid handling system and one or two detectors. The fluid handling system incorporates a precision 3.5 ml syringe-pump and an 8-port or 16-port rotary valve. The syringe is used for sampling, reagent dosing, mixing, dilution and flushing. The valve can select one reagent, standard, inlet, detector or outlet allowing sample and reagents to be mixed and then delivered to the detector.

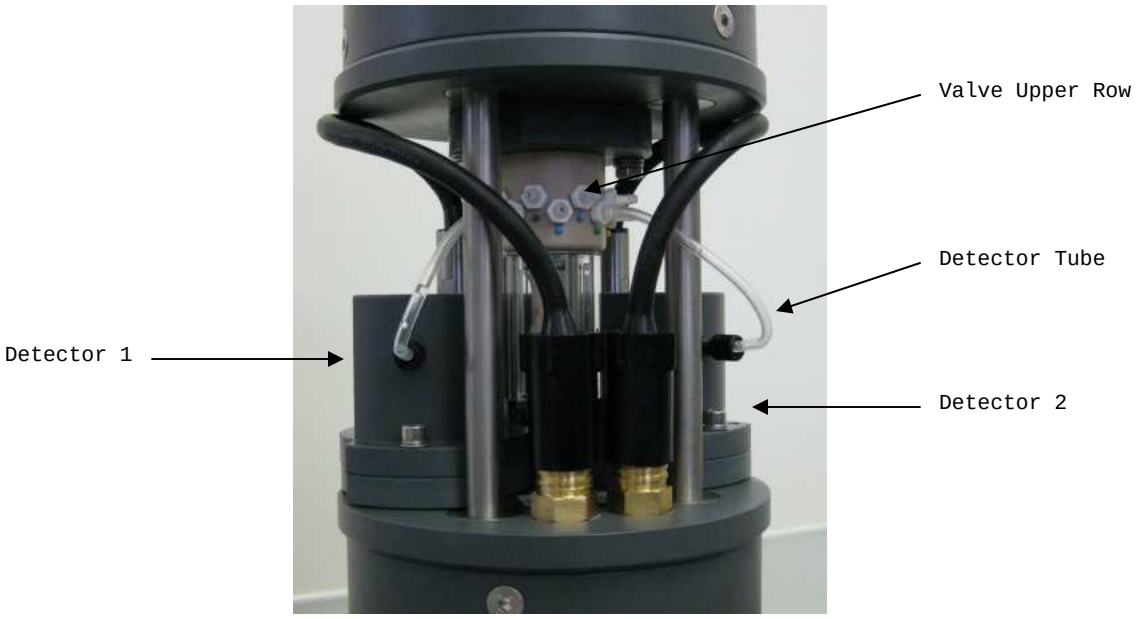


Fig 2 - EcoLAB 2 Analyzer

2.1 Detectors

The detectors incorporate one or two fixed wavelength narrow-band colorimeter channels optimized for the peak response of the selected analyte. EcoLAB detectors adhere to the Beer-Lambert Law. Miniature high-efficiency heaters are integrated into the detector block. Each detector is labeled with the chemistry channels installed.

2.2 Reagent Housing & Guard

When assembled the analytical system is in the center of the guard. Reagents, standards, etc. are stored in gas-impermeable reagent bags on a rack or carousel around the analyzer. Reagents and standards are delivered to the valve via gas-impermeable tubing. Waste can be collected in a waste bag.

The EcoLAB 2 system has been designed to be easy to use. However, it is strongly recommended that this manual and the chemical method manual are read in full before trying to operate the system. A common cause of “new user” problems and frustration is incomplete familiarization and short testing time.

2.3 Important Notes

1. Power Supply: A frequent cause of problems for a new user is an inadequate power supply
2. Valve Nozzle Torque: Valve nozzles must be inserted at the correct torque and should be removed and re-fitted prior to each set-up and deployment. The correct torque is 32 in-oz.
3. Seals: O-rings and sealing surfaces must be totally clean and without scratches. O-rings should be lightly lubricated with silicone grease.
4. Servicing: Insufficient servicing will eventually cause catastrophic damage by flooding
5. Shock & Impact: Heavy impacts should be avoided if at all possible
6. Fasteners: If replacements are needed only 316/A4 stainless steel or grade 2 titanium parts should be used
7. Date: The US date format is used throughout (MM/DD/YY)

3.0 Methods

Analytical routines are based on well established methods using non-proprietary reagent formulations. Many methods are based directly on approved US EPA methods, or where not available the industry standard method. A list of available analyte methods is given below.

3.1 Analyte List

Nitrate
Phosphate
Ammonium
Silicate
Urea
Nitrite
Iron
Chloride

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

3.2 Analysis Macros

EcoLAB 2 utilizes a set of macros routines to perform each analysis. Analyses types include sample, standard, reagent blank, prime & flush. Macros are described fully in section 6.0

4.0 Operation

The EcoLAB 2 system is designed to be easy to use. With an adequate power supply, a clear understanding of the system commands and carefully prepared reagents/standards the user will obtain excellent results. Short-cuts are invariably fatal to the operation of the instrument.

4.1 Power

Power supply: 12 vDC regulated / 3 Amps peak

The EcoLAB 2 system operates at a nominal 12 volts DC.

The recommended range is 10 – 14 volts DC. Reverse polarity and voltages outside the recommended range may cause the unit to malfunction or damaged it.

The power supply must be capable of providing at least 3 Amps for short peaks. The most common cause of “new user” problems is an inadequate power supply. Please consult the factor for advice if unsure.

A suitable power supply is available as an optional extra.

Fig 3 - Power Supply

4.2 Communication

The user or master system can communicate with the EcoLAB 2 using the following configuration.

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

A terminal emulator (e.g. Tera Term or HyperTerminal) may be used to control the system on the bench.

4.3 Connecting up

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

Fig 4 - Electrical Connectors

Remove the dummy plug from the connectors. Connect and secure the communications lead. Connect the red and black jack plugs on the bench lead to a suitable 12 VDC power supply. DO NOT POWER UP.

Attach the **FEMALE** DB9 connector on the bench lead to a suitable RS232 port on any PC.

Start a terminal emulator program (e.g. HyperTerminal) and configure it for the correct communications protocol (above).

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

ECO-2 Vx.xxx
@SD1
@CMD
>

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 "ready for next command". Commands can only be entered when the prompt is shown.

All commands are in the following format:

<Cmd><Arg><CR>

Where: Cmd = Command (capital letter)
Arg = Argument (number)
CR = Carriage return <CR>

5.1 Command Set

Cmd	Arg	Description	Units	Notes
?	None	Query status		@RDY = ready @BSY = busy
$	$	Wake from sleep		
+	1 - 20000	Insert Plunger	Motor steps	
-	1 - 20000	Retract Plunger	Motor steps	
/	1 or 2	Set current detector		
A	1-65535 0	Sets current detector heater threshold Display thresholds for detector 1 & 2		Select detector first then set threshold Ex: /1, A20000 *Factory set
B	0 - 3	Set chemistry for standard entry		0 – NO3 1 - PO4 2 – NH4 3 – SiO4
C	1 – 50,000	Enter on board standard (channel B)		uMol/L or ug/L
D	 0 1 2 3	Download: All raw data New raw data All real data New real data		See below
E	 0 1 2 3	Erase: All raw data New raw data All real data New real data		
F	password	Reset non-volatile config to default		
G	1	Align at port 1		Wait 4 sec after command finished
H	1	Header information		See below
I	1 - 64800	Sample interval	Minutes	1 min to 45 days
J	0 - 9999	Set serial number		
K	1 or 2	Set detector channel		Pre-set the '/' command
L	0 - 4095	Set detector light		Pre-set the '/' command
M	0 1 - 16	Auto-sample Run macro		CTRL-Q to HALT macro Macro details below

N	1 – 3500 0	Number of analyses Resets counter		
O	1	Open serial bus connection		CTRL-D to close connection
P	1 – 16	Go to port	Port	Shortest distance
Q	RESERVED			
R	1 - 3500	Run cycle macro		Analyze back to back CTRL-Q to HALT cycle
S	1	Scan detector		Pre-set the '/' command Set 'K' & 'L' commands
T	1	Set time (RTC)		Format: MMDDYYhhmmss
U	0 – 16 password	Upload Macro Clear all Macros		See below
V	0 – 16	View Macro		See below
W	1	Set wake-up time		Format: MMDDYYhhmmss
X	0,3,4	Report mode		See below
Y	0 or 1	Turn OFF/ON peripheral bus	0 = OFF 1 = OFF	
Z	0	Shutdown		
&	Password 0	Load new firmware Show firmware version		See procedure

5.3 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.) / current macro argument
@BAD – Bad macro command
@BSY – Unit executing a command
@CAL – Calibration data follows
@CMD – Current macro command
@CON – Concentration data follows
@DET – Detector reading follows
@END - End of action (sampling / data download)
@ERR – Error state during macro
@FS: - File system message (e.g. @FS: FILE NOT FOUND)
@HLT – Macro halted by user (CTRL-Q)
@ID# - Unit serial or ID number
@INV - Invalid command
@MAC – Current macro
@MAX – Max number of samples accrued
@MOT - Stepper motor powered off when enabled (moving or holding)
@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 stepper command
@RES – Reserved command / command not available
@RTC – Real-time clock follows
@RST – Resetting (after serial interrupt)

@SCr – Response from stepper (running)
@SCe – Response from stepper (move ended)
@SD1 – Found Smart Data card 1
@SD_ - SD card error
@STP – Stepper drive status (debug mode only)
@STD – Standard data follows
@T/O – Peripheral timed-out (e.g. stepper or detector)
@[O] – Serial connection open
@[C] – Serial connection closed

5.4 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. The system will reset and then require an ESACPE key within 20 seconds to revert to command mode. If not received the system will go back to sleep in deployment mode (i.e. re-enter the deployment or master macro where it was interrupted).

+ & - Move Syringe
The + and – commands insert and retract the syringe respectively. The movement is a number of steps or increments.

Syringe volume: 7300 steps = 1.00 ml
20000 steps = 2.75 ml (MAXIMUM travel)

All syringe movements are relative to the current position. The syringe motor incorporates a "clutch". Over-driving the syringe allows it to home properly, but excessive over-drive will wear the clutch and shorten its life.

/ - Set Detector
The / ("slash) command is used to set the current detector to either 1 or 2. The / command should be used before the other detector commands K, L & S. Detector 1 is the detector connected to the left-hand detector plug. Refer to Figure 1.

A – Reset analysis counter
A1-65535 – sets current detector threshold (first use / command to set detector)
Ex:
/1 (select detector 1)
A20000

A0 – displays thresholds for detectors 1 & 2
If no valid detector is set the default threshold is 20,000

B – Set Channel (for calibration standard)
The B command sets the chemistry for subsequent entry of its standard concentration.

0 = NO3
1 = PO4
2 = NH4
3 = SiO

C – Standard Concentration
Enter the standard concentration as an integer in the range 1 - 50,000. Units are the units of the standard (e.g. mg/L, ug/L, uMol/L, nMol/L, ppm, ppb).

D – Download Data
There are two types of data file:

Raw – Time-stamped data recorded as a 16-bit count (0-65535)
Real – Time-stamped data recorded as absorbance and concentration

There are two locations for each type:

All - All accumulated data
New - All new data

Therefore four data files are created and may be downloaded individually

D0 - All raw
D1 - New raw
D2 - All real/calculated
D3 - New real/calculated

File formats are given in the data section.

“New” data files are intended for periodic download via a telemetry system where only data accumulated since the last download is desirable to limit transmission time and avoid duplicates. Note that the “new” data files are NOT erased by downloading them. The user or master system must erase the new files using the ‘E’ command once a good download has been confirmed. Therefore new data can be re-downloaded if a telemetry connection drops, etc.

E – Erase Data
Each of the data files can be erased with a corresponding E command (e.g. E0<CR> will erase D0).

F – Reset Non-Volatile Variables
All variables are reset to default values using F<password><CR>

G – Align Valve
Align the valve at port 1
Wait 4 seconds after movement is complete

H – Header Information

The "header" is used to view the configuration of the system and command (H1) shows the header. The format is given below:

```
>H1@OK!
@ID#9999 I60 N0/840 X0 U0 12.16V
@STD(NO3)10.000 (PO4)10.000 (NH4)10.000 (SiO4)10.000
@RTC:03/23/10 08:22:29
@PWR:03/22/10 15:57:21
@ALM:03/23/10 09:00:00

<serial/ID#> <interval> <analysis count>/<analysis limit> <reporting> <motor> <supply voltage>

<standard conc.> <standard conc.> <standard conc.> <standard conc.>
<current time>

<last time power removed>

<wake-up/start time>
```

I – Sample Interval

Set the sample interval in minutes. The interval is from the start of one batch of analyses to the start of another. For reliable timing the interval must be greater than the sum of the analysis lengths in the batch. For example, a batch may contain one sample for each analyte installed.

J – Set ID or Serial Number

By default the serial number is set, but the user may change this to any ID number in the range 0 – 9999.

K – Set Detector Channel

Each detector has two channels (1 & 2). This command selects the current channel. The / command should be preset.

L – Set Detector Light

Set the light level (intensity) in the range 0 – 4095 for the current channel of the current detector. The range 0 – 4095 is equivalent to 0 to 25 mA. The / and K commands should be preset.

M – Macro Commands

Command M0 will invoke auto-sampling where the system runs autonomously following the "master macro" routine and running each analysis macro (M1 – M16) as they are called.

Commands M1 through M16 will run the associated (uploaded) analysis macro.

Macros are described in full in section 6.0

Auto-sampling is described further section 9.0.

N – Number of Analyses / Analyses Limit

Ex: N0/840

The N command sets a limit on the number of analyses that will be run during auto-sampling. The analysis counter will be incremented each time a macro M1 – M16 is run. For example, one batch of nitrate, phosphate, ammonium and silicate samples increments the counter +4.

Entering N0<CR> will reset the counter.

O – Open serial comms with stepper

The user may communicate with the peripheral devices (that drive the valve & syringe motors and the detectors). It is recommended that this is done only after receiving advice from technical support.

P – Move to Port

Each port is marked with a colored pin. Each port corresponds to a number 1 to 16 (for 8-port systems only odd numbered ports are open).

The P command moves the valve to a port 1 to 16 via the shortest route.

The port allocations, pin colors and port numbers are given in the chemistry method section.

R – Run Cycle Macro

Run the master macro M0 without any interval (back-to-back). Use for test or to initiate a batch of analyses if used as a slave device within a monitoring system.

The R sequence counter increments when it encounters each Z0 command in the master macro.

S – Scan Detector

Scan the detector. The /, K & L commands should be preset.

T & W – Set Time (T) & Set Alarm (W)

Date & time is set in the format ‘MMDDYYhhmmss’ where time is in a 24 hour format.

Note: The US date format is used.

For date & time entry commands T & W behave in the same way. After T1 or W1 has been entered the date/time capture will open a square bracket [. The time is updated when the last character is entered and the routine will display a closing square bracket.

```
>T1<enter>
[122409235900]
>
```

If the W command is used to set the wake-up time and it is a time that has already passed then the warning @ALM will be displayed.

U – Upload Macros
Macros are uploaded using the U command. The argument of U corresponds to the macro number. For example U0 will upload the master macro and U1 the first analysis macro.

Macros are described in detail in section 6.0.

V – View Macros
Any macro can be viewed with the V command. The argument of V corresponds to the macro number. For example V0 will view (list) the master macro and V1 the first analysis macro.

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 & real data
3: Raw data, absorbance & real 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 ever required please contact us for advice.

Y – Turn OFF/ON Peripheral Bus
When EcoLAB is powered-up the peripherals remain off. To operate them they must be first powered with a Y1 command. Conversely Y0 will turn-off the peripherals and reduce power.

Z – Shutdown
The system may be forced to shutdown all peripherals and go to sleep in a very low power mode with the Z0 command. See the $ command for wake-up information

& – New Firmware
Firmware will be updated from time to time as maintenance releases or to implement new features. New firmware may be loaded via the serial port. Updated firmware and specific installation instructions will be supplied by our technical support.

5.5 Command examples

Master Unit Commands

Y1<CR>	Power-up peripherals (detectors)
W1 [MMDDYYhhmmss]	Set future start auto-sampling date/time e.g. 031210132030 = March 12th, 2010 at 1:20:30 p.m.
I60<CR>	Set sampling interval to 1 hour
M0<CR>	Start auto-sampling
R36<CR>	Run 36 analyses in the main cycle, back-to-back

Detector Commands

/1<CR>	Set unit 1 as current detector
K1<CR>	Select channel 1 in current detector
L3500<CR>	Set LED intensity in current detector channel
S1<CR>	Read current detector channel

6.0 Analysis Macros

EcoLAB analysis is controlled by programmable macros. These are simple ASCII text files. The macros are numbered M0 through M16.

All macros are pre-installed. It is not intended that the user modify or upload new macros without first seeking advice from our technical support.

6.1 Master Macro

The M0 macro is known as the “master macro” and determines analysis batches, sequence and timing.

Macros M1 to M16 are the analytical macros and determine the analytical process.

Macro M0 can call or run any macro M1 to M16. Macros M1 to M16 cannot call other macros.

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 16	Run analysis macro	
Z	0	Shutdown	Must be placed at end of each batch to invoke sleep and the sampling interval
;	0	End of macro	Must be placed at the end of the macro to force it to loop to the start

Master Macro Format
<cmd><arg><CR>

1024 lines maximum

Master Macro Example

```
# “comment” - This is a comment. It is not uploaded
M1          - Sample Ch1 (increment analysis)
M2          - Standard Ch1 (increment analysis)
M3          - Sample Ch2 (increment analysis)
M4          - Standard Ch1 (increment analysis)
Z0          - Enter sleep
M1          - Sample Ch1 (increment analysis)
M3          - Sample Ch2 (increment analysis)
Z0          - Enter sleep
M1          - etc...
M3
Z0
M1
M3
Z0
;0          - Loop to top
```

Note:
Setting I determines the sampling interval and N determines the number of samples.

The sampling interval is from the start of one batch of macros to the start of the rest. i.e. if the interval is 60 and M1+M3 = 20 minutes, then the sleep period will be 40 minutes (Z = I – M1+M3).

Each Macro will increment the analysis counter N by 1. So M1+M2+M3+M4 = N+4. The system will halt when N >= N0/840 (max samples).

6.2 Analytical Macros (M1 to M16)

Macros M1 through M16 are used to perform analyses. They can be run individually directly from the command prompt or automatically via the master macro (M0).

Analytical Macro Locations

By default the various analysis macros are uploaded to the locations below:

M1 – Sample (nitrate)
M2 – Standard (nitrate)
M3 – Reagent Blank (nitrate)
M4 – Sample (phosphate)
M5 – Standard (phosphate)
M6 – Reagent Blank (phosphate)
M7 – Sample (ammonia)
M8 – Standard (ammonia)
M9 – Reagent Blank (ammonia)
M10 – Sample (silicate)
M11 – Standard (silicate)
M12 – Reagent Blank (silicate)
M13 – Flush & Blanks Det1 Ch1 / Ch2
M14 – Flush & Blanks Det2 Ch1 / Ch2
M15 – Prime (all)
M16 – Utility

6.2.1 Analysis Macro Commands

The following list contains the only commands that are valid within the Analytical Macros (M1 – M16):

#/+-DFGHKLPQRSY;

Note: Some, but not all, commands have the same function as in the User Command Set

Cmd	Arg	Description	Units	Notes
#	N/A	Macro comment		Not uploaded
/	1 - 2	Set detector	1 – Detector A 2 – Detector B	Set address before sending a command
+	1 - 23000	Insert syringe plunger	Motor steps	
-	1 - 23000	Retract syringe plunger	Motor steps	
D	1 - 65535	Delay /pause	seconds	
F	0 - 999	Macro Flag		See below
G	1	Align and move to port 1		
H	0 - 3	Switch heaters	0 – Both OFF 1 – Heater A ON 2 – Heater B ON 3 – Both ON	
K	1 - 2	Set detector channel		Precede with: /
L	0 - 4095	Set LED current		Precede with: / & K
P	1 - n	Go to port n – shortest route	Ports	
Q	1 – n	Go to port n – negative direction	Ports	
R	1 - n	Go to port n - positive direction	Ports	
S	1	Read/store detector data		Precede with: /, K & L
T	1	Hold for temperature threshold	Deg C = count/2000 mDeg C = count/2	Time-out ~ 5 minutes
Y	0 - 1	Set detectors OFF/ON		See note*
;	0	End of macro		

Note*: By default the peripheral bus is turned ON at the start of a macro. The Y0 command may be used to save power during a macro – for example, when waiting. However, all power will be removed from all peripherals.

Sampling Macro Format
<cmd><arg><CR>

1024 lines maximum

Example Macro

```
# Heat      - This is a comment. It is not uploaded
H3          - Turn on heaters
G1          - Align valve
P2          - Go to port 2
-1000       - Retract 1000 steps
D2          - Delay 2 seconds
+1000       - Insert 1000 steps
# PO4 Bt    - This is a comment. It is not uploaded
F123        - Flag = Phosphate, Standard, Standard Blank (Bt)
/1          - Detector 1
K1          - Channel 1
L3500       - Light = 3500
T1          - Hold until temp = threshold
H0          - Heaters off
S1          - Read
L0          - Light OFF
;0          - End of macro
```

6.3 Data Flags

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

<flag> = XYZ (e.g. 031)

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

The key to each flag section are given in the tables below:

Analyte	X
0	Nitrate
1	Phosphate
2	Ammonium
3	Silicate
4	Urea
5	Nitrite
6	Iron
7	Chloride

Macro	Y
1	Sample
2	Standard
3	1+2
4	Prime
5	Blanks
6	Cal
7	Flush
8	Utility

Reading	Z
1	Sample Blank (Bs)
2	Sample Reaction (Rs)
3	Std. Blank (Bt)
4	Std. Reaction (Rt)
5	Reagent Blank (Br)
6	Reagent Reaction (Rr)
7	Utility Blank (Bu)
8	Utility Reaction (Ru)

Example

031 = Nitrate, Sample+Standard, Sample Blank (Bs)
112 = Phosphate, Sample, Sample Reaction (Rs)
221 = Ammonium, Standard, Sample Blank (Bs) = INVALID FLAG

6.4 Uploading Macros

All 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). A valid macro file can be uploaded with a 1 ms inter-character delay.

The upload process is invoked by the “Ux<CR>” command, where x is the target macro. Once invoked the ‘:’ character is shown as the macro upload prompt for each line. When ‘:’ is displayed upload or transfer may commence. Every macro must terminate with the “;0<CR>” command. At this point the normal command prompt will resume.

7.0 Data

There are two sources for data: Online (on screen) and downloaded.

7.1 Data Format

Typical output from a phosphate sample is given below:

```
@S0018
03/17/10 13:20:07,11.6,PO4,Smp,Bs,2001,880,0,51329,27957,10184
03/17/10 13:20:11,11.6,PO4,Smp,Rs,2001,880,0,43411,23958,10270
@END
@ABS,PO4,(As),0.0728,(At),0.0000,(Ar),0.0000,(Au),0.0000
@CAL,PO4,(m),75.465,(c),-1.444
@CON,PO4,(Cs),4.047,(Ct),10.000
```

This is equivalent to:

```
<Analysis counter>
<PO4 sample blank data (Bs)>
<PO4 sample reaction data (Rs)>
<End of macro>
<Absorbance data>
<Calibration coefficients>
<Concentration data>
```

7.2 Raw Detector Reading Format

The online and stored formats for raw data are identical.

A single detector reading is shown with field numbers on the line beneath. Values are recorded as a 16-bit integer count (0-65535)

```
03/17/10 13:20:07,11.6,PO4,Smp,Bs,2001,880,0,51329,27957,10184
1                 2    3   4   5  6    7   8 9     10    11
```

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	Transmission (count)
10	LED current (count)
11	Detector temperature (count)

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

Field 9 – Transmission – is the analytical reading. This represents the amount of light able to pass across the analytical path. Transmission readings are used to calculate absorbance.

7.3 Calculated Data Format

Online and stored formats of calculated data are tagged identically. Line headers are omitted in the stored data.

A set of calculated data is shown with a description and key given below:

@ABS,PO4,(As),0.0728,(At),0.0000,(Ar),0.0000,(Au),0.0000
@CAL,PO4,(m),75.465,(c),-1.444
@CON,PO4,(Cs),4.047,(Ct),10.000

Calculated Data Lines
@ABS = Absorbances calculated from the last macro
@CAL = Current calibration coefficients
@CON = Sample concentration from last macro & on-board standard concentration

Key	Description
As	Sample absorbance
At	Standard absorbance
Ar	Reagent blank absorbance
Au	Utility analysis absorbance
m	Slope of calibration line
c	Intercept of calibration line
Cs	Sample concentration (calculated)
Ct	Standard concentration (entered)

Note:
1. Absorbances shown online are from the last macro (only)
2. Any macro can (be programmed to) create more than one type of absorbance
3. Invalid transmission data will not generate absorbance results (e.g. blank < reaction)
4. Invalid absorbance data will not update the calibration (e.g. Ar > At)
5. Concentrations are only calculated if sample a absorbance is generated
6. The standard concentration is fixed (entered by the user)

7.4 Downloaded Data Formats

Raw Data

```
>D0@OK!
03/17/10 12:05:07,11.6,PO4,Smp,Bs,2001,880,0,50247,27957,10895
03/17/10 12:05:11,11.6,PO4,Smp,Rs,2001,880,0,42484,23958,10968
03/17/10 12:05:18,11.6,PO4,Std,Bt,2001,880,0,49528,27958,10911
03/17/10 12:05:22,11.6,PO4,Std,Rt,2001,880,0,34932,19960,11073
03/17/10 12:10:07,11.6,PO4,Smp,Bs,2001,880,0,50640,27956,10626
03/17/10 12:10:11,11.6,PO4,Smp,Rs,2001,880,0,42830,23959,10709
03/17/10 12:15:07,11.6,PO4,Smp,Bs,2001,880,0,50949,27957,10418
03/17/10 12:15:11,11.6,PO4,Smp,Rs,2001,880,0,43091,23958,10501
03/17/10 12:20:07,11.6,PO4,Smp,Bs,2001,880,0,51166,27958,10283
```

Calculated / Real data

```
>D2@OK!
03/17/10 12:05:14,11.6,PO4,(As),0.0729,(At),0.0000,(Ar),0.0000,(Au),0.0000,(m),74.959,(c),-1.434,(Cs),4.029,(Ct),10.000
03/17/10 12:05:25,11.6,PO4,(As),0.0000,(At),0.1516,(Ar),0.0000,(Au),0.0000,(m),75.475,(c),-1.444,(Cs),0.000,(Ct),10.000
03/17/10 12:10:14,11.6,PO4,(As),0.0727,(At),0.0000,(Ar),0.0000,(Au),0.0000,(m),75.475,(c),-1.444,(Cs),4.046,(Ct),10.000
03/17/10 12:15:14,11.6,PO4,(As),0.0727,(At),0.0000,(Ar),0.0000,(Au),0.0000,(m),75.475,(c),-1.444,(Cs),4.047,(Ct),10.000
03/17/10 12:20:14,11.6,PO4,(As),0.0727,(At),0.0000,(Ar),0.0000,(Au),0.0000,(m),75.475,(c),-1.444,(Cs),4.043,(Ct),10.000
03/17/10 12:25:14,11.6,PO4,(As),0.0728,(At),0.0000,(Ar),0.0000,(Au),0.0000,(m),75.475,(c),-1.444,(Cs),4.050,(Ct),10.000
```

8.0 Deployment

EcoLAB 2 is able to run in a stand-alone mode, unattended for extended periods. It may also be integrated into a larger monitoring system.

8.1 Configuring auto-sampling

Auto-sampling mode is configured with the following steps.

1. Check the RTC is correct (command H) and reset if required (command T)
2. Enter the future start time for the deployment (command W)
3. Set the analysis interval (command I)
4. Set the number of analyses required (command N)
5. Start auto-sampling mode (command M) – M0<CR>

Auto-sampling sequence

The system will compare the RTC time and the 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. After each analysis macro the system will broadcast data (as programmed by the reporting mode command ‘X’) and then return to sleep mode until the next sample analysis time.

Analysis interval ‘I’

The analysis interval is between the start of each analysis, so if the first sample was at 13:00 and the interval (I) is 60 minutes, the next analysis will start at 14:00.

Waking the system from sleep

When the system is “asleep” it may be woken with the “$$” command.

Exiting from auto-sampling mode

If the system is “woken” with the “$$” command or it is power cycled while in auto-sampling mode it will remain in auto-sampling mode. To exit auto-sampling mode the ESC key (ASCII 27) must be pressed.

If the ESC key is not pressed within ~20 seconds the system will go to “sleep” again and continue auto-sampling.

8.2 Preparing for Deployment

The following procedure to prepare for deployment is recommended:

1. Review Table 1 to determine the required analytical configuration
2. Prepare all reagents and standards as detailed in the method
3. Set aside 50-100 ml of the standard for laboratory analysis
4. Install the bags in the EcoLAB 2 reagent rack & connect the plumbing in accordance with Table 2 (See Appendix A: Reagent Bag Installation)
5. Prime the system using the prime macro. Ensure that all air is purged. Tubes may also be purged by addressing individual ports using the P, + and – commands.
6. Perform the calibration routine described in section 9.0
7. Compare the results with previous results as a check
8. Download & clear the data files
9. Configure auto-sampling mode as required (section 8.1)
10. Set the wake-up time to ensure the first sample will occur when the system is submerged*
11. Check the plumbing and connect the filter to the inlet
12. Secure all the covers
13. Install the EcoLAB 2 in its deployment assembly
14. Connect the analyzer to the battery pack and/or master system
15. Ensure all unused connectors have dummy plugs fitted.

*If there is a possibility that the system will not be submerged at the time of the first sample then attach a bag of sample to the inlet port. Be sure to remove it and replace the filter prior to deployment.

8.2.1 Reagent Volumes

The reagent, standard and wash consumption is given in Table 2 below.

Total volumes are given for a deployment configured for 30 days duration, sampling every 2 hours with a standard every sixth sample. (Add 10-20% for pre-deployment testing)

	Analysis Volume (ml)	Total Volume (ml)
NH4		
Standard	1.50	90
Salicylate	0.17	60
Hydroxide	0.17	60
Wash	1.50	450
NO3		
Standard	1.50	90
Imidazole	1.88	675
Sulphanilamide	0.12	43
NEDD	0.12	43
PO4		
Standard	1.50	90
Phosphate Molybdate	0.11	40
Ascorbic Acid	0.11	40
Wash	1.50	450
SiO4		
Standard	1.50	90
Silicate Molybdate	0.25	90
Oxalic Acid	0.25	90
Ascorbic Acid	0.25	90
Wash	1.50	450

Table 2 – Reagent Volumes

Reagent recipes are given in the Chemical Methods Manual

8.2.2 Valve Port Allocations

The valve port allocations for connection of the reagents, standards, detectors, etc. are given in a table at the back of the manual.

8.3 Recovery

Immediately after recovery proceed as follows:

1. Connect your PC and download the data from EcoLAB. If the battery is flat you may need a further external power supply
2. Remove power from the instrument by disconnecting the battery pack
3. Remove EcoLAB from the mooring system
4. Washed the exterior of the instrument thoroughly with fresh water to avoid corrosion
5. Remove the cadmium column (if used), reagents and on-board standard from the instrument.
6. Preserve the cadmium column (if used)
7. Freeze a sample of the standard for later analysis
8. If post-deployment servicing is not going to be carried out immediately flush the valve, syringe and colorimeter through with deionized water or a mild solution of hydrochloric acid.

9.0 Calibration

EcoLAB 2 automatically generates a calibration curve based on results from reagent blank and standard analyses.

The absorbance response of colorimetric analysis is linear with respect to sample concentration (Note: Chloride analysis is non-linear)

$$\text{Absorbance} = LOG_{10}[TxB/TxR]$$

Where: TxB = Transmission of the blank
TxR = Transmission of the reaction

The calibration line is in the format:

$$y = mx + c$$

where: y = concentration
m = slope
x = absorbance
c = intercept

The slope (m) and intercept (c) are determined by two points; the reagent blank and standard analysis absorbances.

At least one more point is used to verify the linearity of the calibration. This is typically the test sample.

At least four replicates of one point are used verify precision or noise.

9.1 Pre-Calibration

Remove and retighten all valve nozzles prior to running the calibration procedure and preparing for deployment.

Inspect all fasteners and ensure they are secure.

Check the alignment of the valve at port 1 using the G command (use either an otoscope or a 1 mm dia pin as a feeler-gauge)

9.2 Calibration Procedure

1. Run 4 blank macros (inlet = deionized water)
2. Run 4 standard analyses (inlet = deionized water)
3. Run 4 reagent blanks (inlet = deionized water)
4. Run 4 sample analyses (inlet = sample)

At each step ensure good repeatability and where relevant check the chemistry is functioning and giving a color reaction appropriate for the concentration.

In this context repeatability is defined as the standard deviation of the analysis absorbances divided by the mean absorbance of the standard analyses. For standard concentration >= 0.50 mg/L the repeatability should be better than 2% (typically 0.5 – 1.5%).

After the first reagent blank analysis EcoLAB will generate calibration coefficients (m & c). It will update these with each successive analysis. The calibration is “memorized” until either another reagent blank or standard is run and is based on the latest valid reagent blank and standard. (When deployed or running in auto-sample mode the pre-deployment calibration will be used until either a reagent blank or standard is run as part of the cycle.)
If the calibration is linear between the reagent blank and the standard analysis the sample analysis will calculate the concentration of the sample. Additional calibration samples may be analyzed for further verification.

Repeat the calibration procedure for each channel / chemistry.

10.0 Servicing

After each deployment EcoLAB should be thoroughly cleaned and the valve and syringe assembly serviced. The component parts must be stripped, cleaned, inspected and reassembled. Also the colorimeter should be cleaned. The servicing frequency will be dependent on the operating conditions, especially the suspended solids concentration but as a guideline it is suggested that the valve and syringe assembly is serviced after every deployment.

Please see the Maintenance Manual for specific service instructions.

11.0 Repair

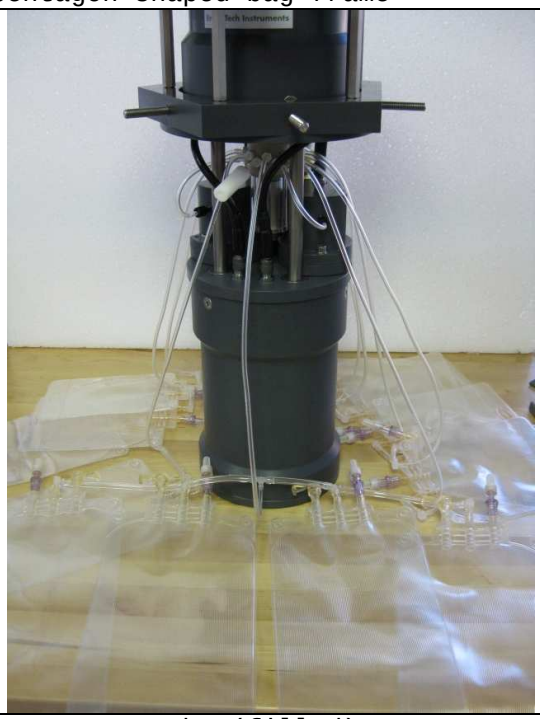
If diagnostic or repair services are required please consult the factory for advice.

Opening the environmental or detector housings without prior authorization will void the product warranty.

11.1 Return Material Authorization

A Return Material Authorization (RMA) number must be obtained prior to returning and equipment to the factory. Equipment received without an RMA number may be refused. All return shipments must pre-paid unless otherwise agreed in writing.

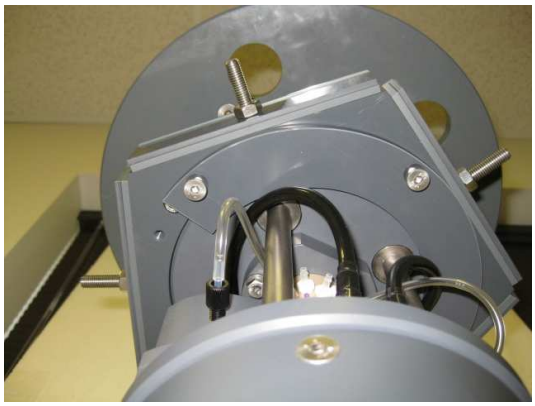
Appendix A: Reagent Bag Installation

	
1. Remove the analyzer from the reagent housing / guard	2. Remove the bag clamps from the pentagon shaped bag frame
	
3. Install the cadmium column (if running nitrate)	4. Lay-out the (filled) reagent bags and connect their supply tubes to the appropriate ports

	
5. Hang the first bag on the reagent frame studs and reinstall the T-clamp	6. Hang the remaining bags on the outside of the T-clamp. Install the external bag clamp. Arrange the bag tops to align with the T-clamp and tighten the securing nut

	
7. Once testing has been completed install the filter with a short (20 mm / ¾″ piece of tube)	8. Install the analyzer assembling inside the guard and secure

Appendix B: Removing the Reagent Frame

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>1. The reagent frame is secured by two semi-circular plates (shown removed)</td><td>2. Look under the upper / valve motor housing. Locate and remove the screws that secure the plates</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3. The reagent frame will now lift off</td><td>4. The analyzer unit without reagent frame</td></tr>
</table>