

Mesocosm User Manual

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Contents

1	Summary	5
2	Contacts	7
3	System Details	9
4	Inventory	15
5	Start-up Guide	17
6	Tidal Manipulation	29
7	Controlling pH	31
8	Apex Programming Guide	33
9	Apex Fusion	39
10	Breaker Box Connections	43
11	Troubleshooting Guide	45

Chapter 1

Summary

This manual describes the design, operation, and maintenance of the mesocosm aquaria, located in the loading bay between Citrus Hall and Eucalyptus Hall at California State University, Northridge, funded and operated by Dr. Nyssa Silbiger.

Chapter 2

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Chapter 3

System Details

Contents

- **Aquaria System**
- **Filtration and Recirculation System**
- **System Operational Parameters**
- **Apex Connection Series**
- **EB832 Outlet Connections**
- **Water Flow Operation**

Aquaria System Component List

- Experimental Tanks (21.25" x 12.5" x 13.5"H) - Per tank:
- 1 Submersible powerhead pump (Hydor Nano Koralia 240 powerhead)
- 1 200 W Heater (Hydor aquarium heater)
- 1 Light (Halo Basic M-110)
- 1 Temperature probe (Apex)
- 1 pH probe (Apex)
- 1 Solenoid valve for pH (Apex)
- 3 Flow sensors (Apex, FS-25 1/4" fitting, flow rates from 3-12 GPH (12-45 LPH))
- 1 Main Supply line: "N"

- 1 Solenoid Supply line: “S”
- 1 Drain line: “D”
- 1 Gate valve (solenoid for water inflow)
- 1 VDM (Apex Variable Dimming Module, 1 unit for 4 tanks)
- 1 FMM (Apex Fluid Metering Module)
- 1 PM1 (Apex Probe Module 1)
- 1 Base Unit (Apex processing unit, 1 unit for 4 tanks)
- 1 EB832 (Apex 8-outlet EnergyBar, 1 unit for 2 tanks)
- 1 CO₂ regulator valve (Tunze pH Controller Set, pressure reducing valve 7077/3)
- 1 Industrial Grade Carbon Dioxide, 50 pound cylinder

Filtration and Recirculation System Component List

- Sump (66.25” x 31.5” x 21”H)
- Chiller (AquaLogic Multi-Temp and Titan Series)
- Heat Pump (AquaLogic Multi-Temp and Titan Series)
- PM1 (Apex Probe Module 1)
- Water pump (PerformancePro Cascade pump)
- UV Sterilizer (Comet Series 95 Watt Lamp)
- PhosBan chemical filter (PhosBan Reactor 550)
- Air compressor
- Airstones (4 units on 4 outflow tubes)
- Carbon filter cells (3 units, CF28AC,28in, ActC)
- Mesh filter (8 units, Matala Filter Media, interchanged 4 Blue high density and 4 Black low density sheets)

System Operational Parameters

- This is a closed loop system where water from each individual tank will recirculate back to a main holding reservoir (sump).
- Normal High Tide operating water level is approximately 12.5" H for a total water volume of 14.37 gal per tank (287.4 gal total for the 20-tank-system).
- Normal Low Tide operating water level is approximately 4" H for a total water volume of 4.60 gal per tank (92.0 gal total for the 20-tank-system).
- Excess water volume to sump at low tide is 9.77 gal per tank (195.4 gal total for the 20-tank-system).
- Normal sump operating water level is 7" water in the filter cell compartment, which has an approximate volume of 82.32 gal. Sump freeboard volume is 107.39 gal.
- Aquaria drain line is in line with a 30 gal sump pump, which will draw water from the aquaria drain line and pump water to the sump.
- Sump is in line with a secondary holding tank for sump overflow at Low Tide.
 - 195.4 gal returning to sump in a Low Tide scenario
 - 30 gal in sump pump
 - 107.39 gal in sump (freeboard volume)
 - 58.01 gal necessarily pumped to secondary holding tank
- Flow rate for each tank is 2-6 GPH (See Tidal Manipulation for specific flow rates).
- Chiller is plumbed inline with the filtration skid which includes mechanical/biological filtration as well as UV sterilization (chemical filtration).
- One main pump recirculates the water flow throughout the experimental tanks and the main holding reservoir.
- Each tank has an immersion heater that allows tank temperatures to be set 15 degF (8.3 degC) above the main holding tank reservoir.
 - **Note: The tank needs to have low flow or be static in order to heat up to a desired temp. Once the temperature has been reached then it can be set to normal operating flow through mode.**

- A small submersible powerhead in each tank provides water circulation throughout the tank.
- Each tank has (2) supply lines, each with (1) Neptune Systems flow sensor and (1) needle valve for incoming flow rate control, and (1) gate solenoid valve in line with (1) supply line for tidal effect. Each tank also has (2) drain lines with (1) flow sensor in line with (1) needle valve for outgoing flow rate control. Incoming and outgoing flow rates have to be manually adjusted for the tidal effect.
- Flow metered water lines
 - N: Main supply
 - S: Solenoid-controlled supply
 - D: Drain
- Tidal effect
 - outgoing tide: incoming flow rate ($N + S$) is lower than outgoing flow rate (D).
 - incoming tide: incoming flow rate ($N + S$) is greater than outgoing flow rate (D).
 - Note: The tank will not be completely empty during low tide events to prevent the recirculating powerhead from running dry.
- Each tank has (1) CO₂ supply line with an airstone connected to (1) Neptune Systems solenoid valve to control and lower pH in tanks.
- CO₂ scrubber comprised of an air compressor connected to a Phosban Reactor will bubble air into the sump to bring pH to ambient or near-ambient conditions in the holding reservoir.
- Each tank has individual LED lighting, which can be controlled for white or blue light by specific times or natural daily light cycles.
- Certain tank conditions can be controlled via Neptune Systems Apex Controllers. Each Apex controls (4) tanks.
- Controllable parameters are pH, temperature, tidal effect, and lighting.

Apex Connection Series

- Each EnergyBar connects to the Base Unit with an AquaBus cable via the AquaBus Ports for power. (2) EB832 units connect to (1) Base Unit.

- Each CO₂ Solenoid valve connects to the EnergyBar via the DC24 Accessory Port on the side of the EB832. (2) Solenoid valves connect in (1) EB832.
- (1)PM1 connects to (1) EnergyBar with an AquaBus cable via the AquaBus Ports, and all PM1 modules connect in series with each other for power.
- VDM connects to the last PM1 in series with an AquaBus cable via the AquaBus Ports for power.
- Temperature probes connect to the PM1 Temp Port or the Base Unit Temp Port. (1) Temperature probe in each PM1, and (1) Temperature probe in the Base Unit.
- pH probes connect to the PM1 pH/ORP Port or the Base Unit pH/ORP Port. Push the BNC female connector of the probe on to the male connector and turn 1/4 turn clockwise to lock the connector in place. (1) pH probe in each PM1, and (1) pH probe in the Base Unit.
- Halo light connects to the VDM or Base Unit via the V1/V2 or V3/V4 Port. (2) Light connections in the VDM and (2) Light connections in the Base Unit.
- (1)FMM connects to (1) EnergyBar (whichever EB832 is not powering the PM1 modules) with an AquaBus cable via the AquaBus Ports, and all FMM connect in series with each other for power.
- (3)Flow sensors connect to each FMM via (3) of the numbered ports.

EB832 Outlet Connections

Note: Each horizontal row on an EB832 corresponds to one tank, yielding 4 outlets per aquarium. Current outlet order, left to right:

1. 200W Heater
2. Hydor Powerhead
3. Water supply line “S” Solenoid
4. Halo Light

Water Flow Operation

- Inflow from the filtration sump to the mesocosm tanks
 - Water from the chiller can be directed either back into the sump (the bypass t-valve is parallel to the pvc, opening flow to the sump, and

the tank t-valve is perpendicular to the pvc, closing flow to the tanks) or to the mesocosm tanks (the bypass valve is angled to allow partial flow to the sump and tanks, and the tank valve is parallel or angled with the pvc, opening flow to the tanks).

- The bypass valve is used to regulate the line pressure going back to the mesocosm tanks. The more closed, the higher the pressure in the line, and the more open, the lower the pressure.
- The chiller has a safety flow switch that requires a minimum flow rate for the chiller to operate, so the bypass valve can be used to regulate the chiller flow as well as the container flow.

- Outflow from the mesocosm tanks to the filtration sump

- Water from the tanks drains to an outdoor underground sump pump, which will automatically pump water out when a certain water level is reached. This water can be directed either back into the sump (the sump inflow t-valve is opened parallel to the pvc, allowing flow to the three dump pipes into the filtration skid), or if you intend to drain water in the event of a water change or the end of an experiment, water can be directed to a drain port (the sump inflow valve is closed and the drain t-valve along the South wall is opened parallel to the pvc).

- Overflow from sump to secondary containment

- When mesocosm water level falls from a high tide to low tide sequence, more water will drain to the sump than what the main sump can individually hold. Excess water can be redirected from the sump (S1) to the secondary containment (S2) by opening the S2 inflow t-valve (allows simultaneous flow of filtered, chilled water to both S2 and the mesocosm tanks), and the overflow t-valve (allows continuous flow exchange between S1 and S2).

Chapter 4

Inventory

Contents

- Experimental Mesocosm
- Filtration
- Spare Items

Experimental Mesocosm

Item	Quantity	Purchase Replacement
Experimental Aquarium	20	
Aquarium Lid	20	
200W Heater	20	\$24.99 Amazon
Suction Heater Slip	40	
Halo Light	20	\$299.99 Amazon
Halo Light Power Cords	20	
Hydor Powerhead	20	\$34.99 Amazon
Temperature Probe	20	\$29.95 Bulk Reef Supply
Suction Temperature Probe Slip	20	
pH Probe	20	\$74.95 Bulk Reef Supply
Suction pH Probe Slip	20	
Salinity Probe	5	124.95 Bulk Reef Supply
pH and Salinity Calibration Pack 7, 10	10	\$6.85 Bulk Reef Supply
CO2 Solenoid Valve	20	\$29.95 Bulk Reef Supply
FS-25 1/4" Flow Sensor	60	\$19.95 Bulk Reef Supply
Flow Solenoid/Gate Valve	20	\$16.99 Electric Solenoid Valves
Inflow Seawater Tubing	40	
Inflow CO2 Tubing	20	
Airstone	20	\$5.99x10pack Amazon
Inflow Tubing Stand	40	
VDM	5	\$99.95 Bulk Reef Supply
FMM	20	\$99.95 Bulk Reef Supply

Item	Quantity	Purchase Replacement
PM1	16	\$84.95 Bulk Reef Supply
Display Module	1	\$99.95 Bulk Reef Supply
Apex Base Unit	5	\$399.95 Bulk Reef Supply
Apex EB832	10	\$249.95 Bulk Reef Supply
Tunze CO2 Regulator Valve	1	
180gal Sump	1	
Chiller	1	

Filtration

Item	Quantity	Purchase Replacement
PhosBan Reactor 550	1	\$85.14 Bulk Reef Supply
PhosBan CDX Carbon Dioxide Absorption Media 3L	1	\$44.38 Bulk Reef Supply
Cascade Water Pump	1	
UV Sterilizer	1	
UV Light	1	
Air Pump	1	
Air Pump tubing to Phosban Reactor 3/8" ID x 10'	2	\$4.93 Home Depot
Airflow Tubing 3/16" ID x 8'	4	\$2.69 Petsmart
Airstone	4	
Carbon Filter Cell	3	
Matala Filter, High Density (Blue)	4	
Matala Filter, Low Density (Black)	4	

Spare Items

Item	Quantity
Solenoid Valve	4
Flow Solenoid/Gate Valve	5
Halo Light	1
Airstone	29
Halo Light-to-Light Cable	16
pH Calibration Pack 7, 10	3
Salinity Calibration Pack 53,000uS	3
FS-25 1/4" Flow Sensor	0
pH Probe	0
Conductivity Probe	0
Temperature Probe	0
Hydor Powerhead	0

Chapter 5

Start-up Guide

Contents

- Basic Operation
- Filtration
- Water Changes
- Sump Flow
- Mesocosm Tank Flow
- CO2 Scrubber
- Draining the Meso and Sump

Basic Operation

1. Operating water level in the filtration sump should be 7" in the filter cell compartment.
2. Overflow water from the tanks will feed down to the outside underground sump pump, then into to the filtration skid inside the Citrus Hall Field Room. The water will flow through mesh filters and be pumped through carbon filters, the UV sterilizer, and chiller, then back to the tanks.

Filtration

- Biological and Mechanical Filtration: Water from the Mesocosm tanks is pumped into the sump by passing through 6 mesh filters. These filters have an accumulated biofilm to biologically filter the water before it enters the sump.
- Chemical and Mechanical Filtration: Water in the sump is pulled through the three carbon filters with mesh filter sleeves by a pump and pushed up into the UV sterilizer, where it is then directed through the chiller chamber.

Water Changes

1. Collecting seawater
 1. The water collected for the mesocosm system is filtered (100um mesh filter) unbuffered seawater from SCMI (Southern California Marine Institute located at 820 S Seaside Ave, San Pedro, CA 90731).
 2. At least 24 hours before collecting water, email Mark Loos (mark.loos@csulb.edu) of your intent to get water, and give him an estimated time of arrival.
 3. Sign out the Ford 450 truck at the Bio Stock Room for your desired day.
 1. Before driving a university vehicle, be sure to complete the Defensive Drivers course. Email Wendy Dunbarr (wendy.dunbarr@csun.edu) for details.
 4. Once you pick up the truck, back it up to the large stacked square bins in the same parking lot, near the side of the building on the grass.
 1. With the help of a willing victim/volunteer, lift and push the top bin into the bed of the truck. Take off the lid of the second bin and lift the second bin onto the bed of the truck. Once in place, put the lid back on. (Lids at ~15lbs of weight, so make it easier on yourself and just remove it before lifting)
 5. Plan to leave for SCMI after 9am to avoid major traffic, and wear or bring closed toed shoes to wear once you arrive.
 6. When you arrive at SCMI, pull into the employee lot (the parking lot to the left of the building) and back up to the lot behind the building parallel to the wire fence
 1. Move the cone before backing into the lot and replace the cone when you leave.
 7. To the left of the wire fence walkway to the docks, there's a large pool hose with a pvc loop attachment. Move the end of the hose to the drain port (hole in the concrete flowing under the walkway), and open the t-valve at the base of the hose (open = t-valve is in line with the PVC).
 8. Walk over to the filtration area in the corner of that lot and open the t-valve on the PVC that is running to the filter chamber (large tan cylinder with round top). That PVC pipe runs from the filter chamber toward the wire fence.
 9. From where you turned the t-valve, look to the wire fence and notice a power box with a large flip switch. Turning this switch ON will initiate flow from the marina, through the filter, and out the end of the pool hose.
 10. Flip the switch to ON and leave the water running for 30 seconds to 1 minute to flush out any standing water in the system.
 11. When you're ready to fill the containers, use the PVC loop on the hose to hang it over the side of the container for hands-free filling and wait.

1. If you're filling up the entire mesocosm system, you will need to fill both bins about 3/4 full twice (two trips to and from SCMI).
2. If you're only doing a water change or refill, fill up as much as you need, and a little more to make sure you have enough.
12. When you're done filling, **first turn off the power supply**, then close the t-valve (turn so the valve is perpendicular to the PVC) on the pipe going to the filter chamber, and finally close the t-valve at the hose.
 1. Closing off either of the other t-valves could cause a pressure build-up in the PVC and may rupture the system.
13. Place the lids on the water containers and use rope/line or ratcheting line to secure the bin lids down (this will help with water spillage on the drive back to CSUN). 1. Filling the sump
14. Once back at CSUN, pull into the loading bay between Citrus and Eucalyptus, and back up toward the Field Room, leaving just enough space to open the door.
15. Unstrap and remove the lids. Place one end of the large pool hose in one of the containers, and use a weight to keep it from floating up.
16. Pull the free end of the hose to the sump, and start a siphon. Gently wedge the end of the hose into the mesh filters in the sump for a. hands-free siphoning and b. filtering the water as it goes into the system.
17. When you're ready to switch bins, maintain the siphon by cupping the palm of your hand against the hose end, moving that hose to the next bin, then removing your hand once submerged.
18. If you're collecting water again, simply replace the lids, and drive back to SCMI for another round.
19. Once you're done emptying the bins, attach the garden hose (stored next to the secondary sump) to the fresh water tap on the outside of the Field Room, and turn on water by using the metal screw key hanging on a pipe just inside the Field Room to the left, next to the outlets.
20. Hose down the entire back, bed, and sides of the truck, everything that may be touched by salt water.
21. Place the large pool hose back in the bins, and once you turn off the hose water, replace the garden hose and key to where you found them.
22. Before parking the truck, back it up to the same location where you picked up the bins, and drop/place the bins back on the grass. If there is any water left in the bins, dump that out before leaving them. stacked.

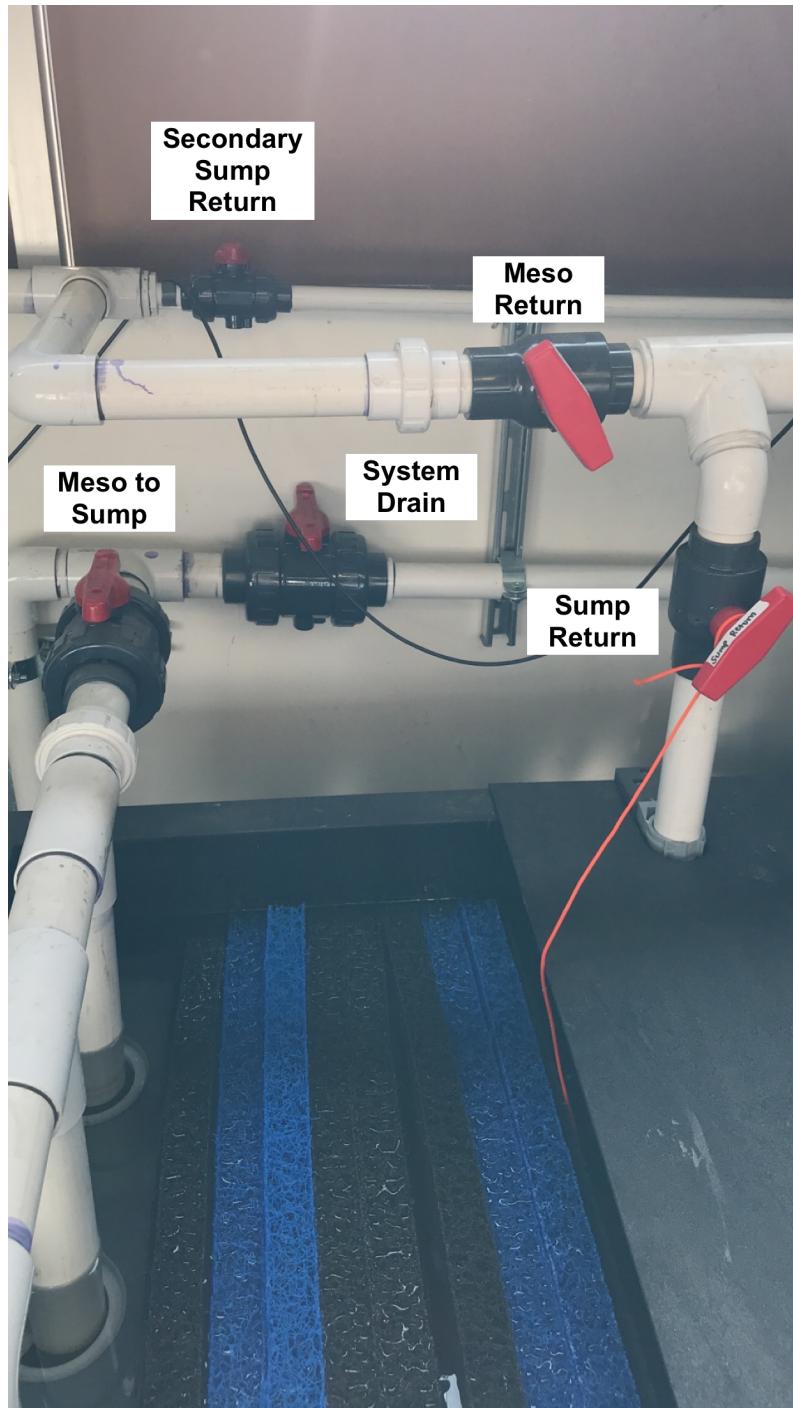
Sump Flow

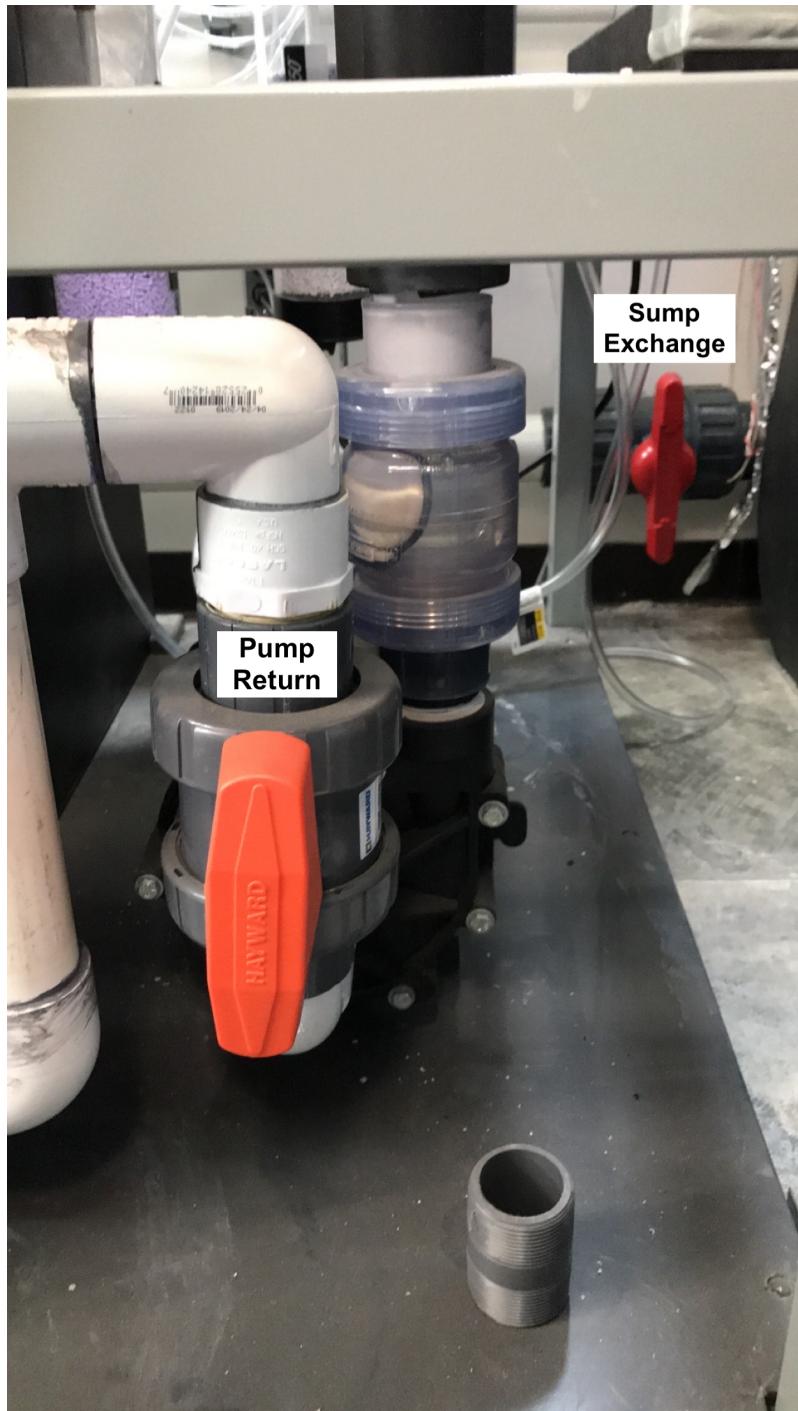
1. Preparing for flow in the sump

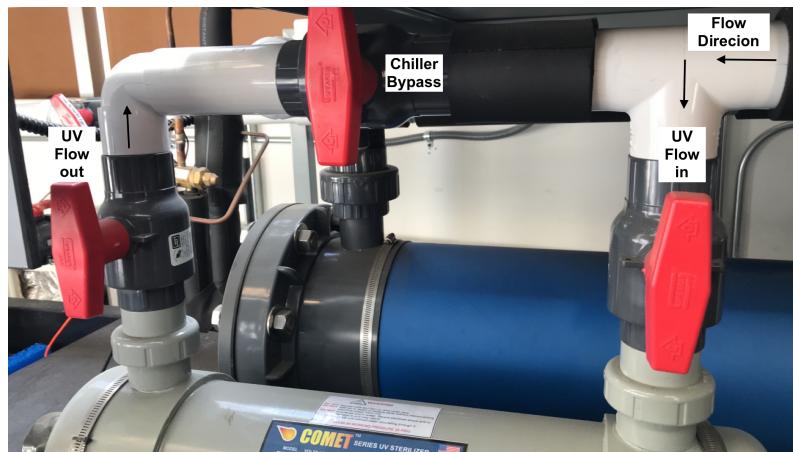
1. Before turning on the pump to initiate flow, make sure the t-valves are aligned to direct flow where it needs to go.
2. The meso return valve should be vertical in the “closed” position (perpendicular to the PVC), and the sump return valve should also be vertical in the “open” position (in line with the PVC).

1. See Figure 1 to identify valves

3. The pump return valve should be vertical in the “open” position to allow flow from the sump through the pump up to the UV filter and chiller compartments. See Figure 2.
4. The two UV flow valves and the chiller bypass valve should all be vertical. This directs flow down through the UV light before returning up to the chiller chamber. See Figure 3.







2. Turning on sump flow

1. Once all the valves are properly opened/closed as described above, plug in the Cascade Pump and make sure water is running through the system properly without any leaks. There may be some initial sputtering while air is pumped out of the pipes, but that should stop within a couple minutes.
2. Look at the pump and make sure you can see water being pushed through the clear junction.
 1. If it looks like water is not running through the pump for some reason, **unplug the pump immediately**. Running the pump dry can burn out the motor.
 2. If everything seems to be stable, plug in the UV light.
 3. To stabilize the pH in the system, fill and plug in the CO2 scrubbers as detailed below.

Mesocosm Tank Flow

1. Filling the mesocosm tanks

1. Make sure the drain valve located under each tank is closed (turned clockwise all the way, finger-tight).
2. Open the N flow valve for each tanks (and S flow valve if you're turning the Solenoid ON to fill the tanks).
3. To open flow from the sump to the tanks, first make sure the circular flow within the sump itself is stable. Then slowly open the meso return valve (turn counterclockwise) until the t-valve is sitting about 45 degrees to the PVC pipe. This splits flow to both the sump and now the mesocosm. You can further adjust water pressure to the tanks by turning the sump return valve slightly to direct more flow

- to the meso, less flow to the sump, while always keeping the line to the sump partially open.
4. Fill each rack one at a time (only open the N flow valves for one set of 4 tanks at a time) and make sure rack and filtration skid flows are balanced before moving on to the next rack.
 5. Make sure the complete system reaches equilibrium in standard recirculation mode before setting up the tidal cycle.
2. Set flow in tanks
 1. Calculate your desired residence time. When full, each tank holds 55 liters, so divide 55L by your desired residence time and use that estimated value as your flow rate. Example: for a RT of 8 hours: $55\text{L}/8\text{hr} = 6.88 \text{ L/hr}$ or 114.67 mL/min
 2. If you have an acceptable range for your residence time, set flow rate to within that range, as close to your desired flow as possible. Example: for a RT of 7.5-8.5 hours: $\text{RT} = 6.47-7.33 \text{ L/hr}$ or $107.83-122.17 \text{ mL/min}$
 3. Use the Neptune Systems flow meters as a guide for setting the flow, but for the most accurate flow rates, use a graduated cylinder to estimate flow into each tank.
 4. Flow will slightly change throughout the day, so it is recommended to set flow twice per day: once in the morning and once in the afternoon/evening.

CO2 Scrubber

1. Replacing media in the Phosban Reactor
 1. Unplug the airpump connected to the Phosban Reactor and disconnect both sets of tubing going into/out of the Reactor tube to easily remove and work with the Reactor tube.
 2. Unscrew the lid of the Reactor, take off the red cap and black mesh, and pour out the used up media (purple if freshly used up, grayish white if used and stale) into a bag or some containment.
 3. Use tape or parafilm to cover the hole of the small tube inside the Reactor before pouring in the new media (stark white pellets). Fill to an inch **below** the top of the small tube, so no media falls into the tube. Remove the covering from the small tube and replace the black mesh and red cap, aligning the red cap so it encapsulates the small tube.
 4. Screw the lid back on, finger tight, and replace the tube on the side of the sump. Reconnect the tubing from the airpump to the side of the Reactor tube and from the air splitter to the front of the tube.
 5. Once you're sure everything's securely placed, plug in the air pump.
 6. Listen and feel for any air leaks and adjust tubing as necessary.

Draining the Mesocosm and Sump

1. The first step before draining any water is to turn off the powerheads, heaters, and CO2 bubblers in all mesocosm tanks. **The powerheads and heaters cannot be on when dry or they will be damaged.**
2. You must also place caps on each pH probe filled with either DI water for temporary storage or KCl storage solution for long-term storage. **The probe tips cannot dry out or they will be damaged.**
3. When draining the tanks, drain one rack of 4 tanks at a time, to not overflow the drainage system.
4. Water flow
 1. If you intend to only drain the mesocosm tanks, but not the sump, then turn off the flow from both the N and S valves into the tank, turning both clockwise, then remove the PVC tubing as described below. If needed, divert excess water into the secondary sump following the steps below, and disregard the rest of these draining instructions.
 2. If you intend to drain the sump as well to fully shut down or clean out the system, then maintain high flow through the N valve into all tanks. Continue following this set of instructions.
5. Divert flow from the sump to the drainage port
 1. We need to stop flow of water from the mesocosm tanks to the sump and divert this water to a drainage port (there is a drain in the Mechanical room behind the Field Room with PVC pipe facing downward inside. This PVC is connected to our system and will be the location of drainage)
 2. Refer to Figure 1. for t-valve identities.
 3. **First open the System Drain Valve** by turning the valve so it aligns parallel to the PVC. This opens flow to the drainage port in the back room. Always open an avenue of flow before closing an avenue of flow to avoid back pressure build up.
 4. Second, close the Meso to Sump Valve by turning the valve so it sits perpendicular to the PVC. This will stop incoming water from the mesocosm from entering the sump and will divert all flow out of the system.
6. Open tank drains
 1. Under each tank is a needle valve controlling drain flow through the smaller PVC tubing in each tank. Fully open this valve for the rack of 4 tanks, turning the needle counterclockwise.
7. Pulling out the PVC drainage tubing
 1. In each of the four tanks, **unscrew** the larger PVC tube until it is fully removed and water in the tank can drain out from the lowest point in the tank.

2. The smaller PVC tube can be pulled out from its slot, sometimes needing to be twisted to be unwedged.
3. Tanks with both PVC removed will drain faster.
8. The sump pump located in the ground between the Mesocosm container and the Field Room will function normally to push water from the tanks to the Field Room system, but as we drain large volumes of water, periodically check to make sure water isn't overflowing out of the ground sump pump.
9. Also periodically check on the drainage port to make sure the water being pumped in from the tanks isn't overflowing onto the floor.
 1. If you notice the water is overflowing, slightly open the Meso to Sump valve to divert some water back into the sump and reduce the water volume diverted to the drainage port.
 2. **We cannot let salt water overflow onto the floor of the Mechanics room**
10. Sump flow
 1. Unplug the UV light and CO2 scrubbers, but leave the pump on for now.
 2. Allow the sump to continue pumping water from the main reservoir into the tanks, where the water will continuously drain out of the system.
 3. Once the water level in the sump is about an inch or two below the top of the carbon filters (the three white cylinders inside the sump), unplug the Pump. **The pump must be turned off before it runs dry, otherwise the pump will be damaged**
 4. At this point there will still be some water left in the sump, which can either be siphoned out and dumped into the drainage port, or you can use a small aquarium pump to pump out the water in the main reservoir, the bio-filtration reservoir, and the 50-micron mesh reservoir.
 5. **Be cautious to not let this pump run dry either, or it may be damaged**
 6. To access the bio-filtration reservoir, remove the black and blue mesh filters, and bring them outside to clean by hosing down with freshwater.
 7. To access the 50-micron mesh reservoir, remove the PVC tubing located directly after the Meso to Sump Valve (see Figure 1) by unscrewing the PVC at the junction. The PVC with three outports can be temporarily removed, so the mesh can be taken out and also sprayed down to clean.
11. Post-drainage
 1. Once the system is fully drained of seawater, screw back on the PVC at the junction by the Meso to Sump Valve and screw in or wedge in each tank's PVC tubes back in place.

2. Follow the instructions above for filling the sump and the order of operations for turning flow back on.
3. You will not have to plug in the UV light or CO₂ scrubbers since you are not maintaining any water chemistry, but rather just flushing the system.
4. Let fresh water run through the system for a couple days before following these same steps for draining the freshwater.

Overflow into Secondary Sump

1. If you need to contain more water in the system than the tanks and main reservoir can hold at one time (ex. during a “low tide event” when half of the tank water is drained into the sump), then you can open flow to/from the secondary sump.
2. First unplug the Sump Pump to make sure the pump will not run dry if there is not enough water (see details below).
3. To direct some flow from the system into the secondary sump, partially or fully open the Secondary Sump Return Valve (Figure 1), so that the t-valve runs parallel with the PVC. Filtered sump water will then be simultaneously directed into the mesocosm and the secondary sump, via PVC tubing that diverts water into the top of the secondary reservoir.
4. To then open flow between both the main holding reservoir and the secondary sump, open the Sump Exchange Valve (Figure 2), so the t-valve runs parallel with the PVC.
 1. Because this flow-through connection will allow water to flow between both reservoirs to establish water level equilibrium, make sure the water level in the main reservoir is still about 2 inches above the carbon filters after this water exchange has occurred. If not, add more seawater to the system until the carbon filters are once again submerged **to avoid the sump pump running dry**.
 2. Once the filters are appropriately submerged (seawater only two inches above the filters, not much more), turn the Sump Pump back on by plugging it in.

Chapter 6

Tidal Manipulation

Controlling the tidal cycle of each experimental tank with the Apex. This is achieved by manipulating the incoming and outgoing flow rates of each individual tank with the needle valves described in the System Details, and setting the ON/OFF time cycle of the supply line with the solenoid. The basic procedure is outlined below.

1. Set the flow rate of the supply line $N[\#]FLW$ (without the solenoid), for example 10.5 Liters/Hr, by slowly turning the black knob counterclockwise to increase flow or clockwise to decrease flow.
 1. You can view rates on the Fusion dashboard.
 2. Note that the Apex controller has some lag time in registering the flow rate after the valve has been adjusted, and the delay can be up to 30 seconds or more, so make small adjustments and monitor the change on Fusion.
 3. Once the rate is set you should check periodically to make sure the rate has not changed both on Fusion and by using a graduated cylinder and a timer.
2. Adjust the outgoing flow rate of the drain line $D[\#]FLW$ higher than the $N[\#]FLW$, for example 15 Liters/Hr.
 1. With the above condition, the outgoing flow rate is higher than the incoming, so this will create a low tide effect over a 5-5.25 hr period.
 3. To create a high tide effect, change the setting of SOL-TNK-# (outlets 3 and 7 on each EB832) to ON on the Fusion dashboard, then manually turn on and adjust the flow rate of the supply line $S[\#]FLW$, for example 10 Liters/Hr.
 4. Once the $S[\#]FLW$ is set, change the setting of SOL-TNK-# to AUTO on the Fusion dashboard.

1. With the above condition, the total incoming flow rate (N+S) is higher than the outgoing (D), so this will create a high tide effect over a 5-5.25 hr period.
2. For a constant ON/OFF cycle over a 12.5 hour period, the Advanced program should look like the program below:

Fallback ON
Osc 000:00/375:00/375:00 then ON

1. In the event the EnergyBar loses connection with the Apex Base, “Fallback ON” will keep the solenoid open, allowing water to continuously flow from S[#]FLW.
2. The oscillate (Osc) command as written will open flow from S[#]FLW for 6.25 hours, initiating the High Tide scenario, then close for 6.25 hours, initiating the Low Tide scenario. This will provide the effect of two high and two low tides of a semidiurnal tidal cycle over a 25 hour period.
 1. Using the flow rates stated above, each tidal shift will last 5.25 hours and maintain the tide height for 1 hour.

For more advanced programming features, see the Comprehensive Manual. Start on Page 65 for Seasonal Features and Moon cycles.

Chapter 7

Controlling pH

The pH is controlled with the addition of CO₂ gas to the system. The gas is delivered to the tank by air stone and is controlled through the Apex Controls with a solenoid valve connected to the EB832.

1. Once the CO₂ regulator is connected to a tank, open the main tank valve.
2. Use the pressure adjusting screw (larger knob in front with Tunze label) to adjust the pressure (in bar) on the pressure gauge. Turning **clockwise to open**, thus increasing pressure, while turning **countrerclockwise to close**, thus reducing pressure.
3. The pressure should be set to 0.5 up to 1 bar on the gauge (~7.5psi) - ideally 0.6 bar.
4. Open the fine adjustment valve (smaller valve next to the tubing connecting the regulator to the tanks) to allow gas to the tank solenoid. If the pressure on the gauge is too high this may prevent the CO₂ solenoid from completely closing, which will inject excess CO₂ into the system.
5. Programming the solenoid for a consistent pH: pH-TNK-#

Control type: pH Control

Probe name: pH

Fallback: OFF

High Value: 8.2

Low Value: 7.9

On when: High

6. Programming the solenoid for diel variance:

- Using Advanced programming and Virtual outlets
- Create a unique virtual outlet for every time block which requires a different pH, and for every tank/probe which requires that pH treatment.

- Virtual Outlet Example (for the 6 hours between 6:31am and 12:30pm, the CO2 solenoid will dose CO2 into tank 1 while the probe reads 8.10 or above):

Fallback OFF
Set OFF
If Time 06:31 to 12:30 Then ON
If pH-1 < 8.10 Then OFF

* Advanced Program Example (Every 6 hours, the pH setpoint changes, and each of the four time blocks has a unique virtual outlet name, as presented below in the four programming lines. The CO2 solenoid will dose the tank when the conditions of the virtual outlet program are met):

Fallback OFF
Set OFF
If Output pH_1_630 = ON Then ON
If Output pH_1_1230 = ON Then ON
If Output pH_1_1830 = ON Then ON
If Output pH_1_0030 = ON Then ON

Refer to Comprehensive Manual for set point programming.

Chapter 8

Apex Programming Guide

Recommendations for programming the Apex aquarium controllers designated for the Silbiger Lab Mesocosm, located in the loading bay between Citrus Hall and Eucalyptus Hall at California State University, Northridge. These recommendations are for maintaining tanks at ambient conditions. Changes should be made according to your study aims.

The following are using the numbered system of Apex1_39106, controlling tanks 1-4. All methods are transferrable across all 5 Apex controllers to yield the same outcome in all 20 tanks, or change programs for varied results.

Contents

- Accessing the Programming Edit Screen in Apex
- Probes
- Modules, Outlets, and Ports
- Outlet Setup in ApexFusion
- Profiles

- For some quick tutorials on advanced programming in Fusion, check out Neptune Systems' Control Freak page.

Accessing the Programming Edit Screen

1. From the ApexFusion Dashboard, select the Expand icon (gears) from the top toolbar to provide more options.
 - Outputs: grants access to the page controlling all outlets and connected items that are programmable by the apex
 - Profiles: create a scenario that can occur if some condition is met for an Output program (see example with the Lights below)
 - Modules: to update, rename, or set units for a module connected to the Apex

- Inputs: to calibrate, rename, or set units for any probes and other inputs providing data to the Apex
 - Misc Setup: to restart the apex or set the frequency of data logging
 - Network Setup: to manually configure network settings or check current network settings
2. The most utilized option above is often Outputs, where you can program anything plugged into the Apex. Select this icon.
 3. You can either select an output already configured to program that outlet, or create a “Virtual Outlet”, which, similar to profiles, allows you to program a particular condition that if true, can trigger some other action in the program of a “real” Output.
 - When using a Virtual Outlet in programming a “real” Output, select Advanced prgoramming and use the folling line as an example: If Output your_output_name = ON Then ON
 4. For all other Outputs, you can use the drop down menu to select the type of item you’re programming for a fill-in style program option, or select Advanced to create your own program.
 - Examples of Advanced programming for different types of Outputs are below and in the controlling_pH guide.

Probes

- Salt-1 (Base)
- TMP-1 (Base)
- PH-1 (Base)
- TMP-2 (PM1_2)
- PH-2 (PM1_2)
- TMP-3 (PM1_3)
- PH-3 (PM1_3)
- TMP-4 (PM1_4)
- PH-4 (PM1_4)

Modules, Outlets, and Ports

- Base Unit Variables
- WHITE-TNK-1
- BLUE-TNK-1
- WHITE-TNK-2
- BLUE-TNK-2
- Base Unit Alarms
- SndAlm_I6
- SndWrn_I7

- EmailAlm_15
- EB832_1
- HEATER-1
- PWRHD-1
- SOL-TNK-1
- LIGHT-TNK-1
- HEATER-3
- PWRHD-3
- SOL-TNK-3
- LIGHT-TNK-3
- PH-TNK-1
- PH-TNK-3
- EB832_2
- HEATER-2
- PWRHD-2
- SOL-TNK-2
- LIGHT-TNK-2
- HEATER-4
- PWRHD-4
- SOL-TNK-4
- LIGHT-TNK-4
- PH-TNK-2
- PH-TNK-4
- VDM
- WHITE-TNK-3
- BLUE-TNK-3
- WHITE-TNK-4
- BLUE-TNK-4
- BluLED_11_5
- WhtLED_11_6
- FMM_1
- S1-FLW
- N1-FLW
- D1-FLW
- FMM_2
- S2-FLW
- N2-FLW
- D2-FLW
- FMM_3
- S3-FLW
- N3-FLW
- D3-FLW
- FMM_4
- S4-FLW
- N4-FLW
- D4-FLW

Outlet Setup in ApexFusion

All configurations are for Control Type: Advanced

- HEATER-#
 - Fallback OFF
 - Set OFF
 - If Tmp-# < 17.0 Then ON
- PWRHD-#
 - Fallback ON
 - Set ON
- Alternative program is to set Control Type: Always
- SOL-TNK-#
 - Fallback ON
 - OSC 000:00/375:00/375:00 Then ON (for tidal oscillations)
- Log Enabled
- LIGHT-TNK-#
 - Fallback OFF
 - Set OFF
 - If Sun 0/0 Then ON
 - If Moon 0/0 Then ON
 - If Tmp-# > 35.0 Then OFF
 - Min Time 030:00 Then OFF
- Log Enabled
- PH-TNK-#
 - Fallback OFF
 - Set OFF
 - If pH-1 > 8.10 Then ON (for more specific examples, see controlling_pH(#controlling_pH))
- Log Enabled
- WHITE-TNK-#
 - Fallback OFF
 - Set OFF
 - If Sun 0/0 Then RampUp
- BLUE-TNK-#
 - Fallback OFF
 - Set OFF

If Moon 0/0 Then Blue

- WhtLED_#
- Fallback OFF
Set OFF
- If Sun 0/0 Then RampUp
- BluLED_#
- Fallback OFF
Set OFF
- If Moon 0/0 Then Blue

Profiles

- RampUp:
- Type: Ramp
- Ramp Time: 30 min
- Start Intensity: 0
- End Intensity: 100
- Blue:
- Type: Ramp
- Ramp Time: 30 min
- Start Intensity: 0
- End Intensity: 100

Chapter 9

Apex Fusion

To access the Silbiger Lab Fusion account, go to ApexFusion.com, click “Get Control” and enter the login information:

Username: SilbigerLab

Password: silbigerlab

Contents

- Dashboard Display
- Module Setup
- Outlet Setup
- Downloading Data Logs
- Update System

- For some quick tutorials on advanced programming in Fusion, check out Neptune Systems’ Control Freak page.

Dashboard Display

- Left column displays the current system time, Reminders, and Temperature and pH trending line graphs for each tank.
- Middle and right columns display the Watt, Amp, and Volt readings for each EB832, the state of each outlet (OFF, AUTO, or ON), and the flowmeter readouts for the N-valve (continuous inflow), S-valve (controllable inflow) and D-valve (outflow) for each tank.
- You can manually control the state of the outlet by moving the slide bar to either OFF or ON. To let the program settings control the outlet state, move the slide bar to AUTO.
- Adjusting the Solenoid status bar to OFF will stop flow from the S-valve, while adjusting the status to ON will open flow from the S-valve. Adjusting the status to AUTO will allow your program to control when the Solenoid opens and closes.

- To modify the dashboard (add, remove, or reorganize items), click the padlock icon in the upper right-hand corner then click and drag a tile to move it or click the “x” to store it in the upper tile bank.

Module Setup

1. Expand the Options menu and select the Modules icon to view all modules.
2. Click any module to view a summary of its connection and software status, rename the module, or perform an action with that module (Configure, Update Software, or Delete).

Outlet Setup

1. Click the Outlets icon in the upper left-hand options bar.
2. Outlets are arranged by the name you give them, the module they’re associated with, the type of output, and whether or not you have chosen to log activity.
3. Select an outlet to modify its name, display symbol, and program settings.
 1. To use a program template, use the “Control Type” dropdown menu to select which item you intend to use in this outlet location, then fill in the required information to control the outlet state.
 2. To write your own program, select Advanced from the dropdown menu, and write your program in the source code box that appears.
4. Once you’ve completed your settings and program, click the orange cloud icon in the upper right to send your new settings to the Apex.

Downloading Data Logs

When connected to the same network as the Apex units, you can download data logs for the systems following the directions below.

Note To connect to the same network, you must plug your device into one of the live ethernet cables in the Mesocosm.

Format for your internet browser URL:

`http://:/cgi-bin/outlog.xml?sd=yyymmddhhmm&days=n`
`http://:/cgi-bin/datalog.xml?sd=yyymmddhhmm&days=n`

- Accessible logs:
- Outlog – every time the Apex changes the state of an outlet a record is written to this log. If no outlet ever changed state you would have zero records in this log. A new log is started daily at midnight. Log is named “yyymmdd.odat”.
- Datalog – records probe value snapshots (Temp, pH, ORP, etc.) based on the logging interval you define (default = 20 minutes). You can change the interval via the Display module under Data Log – Log Interval. A new log is started daily at midnight. Log is named “yyymmdd.pdat”.

Examples of what to enter into your internet browser:

<http://172.24.113.25/cgi-bin/outlog.xml?startdate=191005>

<http://172.24.113.25/cgi-bin/outlog.xml?startdate=191005&days=7>

- The value after date= is the start date for when you want logged information, and days=n yields data n days after that start date.
- Hours and Minutes are optional in the date parameter.

1. Following the above format, enter the unique IP address for the Apex containing the logs you want to access.

1. Apex_39106: 172.24.113.25
 Apex_40216: 172.24.113.22
 Apex_39952: 172.24.113.23
 Apex_37810: 172.24.113.21
 Apex_41239: 172.24.113.24

2. Import Log Data (Windows/PC)

1. Open a new Excel file and go to the Data tab
2. Select From Web in the Get External Data box
3. A New Web Query dialog box will open. Type or copy the url from your browser into the data source Address field. Click Import.
4. Your XML data should be imported into your empty spreadsheet and automatic filters created for each column making it easy to select and analyze data.

3. Import Log Data (Mac)

1. Open the web browser for the apex data you want to download
2. Wait for the page to fully load (the top line of the page will read “This XML file does not appear to have any style information associated with it. The document tree is shown below.”)
3. Right click somewhere on the webpage and click Save As.
4. Save your file in an accessible location or in your R workspace with a name identifying the apex unit and date.
 1. Manually type .csv to save the file as a csv instead of an xml file.
 2. Ex. 39106_191127d6.csv identifies Apex_39106, the saved data starts on 11-27-2019, and the data is saved through 6 days after the start date (through 12-3-2019).
5. Refer to Mesocosm_Environmental_Data/Datalog_Data_Tidy.R for a guide to clean up the data into a usable format.

Update System

1. From the Apex List menu

1. If the orange icon next to the apex name shows an upward facing arrow in a circle, click that icon and select “Update Available” from the dropdown menu.
 2. The popup window will display the current AOS version and the most recent AOS version available for the system. If the popup says “it’s recommended that you update”, then make sure the Apex is connected via ethernet cable and click “Update”.
2. From the Dashboard Display
 1. Click the down arrow next to the apex name in the upper left corner and select “Network” from the dropdown menu.
 2. Under “Apex Operating System” you can view the installed AOS and Available AOS. If the installed version is out of date, there will be an orange bar next to “AOS Update” recommending you “Update AOS”. Click the bar, then make sure your Apex is connected via ethernet cable and click “Update”.
 3. Once the system has completed the update, go to your Modules page. If any modules need to be updated (under “Status” there will be an error icon rather than a check mark), click that module and change the Configuration Action to “Update Software” then click the orange cloud icon.

Chapter 10

Breaker Box Connections

Following switches from top-down, then left-right:

- 1,3: Main Disconnect
- 5,7: Air Conditioner
- 9,11: Condenser (Chiller, Filtration)
- 2: General Power (Lights and Outlet Box #1)
- 4: Outlet Box #2 (Tanks 17-20)
- 6: Outlet Box #3 (Tanks 13-16)
- 8: Outlet Box #4 (Tanks 9-12)
- 10: Outlet Box #5 (Tanks 5-8)
- 12: Outlet Box #6 (Tanks 1-4, outdoor sump pump)

Powering the container:

1. Turn on (flip left to right) the Main Disconnect switches. Once powered, the remaining switches will supply power to their individual breakers.
2. Turn on (flip right to left) the General Power switch. Once powered, the light switch to the right of the entrance will turn on/off the overhead light, the O2 sensor above the light switch will be activated, and all outlets in Outlet Box #1 will be active.
3. Turn on (flip left to right) the Air Conditioner switches. Once powered, the A/C unit can be controlled via remote control or the front display panel on the unit.
4. Switches 4, 6, 8, 10, and 12 all correspond to outlet boxes lining the upper perimeter of the container. Each box is used to power up to two (2) Apex units and enough modules and other devices for up to four (4) tanks. Each outlet covering has a number corresponding to the labeling for these switches. To turn any or all on, flip the switch(es) right to left.
5. Leave the Condenser switches (9 and 11) in the “off” position unless the chiller and filtration system become connected

Chapter 11

Troubleshooting Guide

Contents

- Loss of Power to the Sump/Tripped Breaker
- Flowmeter Misreadings
- Rebooting the Apex
- Sump Pump Malfunction
- Turning off Sump flow
- Light not responding to program
- pH probe malfunction
- pH spikes

Loss of Power to the Sump/Tripped Breaker

1. Breaker tripped in the field room (pump, UV filter, CO2 scrubber all off)
1. If you just plugged in an item that correlated with the power shutting off, unplug that item. It may have tripped the breaker. 1. Check for other items plugged into EDP C-4 outlets that shouldn't be plugged in or seem out of place. Alert PPM of anything that shouldn't be plugged into those outlets (e.g. CSUN golf carts). 1. Make sure it's a tripped breaker and not the GFI outlet needing to be reset. 1. On the West wall inside the Field Room, just to the right of the secondary sump, there is a quadplex (4-plug outlet) that has a Reset button. Push that button until you hear a click. If you hear the click but the power is not restored, then follow the next steps. 1. This GFI outlet is also connected to the quadplex down by the sump on the South wall, so all 8 outlets are controlled by the GFI and could initiate the need for a Reset. 1. Call PPM (818-677- ext. 2222) and let them know a breaker tripped at Citrus Hall in outside room 3114 - the room next to the Mechanics Room on the outside and South side of Citrus Hall. 1. When PPM arrives, let them know the breaker box is on the 3rd floor of Citrus in Room 3303 and the switch is for EDP C-4

Sump Pump Malfunction and Turning off flow to the Mesocosm Tanks

1. If the sump pump (the outside underground pump between the Mesocosm container and the Field Room) stops pumping water to the sump, it will overflow

out onto the concrete and into the loading bay driveway. 1. If you notice the pump has malfunctioned, do the following: 1. Check if the GFI outlet on the outside of the Mesocosm container needs to be reset. On the 2-plut outlet, there is a Reset button. Push that button until you hear a click. If you hear the click but the pump does not respond (or you see the light at the bottom right corner of the outlet flash red), then follow the next steps. 1. Turn off flow to the Mesocosm tanks 1. There is a **T-valve** located along PVC which goes from the chiller to outside the Field Room. Turn this T-valve **clockwise** so it sits perpendicular to the PVC, closing off flow from the sump to the mesocosm, but retaining circulating flow within the sump. 1. The T-valve is in line with a PVC pipe running parallel to the sump, slightly above and to the side of the blue and black biofilter mesh.

Turning off Sump Flow

1. If a situation arises where you need to shut off the recirculating flow of the entire system, unplug the UV light from the South wall quadplex, then unplug the pump from the same quadplex. 1. If you would like to also turn off the CO₂ scrubber, unplug both air pump plugs from the same South wall quadplex.

Flowmeter Misreadings

1. Flowmeter on ApexFusion is reading 0 or some incorrect value 1. Sometimes the flowmeters (FM) inline with water flow will either have a bubble or some debris affecting the spin of the turbine within the FM. 1. Make sure to check the flowmeter connections back at the FMM module for a connection issue. Unplug and plug back in the cable for the FM in question. 1. Try clearing bubbles. If gently tapping the FM doesn't resolve the issue, you may have to remove the FM to clear it out. 1. Removing the FM for cleaning 1. Turn off flow to the Mesocosm Tanks and wait 15-20 minutes to ensure there is no flow to the tanks. 1. Unscrew the FM at both of its compression fittings until the fittings are loose on the tubing, then pull gently at the tubings to remove them from the FMM (if the compression fitting is all the way unscrewed, but the tube isn't coming out of the FMM, pull a little harder because sometimes the tubing just gets stuck in the FM). 1. Visually inspect the inside of the FM, and if needed, use a small long object to probe and spin the internal turbine to dislodge any debris.

Rebooting the Apex

1. If the Apex needs to be restarted for any reason, there are multiple ways to reboot the system. 1. Apex Fusion 1. Click the Expand Settings gears icon and go to the Misc page (wrench icon). 1. Under Power, check the box for Reboot: Restart Apex, then click the orange cloud in the upper right corner to send this command to Apex. Wait a few minutes for the devices to come back online. 1. Restart Button 1. Under the Apex Base Unit, above the pH port, there is a small hole encasing the Restart button. 1. Insert a push pin or small object until you feel the button press down and hold about 10 seconds. 1. If you require a full system reboot back to factory settings, hold this button for 1 minute. This will erase all modules, programming, log data, and probe calibrations, so be very sure.

Light not responding to program

1. Sometimes manually turning the light OFF on Apex, then back ON again, the light will function properly. 1. If a light doesn't turn on when the program indicates it should be ON, go into Programming settings for Light-TNK-#, adjust the advanced program slightly (e.g. change an "ON" to an "OFF") and click the orange cloud to send to the Apex. Then change the program back to what it was before you made a change, then see if the light resumes its proper program. 1. If the light still doesn't turn on, try rebooting the apex.

pH Probe Malfunction

1. If a pH probe is giving an 'off' reading, first calibrate the probe. 1. On your Fusion dashboard, click the gear symbol to the right of the pH reading to go to its settings. 1. Select Automatic Calibration, and follow the instructions, using new packets of 7 and 10 calibration solution. 1. When placing the probe into the calibration solution, swirl the probe in the solution a little before starting the reading. 1. If the reading is still off, go back into the pH probe's settings on Fusion and select Advanced to do a Manual Calibration. 1. Make sure Temp Compensate is Disabled then select Manual Calibration, and follow the instructions. 1. When placing the probe into the calibration solution, swirl the probe in the solution a little before starting the reading. Let the probe sit in the calibration solutions for about 5 minutes (or longer as necessary) to ensure a stable reading. 1. If the reading is still off after both the Automatic and Manual Calibrations, try a Factory Reset. 1. Go back into the pH probe's settings on Fusion and select and select Advanced. 1. Select Manual Calibration again, but this time just click "Next" through the steps quickly. Don't let the numbers settle. Then click "Finish". If the numbers for the 7 and 10 calibrations are the same, the probe calibration will be wiped and reset, ready for a new calibration. 1. From the Apex's "Misc" settings, check the box for Reboot: Restart, and click the orange cloud to send this command to the Apex. Wait for the Apex to fully reboot. 1. Run through the Manual Calibration steps again. 1. If after following the above steps, the pH probe is still malfunctioning, call Neptune Systems for support.

pH Spikes

1. If you noticed the pH in your take plummeting down when the CO2 solenoid is actively dosing. 1. It is likely that the fine tuning needle valve on the tank's CO2 solenoid needs to be closed a little more (turned slightly clockwise) to bring the flow of CO2 out of the air stone bubbler down. 1. If the flow is too high, this could cause rapid changes in pH in your tank before the probe can even detect the change. 1. By the time the probe detects the change and turns off the bubbler, plus with a slight residual time between the solenoid closing and the remaining CO2 gas being emitted from the bubbler, the pH may have dropped lower than desired. 1. Turn the CO2 flow down using the large nob on the solenoid's needle valve so that you see a gentle stream of bubbles slowly coming from the bubbler. 1. The CO2 solenoid is connected to the tank's bubbler tubing. It is a white box with the Neptune Systems logo and an arrow indicating flow direction. Connecting the tubing and the white box is a metal

needle valve. The end knob of that needle valve can be turned slightly for fine tuning gas flow.