Underwater Snail Barrier

Owner’s Manual

By DesignTek RF LLC

Overview

New Zealand mudsnails (NZMS) are a tiny aquatic snail reach about 4 to 6 mm in length. They are generally gray or light brown in color. This species are live-bearers, which mean they release live young rather than eggs, and those offspring are clonal (genetically identical) females that are asexually

reproduced. When born, offspring already contain developing embryos within their reproductive system. Upon reaching maturity at 3 mm, females can produce 230 new females per year; estimates indicate that one snail and its offspring can result in over 2.7 billion snails within 4 years.[1]

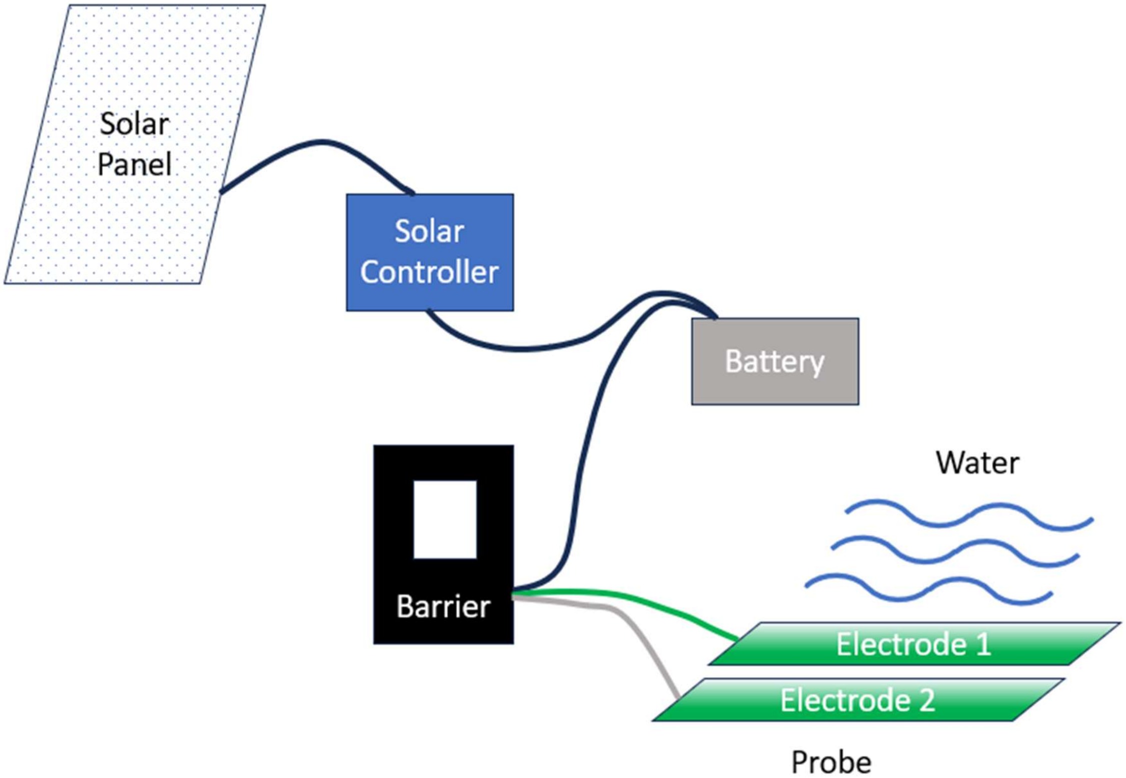
When fish consume mudsnails they generally pass right through the digestive system alive and thus can be transported between waterbodies, through mechanisms such as: hatchery activities, angling, and animal transport.

The goal of the snail barrier is to prevent snails from entering fish hatcheries through hatchery outflows. These snails travel slowly and will travel along stream channel substrates or along the water surface tension if the water is moving slowly. Two electrodes spaced close together located in the channel in such a way that that only way for the snails to travel upstream is to cross the electrodes then barrier will be effective and shock them as they try to cross the electrodes. This shock does not kill the snail it only creates a release response and thereby washing the snails back downstream.

Installation

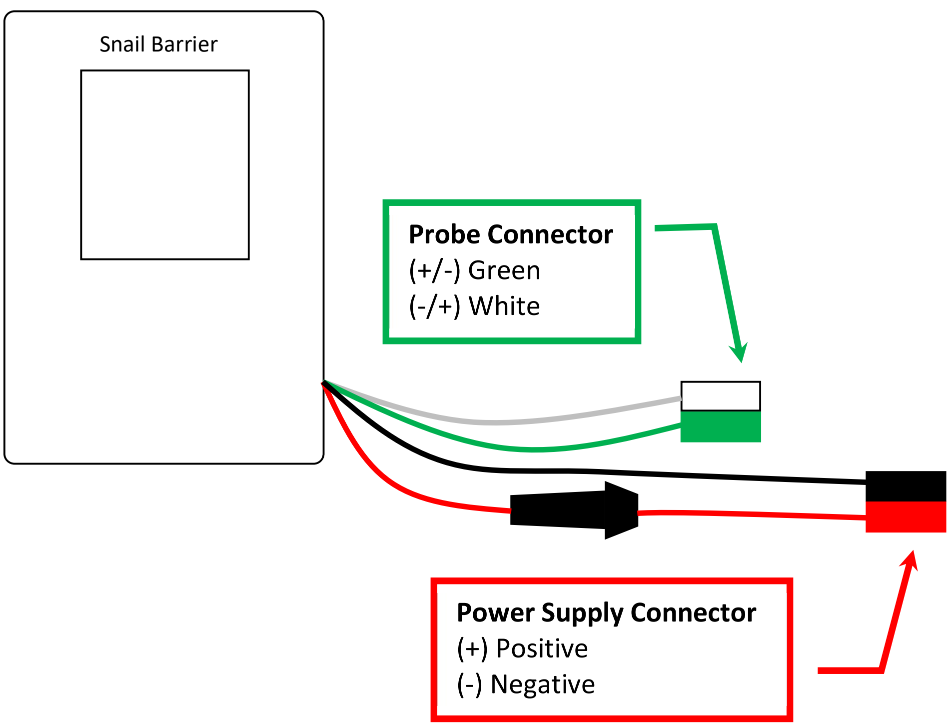
The following figure shows an overview of a typical barrier installation.

[1] https://wildlife.ca.gov/Conservation/Invasives/Species/NZmudsnail


Solar
Panel
Solar
Controller
Battery
Water
Barrier
Electrode 1
Electrode 2
Probe

Controller

Connect the **Probe** (electrodes) to the Green / White connector and the **Power Supply** to the Red / Black connector. The Power supply should be between 7 and 30 Volts. The Snail Barrier will automatically power up and the display will show a title banner, start pulsing then display barrier measurements and status.



Power Source

The snail barrier is generally powered by a sealed lead acid battery, although any type of battery would work that provides sufficient voltage and current to handle the load resistances of the water. Typically, a 12 Volt sealed lead acid battery is used. See the appendix for proper battery amp-hour sizing.

Probe Overview and Installation

The probe generally consists of two stainless steel strapping bands, called electrodes, secured to an insulated, immovable substrate separated with a rubber cushion in-between. The rubber cushion is used to eliminate any small gaps between the electrodes and the mounting substrate so the NZMS do not crawl under the electrodes. The two electrodes are separated horizontally by 1/8 inch. Gaps wider that 1/8 inch have not been examined extensively to determine their effectiveness. However, if these electrodes are spaced further apart the current density will decrease reducing the barrier strength. This probe assembly must be located underwater to be effective at blocking the NZMS from traveling upstream crawling along channel surfaces.

The probe substrate must be secured to the water channel in such a way to prevent these tiny snails from traveling underneath the probe and mounting surface. This is why a rubber cushion is also used underneath the mounting substrate. Mounting holes are drilled in the substrate to secure the probe assembly to the bottom and sides of the water channel. **If possible, the connection point of the wires coming from the controller to the probe should be located outside of the water. This connection point can corrode very easily thereby making the snail barrier ineffective.**

Fig 1 Top view of probe

Fig 2. Bottom View of Probe Mounting Substrate

The probe front view as shown in Fig 3 is what the NZMS sees and they only have one option which is to crawl over the top of the electrodes.

Fig 3. Front View of Probe

One stainless steel strap will serve as the positive electrode and the other the negative. Once the electrodes are placed under water the circuit is completed and snails will be shocked as they physically move between the two electrodes. This causes them to release their grip on the channel surface and will be washed downstream. Contacting a single electrode will not cause the snails to be shocked. The snail barrier will change is polarity about every 24 hours to minimize corrosive buildup.

Royal Building Products 1-1/2-in x 8-ft PVC Lattice Moulding (Lowes)

Foam Tape: Continuous Roll, Black, 1/2 in x 16 11/16 yd, 3/16 in Tape Thick, 1 Pack Qty, Rubber Foam

Stainless Steel Band: 0.03 in Strapping Thick, 1,500 lb Break Strength, 50 ft Strapping Lg

Tapping Sheet Metal Screw: #6 Size, 3/8 in Lg, 18-8 Stainless Steel, Plain, Flat, Phillips

CAROL Hookup Wire: 18 AWG Wire Size, Red, 100 ft Lg, 300 V Volt

CAROL Hookup Wire: 18 AWG Wire Size, Black, 100 ft Lg, 300 V Volt

Probe Installation in a Channel

Here are a few examples of a probe installed install in a channel.

Probe Installation on Pipe

Probes can either be installed on the inside or the outside of a pipe. On the outside of the pipe, you can use the Band-IT clamp tool. You can follow instructions that come with Band-IT tool on how to operate tool. To install the probe on the outside of the pipe no part of the pipe can be buried in sediment or vegetation. The pipe needs to be partially covered in water. In no water is in contact with the outside of the pipe then the probe should be installed on the inside of the pipe. When installing the probe on the inside of the pipe only the stainless-steel bands, the rubber cushion and stainless-steel screws are needed. An important thing to note is that it is imperative that there are no air gaps between the rubber cushion and the pipe. It is also very important to maintain the 1/8" gap between the stainless-steel bands anywhere the probe will come in contact with the water.

BAND-IT Band Clamp Tool: 0.1875 in Min. Strapping Wd, 0.75 in Max. Strapping Wd, 8 in Tool Wd

Strapping Buckle: Fits 1/2 in Strap Wd, 201 Stainless Steel, Flat, 50 Qty, 50 PK

Here are some examples of a probe installation on a pipe.

Controller Operation

Operation of the snail barrier is very simple. It is plug and play operation. There is no on / off switch or user settable options. Once power is applied the controller will begin to pulse at the designated rate which is a 25 millisecond **on time** and a 3 second **off time**.

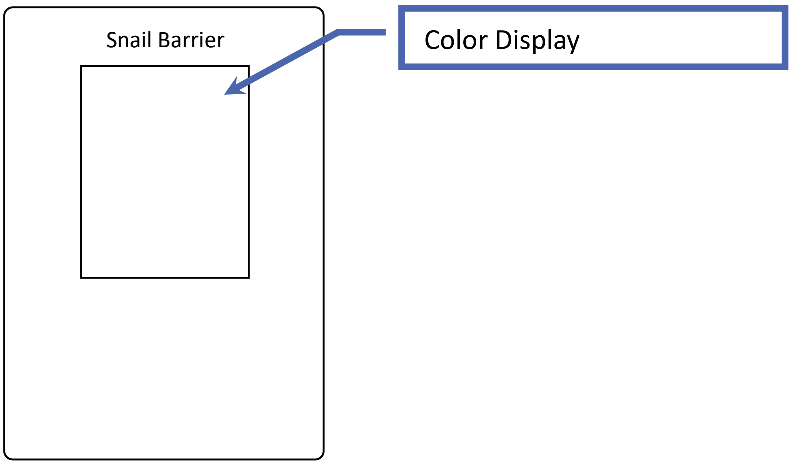
Boot Sequence

When the controller is first powered up it follows the sequence:

1. Pulse positive polarity (Blue Dot)
2. 3 Second delay
3. Pulse negative polarity (White Dot)
4. 3 Second delay
5. Pulse positive polarity (Blue Dot)
6. 3 Second delay
7. Pulse negative polarity (White Dot)

8. 3 Second delay
9. Pulse positive polarity (Blue Dot)
10. 3 Second delay
11. Pulse negative polarity (White Dot)
12. 3 Second delays
13. Pulse positive polarity (Blue Dot)
14. Normal pulse operation begins

The pulse count and the number of pulses before polarity toggle is shown on the bottom line of the display if there are no errors or warnings.



Color Display

The color display shows all probe measurements, pulse status, pulse polarity, serial number, firmware version and messages on a single screen.

Probe Measurements

Three measurements and one quality factor are displayed for the probe.

Probe Current

The **probe current** is measured 10 times and averaged during the pulse on time. The current is displayed in milliamps (mA). The higher the current the stronger the electric field is between the two probe electrodes and the longer the probe length that can be supported.

Probe Voltage

The **probe voltage** is measured 10 times and averaged during the pulse on time. Typically, the probe voltage is a little less than the **battery voltage**. However, this voltage drop can become larger as the probe current increases.

Probe Resistance

The **probe resistance** is calculated as the **probe voltage** divided by the **probe current**. The measurements unit for resistance is ohms (Ω).

Probe Effectiveness Quality Factor

This quality factor is ***based on the current density for a probe electrode spacing of 1/8 inch***. This quality factor is given as a length of probe that can be effective given proper probe installation. If the probe length being used is less than this **quality factor** length the barrier will be effective in preventing snails from crossing. If the barrier length is longer than the **quality factor** length that does not mean that the barrier is not effective rather it means that testing has not been done at that current density so the barrier effectiveness cannot be guaranteed. For example, the display picture in this document shows a probe quality factor of **60.8 ftMax**. This means that any length of probe less than 60.8 ft will be effective as preventing snail crossing assuming proper probe installation.

Battery Measurements

Battery Voltage

This is the measured **battery voltage**. If the battery voltage is less than 10.8 volts a low voltage warning will be display. Sealed lead acid batteries do not like to be over discharged.

Device Information

The serial number and firmware version of the barrier are displayed. There is also a letter designating the type of device (B – Snail Barrier). The adjacent icon displays the current operating mode of this device. A picture of a snail indicates the device is operating in Snail Barrier.

Pulse Status

The status of the pulse is displayed in as a pulsing dot in the upper right corner of the display. The dot appears during the probe **on time**, when power is applied to the probe load.

The color of the dot indicator has different meanings.

- BLUE – Normal pulse operation. Polarity (green terminal) is ***positive***.
- WHITE – Normal pulse operation. Polarity (green terminal) is ***negative***.
- RED – No pulsing. Shorted probe detected.

Indicates an over current state has been reached. The probe pulsing is stopped for 1 minute and the device will reset and begin is pulsing again. If the reason for the over current condition has not been resolved the process will be repeated.

The words ***Pos*** or ***Neg*** are displayed next to the pulse indicator dot to show probe polarity also.

Warnings and Errors

Warnings and errors are displayed on the bottom line of the display in red. The messages are:

- Low Current (Probe Current < 18 mA)
- Low Battery Voltage (Battery Voltage < 10.8V)
- Over Current (Probe Current > 5100 mA)

Low Current

This error message generally indicates that the probe is not connected to the controller.

Low Battery Voltage

Generally, indicates that the battery is not being charged or that the solar panel is undersized and cannot keep up with the current required by the barrier.

Over Current

This typically means that the probe electrodes have been shorted. When this happens this error message is displayed, the probe status dot will be changed to red and the controller will stop pulsing to protect the controller from destroying itself. After 1 minute the controller will restart and an attempt will be made to start the pulsing again. If the short still exists the process will repeat.

Pulse / Toggle Count

The pulse count and the number of pulses before polarity toggle is shown on the bottom line of the display if there are no errors or warnings. For example, the display at the beginning of this section shows **85** pulses have occurred either since power up or the last polarity toggle. When the pulse count gets to **28565** the probe polarity will toggle and the pulse count will begin again.

Operation Summary

There are two primary indicators that show barrier effectiveness.

1. No red error or warning messages
2. The **Barrier Effectiveness Quality Factor** (BEQF) has a longer length than the underwater probe length.
3. The **Battery Voltage** for a sealed lead acid battery is typically between **11.0 and 13.0 Volts**.
4. The **Probe Voltage** is typically equal to or a few tenths of a volt below the Battery Voltage.
5. The **Probe Current** can vary from installation to installation. If the BEQF is longer than your underwater probe length you do not need to worry about this measurement. However, it should remain fairly constant over time. If this decreases substantially over time it typically indicates the probe is dirty and needs to be cleaned.

Probe Maintenance

The Probe Current may decrease over time. If the decrease is significant this may indicate that probe needs to be cleaned. The probes should be cleaned with a non-metallic stiff bristled brush should algae grow on them or gets covered with sediment. A suggested clearing schedule should be at least once a week. This could vary based on the speed of vegetation growth and sediment within your watercourse.

Reverse Battery Voltage Protection

When the battery voltage is accidentally reversed to the input to the controller circuitry will prevent damage to the controller. In a rare event the protective fuse may blow.

Technical Specifications

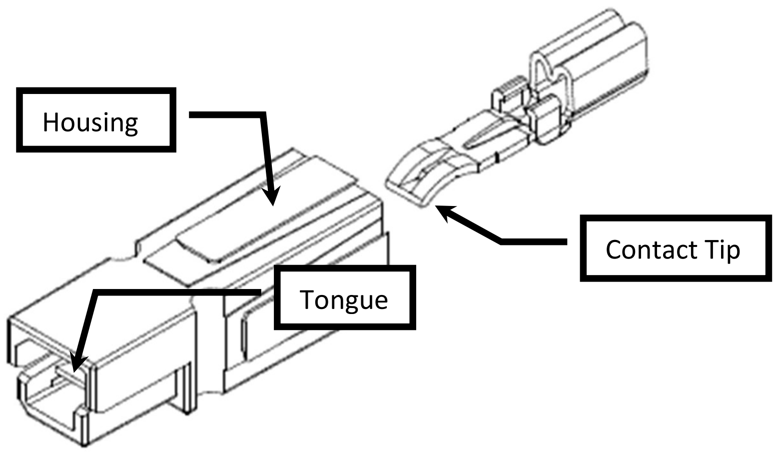
Specifications				
Parameter	Minimum	Typical	Maximum	Units
Input (Battery) Voltage Range	7	12	30	Volts
Probe Current Range*	40		5000	mA
Probe Voltage Range	7		30	Volts
Probe Resistance Range*	3		500	Ohms
Pulse On Time		25		ms
Pulse Off Time		3000		ms
Polarity Switch Count		28565		
Polarity Switch Time		24 hours		
Battery Voltage Measurement Accuracy	-5.0		+5.0	%
Probe Voltage Measurement Accuracy	-5.0		+5.0	%
Probe Current Measurement Accuracy	-8.0		+8.0	%
Probe Resistance Measurement Accuracy	-8.0		+8.0	%
Low Voltage Warning		< 10.8		Volts
Low Current Warning		< 18.0		mA
Overcurrent Warning		> 5100		mA
Probe and Battery Connectors	Anderson Powerpole			
Fuse Size	2.0 A			
Size	5.245" x 3.076" x 1.375"			
Weight	7 oz			
Current Draw (Quiescent)	35 mA Nominal plus probe current at 0.83% duty cycle			

*Small current and large resistance measurements outside the specified ranges are less accurate

Appendix

Overview Power Pole Connectors

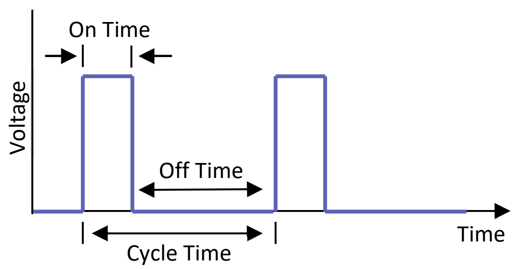
Power pole connectors are used for the probe and power supply. They are unisex connectors. The following figure shows relationship of the contact and the housing.



When the contact is inserted into the housing correctly the tip of the contact will extend over the tongue in the housing.

Duty Cycle

This is the ratio of the probe *On Time* to the total time of the cycle which is the *On Time* plus the *Off Time*. For the snail barrier the ***On Time*** has internally been defined to be **25 milliseconds (ms)** and the ***Off Time*** has been set to **3 seconds (s)**. This value is not adjustable by the user.

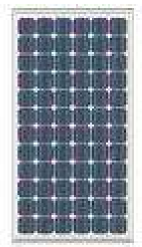


$$Duty\ Cycle = \frac{On\ Time}{On\ Time + Off\ Time} \times 100\ \%\ (1)$$

$$Barrier\ Duty\ Cycle = \frac{0.025s}{0.025s + 3s} \times 100\ \% = \ 0.8264\%$$

Determining Solar Panel and Battery Requirements

If the snail fence is operated in a remote environment a solar panel, solar charge controller, and sealed lead acid battery can be used to provide power to the snail fence.




Battery Requirements

The battery requirements are largely determined by the average probe current. Batteries are rated in terms of AH (Amp Hours). This is the amount of current a battery can deliver over the period of 1 hour. For example, if the battery has a 10 AH rating, then the battery could deliver 10 Amps of current for 1 hour, 1 Amp for 10 hours, or 0.1 Amps for 100 hours. Typically, battery manufactures specify the battery at a 20-hour rate. When current is drawn faster than that generally the actual AH capacity of the battery is less than the 20-hour rate.

The worst-case probe load current is equal to the peak current draw multiplied by the duty cycle.

$$Probe\ Load\ Current_{(worst\ case)} = Peak\ Probe\ Current * Duty\ Cycle \quad (2)$$

To determine the total supply current required find the worst-case *average* probe load current and add it to the quiescent barrier current. This will give the total *average* current that needs to be supplied by the battery on a continuous basis.

$$Total\ Supply\ Current = Probe\ Load\ Current_{(worst\ case)} + Quiescent\ Barrier\ Current\ (3)$$

To determine the capacity requirement of the battery the user must consider a worst-case charging scenario where the battery would need to supply the total current in the absence of being charged. Battery ratings generally degrade with time so some margin should be added to the capacity to account for this degradation over time.

$$Battery\ Capacity = Total\ Supply\ Current\ \times Number\ of\ Hours\ without\ Charging\ (4)$$

The peak current capacity of the battery should also be considered. Even though the average current may be small enough to be powered by a very small battery this battery may not have the ability to provide large peak currents.

Example

Calculate the battery size for the following situation:

- Worst-case probe current is 2.0 Amps at 12 Volts
- Number of days without charging is 7 days

1. Calculate the worst-case average probe current by using equation (1). Use the Duty Cycle calculated in the prior section.

$$Probe\ Load\ Current_{(worst)} = 2.0\ A\ \times 0.008264 = \ 0.0165\ A\ or\ 16.5\ mA$$

2. Calculate the total supply current using equation (3).

$$Total\ Supply\ Current = 16.5\ mA + 35\ mA = 51.5\ mA\ or \sim 52\ mA$$

Remember: The 35 mA current draw is what it takes to run the controller and display on a continual basis.

3. Calculate the battery capacity using equation (4).

$$Battery\ Capacity = 0.052\ A\ \times\ 7\ days\ \times 24\frac{hours}{day} = 8.736\ AH$$

Allowing some margins the choice would probably be a 9 or 10 AH battery.

Solar Panel Requirements

A solar panel is used to keep the battery charged. Solar panels are generally rated for peak power, voltage, and current. Under the best sunlight conditions the panel will produce the given output.

$$Panel\ Power_{(peak)} = Panel\ Voltage_{(peak)}\ \times Panel\ Current_{(peak)}\ (5)$$

The panel voltage is selected to be larger than the battery voltage. For example, if the chosen battery is 12 Volts, then a 17 Volt solar panel or higher voltage is required.

The panel current should be chosen to provide the *Total Supply Current* plus additional current to charge the battery. For example, a typical 25-Watt solar panel will provide a peak voltage of 17 volts with a peak current of 1.5 A. In the above battery capacity example only 52 mA of current is needed on an on-going basis. This panel would produce and extra 1450 mA to charge a battery. However, we need to remember that a battery can be charged only part of the day during good sunlight.

The solar panel should never be directly connected to a battery. It can damage it by overcharging it and can even discharge the battery during times of poor or no sunlight. A solar charge controller can be purchased for the given voltage and current conditions to provide proper battery charging. The solar panel should be connected to the solar charge controller which in turn is connected to the battery.