Report on a Mobile, Solar-powered Pump and Livestock Waterer

September, 2015

HEADWATERS SWCD SOIL & WATER CONSERVATION DISTRICT

Report compiled by Matt Booher, Virginia Cooperative Extension.

Cooperators:
Alston Horn, Chesapeake Bay Foundation
David Fiske, Virginia Tech AREC
John Ignosh, Virginia Tech
Joe McCue, Friends of Middle River
Bud Shaver, Cooperating farmer

Objective: To build and demonstrate a mobile livestock waterer powered by solar, for the purpose of facilitating stream exclusion and grazing management where conventional watering systems are not viable.

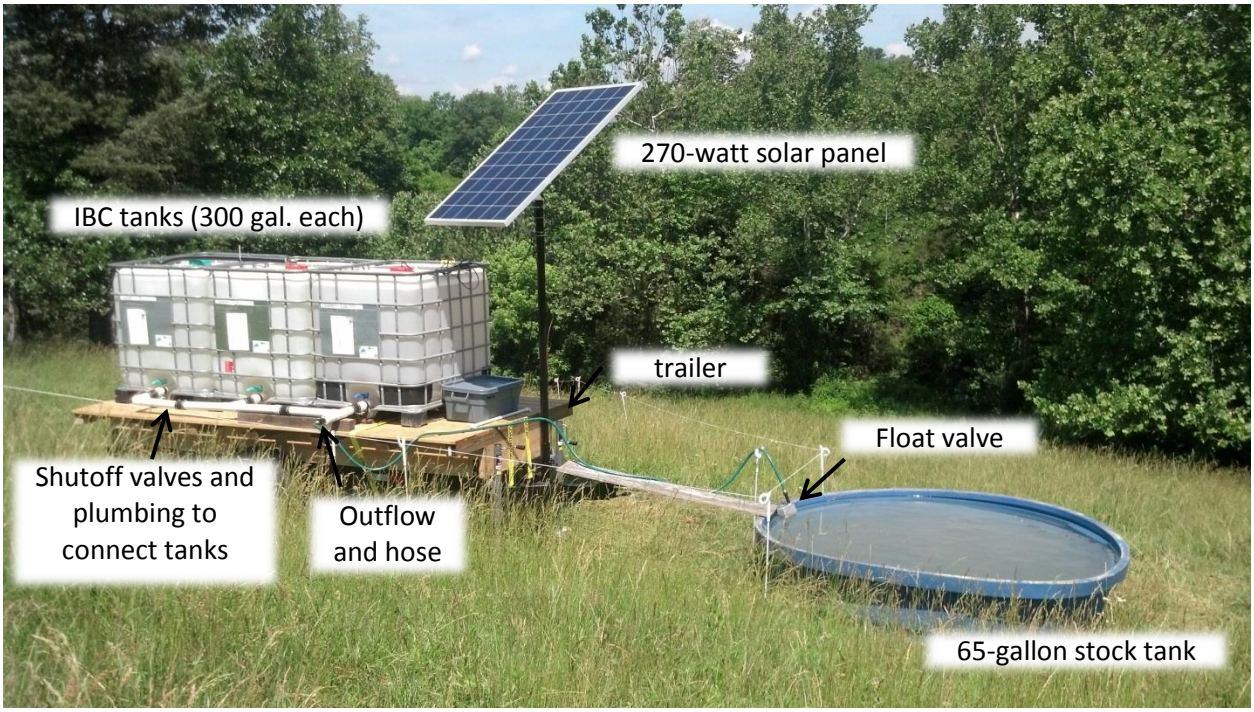
Contents:

System Overview

This system uses a 270 watt solar panel to power a positive displacement pump that can be submerged in a number of water sources found on farm, including springs, ponds, rivers, or impounded sections of streams. Solar systems typically use either batteries or water reservoir to store excess energy produced or excess water pumped. This system uses a series of three, 300 gallon IBC (intermediate bulk containers) plumbed together, to store excess water that then gravity flows to a livestock watering tank. With the storage capacity of the 650 gallon livestock tank, the system has a total of approximately 1,500 gallons of water in reserved. This reserve is essential to provide water during periods of low solar output, and for water recharge during short periods of heavy water use by grazing animals. This system is mounted on a movable trailer to allow for transport within and between farms. The capability of this system is naturally dependent upon weather and number of daylight hours. Under ideal conditions this system is expected to pump around 2.5 gallons/minute.

System Components

The following diagram outlines the components of this system.



Left: Grounding system for lightning protection

Middle: Housing unit for pump, suspended from floating frame to allow use in ponds or rivers.

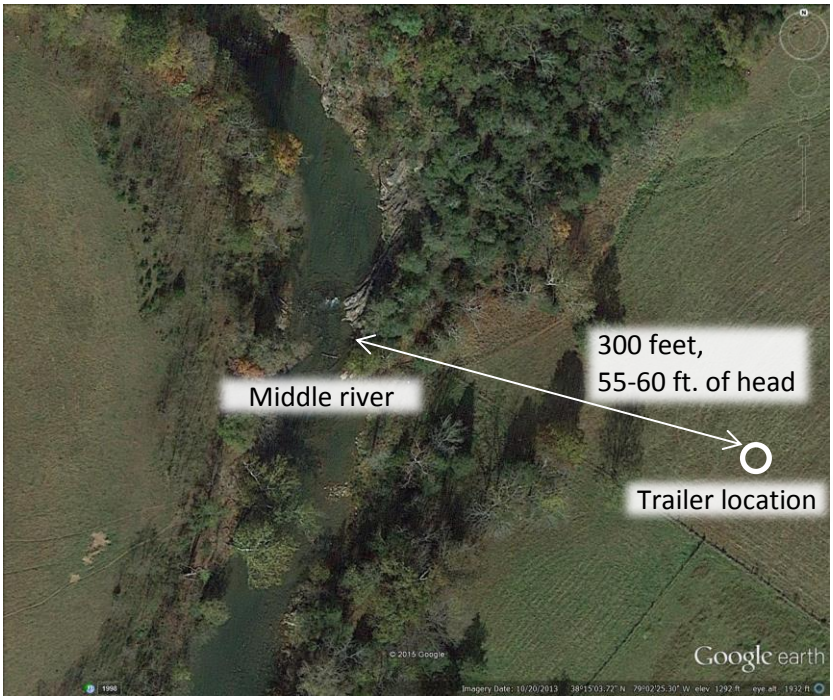
Right: The positive displacement, submersible pump.

Review of performance

This unit was tested on two farms in the Middle River Watershed of Augusta County, VA from May through September.

Location 1

Located on Todd Rd, this location was the southwest corner of a 50 acre pasture field adjacent to Middle River. The river was already fenced, and the pasture was stocked with 25 cows. The cows were currently using a permanent waterer at the north end of the property. The pump was placed in an eddy of Middle River and 1.25" black poly-pipe was laid aboveground to move water 300 feet uphill to the reservoir trailer. For this particular application, the suspended pump needed to be held in place so that the river's flow did not push the pump to the bank, toward mucky water, shallow water, or into the main current. We anchored the pump by its harness, with long ropes attached at three points – two points on the bank, and the third from an anchor placed in the main current of the river. In the event of a major flood event, this three point anchoring setup would allow the pump to rise with the floodwaters. We also installed a quick-coupler release where the pipe and pump connect, to allow for quick disconnection in the event of a worrisome flood. The discharge head (elevation gain) from the river to the reservoir tanks was approximately 55-60 feet. This was a very challenging set of conditions for this solar/pump array, and a loss of pumping capacity was expected. After setting up the system, a flow rate of 1.0-1.25 gal./minute was recorded under sunny skies. It took cattle more than a week to find the water, as they still had access to the permanent waterer, and were not accustomed to grazing in the corner of the pasture where the solar unit was set up. We protected the trailer and stock tank float valve from cattle by utilizing temporary electric fence to restrict access to those areas. We were able to tie in to existing electric fence, although a solar fence charger could have been used. After roughly two months at this location, use of the solar waterer remained light. As a result, turnover of water was slow, water grew algae, and grew somewhat stagnant. A water sample from Middle River and from the stock tank were both tested for ecoli, to determine any potential animal health hazards. Both samples tested at one colony(33.5 cfu/100 ml) well below the state standard of 235 cfu/100 ml. During the course of its time at this site, we learned that the system required weekly maintenance to clean the pump's filtration system free of silt and debris. Clogging by silt caused the pumps flow to decrease dramatically, and caused the pump to struggle. The need for cleaning was discovered to be apparent based on the sound of the pump as it ran; a clogged filtration system sounded duller and slower. Also, water flow into the reservoir tanks was noticeably diminished. This location was very steep, and the trailer sat on somewhat of an incline (despite being on a "flat" spot). In building the trailer, we welded adjustable jack stands onto each corner. These turned out to be essential to leveling the trailer, reservoir tanks and plumbing, and



supporting the massive weight of the full tanks. When the time came to move the unit to the next farm, disassembly only took about one hour. Details of disassembly will be discussed in the “setup and disassembly” section.

Above: View of the solar unit placement at the top of the hill, with a run of 300 linear feet and 55-60 feet of head to the river

Left: View of solar unit from the bottom of the hill.

Below: The submerged pump, suspended from the floating frame visible in the photo. The anchor is barely visible in the current several feet out from the pump. The two ropes can be seen, anchored to trees in the back- and fore-ground.

Top: Cleaning sediment off of the sand sock sleeve which covers and protects the pumps intake.

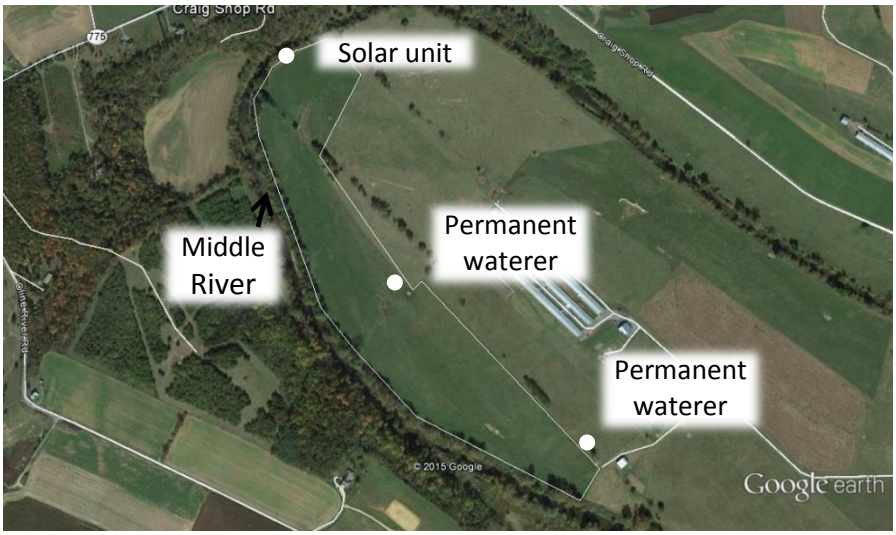
Middle: Suspended sediment in Middle River clogged the sand sock protecting the pump, restricting the flow of water. The pump filtration required cleaning about once a week. In this photo the fine layer of sediment can be seen on the sock.

Bottom: For further filtration we built a PVC housing for the pump, in which we drilled holes to allow water to seep in but helped keep larger debris out. This housing was then wrapped in standard weed barrier fabric and kept in place using cable ties. It is important to filter the water entering the pump, without restricting the flow of water too much. The black 1.25” poly pipe can be seen, complete with the white quick release coupler.

Location 2

This site was located on Middle River in Weyers Cave. The pasture was a narrow "J" shaped field bordered by Middle River. Middle River is fenced off and permanent waterers are at the eastern end and of the pasture. The western end lacks a waterer and, as a result, grazing patterns in the field show a tendency toward overuse in the eastern portion of the field, and underuse on the western end. Virginia Tech research has found that cattle will not walk much beyond 800-1000 feet to go to water, rather, they will re-graze pasture closer to water and drastically underutilize the rest of the field. In this pasture, cattle walk a distance of about 800 feet to access the eastern part of the pasture. To gain access to the westernmost portion of the pasture animals must walk over 2,000 feet.

We set up the solar unit on the western end of the field, pulling water again from Middle River. By doing so, we more equally provided water throughout the pasture, improving forage utilization and grazing management. As a test site for the solar capacity, this location allowed us close access to the river, with little head. The pumping distance was 100 feet, and the discharge head was around 15 feet. We were therefore able to test the full capacity of the unit with little friction loss or gravity to overcome. Additionally, the farmer stocked the field with 100 cow-calf pairs, allowing us to see if the solar unit, its pumping capabilities, and its reservoir storage would meet the requirements of a large herd.



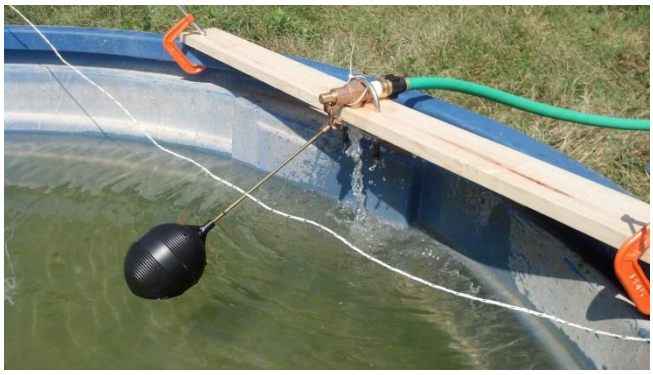
At this location we measured the pumps flow to be around 2-2.5 gal./minute. With around 12 hours of direct sunlight, the empty system therefore filled in about a day (12 hours x 60 minutes x 2 gal./minute). The farmer then prevented access to the other waterers using temporary electric fencing, and forced animals so graze the western part of the field and to use the solar waterer. Immediately, we ran into problems: 100 cow-calf pair, watering at the same time drained the stock tank faster than it could recharge. The animals then pushed the stock tank, knocking out the float valve and hose as well as the temporary electric fencing protecting the unit. This was not altogether surprising, as research has quantified that a mature cow will consume roughly 25 gallons of water per day- 500 lb. calves will consume about 12 gallons per day. The total water requirement of this herd was around 3700 gallons per day. The capacity of the solar system in this application is around 1500 gallons/day – enough for about 50-60 brood cows.

We then reopened access to the other water to take pressure off of the solar unit. We immediately encountered the same problem as before; even with an additional waterer in the field cattle visited the waterer in large groups which drew down the water in the stock tank faster than it could recharge. Additionally, the float valve we were using was a restricted flow valve with a small orifice that became easily clogged with algae. To counter both problems we changed float valves from a restricted flow valve

to a full flow valve. After this we had no problems and the unit was able to keep up with the herd. We continued to conduct weekly maintenance on the pump, cleaning it and monitoring its suspension in the water as the river's water level dropped during a small August drought. We also had to clean algae from the float valve about once a week. We therefore recommend a weekly maintenance schedule to check the water lines and valves for clogs and to clean the pump. In the future, we will explore the use of a small amount of bleach in the reservoir tanks to keep the system free of algae. This will likely be part of the weekly maintenance.

Top: The herd watering.

Left: Pump maintenance to remove sediment from the filtration surrounding the pump. This is recommended to be done on a weekly basis.



Top left: Standard stock tank float vales are restricted flow and caused issues with water recharge rates and algae accumulation.

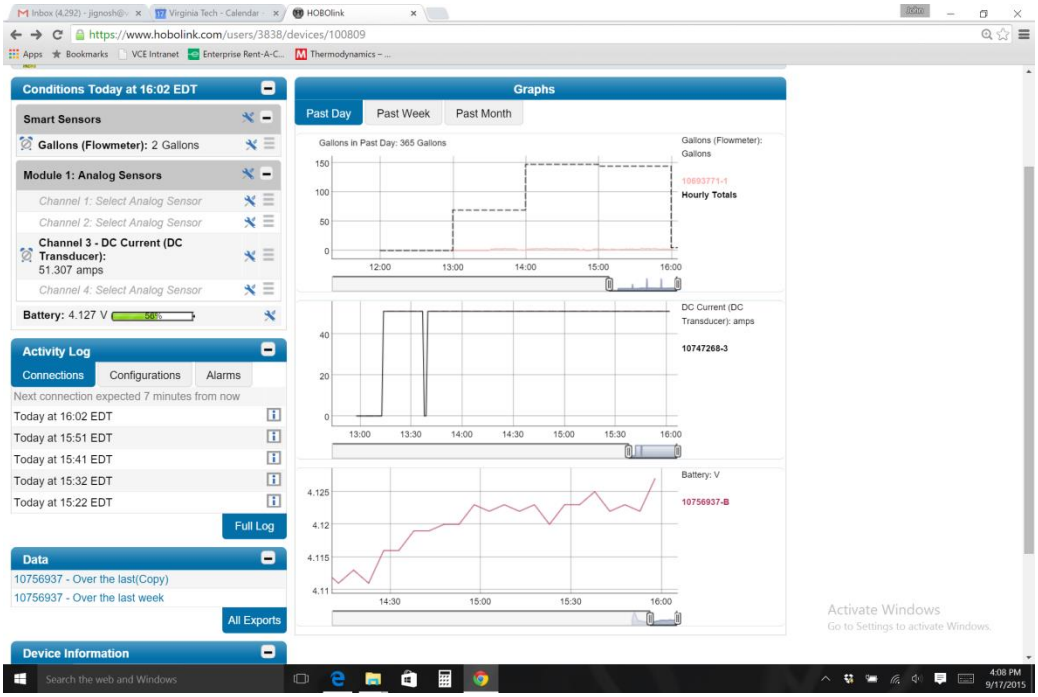
Top right: A full or unrestricted flow float valve. No issues.

Bottom: As many as seven or eight cattle were observed to water at the same time from the stock tank. This is important, as it limits aggressiveness at the water and ensures animals can water quickly and completely. This is a 650 gallons stock tank, which allowed many animals to water quickly and served as additional reservoir storage and more importantly, and immediate reservoir during the watering event.

Top: Algae can cause problems. A quick turnover is important to minimize algae problems. We recommend sizing the system to the number of cattle that can cycle through the water every day or two. This solar unit's reservoir system is comprised of three tanks plumbed together, allowing for one or more of the tanks to be shut off. This would allow for a smaller amount of water in the reservoir storage, and a quicker turnover of water if smaller herds of cattle are to be used. Additionally, we plan to explore the use of chlorine to help with algae problems.

Location 3

The solar unit is currently at a third location with a similar setup to location two. A data logger and flow meter have been added to collect information on electricity produced by the solar panel, as well as the flow rate of water coming from the pump. At last check, the pump was producing around 3 gallons/minute. Updated data can be obtained from John Ignosh, Biological Systems Engineering Area Specialist with Virginia Tech; 540-432-6029*108. Additionally, another E.coli test was performed in the river and in the stock tank, resulting in a score of 67 cfu/100 ml (2 colonies) at the pump and 0 colonies from the water trough- both well below the state standard of 235 cfu/100ml.



Top: Example of data produced.

Bottom: Location 3; EPA site visit

Setup and disassembly

Setup and disassembly proved surprisingly simple. The solar panel itself is equipped with quick connect wires to allow the user to attach or remove wires simply for transport. Once removed, the wires are rolled up and kept with the pump. The stock tank can be inverted and stored on top of reservoir tanks for transport. The solar panel can be lifted easily from its post, wrapped in a protective blanket, and transported on the seat of a vehicle or truck bed. The post remains on the trailer. The black poly pipe can be rolled easily for storage or transport, by placing temporary fence posts in the ground in a circle configuration, and then wrapping the pipe into a roll within the diameter of the posts. The roll is then taped with electrical or duct tape. The entire process of setup or disassembly takes two people approximately one hour. We evaluated the site after cleanup; there was minor denuding of the ground around the waterer, and a couple cattle trails, but overall the site was not damaged and will recover quickly. The trailer quickly hooks to a truck or tractor hitch for transport, jack stands are cranked up and swiveled out of the way, and it is road-worthy up to about 45-50 mph on a good road. The whole unit weighs very little when tanks are empty.

Top: View of the reservoir tanks and plumbing, which allows individual tanks to be shut off from the system, allowing for faster turnover of water in the system.

Right: Underside of the solar panel. Circled are the quick attachments for the wiring assembly.

Top: A month's use of the solar system resulted in very little damage to the sod, a small denuded area and a couple of cattle trails. The denuded area does not appear to be permanently damaged and is expected to green back up this fall.

Bottom: Disassembled system ready for transport.

Itemized cost breakdown

The itemized cost of this system is shown below. It is very important to note, that the expense of the solar components should be considered separate from the trailer expenses. Many farmers could make use of existing trailers or build one from existing equipment for less cost than we did. We needed a trailer built to rigorous specifications because of the distances it will cover across Augusta County, and for liability reasons as it is used on various farms and under situations. Overall, the cost of the solar portion of the project was roughly $3,000.00. Plumbing expenses represented the next greatest cost- about $900, including the stock tank.

Company	*phone*	*Item description*	*# of units*	*Item number*	*Price*	*Shipping*	*Total Price*
Advanced Power	866-519-7892	3 panel 255 watt, quad pump w/ 100 ft wire	1	K250 RP4	$2,945.00	110	$2,945.00
			1	ALC1275	$125.00		$125.00
	540-896-6939	4' x 3.5' cage tank	5		$25.00		$125.00
Tractor supply	540-887-2569	8'x2' round blue plastic stock tank, 625 gal., drain	1	2177188	$350.00		$350.00
		T-posts	4		$3.59		$14.36
		stock tank float valve	1	217031499	$19.99		$19.99
Noland	540-248-4840	1 1/4" black poly pipe	200		$0.51		$102.00
		parts for floating dock	1		$64.00		$64.00
		fittings, clamps, elbows for pipe					$95.00
		misc. plumbing parts for ibc tanks	3		$15.99		$125.00
Ben Meadows		jacks	4		$80.00		$320.00
Lowes		rope, ground rod & wire, hardware, cable	1		$95.00		$95.00
		100' 12-2 Romex underground feeder cable	1		$47.50		$47.50
		underground splice kit	2	34196	$11.47		$22.94
		Temflex rubber splicing tape	1		$2.48		$2.48
		2" x 10" x 12'	3		$14.97		$44.91
		4" x 4" x 6'	7		$6.97		$48.79
		deck boards 50 square ft. 6" x 12'	12		$8.33		$99.96
		deck screws	1		$30.00		$30.00
		paint	1		$15.00		$15.00
		misc. hardware for trailer (Fiske selected)	1		$50.00		$50.00
		brackets (for joining wood)	14		$1.50		$21.00
		PVC sleeve materials	1		$40.00		$40.00
		8" lag screws (5/16" x 5 1/2")	1		$8.96		$8.96
		welding rods	6				$90.00
		garden hose	1		$8.00		$8.00
Staunton Machine	886-0733	10 ft. of 2 3/8 OD metal pole	1		$63.56		$63.56
		misc. trailer	1		$60.00		$60.00
Virginia Frame	540-337-4369	timber lock screws	1		$9.00		$9.00
		5" channel iron, other metal	46		$4.10		$188.60
Climatestore		water usage meter	1		$26.74		$26.74
Misc.		hardware, silicone, etc.	1				$500.00
							$5,757.79

Water Alarm Project

Company	*phone*	*Item description*	*# of units*	*Item number*	*Price*	*Shipping*	*Total Price*
Security Snobs	888-560-9947	Mobey water alarm		CM2300FS	$225.00	11	$236.00
Sprint	851-0227	AT&T 1-year text plan	1		$100.00		$100.00
							$336.00

Summary
This project proved to us that solar can be a viable alternative to permanent waterers on summer pasture. One must consider the number of animals to be watered, the site specific limitations that may limit pumping potential, and the potential recharge rate of the setup. The design of a mobile system must be carefully planned to allow appropriate leveling of the reservoir tanks and protection of the solar components. Maintenance must be performed weekly on the plumbing components of this solar system for optimal performance. It is our opinion that this and other similar systems are viable options for a limited number of producers. It is relatively expensive, but like any other tool, solar is not a fit for every situation. In the right situation - where grazing management can be greatly enhanced over a number of years, or where producers do not have an incentive to install a well and permanent waterers- this system would be well worth the money.

Appendix

Advanced Power Inc.

1520 East Eagle Road
Weatherford, OK 73096

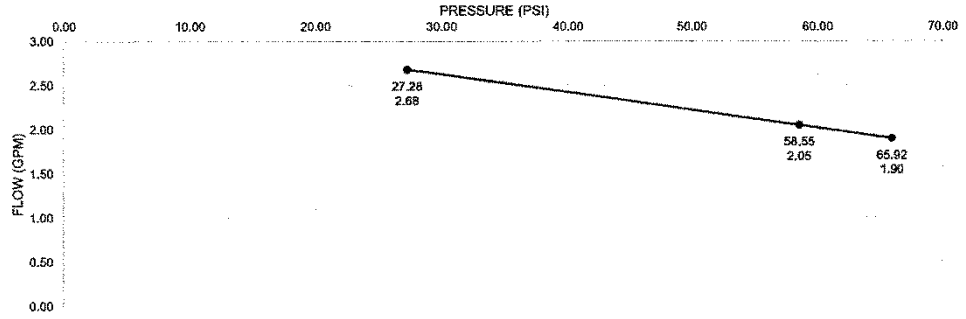
Phone: (580) 774-2220
Fax: (580) 774-1164
E-mail: service@solarpumps.com

Pump Test Data Sheet

34VDC RP4

Pump Serial # RP4 4151070

Relative Time	Date	Time Stamp Local	PSI	GPM	AMPS	Volt	Event Marker Comments	Chn 2 Events
0	4/16/2015	5:07:15 PM	65.92	1.90	4.17	-0.001220703		
10	4/16/2015	5:07 PM	58.55	2.05	3.94	-0.001220703		
20	4/16/2015	5:07:35 PM	27.28	2.68	2.87	-0.001220703		



Pump Flow/Pressure Chart at 34volts DC

ALC 1275

Water Sensor Manual

ALC 1275 sensor is designed for DC voltage only, **DO NOT** use with AC voltage.

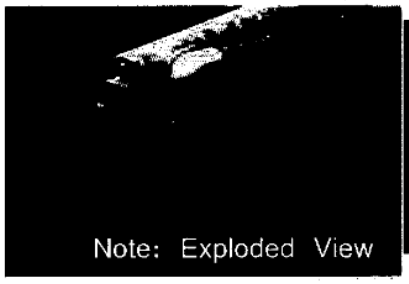
STEPS FOR INSTALLING:

1. Install the *ALC 1275* water sensor under the array to better protect the sensor from the weather. When the unit is used with *Advanced Power Inc. Kits*, the ALC simply plugs in to the existing wire harness using weather-pack connectors. Mount ALC on lower bottom corner of the panel.

2. Holes are provided on the mounts to secure the sensor, using two self-drilling screws provided. Grounding wire (blue eyelet) will need to be mounted between the hole and screw when mounting the *ALC 1275* controller. (See back page for illustration.)

3. Simply route the black water sensor wire to the tank and hang sensor wire with red ends over top tank edge to the desired water height. (For protection & if possible, it's better to route the sensor wires inside plastic conduit to the storage tank.)

Sensor ends seperated at water level desired.



Note: Exploded View

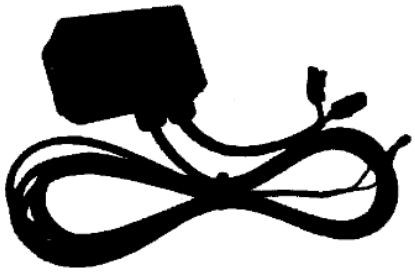
SPECIFICATIONS:

Minimum Volts DC.....11.5
Maximum Volts DC.....75
MAX Amp Load.....5
Sensor Wire Max Length...1500 ft.

- When extending the sensor wire use only direct burial, sunlight reistant 18-2 or smaller (18-24) guage wire. There is 20 feet of water sensor wire included but sensor wire may be extended up to 1500ft. max.

ALC sensor has an automatic start and stop feature, when tank water level rises and reaches the sensor ends for approximately 8 seconds, consistently the sensor will shut off power to the pump.

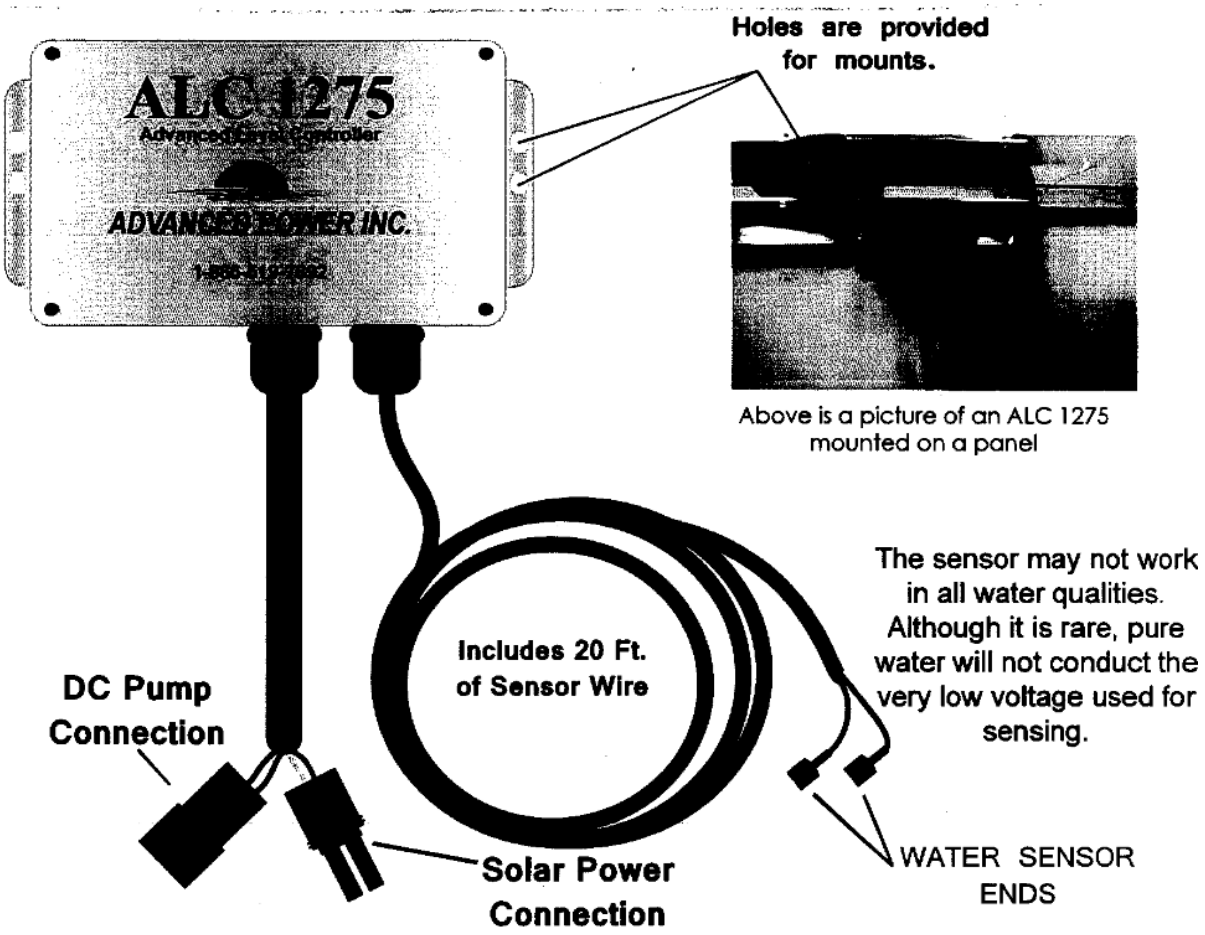
- The sensor will allow the pump to start again, when both sensor ends are not touching water for 8 seconds and water level recedes below them. Sensor ends may become corroded over time, simply clean or replace them. These connector ends are installed for 2 reasons: First, if "moss" develops in the storage tank the ends will protect against wicking of the water, giving a false water level. Secondly, these connector ends allow you to plug the two wires together for manual shut down. If desired, weather resistant ON and OFF switches may be installed in either power wire (These are available from API).



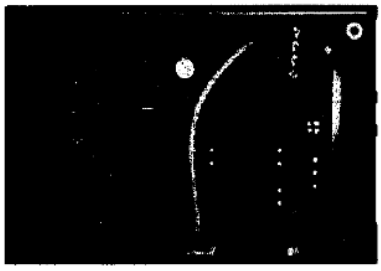
- The *ALC 1275* will disconnect the load from the power supply (solar, batteries, etc.) when the power drops below 11.5 VDC. It automatically reconnects when the power reaches 12 volts.

- The maximum voltage for this unit is 75 VDC.There is no voltage regulator in the *ALC 1275*, therefore ***voltage in excess of 75 VDC may damage the sensor.*** Five(5)amp Inline fuses are recommended(but not required) in the power side, either positive or negative will work. There are no switches or settings inside the *ALC 1275* to adjust, it is a preset/automatic device.

VIEW BACK FOR ILLUSTRATION



Troubleshooting:
If the unit will not turn on or off correctly, check the connections. Lid can be removed and terminal connections checked. Check for corrosion at the end of the sensor wire. These connectors must be reasonably clean and free of corrosion.
If highly corrosive conditions, stainless steel bolts or probes can be used.



Wire Codes:

Yellow	SOLAR+
	SOLAR-
	LOAD +
	LOAD-
G	NO POLARITY

If you are still experiencing difficulties with installing the unit or troubleshooting please contact our technician line and we will be happy to help you.

Shipping Address:
1520 E. Eagle Road
Weatherford, OK 73096

ADVANCED POWER
apiOk.com

Technical Assistance:
(Toll Free)1-877-519-7893
1-580-774-2220

WARRANTY REGISTRATION

We greatly appreciate your business and look forward to serving you in the future!
Online Registration is available at our website: ***www.solarpumps.com***

PERSONAL INFORMATION:

Name: Matt Booher
Address: 13 Govt Center Ln.
Verona, VA 24482
Phone: 540-245-5750 Cell: 540-416-5339
E-mail: mrbooher@vt.edu

COMPANY CERTIFICATION

PUMP INFORMATION:

Install date: 6/1/15
Model: 535474
Serial Number: 4151070
Float Switch: (Yes) / No (Circle one)
Pipeline: (Yes) / No If yes: 2000 ft./meter
Well Depth stream ft./meter
Water depth stream ft./meter
Total Module Watts: 250
Pressure Tank/Switch: Yes / No
Water Demand: 1260 Gal/Day
Wiring: Series / Parallel (Circle one) N/A

Sand Sock: (Yes) / No
Pipe Size: 1¼ inches
Well Diameter: stream inches
Batteries: Yes / (No)
Total Module Voltage: 32

This must be returned within 30 days of purchase date to receive the 5 year warranty. Please keep record of the ship date, shipper name, and tracking number for your own records.

Please return *Registration Sheet* AND a copy of the original receipt to:
Advanced Power Inc.
Box 1937
[illegible], OK 73096

www.solarpumps.com
1-866-519-[illegible]

This is a Positive Displacement PUMP.
RP2 & SR2 series are rated to 85 PSI.
RP4 & SR4 series are rated to 65 PSI.
It can be damaged if flow is restricted.
Install with NO flow restriction.

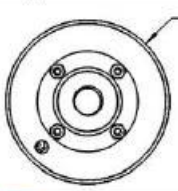
WARRANTY VOIDED IF: Disassembled, Modified or Exposed to Excessive Debris, Excessive Pressure, Restricted Flow, Lightening, High Voltage spikes or directly powered by AC Power Source.

For increased LIGHTNING Protection ground Aluminum frame of solar array to an 8 ft. minimum ground rod.

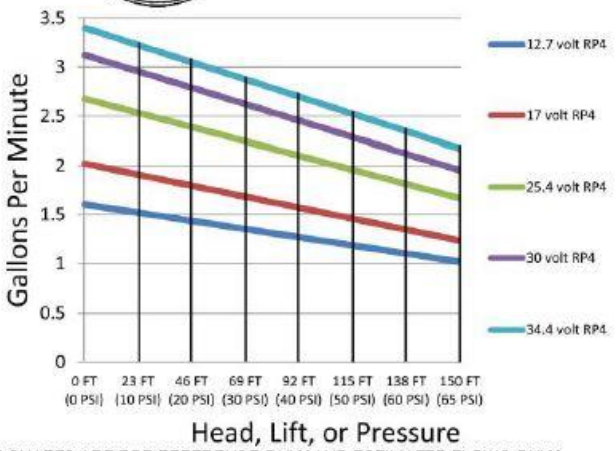
For exceptions please call **1-866-519-7892**

During normal operation, the pump may cycle on and off periodically.

RANCHPUMP4 SERIES SPECIFICATIONS



SHIPPING WEIGHT: 13LBS



THE CHARTS ARE FOR REFERENCE ONLY AND ESTIMATED FLOWS ONLY, THAT THERE ARE NO GUARANTEED FLOWS IMPLIED

RANCHPUMP4 COMES WITH 5 YEAR WARRANTY WITH REGISTRATION
- 3 YEAR WARRANTY FULL FACTORY
- ADDITIONAL 2 YEAR PRO-RATED

3.5 GALLONS PER MINUTE WITH NO HEAD PRESSURE

ALL PUMPS COME STANDARD WITH 100' OF 14-2 PUMP CABLE CONNECTED TO PUMP.
NO UNDER WATER SPLICE IS NEEDED.
AN ADDITIONAL 50 FEET OF WIRE MAY BE PURCHASED AND ADDED TO THE PUMP.

FEATURES:

- REQUIRES MINIMUM 5" WELL CASING
- 1/2" MALE NPT COUPLING REQUIRED
- MAXIMUM OPERATING PRESSURE: 65PSI (150FT OF VERTICAL LIFT)
- MAXIMUM DEPTH UNDER STATIC WATER LEVEL: 50FT
- MAXIMUM OPERATING TEMPERATURE IN WATER: 100°F
- CNC MANUFACTURED AND ENGINEERED FROM AIRCRAFT GRADE ALUMINUM
- ANODIZED FOR ABRASION AND CORROSION RESISTANCE
- 180W 1/5HP BRUSHLESS 12-40 VDC HEAVY DUTY MOTOR
- SENSORLESS FREQUENCY DRIVER
- LIMITED OVERVOLTAGE PROTECTION
- THERMAL PROTECTION
- REVERSE POLARITY PROTECTION
- POSITIVE DISPLACEMENT
- FACTORY REBUILDABLE
- TEMPORARY RUN DRY CAPABILITY
- PRESSURE RELIEF VALVE

ADVANCED POWER INC.
1520 E EAGLE RD
WEATHERFORD, OK 73096

TECH: 580.774.2220
TOLL FREE: 877.519.7893
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Summary table of common problems and actions taken.

Problem	**Action**
Pump floating into bank	tether from anchor placed farther into middle of river
Excessive algae growth	match number of animals to reservoir size to generate constant turnover
	disconnect one reservoir tank to promote faster turnover of water
	drain livestock tank periodically if use is slow
	chlorine
Slow recharge rate into stock tank	switch from restricted flow valve to full flow valve
Low pump output	clean pump filtration system weekly
Float valve not activating properly	switch from restricted flow valve to full flow valve
Animals pushing into equipment	utilize temporary electric fencing over back half of stock tank