

# *The Watter Buddy*®

HV

Owner's Manual

**Please Read Carefully**

Made in North America

By



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Congratulations on your purchase of a new *Watter Buddy*®.

May your RE adventures prove successful!

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Table of Contents

Introduction..... 3-4  
Site Evaluation..... 4  
Head Measurement ..... 5  
Flow Measurement..... 5-6  
*Watter Buddy Output in Watts Table*..... 7  
*Watter Buddy Head and Flow Rate Table* ..... 7  
Intake, Pipeline & Tailrace ..... 7-9  
Batteries, Inverters & Controllers ..... 9  
Wiring and Load Center..... 10  
High and Low Range, Measuring Output ..... 11  
High Voltage ..... 12  
Determining Nozzle Size ..... 12  
Bearing Replacement ..... 13  
Installation Examples..... 13  
*Copper Wire Resistance Chart* ..... 13  
*Pipe Friction Head Loss Charts* ..... 14-15

## INTRODUCTION

This manual describes **Watter Buddy**, which is manufactured by Energy Systems and Design Ltd. The installer must have some knowledge of plumbing and electrical systems, as should the end user of the system. These machines are small, but can generate very high voltages. Even 12-volt machines can produce high voltages under certain conditions. Practice all due safety. Electricity cannot be seen and can be lethal. Electrical systems must be installed in accordance with local laws by a qualified person.

It is important to consult with local officials before conducting any watercourse alteration. ES&D advises following all local laws and ordinances regarding watercourses.

Electricity is produced from the potential energy in water moving from a high point to a lower one. This distance is called "head" and is measured in units of distance (feet, meters) or in units of pressure (pounds per square inch, kilo-Pascals). "Flow" is measured in units of volume (gallons per minute - gpm, or liters per second - l/s), and is the second portion of the power equation. The power available is related to the head and the flow.

The Watter Buddy is designed to operate over a wide range of heads and flows. Nozzle diameters of 3 to 7mm are available, and up to four nozzles can be used on one machine, to utilize differing heads and flows.

This little machine generates DC power from a source such a stream running down a hillside. Some water is channeled into a pipeline that is long enough to build up sufficient pressure. It can also be used with water systems that are under pressure like the water in city supplies. The water then passes through a small nozzle where it gives up pressure for velocity. The water then passes through the turbine runner which converts the energy in the water into shaft power and spins the generator. In the generator there are magnets that move past coils of wire where the electricity is generated. This electric power is first alternating current (AC) that is converted into direct current (DC) with a device called a rectifier. The power then goes to the output terminals (binding posts) where it is available to charge batteries or use directly with suitable appliances.

The two binding posts are colored red for the positive (+) connection and black for the negative (-). If these are connected backwards to a battery, the rectifier will likely be destroyed. For this reason, all connections to a battery must have fuses or circuit breakers to prevent further damage (like a fire!!). The switch on the side of the cover changes the internal connections and gives the machine a high and low range. One position will give a higher output than the other. To measure current an ammeter can be spliced into either of the transmission lines to monitor how much power you are generating. Also, a digital multimeter with a millivolt scale can measure amps using the white jack and black terminal post. To measure volts, connect the meter to the red and black binding posts. There is a 12/24 volt (low voltage) version and a 48/120 volt (high voltage) version.

Brass nozzles are supplied with the machine in sizes from 3-7 mm. A range of sizes is provided so that you can match the flow rate (l/s or gpm) of your source. Higher head (pressure) sources can use smaller nozzles and pass the same flow as larger nozzles at a lower head. The brass fitting on the machine is made to have the nozzles on the inside end and the inlet pipe connection on the outer end. This fitting has 1/2" pipe threads on the outer end for use with threaded type plumbing, and a plastic adapter is supplied that fits 3/4" plastic pipe if you wish to use that. Access to the inner end of this fitting can be gained by threading the nozzle holder from the housing. The machines can be supplied with 1 to 4 nozzles installed in the housing.

Flexible lines work best to make the connection at the machine. One arrangement is to install a stop valve upstream of the flex line and then a pressure gauge upstream of that. This enables you to determine the pressure when there is no flow (static or gross head) and when the machine is operating and the stop valve is open (net or dynamic head). These readings can also tell you when there are problems with the water supply. A lower than usual pressure with the valve closed tells you that there is air in the pipeline and you are running out of water or the intake is clogged. If the pressure is lower than normal when the valve is open it indicates that the problem is upstream. If it is higher, the problem is downstream and is usually a clogged nozzle. Many water sources wash down leaves, twigs, grit and other things that conspire to keep you alert. The intake box of the pipeline should be constructed with a suitable size mesh to filter the water and prevent debris in the water line.

## **SITE EVALUATION**

Certain information must be determined concerning your site, in order to use its potential for maximum output. Head and flow must first be determined. Other factors are: pipeline length, transmission distance, and the system voltage. These factors determine how much power can be expected.

Power is generated at a constant rate by the Watter Buddy and can be stored in batteries as direct current (DC). Power is supplied, as needed, by the batteries, which store energy during periods of low consumption for use in periods where consumption exceeds the generation rate. Appliances can be used that operate directly from batteries, or 120 volt alternating current (AC) power can be supplied through an inverter, converting DC to AC power.

Sites may vary, so carefully consider flow and head when choosing yours. Remember, maximum head can be achieved by placing the Watter Buddy at as low an elevation as possible, but going too low may cause the machine to become submerged (or washed away!).

## HEAD MEASUREMENT

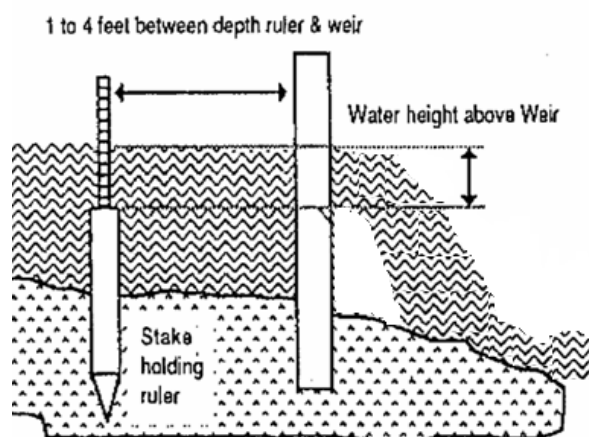
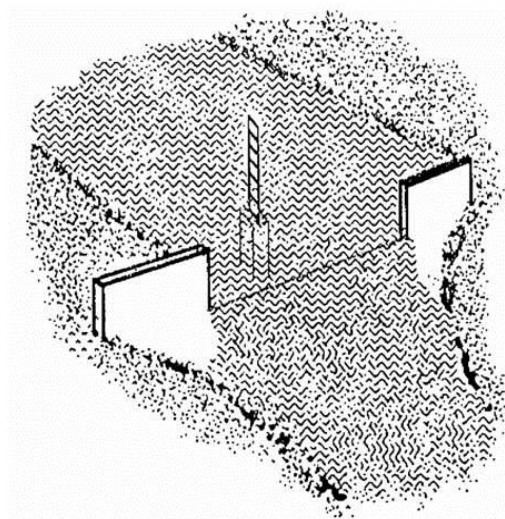
Head may be measured using various techniques. A garden hose or length of pipe can be submerged with one end upstream and the other end downstream. Anchor the upstream end with rocks or have an assistant hold it; water should flow out the low end, especially if the pipeline is pre-filled. Once water is flowing, raise the downstream end until it stops. Do this slowly since the water tends to oscillate. When the flow has stabilized, measure the distance down to the level of water in the stream with a tape measure. This will give a very accurate measurement of that stream section. Mark the spot and then repeat the procedure until the entire distance is covered.

Another technique is to use a surveyor's transit. This method can also be approximated using a carpenter's level along with a measuring stick or a "story pole." This technique is also done in a series of steps to arrive at the overall head. A variation on this method is the use of altimeters. GPS equipment could also be used to measure elevation.

## FLOW MEASUREMENT

The easiest method to measure small flows is to channel the water into a pipe using a temporary dam and to fill a container of known volume. Measuring the time to fill the container enables you to calculate the flow rate.

The weir method can also be used to measure flow.



<b>WEIR MEASUREMENT TABLE</b>								
Table shows water flow in gallons/minute (gpm) that will flow over a weir one inch wide and from 1/8 to 10-7/8 inches deep.								
Inches		1/8	1/4	3/8	1/2	5/8	3/4	7/8
0	0.0	0.1	0.4	0.7	1.0	1.4	1.9	2.4
1	3.0	3.5	4.1	4.8	5.5	6.1	6.9	7.6
2	8.5	9.2	10.1	10.9	11.8	12.7	13.6	14.6
3	15.5	16.5	17.5	18.6	19.5	20.6	21.7	22.8
4	23.9	25.1	26.2	27.4	28.5	29.7	31.0	32.2
5	33.4	34.7	36.0	37.3	38.5	39.9	41.2	42.6
6	43.9	45.3	46.8	48.2	49.5	51.0	52.4	53.9
7	55.4	56.8	58.3	59.9	61.4	63.0	64.6	66.0
8	67.7	69.3	70.8	72.5	74.1	75.8	77.4	79.1
9	80.8	82.4	84.2	85.9	87.6	89.3	91.0	92.8
10	94.5	96.3	98.1	99.9	101.7	103.6	105.4	107.3
<p>Example of how to use weir table:            Suppose depth of water above stake is 9 3/8 inches. Find 9 in the left-hand column and 3/8 in the top column. The value where they intersect is 85.9 gpm. That's only for a 1-inch weir, however. You multiply this value by the width of your weir in inches to obtain water flow.</p>								

The weir method is more versatile and may prove useful for higher flows. This technique uses a rectangular opening cut in a board or piece of sheet metal set into the brook like a dam. The water is channeled into the weir and the depth is measured from the top of a stake that is level with the edge of the weir and several feet upstream. Looking at the chart will enable you to convert the width and depth of flowing water into gallons per minute.

Measuring the flow at different times of the year helps you estimate maximum and minimum usable flows. If the water source is seasonally limited, you may have to depend on some other source of power during dry times (solar, wind). Keep in mind that a reasonable amount of water must be left in the stream (Don't take it all, that water supports life forms).

When head and flow are determined, the expected power output can be determined from the output chart. Keep in mind that chart values represent *generated* output and that actual power delivered to the batteries will be reduced by transmission lines, power converters, and other equipment required by the system. All systems should be carefully planned to maximize power output.

## Watter Buddy® Nozzle Size Chart with Power Output in Watts

Nozzle number and nozzle size in mm 48 and 120 volt														
	(1) 3mm	(1) 3mm	(1) 4mm	(1) 4mm	(1) 5mm	(1) 5mm	(2) 5mm	(2) 5mm	(1) 6mm	(1) 6mm	(1) 7mm	(1) 7mm	(2) 7mm	(2) 7mm
PSI	48v	120v	48v	120v	48v	120v	48v	120v	48v	120v	48v	120v	48v	120v
10							4		2					16
20					8		25		18		26		68	36
30			9		24	10	62	12	40	21	56	12	124	88
40			18	11	40	30	89	74	63	48	85	73	200	205
50			33	23	59	59	157	161	104	88	141	155	306	324
60			49	35	89	94	205	232	147	144	200	212	418	444
70			58	61	120	139	264	296	190	216	250	285	503	
80		12	80	85	150	167	327		237	267	306	350	614	
90		22	100	121	182	207	390		273	324	360	428		
100			121		213		451		323		420			

1 psi is equal to 2.3 feet of head (0.7 meter)

**Not recommended for continuous operation**

## Watter Buddy® Nozzle Flow Chart with Head and PSI

Head (feet)	Head (meter)	PSI	WATTER BUDDY® Nozzle Size (inch and mm) and Flow ( usgpm and l/s) Energy Systems and Design Ltd.									
			0.118"	3mm	0.157"	4mm	0.197"	5mm	0.236"	6mm	0.276"	7mm
			usgpm	l/s	usgpm	l/s	usgpm	l/s	usgpm	l/s	usgpm	l/s
23.1	7.04	10	1.30	0.08	2.31	0.15	3.61	0.23	5.20	0.33	7.07	0.45
46.2	14.1	20	1.83	0.12	3.25	0.21	5.08	0.32	7.32	0.46	9.96	0.63
69.3	21.1	30	2.25	0.14	4.00	0.25	6.26	0.40	9.00	0.57	12.3	0.78
92.4	28.2	40	2.60	0.16	4.63	0.29	7.23	0.46	10.4	0.66	14.2	0.90
115	35.1	50	2.90	0.18	5.15	0.33	8.05	0.51	11.6	0.73	15.8	1.00
139	42.4	60	3.18	0.20	5.65	0.36	8.84	0.56	12.7	0.80	17.3	1.10
162	49.4	70	3.43	0.22	6.10	0.39	9.54	0.60	13.7	0.86	18.7	1.20
185	56.4	80	3.67	0.23	6.53	0.41	10.2	0.64	14.7	0.93	20.0	1.30
208	63.4	90	3.90	0.25	6.92	0.44	10.8	0.68	15.6	1.00	21.2	1.34

Note: This chart is for one nozzle. More than one nozzle can be used to accommodate greater water flow.

### INTAKE, PIPELINE, AND TAILRACE

Most hydro systems require a pipeline. Even systems operating directly from a dam require at least a short plumbing run. It is important to use the correct type and size of pipe to minimize restrictions in the flow to the nozzle(s). When possible, pipelines should be buried; this stabilizes the line and prevents animals from chewing it.

At the inlet of the pipe, a filter should be installed. A screened box can be used with the pipe entering one side, or add a section of pipe drilled full of holes wrapped with screen or small holes and used without screen. Make sure that the filter openings are smaller than the smallest nozzle used.

The intake must be above the streambed so as not to suck in silt and should be deep enough so as not to suck in air. The intake structure should be placed to one side of the main flow of the stream so that the force of the flowing water and its debris bypasses it. Routinely clean the intake of any leaves or other debris.

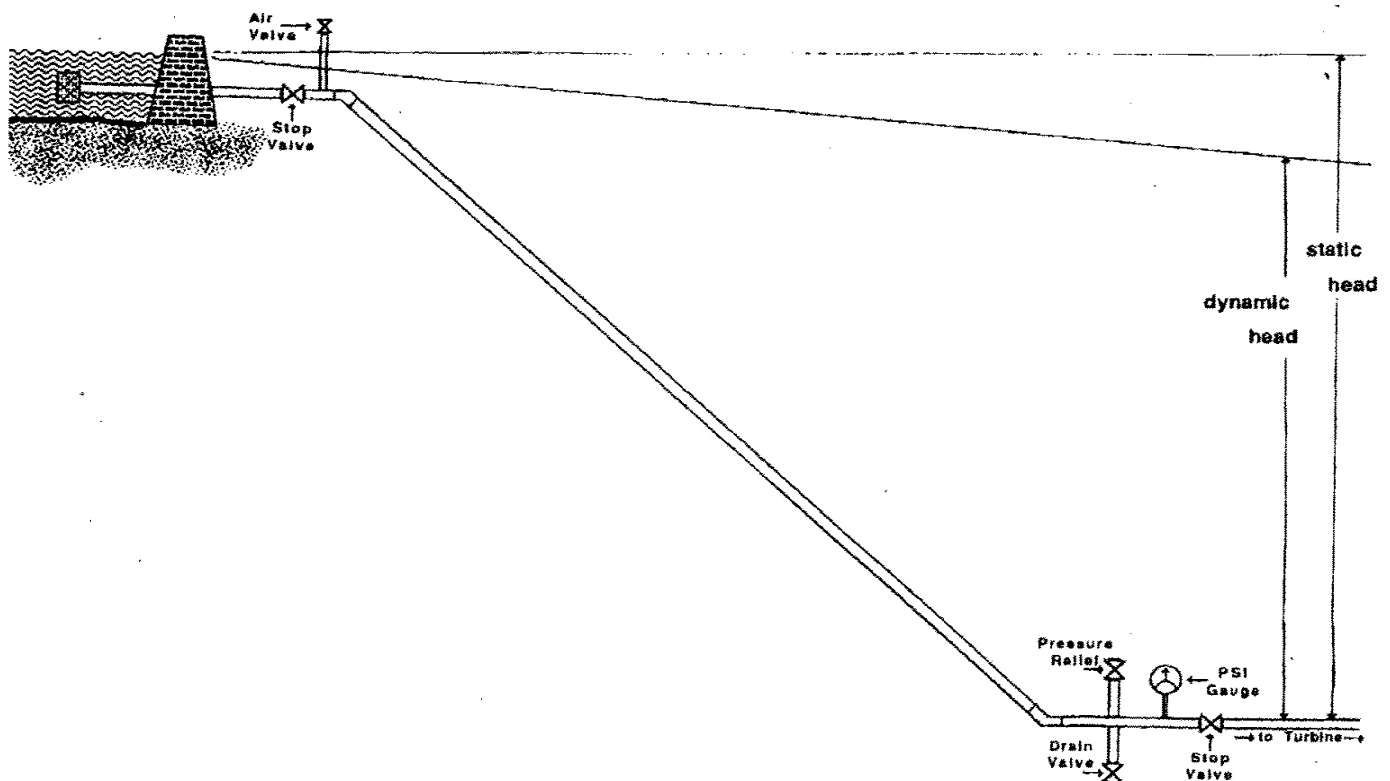
If the whole pipeline doesn't run continuously downhill, at least the first section should, so the water can begin flowing. A bypass valve may be necessary. This should be installed at a low point in the pipe.

For pipelines running over dams, or in conditions that create a siphon, the downstream side may be filled by hand. Once filled, the stop valve at the turbine can be opened to start the flow. If full pressure is not developed, or air builds up in the line, a hand-powered vacuum pump can be used to remove air trapped at the high point.

At the turbine end of the pipeline a bypass valve may be necessary to allow water to run through the pipe without affecting the turbine, purging the line of air or increasing flow to prevent freezing.

A stop valve should be installed upstream of the nozzle. A pressure gauge should be installed upstream of the stop valve so both the static head (no water flowing) and the dynamic head (water flowing) can be read.

The stop valve on a pipeline should always be closed slowly to prevent water hammer (the column of water in the pipe coming to an abrupt stop). This can easily destroy your pipeline and for this reason, you may wish to install a pressure relief valve just upstream of the stop valve. This can also occur if debris clogs the nozzle. In a single nozzle machine a nozzle that becomes clogged suddenly may create water hammer. The use of flexible pipe makes it easier to remove the plumbing from the nozzles.





The turbine housing can be mounted on two boards to suspend it above the stream. It is recommended to have the Watter Buddy in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment. Mounting the machine in concrete is also possible (you may wish to try a temporary wood mounting first). The opening under the housing to catch the water should be at least the size of the turbine housing opening, and preferably a little larger. Make certain the tailrace (exit channel) provides enough flow for the exiting water. The diameter of the bolt holes is ¼” (6mm). In cold climates, it may be necessary to build a "trap" into the exit. This prevents outside air from entering the housing and causing freeze-ups.

## **BATTERIES, INVERTERS & CONTROLLERS**

### System Voltage

A small system with a short transmission distance can be designed to operate at 12 volts. Larger systems can also be 12 volts, but if higher power is desired or the transmission distance is long, then a system of 24 volts or higher may be preferable. This is especially true if all loads are inverter-powered. In a 12-volt system operating at a low power level, it may be advantageous to operate all loads directly from batteries. Many 12-volt appliances and small inverters are available. In 24-volt systems, it may also be preferable to operate the loads directly (although not as many appliances are available).

In higher power systems, it is usually better to use an inverter to convert battery voltage to regular 120 volt AC power at 60Hz (cycles per second), or 240 volt 50Hz in some countries. This has been made feasible with the advent of reliable high power inverters. Thousands of home power systems are in operation with only AC loads.

### Sizing Battery Bank

A typical hydro system should have about one or two days of battery storage capacity. This will generally keep lead-acid cells operating in the middle of their charge range where they are the most efficient and long-lived.

Batteries should be located outside of any living space, or adequate ventilation should be provided, as a rising charge level tends to produce both hydrogen gas and corrosive fumes. Also, distilled water should be added as needed to maintain the electrolyte level.

### Charge Control

Unlike solar systems, a hydro system must always be connected to a load even when the batteries are fully charged. If the output power does not have a load, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power like water or space heating.

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the excess power be diverted to the dump load. Most charge controllers permit different charge levels such as bulk, absorption, and float. Literature supplied with the controller should be consulted to determine the set points of the charge controller. Also, be sure to set the charge controller to diversion mode for micro hydro, and to have an appropriately sized diversion load. The diversion load must be larger than the output of the machine to prevent battery overcharge.

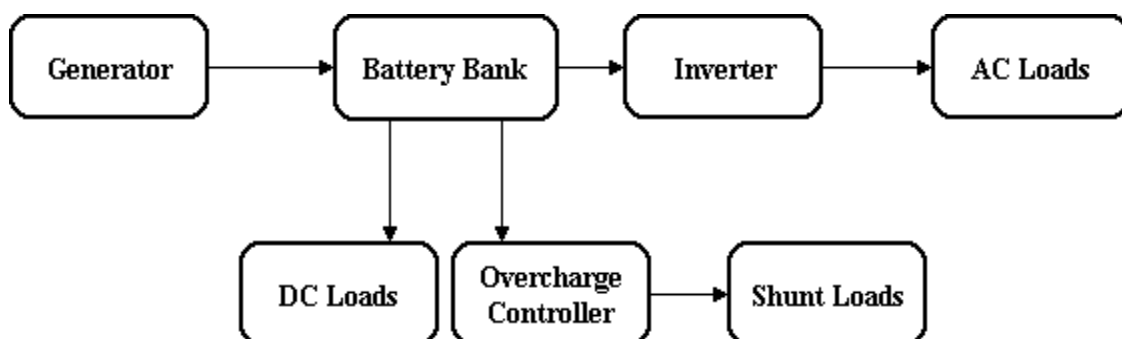
Watt-Hour meters are available that monitor the battery state of charge.

An ammeter that monitors turbine output should always be installed in a high traffic or living space so difficulties with the machine can be easily detected. If a drop in output is noticed, the machine should be inspected. This could be caused by air in the pipeline, or a blocked or partially blocked nozzle. More importantly, a drop in output could be the beginning of bearing failure. Bearing failure will cause serious damage to the machine. Early detection of problems with the bearings is vital.

### **WIRING AND LOAD CENTER**

Every system requires wiring to connect the various components. Load centers are available as a complete package that easily facilitates the connection of loads and power source(s). All circuits in the system should use wire of adequate size and have fuses or breakers of sufficient capacity to carry the expected load current. The Watter Buddy must be fused in a battery system since it can suffer from a short or similar fault just like anything else in the system.

### **Diagram of a typical battery-based system:**



When the machine is fully installed and running, it can be adjusted for high or low range. One position will give more power than the other. Try them both to see which works best for your conditions.



## Measuring Output

A digital multi meter can be used to measure current and voltage. A digital multimeter with a millivolt scale can measure amps using the white jack and black terminal post. To measure volts, connect the meter to the red and black binding posts. The power output in watts is determined by multiplying amps (current) times volts.



This machine can be used to generate higher voltages that are used to send the power long distances. Then either maximum power point trackers (MPPT's) or solid state battery chargers can be used to convert the power to battery voltage. It may also work to use an MPPT with the low voltage machine to convert to battery voltage.

### **DETERMINING NOZZLE SIZE**

Optimum nozzle size depends on the head and flow. Trying different nozzles can help determine the best size and number to use. When using two or more nozzles they do not have to be the same diameter.

The Watter Buddy is supplied with nozzles with a 1/2" female pipe thread and an adaptor that fits 3/4" hose. The plumbing should be sized to minimize restrictions that will result in reduced power output.



## BEARING REPLACEMENT

The Watter Buddy has two #6203 ball bearings that can be replaced. If any bearing noise or wobble is noticed they should be replaced. A power loss could also indicate a bearing change is needed. The bearings are pressed onto the shaft. A puller is needed to take the bearings off and a press is needed to put the new bearings onto the shaft.

## INSTALLATION EXAMPLE

**Watter Buddy on testing set up. Note flexible line and pressure gauge.**



### Copper Wire Resistance Chart

Wire Gauge	Diameter Inches	Ohms per 1000'	Ohms per Mile
0000	0.460	0.05	0.26
000	0.410	0.06	0.33
00	0.364	0.08	0.42
0	0.324	0.10	0.52
2	0.258	0.16	0.84
4	0.204	0.25	1.34
6	0.162	0.40	2.13
8	0.128	0.64	3.38
10	0.102	1.02	5.38
12	0.081	1.62	8.56
14	0.064	2.58	13.6
16	0.051	4.10	21.6
18	0.040	6.52	34.4

**PIPE FRICTION LOSS - PVC Class 160 PSI Plastic Pipe**

Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches					
	1	1.25	1.5	2	2.5	3
1	0.05	0.02				
2	0.14	0.05	0.02			
3	0.32	0.09	0.04			
4	0.53	0.16	0.09	0.02		
5	0.80	0.25	0.12	0.04		
6	1.13	0.35	0.18	0.07	0.02	
7	1.52	0.46	0.23	0.08	0.02	
8	1.93	0.58	0.30	0.10	0.04	
9	2.42	0.71	0.37	0.12	0.05	
10	2.92	0.87	0.46	0.16	0.07	0.02
11	3.50	1.04	0.53	0.18	0.07	0.02
12	4.09	1.22	0.64	0.20	0.09	0.02
14	5.45	1.63	0.85	0.28	0.12	0.04
16	7.00	2.09	1.08	0.37	0.14	0.04
18	8.69	2.60	1.33	0.46	0.18	0.07
20	10.6	3.15	1.63	0.55	0.21	0.09
22	12.6	3.77	1.96	0.67	0.25	0.10
24	14.8	4.42	2.32	0.78	0.30	0.12
26	17.2	5.13	2.65	0.90	0.35	0.14
28	19.7	5.89	3.04	1.04	0.41	0.16
30	22.4	6.70	3.45	1.17	0.43	0.18
35		8.90	4.64	1.56	0.62	0.23
40		11.4	5.89	1.98	0.78	0.30
45		14.2	7.34	2.48	0.97	0.37
50		17.2	8.92	3.01	1.20	0.46
55		20.5	10.6	3.59	1.43	0.55
60		24.1	12.5	4.21	1.66	0.64
70			16.6	5.61	2.21	0.85
80			21.3	7.18	2.83	1.08
90				8.92	3.52	1.36
100				10.9	4.28	1.66
150				23.2	9.06	3.50
200					15.5	5.96
250					23.4	9.05
300						12.6
350						16.8
400						21.5
450						
500						
550						
600						
650						
700						
750						
800						
850						
900						
950						
1000						

**PIPE FRICTION LOSS Polyethylene SDR - Pressure Rated Pipe**  
 Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches							
	0.5	0.75	1	1.25	1.5	2	2.5	3
1	1.13	0.28	0.09	0.02				
2	4.05	1.04	0.32	0.09	0.04			
3	8.60	2.19	0.67	0.19	0.09	0.02		
4	14.6	3.73	1.15	0.30	0.14	0.05		
5	22.1	5.61	1.75	0.46	0.21	0.07		
6	31.0	7.89	2.44	0.65	0.30	0.09	0.05	
7	41.2	10.5	3.24	0.85	0.42	0.12	0.06	
8	53.1	13.4	4.14	1.08	0.51	0.16	0.07	
9		16.7	5.15	1.36	0.65	0.18	0.08	
10		20.3	6.28	1.66	0.78	0.23	0.09	0.02
12		28.5	8.79	2.32	1.11	0.32	0.14	0.05
14		37.9	11.7	3.10	1.45	0.44	0.18	0.07
16			15.0	3.93	1.87	0.55	0.23	0.08
18			18.6	4.90	2.32	0.69	0.30	0.09
20			22.6	5.96	2.81	0.83	0.35	0.12
22			27.0	7.11	3.36	1.00	0.42	0.14
24			31.7	8.35	3.96	1.17	0.49	0.16
26			36.8	9.68	4.58	1.36	0.58	0.21
28				11.1	5.25	1.56	0.67	0.23
30				12.6	5.96	1.77	0.74	0.25
35				16.8	7.94	2.35	1.00	0.35
40				21.5	10.2	3.02	1.27	0.44
45				26.8	12.7	3.75	1.59	0.55
50				32.5	15.4	4.55	1.91	0.67
55					18.3	5.43	1.96	0.81
60					21.5	6.40	2.70	0.94
65					23.8	7.41	3.13	1.08
70					28.7	8.49	3.59	1.24
75					32.6	9.67	4.07	1.40
80						10.9	4.58	1.59
85						12.2	5.13	1.77
90						13.5	5.71	1.98
95						15.0	6.31	2.19
100						16.5	6.92	2.42
150						34.5	14.7	5.11
200							25.0	8.70

## GUARANTEE

This machine is guaranteed to change your life.

### *The fine print:*

This ES & D water powered generator is warranted against defects in workmanship and materials. The period that this covers is 90 days, starting at the date of shipment to the customer.

In the event that an ES & D machine is found to have defects in material or workmanship, the remedies of repair or replacement of parts shall in each case be at the reasonable discretion of ES & D. Machines that the purchaser claims are defective must be returned at the purchaser's cost.

ES & D will not be responsible for problems caused by improper maintenance, faulty installation, unauthorized modifications or additions, abuse, or any other cause not due to defects in the machine.

ES & D will not be held liable for consequential damages or interruption of service to the buyer. The buyer, furthermore, by acceptance of the equipment assumes all responsibility for the consequences of its use.

After one year from the shipping date, all liability terminates and no action for any breach of any such warranty may be commenced.



# Personal Hydropower

## Product Information

Model # \_\_\_\_\_ Serial # \_\_\_\_\_

Date Purchased \_\_\_\_\_

Purchased From \_\_\_\_\_

Name: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_

State/Prov: \_\_\_\_\_ Zip/Postal Code: \_\_\_\_\_

Telephone: \_\_\_\_\_

Email: \_\_\_\_\_

Comments: \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_



Made in Canada

By

**Energy Systems and Design Ltd.**

**PO Box 4557**

**Sussex NB**

**Canada E4E 5L7**

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