

STATE OF IDAHO
DEPARTMENT OF WATER RESOURCES
BENEFICIAL USE FIELD REPORT

A. GENERAL INFORMATION

Permit No: 96-9438
Exam Date: 5/23/2013

1. Current Owner: JAMES W AKERS
5046 EUREKA RD
SAGLE ID 83860-8839
(208)304-1087
2. Accompanied by: James W. Akers
Phone No: Same as Above
Address: Same as Above
Relationship to Permit Holder: Owner

3. **SOURCE**

UNNAMED STREAM

TRIBUTARY

LAKE PEND OREILLE

B. OVERLAP REVIEW

1. Other water rights with the same place of use: None
2. Other water rights with the same point of diversion: None

C. DIVERSION AND DELIVERY SYSTEM1. **LOCATION OF POINT(S) OF DIVERSION:**

UNNAMED STREAM NE1/4NE1/4 Sec. 34, Twp 57N, Rge 01W, B.M. BONNER County

Method of Determination: Visual Inspection and GPS

2.

PLACE OF USE: POWER STORAGE AND POWER FROM STORAGE

Twp	Rge	Sec	NE				NW				SW				SE				Totals
57N	01W	34	<u>NE</u>	<u>NW</u>	<u>SW</u>	<u>SE</u>	<u>NE</u>	<u>NW</u>	<u>SW</u>	<u>SE</u>	<u>NE</u>	<u>NW</u>	<u>SW</u>	<u>SE</u>	<u>NE</u>	<u>NW</u>	<u>SW</u>	<u>SE</u>	
			X																

Method of Determination: GIS, GPS and Visual Inspection

3. YES Delivery System Diagram Attached (required). Indicate all major components and distances between components. Indicate weir size/pipe as applicable.
YES Aerial Photo Attached (required for irrigation of 10+ acres).
YES Photo of Diversion and System Attached

4.

Well or Diversion Identification No.*	Motor Make	Hp	Motor Serial No.	Pump Make	Pump Serial No. or Discharge Size
Dam	N/A	N/A	N/A	N/A	1 inch

*Code to correspond with No. on map and aerial photo

D. FLOW MEASUREMENTS

1.

Measurement Equipment	Type	Make	Model No.	Serial No.	Size	Calib. Date
NONE						

2. Measurements: The piping was too small to put a measurement device on the piping. We used the standard nozzle size verses pressure test to determine the flow rate much like a sprinkler test.

E. FLOW CALCULATIONS X Additional Computation Sheets Attached

Measured Method

No diversion rate is required for a storage and diversion from storage water use. However, we did use the diversion from storage diversion rate to calculate the total volume use for this permit. The diversion from storage was 23 to 30 gpm.

F. VOLUME CALCULATIONS**1. Volume Calculations for Irrigation:**

$$V_{I.R.} = (\text{Acres Irrigated}) \times (\text{Irrigation Requirement}) = \underline{\hspace{2cm}}$$

$$V_{D.R.} = [\text{Diversion Rate (cfs)}] \times (\text{Days in Irrigation season}) \times 1.9835 = \underline{\hspace{2cm}}$$

$$V = \text{Smaller of } V_{I.R.} \text{ and } V_{D.R.} = \underline{\hspace{2cm}}$$

2. Volume Calculations for Other Uses:

See Pond Spreadsheet. The pond capacity is 1.2 acre feet. The system can use between 9.6 to 15.9 acre feet. The seepage and evaporation is estimated at 25.7 acre feet. The seepage and evaporation are skewed, since they calculate values for the entire year instead of the 120 days that water is in the pond.

The permit limits this water right to storage of volume of 8.6 acre feet which is less than the 1.2 capacity plus 25.7 acre feet evaporation and seepage calculation. The permit limits the from storage use to 5 acre feet, which is less than 9.6 to 15.9 acre feet of maximum use calculation.

Therefore, I am recommending this permit for the full amount permitted of 8.6 acre feet of storage and 5 acre feet from storage.

G. NARRATIVE/REMARKS/COMMENTS

The water is diverted from the pond through a 1 inch black plastic pipeline approximately 800 feet downhill to the Water Baby turbine/generator. The power generated at the turbine is transported through a power line back uphill to the home. The home is powered by both solar panels and the hydropower plant. The hydropower plant does not provide a water use for year round use, and can only be used for a maximum of 120 days. The power is stored in 24 – 2 volt batteries. This is a 48 volt system. At the time of the field exam, the system was operating at 238 watts.

Please see attached memo for additional information on the power calculations and the system design.

There are two other water rights that overlap the place of use for this permit, but both of those water rights are for different owners and different water sources. There is no significant overlapping water rights.

I changed and added conditions per the suggest conditions function in Workflow per recommendation from staff familiar with hydropower rights. I also used the full 25 year life of the equipment in condition 258. The owner takes very good care of this system, and it is in very good working order. The date was calculated from the date the permit was filed plus 25 years. I adjusted the ending date to the end of the year or December 31, 2034.

Have conditions of permit approval been met? ☒ Yes ☐ No

H. RECOMMENDATIONS**1. Recommended Amounts**

<u>BENEFICIAL USE</u>	<u>PERIOD OF USE</u>	<u>DIVERSION RATE</u>	<u>ANNUAL VOLUME</u>
POWER STORAGE	01/01 to 12/31		8.60 AF
POWER FROM STORAGE	01/01 to 12/31		5.00 AF
<u>Totals:</u>			8.60 AF

2. Recommended Amendments

☐ Change P.D. as reflected above ☐ Add P.D. as reflected above ☐ None

☐ Change P.U. as reflected above ☐ Add P.U. as reflected above ☐ Other

I. AUTHENTICATION Daniel A. Nelson – Staff Hydrologist

Field Examiner's Name Daniel A. Nelson Date 12-19-2013

Reviewer _____ Date _____

State of Idaho
Department of Water Resources

Field Exam

96-9438

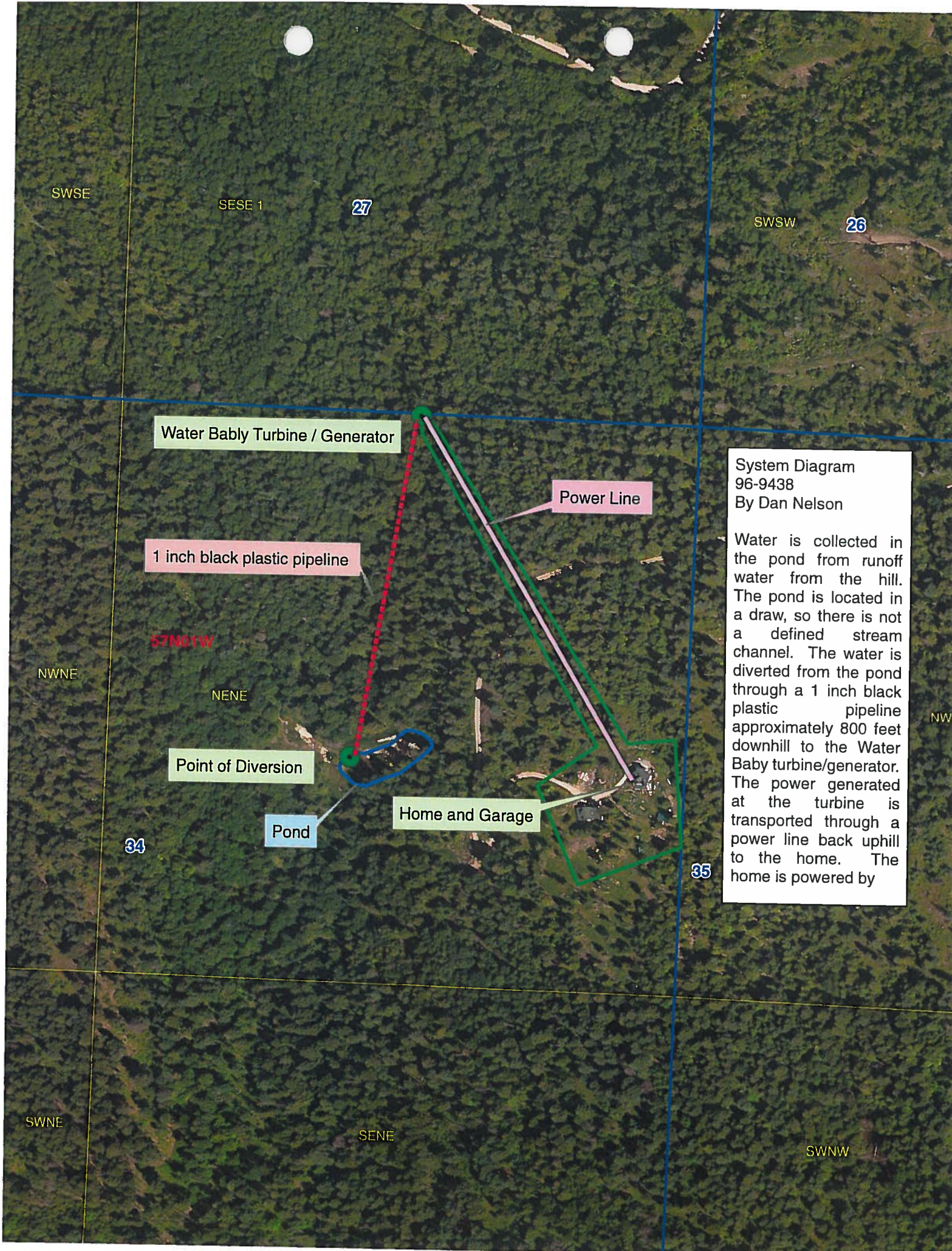
This map depicts the POWER STORAGE and POWER FROM STORAGE place of use boundary for this water right at the time of this approval and is attached to the approval document solely for illustrative purposes.



-  Point of Diversion
-  Place Of Use Boundary
-  Townships
-  PLS Sections
-  Quarter Quarters

0 0.0425 0.085 0.17 Miles





Water Baby Turbine / Generator

1 inch black plastic pipeline

Point of Diversion

Pond

Home and Garage

Power Line

System Diagram
96-9438
By Dan Nelson

Water is collected in the pond from runoff water from the hill. The pond is located in a draw, so there is not a defined stream channel. The water is diverted from the pond through a 1 inch black plastic pipeline approximately 800 feet downhill to the Water Baby turbine/generator. The power generated at the turbine is transported through a power line back uphill to the home. The home is powered by

Flow Rate Calculation Sheet

Permit 96-9438

I performed the field exam for water right 96-9438 on a small hydropower plant. The small hydropower generator was a "Water Baby" turbine by Energy Systems and Design, Inc. During my field exam, I measured the water pressure at the turbine at 60 psi. The owner stated that the pressure generally ran at about 70 psi. We discovered that there was a leak in the pipe delivering water to the generator, so it is reasonable that system operates between 60 and 70 psi.

The system can use 1 to 4 nozzles, but this system was operating with only two nozzles. You can see the two lines going into the hydropower unit in the field exam photos. The nozzles the owner used were 7/32 to 1/4 inch nozzles. The Water Baby Owner's Manual has a nozzle rating chart on page 13 that lists the flow rate for 7/32 nozzle at 65 psi as 11.5 gpm and the 1/4 inch nozzle at 65 psi as 15 gpm. The Water Baby Owner's Manual chart goes from 52 psi to 65 psi to 86.6 psi, so 65 psi is the only pressure that can be used.

The owner of the system operates the system pretty much non-stop for 4 months or 120 days. The stream supplying water to the pond and the hydropower plant is a runoff stream, that only runs a short time in the spring and the late fall.

The annual volume should be calculated as follows:

$$11.5 \text{ gpm} \times 2 \text{ nozzles} \times 1440 \text{ min./day} \times 120 \text{ days} / 325850 = 9.6 \text{ acre feet}$$

$$15 \text{ gpm} \times 2 \text{ nozzles} \times 1440 \text{ min./day} \times 120 \text{ days} / 325850 = 15.9 \text{ acre feet}$$

Using the above calculations, this system uses between 9.6 to 15.9 acre feet of water under ideal conditions. Unfortunately, this system doesn't operate at ideal conditions very often. The permit requests 5.0 acre feet of water from storage, so that is the total amount we can allow to be diverted from the pond.

In order to double check the values shown above, I referenced a chart on Page 12 of the Owner's Manual, that states that at 100 feet of head and 24.6 gpm using 2 of the 1/4 inch nozzles that this system should be producing approximately 215 watts. The system was operating at 238 watts when I was on site at 60 psi or 138.6 feet of head using 2 – 7/32 nozzles. The system was using slightly smaller nozzles with more head and producing slightly more power, so I feel this system is operating within the standards set in the Operator's Manual. Therefore, the diversion rates and volumes calculated above do seem reasonable.

All of the water for this plant comes from the pond. The pond can store 1.2 acre feet of water, so the pond is emptied and filled multiple times during the operation of the hydropower plant. The additional water needed for storage is calculated below:

5 acre feet total allowable hydropower use from storage – 1.2 af pond capacity = 3.8 acre feet available for multiple fills of the pond.

The power from storage is limited to 5 acre feet, but the power storage can include evaporation and seepage losses. The attached spread sheet shows that evaporation and seepage losses can be up to 22.2 acre feet. This is an on-stream pond, but the stream is an intermittent stream, so the seepage could be very high. I recommend that the full 8.6 acre feet be recommended for the power storage component.

IN CONCLUSION:

I found that owner is using the full amount of the permit if not a bit more. Therefore I am making the following recommendations:

Power Storage = 8.6 acre feet

Power From Storage = 5 acre feet.

We cannot change the water right as listed. It does appear as though the system was designed to use up to 15.9 acre feet of water, however, that was not what was applied for in the water right application. Using the above information, we can calculate the number of days the system can operate with 5 acre feet of water allowed by the permit using the following formulas:

Using the 7/32 Nozzles =

$$(5 \text{ acre feet} \times 325,850) / (11.5 \text{ gpm} \times 2 \text{ nozzles} \times 1440 \text{ min./day}) = \textbf{49 days of use}$$

Using the 1/4 Nozzles =

$$(5 \text{ acre feet} \times 325,850) / (15 \text{ gpm} \times 2 \text{ nozzles} \times 1440 \text{ min./day}) = \textbf{38 days of use}$$

Therefore, if the owner wishes to operate this system for more than 49 days using the 7/32 nozzles or 38 days using the 1/4 inch nozzles, they will need to file another water right application for the additional water use needs.

TOTAL STORAGE

FILE NUMBER	96-9438
REVIEWER	Dan Nelson
DATE	11/26/2013

This spreadsheet has been designed by Idaho Department of Water Resources to estimate the total seepage, evaporation and fill capacity required for a pond

Surface Area (In Acres)	0.3	"Surface Area" is automatically carried over from the "Seepage Loss Sheet"
Average Pond Depth (In feet)	4	"Average Pond Depth" depicts the actual depth of the pond either measured or estimated. Note: If you know the maximum depth and not the average depth, the field examiner's handbook suggest multiplying the maximum depth by 0.4 to get the average depth, or you can use any method that
Pond Capacity (In acre feet)	1.2	Pond Capacity is calculated by multiplying the Pond Surface Area by the Average Pond Depth. If you know the capacity, divide the capacity by surface area and enter the average pond depth in the

Volume Needed Above Initial Fill to Fulfill From Storage Needs- "Multiple Fills" (in acre feet)	3.8	The "Volume Needed Above Initial Fill" is the acre-feet of water required to meet a <i>from storage</i> component if the <i>from storage</i> component exceeds a one time fill. This section should not include the amount of water needed to fill the pond initially or the amount of water needed to maintain the pond level due to evaporation or seepage. For example: If a pond has a capacity of 5 acre feet and 2.5 acre feet of seepage and evaporation, but the pond is used for irrigation that requires 10 acre feet of from storage for the irrigation use, then you would insert 5 acre feet into this location (10 acre feet needed - 5 acre feet from the initial fill = 5 acre feet of additional storage needed). PLEASE NOTE: You must have a "From Storage" component exceeding the initial fill on the permit to include a volume in this space.
Estimated Seepage Loss (in acre feet)	21.90	The "Estimated Seepage Loss" is automatically carried over from the Seepage Loss Sheet
Estimated Evaporation Loss (in acre feet)	0.33	The "Estimated Evaporation Loss" is automatically carried over from the Evaporation Loss Sheet
Total Volume Required (in acre feet)	27.2	"The Total Volume Required" is calculated by adding the Pond Capacity, Multiple Fills, Seepage Loss, and Evaporation Loss amounts to determine the total amount of storage required.

Flow Rate Into Pond (In cfs)	1.00	The "Flow Rate" into the Pond depicts the actual flow either measured or estimated into the pond.
Highest Daily Evaporation Rate From Evaporation Tab. (In mm/day)	3.34	This number is automatically selected by picking the highest recorded number in the "Precipitation Deficit Table".
Maximum Required Daily Maintenance Volume (in acre feet per day)	0.06	"Maximum Required Daily Maintenance Volume" is the maximum volume of water needed on any given day during the year, and is calculated by adding the highest daily evaporation loss to the average daily seepage loss in acre feet. The average daily seepage loss is calculated by dividing the "Estimated Seepage Loss" by 365 days. This is acceptable, since the seepage rate shouldn't vary throughout the season unless the pond completely freezes over during the winter months. The highest daily evaporation loss is calculated by dividing the Highest Daily Evaporation Rate by the 304.8 conversion factor and multiplying this number by the pond surface area to attain a combined daily acre feet requirement.
Minimum Maintenance Flow (In cfs)	0.03	The "Minimum Maintenance Flow" is the minimum amount of flow required to maintain the level of the pond. This number is determined by dividing the "Maximum Required Daily Maintenance Volume" by 1.9835. This flow can be used to determine if the flow rate into the pond is adequate to maintain the pond level.
Days Required to Fill the Pond	1	The "Days Required to Fill the Pond" is calculated by dividing the "Pond Capacity" by the "Flow Rate" minus "Minimum Maintenance Flow" multiplied by 1.9835. This section will assist you in determining if the flow rate being diverted to the pond is adequate to fill the pond while maintaining the pond level. The length of time to fill the pond will help determine if the flow rate is adequate for the size of pond being proposed. This number should be between 1 and 365 days for a project to be successful.
Days Required to Fill the Pond at 13,000 gallons per day	-51	The "Days Required to Fill the Pond at 13,000 gallons per day" is calculated converting the "Pond Capacity" and the "Maximum Daily Maintenance Volume" to gallons. The "Pond Capacity" is then divided by 13,000 gallons minus the "Maximum Daily Maintenance Volume" in gallons to determine the number of days to fill pond. This number should be between 1 and 365 if this pond is to be described as a domestic use.

User Input
Calculated value
Formula Explanations

Evaporation Loss Calculation

FILE NUMBER	96-9438
REVIEWER	Dan Nelson
DATE	11/26/2013

This spreadsheet has been designed by Idaho Department of Water Resources to estimate the annual evaporation losses from a pond.

The acronyms used on the Kimberly Research Center website are defined below:

P = Precipitation
ET= Evapotranspiration
P _d = Precipitation deficit
P _d =ET-P

USING THIS SPREADSHEET

To ascertain the evaporation from a pond, you will need to go to the Kimberly Research Center website. The link is found below. This web site provides the Precipitation Deficit for the area where the pond is located. The Precipitation Deficit is the total amount of free pan evaporation minus the precipitation for a given area, which gives the total amount of evaporative losses incurred by the pond. There are several weather sites that are used, and the entire state is pretty much covered. IDWR staff can find the nearest site using Arc Map. The shape file containing the sites can be found at X:/Spatial/Climate/ETIdahostations.shp.

User Input

Calculated value

Formula Explanations

Found at: <http://www.kimberly.uidaho.edu/ETIdaho/online.php>

Precipitation Deficit

Station: Twin Falls 2 NNE (NWS -- 109294)

Month	mm/day ¹	Days per month	mm/Month
Jan	0.00	31	0.00
Feb	0.00	28	0.00
March	0.00	31	0.00
April	0.56	30	16.80
May	0.91	31	28.21
June	1.69	30	50.70
July	3.34	31	103.54
August	2.91	31	90.21
September	1.65	30	49.50
October	0.00	31	0.00
November	0.00	30	0.00
December	0.00	31	0.00

PLEASE NOTE: We cannot use the season average, because there are several areas in Northern Idaho with a negative Precipitation Deficit. Therefore, we must enter each monthly deficit, and enter in a zero (0) for each negative month. The reason for this is that precipitation can only offset evaporation to the extent of the evaporation.

Please enter the daily average Precipitation Deficit as shown in the example below.

Although it has sometimes been useful to consider wintertime evaporation to be zero, Allen and Robison (2007, p. 169) noted, "Evaporation during nongrowing (wintertime) periods varies widely"

¹Negative monthly mean values should be entered in the above table as "0".

Total mm/year = **338.96**

$[(\text{mm/yr}) \div (\text{convert to feet})] \times (\text{Surface area of pond, in acres}) = \text{Evaporation Loss in Acre Feet}$

(**338.96** $\div$ **304.8**) $\times$ **0.30** = **0.3 AFA**

Surface Area of Pond is automatically Carried over from the Seepage Loss Sheet.

SEEPAGE CALCULATIONS

This spreadsheet has been designed by Idaho Department of Water Resources to estimate the total annual seepage losses from a pond.

FILE NUMBER	96-9438
REVIEWER	Dan Nelson
DATE	11/26/2013

User Input
Calculated value
Formula Explanations

INPUTS

SQ. FT. Calculator
Pond Surface area in acres
0.3

POND SURFACE AREA (SQ. FT.)	13068
-----------------------------	-------

SUGGESTED SEEPAGE RATE (FT/DAY)	0.2000
---------------------------------	--------

Use the table below to find the "SUGGESTED SEEPAGE RATES".

FORMULA: (Surface Area X Seepage Rate) / 7.48 = Gallons Per Day loss

CONVERT TO GPD	19550	GPD
----------------	-------	-----

TOTAL SEEPAGE LOSS (AFA)	21.9	AFA
--------------------------	------	-----

SUGGESTED SEEPAGE RATES FOR DIFFERENT SOIL TYPES:
GW, GP, GM, GC, SW, SP and SM (silty sand, sand silt mixtures and gravel mixtures) = 0.20 ft per day
OL and ML (inorganic silts - very fine sands, silty, or clayey fine sands) = 0.016 ft per day
SC (clayey sands, sand clay mixtures) = 0.007 ft per day
CL (Low to medium plasticity clays) = 0.003 ft per day
MH, OH, PT and CH (high plasticity clays) = 0.0003 ft per day
LINED PONDS (liners can be chemical, fabric, or bentonite) = 0 ft per day
Ponds Intercepting Groundwater (excavated ponds filled with shallow Ground Water) = 0 ft per day

PLEASE NOTE: The initial basis for the Suggested Seepage Rates in the table above is found on Page 16 of Seepage from Fish Ponds, Bulletin 599, August 1989 Alabama Agricultural experiment Station, Auburn University, Auburn University Alabama. If you don't know the soil type, please refer to the map provided at X:\Spatial\Soils\USCS\PondSoils.lyr. Use "0" if the ponds intersect the water table.

ET_{Idaho} 2012 -- Evapotranspiration and Consumptive Irrigation Water Requirements for Idaho

Please send suggestions for improving this site to robison at kimberly dot uidaho dot edu Copyright 2012, University of Idaho.

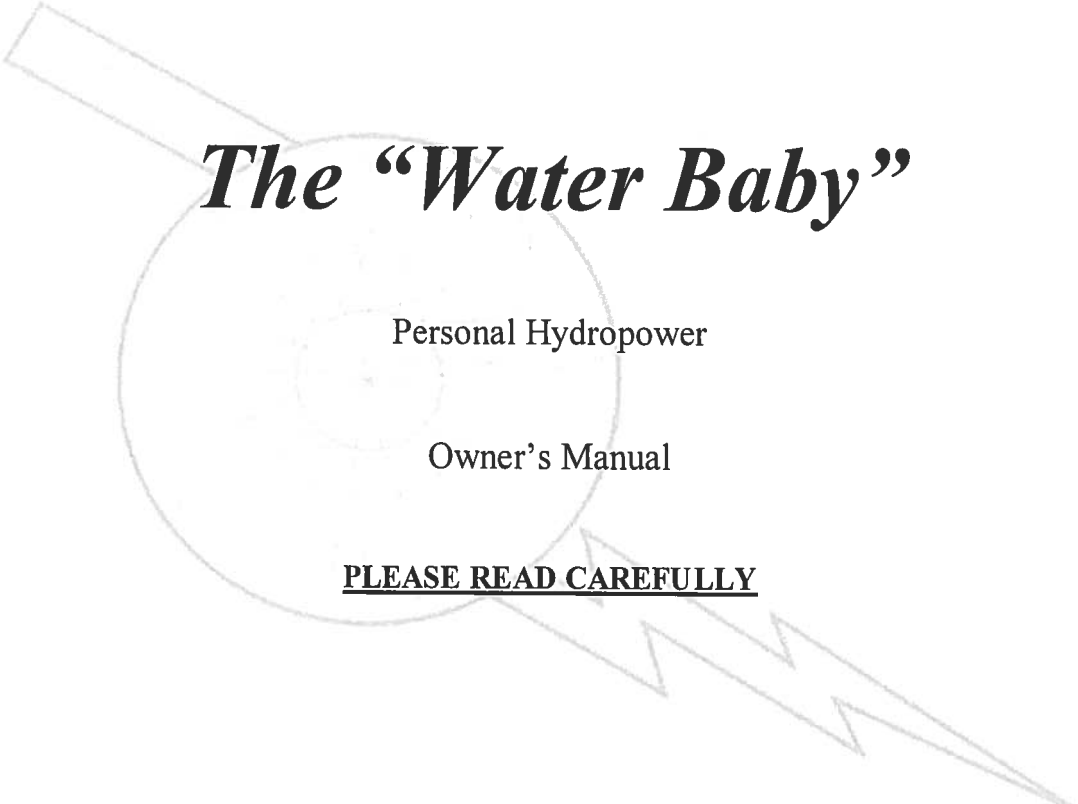
Sandpoint KSPT (NWS -- 108137)

Statistics based on thirty year normal spans 1973 to 2007 years

For a different land cover or crop click on the above link.

You can highlight this table and copy via the clipboard to a Microsoft Excel or OpenOffice spreadsheet to plot or otherwise work with this data.

Open water - shallow systems (ponds, streams)															
Precipitation Deficit (Click here for a graph)															
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Growing Season ^a	Non Growing Season ^b	Annual
Mean ^j	mm/day												mm		
Monthly ^c	-3.32	-2.24	-0.87	0.56	0.91	1.69	3.34	2.91	1.65	-0.51	-3.98	-3.73	-106	0	-106
15-Day Moving Average ^d	-3.40	-2.54	-0.92	0.53	0.96	1.56	3.28	2.89	1.51	-0.47	-3.99	-3.63			
7-Day Moving Average ^e	-3.35	-2.35	-0.93	0.51	0.94	1.58	3.32	2.90	1.58	-0.46	-4.07	-3.61			
3-Day Moving Average ^f	-3.31	-2.24	-0.88	0.53	0.92	1.62	3.33	2.91	1.63	-0.49	-4.00	-3.70			
Standard Deviation ^k	mm/day												mm		
Monthly ^c	2.53	1.87	1.59	1.01	1.78	1.23	2.17	2.02	1.19	2.04	1.93	2.28	157	0	157
15-Day Moving Average ^d	2.57	2.51	1.67	1.47	1.97	1.90	2.04	1.90	1.72	1.90	2.52	2.35			
7-Day Moving Average ^e	3.49	3.39	2.26	2.30	2.69	2.71	2.33	2.52	2.24	2.52	3.75	3.40			
3-Day Moving Average ^f	4.68	4.38	3.22	3.16	3.73	3.72	2.91	3.25	2.91	3.34	5.43	4.92			
20% Exceedance ^l	mm/day												mm		
Monthly ^c	-2.25	-0.58	-0.02	1.42	1.87	2.62	4.29	4.15	2.89	0.48	-2.46	-2.40	17	0	17
15-Day Moving Average ^d	0.03	0.08	1.31	2.55	3.62	4.21	5.05	4.72	3.55	1.77	0.00	0.00			
7-Day Moving Average ^e	0.30	0.88	1.98	3.29	4.76	4.94	5.38	5.17	3.94	2.40	0.66	0.16			
3-Day Moving Average ^f	0.46	1.23	2.48	3.85	5.11	5.63	5.70	5.48	4.40	2.64	0.96	0.31			
80%	mm/day												mm		



The “Water Baby”

Personal Hydropower

Owner's Manual

PLEASE READ CAREFULLY

Made in Canada

by

Energy Systems and Design Ltd.

PO Box 4557

Sussex NB

Canada E4E 5L7

Phone +1 (506) 433-3151

Fax +1 (506) 433-6151

Email: support@microhydropower.com

Website: www.microhydropower.com

The **Water Baby** is a Trademark of Energy Systems & Design Ltd.

Congratulations on your purchase of a new *Water Baby* micro-hydro generator! With a thorough installation and a little routine maintenance, your Water Baby will provide you with years of trouble-free operation. This manual will help you to install your Water Baby as well as assist you in troubleshooting and problem solving. Of course, you may contact Energy Systems & Design Ltd. if you run into trouble.

May your RE adventures prove successful!

Table of Contents

1. Introduction	3
2. Site Evaluation	4
3. Head Measurement	4
4. Flow Measurement	5
5. Intake, Pipeline & Tailrace	6
6. Batteries, Inverters & Controllers	8
7. Wiring and Load Center	9
8. Design Example	9
9. Output Adjustment	11
10. High Voltage Models	12
11. Water Baby Output.....	12
12. Bearings, Service and Assembly	12
13. Nozzle flow chart	13
14. Copper Wire Resistance Chart	13
15. Pipe Friction Head Loss Charts.....	14,15
16. Water Baby Diagram.....	16
17. Wiring Diagrams	17

INTRODUCTION

This manual describes **The Water Baby**, which is manufactured by Energy Systems and Design Ltd. The installer must have some knowledge of plumbing and electrical systems, and the user of the system should also. These machines are small, but can generate some 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.**

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 moving water 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 Water Baby is designed to operate over a wide range of heads and flows. Nozzle diameters of 1/8 to 1/4 inch (3-6 mm) are available, and up to four nozzles can be used on one machine, to utilize heads as low as 50 feet (15 m) and as high as hundreds.

The Water Baby uses a permanent magnet type alternator. This design eliminates the need for brushes and the maintenance that accompany them while increasing efficiency. The Water Baby's output can be optimized by simply adjusting the position of the stator.

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 Water Baby and 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 Water Baby at as low an elevation as possible, but going too low may cause the machine to become submerged (or washed away!).

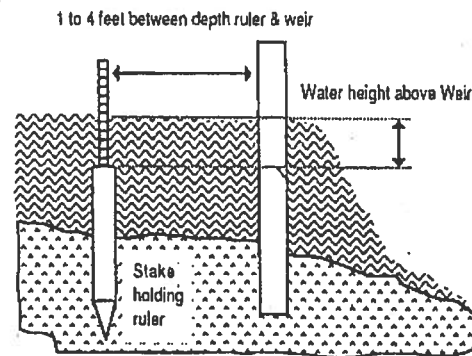
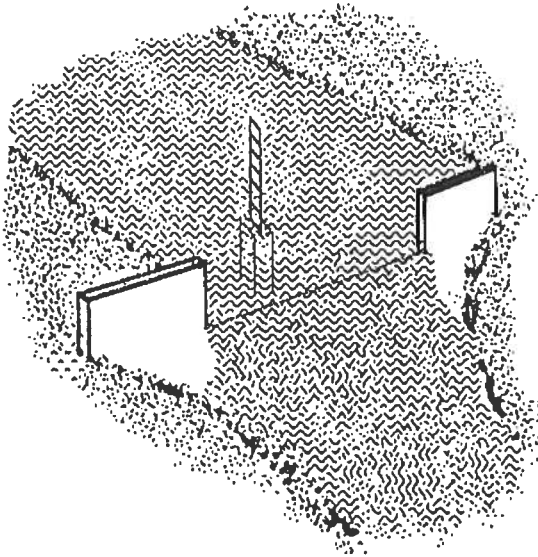
HEAD MEASUREMENT

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 using 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. Casio makes a wristwatch with a built-in altimeter.

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 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.

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 following 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.

WEIR MEASUREMENT TABLE								
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
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.								

INTAKE, PIPELINE, AND TAILRACE

All 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, 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, a hand-powered vacuum pump can be used to remove air trapped at the high point.

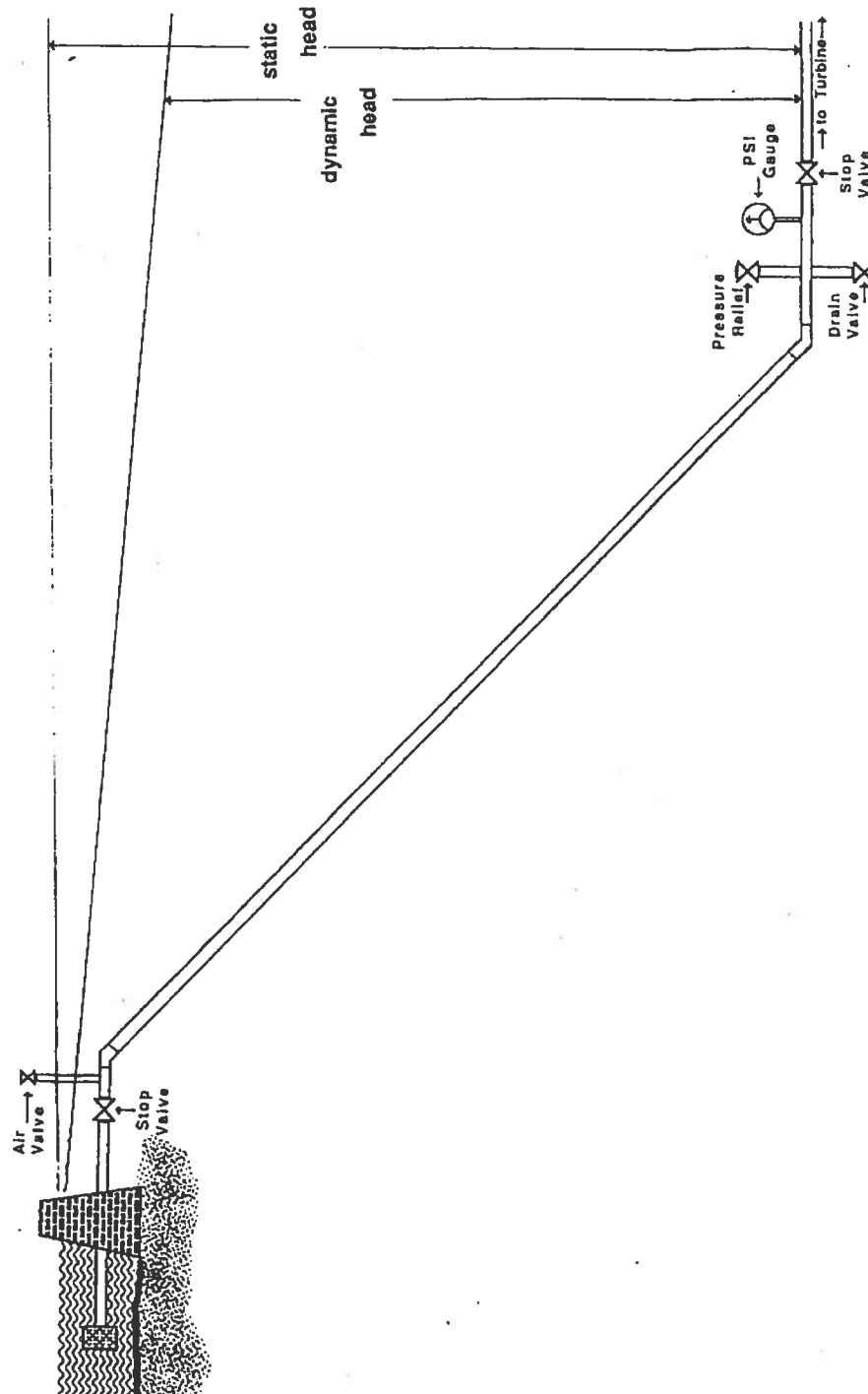
At the turbine end of the pipeline a bypass valve may be necessary to allow water to run through the pipe without affecting the turbine, purging the line of air or increasing flow to prevent freezing.

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.

Nozzles can be installed or changed by removing the nozzle holder by backing off the setscrew using a 1/8" (3 mm) hex wrench which is supplied with the machine. The use of flexible pipe or union valves makes it easier to remove the plumbing from the nozzles. The nozzle holders have a '1' marked on the top side. This is to position the holder with a small indentation that lines up with the



set screw that retains the holder. If this is not correctly positioned, the setscrew will make a raised mark on the surface and make it difficult to remove.

The turbine housing can be mounted on boards to suspend it above the stream. It is recommended to have the Water Baby in a small enclosure or under some cover to keep it dry and provide a place for auxiliary equipment.

Mounting the machine on 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 housing opening is 5-1/2 inches in diameter, the bolt holes are on a five-inch square, and the housing is six inches square.

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 is usually 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 VAC power. 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 Capacity

A typical hydro system should have about 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. Alkaline batteries like the nickel-iron and the nickel-cadmium types can have a lower capacity since they can be more fully discharged without harm.

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

Charge Control

A hydro system requires that a load be present so that the power has somewhere to go. Otherwise, system voltage can rise to very high levels. This situation provides an opportunity to do something with the excess power (a dump load can be used for water heating).

As the batteries become fully charged, their voltage rises. At some point, the charging process should stop and the power be diverted to the dump load (there is a fair bit of guesswork involved here). The voltage set-point should be about 13.5 to 14.5 for a 12-volt system depending on the charge rate. The higher the charge rate, the higher the voltage can go. If batteries are often in a state of charge, the voltage limit should be on the low end of the range.

A voltmeter or a watt-hour meter can be used to monitor battery charge level. Battery voltage is roughly a function of the charge level, and varies according to the load level and charge rate. As you gain experience, the battery voltage can be used to assess the charge level more accurately.

WIRING AND LOAD CENTER

Every system requires some 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 Water Baby must be fused since it can suffer from a short or similar fault just like anything else in the system.

Inside the junction box on the side of the machine are two terminal blocks for the battery wiring. The negative terminal is bolted to the box and the positive terminal is bolted to the plastic plate. Your transmission wire ends are inserted into these two connectors (after being stripped of insulation) and then tightened. Make sure that the battery wiring is correctly connected or the rectifier will be destroyed. Do not operate the machine without being connected to the batteries as very high voltages may be generated.

The multi-meter connected to the shunt terminals (see *new current measurement technique*, pg. 17) will measure current output and is comparable to the speedometer of a car. A voltmeter connected to the batteries will roughly indicate the charge level, as described in Charge Level above, and is comparable to the gas gauge.

DESIGN EXAMPLE

This example shows how to proceed with a complete installation. The parameters of the example site are:

- 115 feet of head over a distance of 1000 feet
- a flow of over 15 gpm (most of the time)
- 100 feet distance from the house to the hydro machine
- 12 volt system

The first thing we do is determine the pipeline size. Although maximum power is produced from a given size pipe when the flow loss is 1/3 of the static head, more power can be obtained from the same flow with a larger pipe, which has lower losses. Therefore, pipe size must be optimized based on economics.

We decide to use a flow of 12 gpm as that is the flow through a 1/4" nozzle at a head of 100'. The pipe flow charts show us that 1-1/2" diameter polyethylene pipe has a head loss of 1.11 feet of head per 100 feet of pipe at a flow rate of 12 gpm. This is 11.1 feet of loss for 1000 feet of pipe.

Using 1-1/2" PVC gives us a loss of 0.64 feet of head per 100 feet of pipe or 6.4 feet for 1000 feet.

Polyethylene comes in continuous coils because it is flexible (and more freeze resistant). PVC comes in shorter lengths and has to be glued together or purchased with gaskets (for larger sizes). Let's say we select polyethylene as the head loss is still very low and poly has very few joints and conforms better than PVC to the landscape.

A flow of 12 gpm gives a net head of 103.9 feet (115' – 11.1'). The losses caused by the various pipe fittings and intake screen will further decrease the dynamic head, so 100 feet is a good working figure for the net head.

At this head and flow condition, the output of the machine is equal to about 100 watts.

Since we require 12 volts and the transmission distance is short, we can generate and transmit 12 volts using the Water Baby. This Water Baby could also be used for higher voltages like 24, 48, 120 and 240, and power could be transmitted longer distances.

Looking at the nozzle flow chart, we see that a 1/4" nozzle will produce a flow of 12.3 gpm at a 100' head. We need to go 100' with 100 watts at our site. This will be about 6.7 amps at 15 volts at the generator. Note that there will be some voltage drop in the line and batteries require somewhat higher voltages than nominal to become charged. So the 6.7 amps must pass through 200' of wire for the round trip. Resistance losses should be kept as low as economics permit, just like the pipeline losses.

Let's say we wish to have around a 10% loss. This is 10 watts out of the original 100. The formula for resistive loss is $I^2R = \text{watts}$ when $I = \text{Intensity (current in amps)}$ and $R = \text{Resistance (in ohms)}$. Solving for resistance is as follows.

$$\begin{aligned}(6.7 \text{ amps}) \times (6.7 \text{ amps}) \times R (\text{ohms}) &= 10 \text{ watts} \\ 44.9 \text{ amps} \times R (\text{ohms}) &= 10 \text{ watts} \\ R &= 10 \text{ watts} / 44.9 \text{ amps} \\ R &= 0.22 \text{ ohms}\end{aligned}$$

This is the wire resistance that will produce a 10% loss. The wire loss chart shows loss per 1000', so:

$$1000' / 200' \times 0.22 \text{ ohms} = 1.1 \text{ ohms per } 1000'.$$

The chart shows 10 ga. wire has a resistance of 1.02 ohms per 1000', so:

$$\begin{aligned}200' / 1000' \times 1.02 \text{ ohms} &= 0.204 \text{ ohms. This is close to the desired level.} \\ 6.7 \text{ amps} \times 6.7 \text{ amps} \times 0.204 \text{ ohms} &= 32 \text{ watts of loss.}\end{aligned}$$

Increasing the wire size further reduces the losses. Voltage drop in the wire is equal to:

$$IR = 6.7 \text{ amps} \times 0.204 \text{ ohms} = 1.4 \text{ volts}$$

So if the battery voltage is 13.6 the generator will be operating at 15.0 volts. Keep in mind that it is always the batteries that determine the system voltage. That is, all voltages in the system rise and fall according to the battery's state of charge.

At this site, we would be generating 6.7 amps continuously. If we use lead acid batteries and wish to have two days of storage capacity, then:

$$6.7 \text{ amps} \times 24 \text{ hrs} \times 2 \text{ days} = 322 \text{ amp. hrs. capacity}$$

We would probably use an inverter and load controller with the system. The diagram for such a system would look like this:

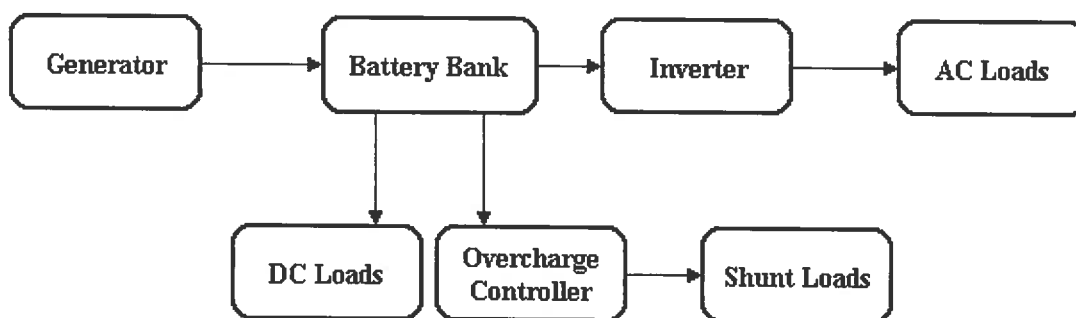


Diagram of a typical battery-based system

OUTPUT ADJUSTMENT

The machine should be adjusted in order for it to produce the maximum output. This can be done by rotating the upper stator to the best position. This is done by first loosening the thumbscrews and then slowly rotating the stator while observing the output current. The current can be measured using the supplied meter with the test leads plugged into the "shunt" in the junction box. Use the millivolt scale which is labeled 200m which puts the handle in the nine o'clock position. The leads should plug into the meter in the normal position for measuring voltage as we are measuring the voltage drop across a resistance. Then these are inserted into the color coded jacks in the shunt in the junction box. This adjustment is necessary to best match the output of the turbine with that of the generator. The upper stator has an adjustment range of 45 degrees of movement. This means that it can be moved from a position that has the thumbscrews at the corners of the machine to a position where they are perpendicular to the base. NOTE that the output often increases over time for the first day or so.

High Voltage models Only

When operating a Water Baby using transformers, it will require a different technique in order to optimize the output. This can be done at the turbine by adjusting for maximum voltage rather than maximum current. AC voltage can be measured across any two of the (AC) output terminals. These terminals are the same on the terminal board as for low-voltage DC systems. Make output adjustments in the usual manner. An on/off switch is supplied in the transformer panel for the incoming AC power. In normal use the switch is left on.

Water Baby Output in Watts (Continuous)

Flow in (US gallons per minute) and liters per second

Nozzle Size	NET HEAD	
	100 feet (30 meters)	200 feet (60 meters)
1/8 inch (3mm)	15 watts (3.1) 0.20	50 watts (4.3) 0.27
1/4 inch (6mm)	105 watts (12.3) 0.77	285 watts (17.4) 1.08
2 x 1/4 inch (6mm)	215 watts (24.6) 1.55	540 watts (34.8) 2.16

BEARINGS, SERVICE & ASSEMBLY

To gain access to the bearings, loosen the thumbscrews and then lift off the top stator. This may require a bit of effort as there is the magnetic attraction to overcome and the top bearing must pull out of its bore which has an O-ring inside it to keep the bearing from rotating. The upper bearing is retained with a small screw and is a slip fit on the shaft. To remove the lower bearing the turbine runner is first removed by holding the magnet rotor and then removing the bolt holding the turbine runner using a 7/32" Allen wrench that is supplied with the machine. Once this is done, the rotor assembly can be pulled out of the bearing. Then the bearing can be removed after removing the two retaining screws. The Baby uses two # 6201 ball bearings with non-contact seals. If these are not available, bearings with contact type seals can be used as these are fine too and the only difference is a little extra friction from the seals.

NOZZLE FLOW CHART FLOW RATE IN U.S. GALLONS PER MINUTE

Water Baby nozzles are labeled with numbers from 4 to 8 and represent the size of the nozzle in increments of 1/32 of an inch. For example: a nozzle with a number 6 is a 6/32" (3/16") nozzle.

1 METER = 3.28 FEET

1 US GALLON = 3.79 LITRES

Head Feet	Pressure PSI	NOZZLE SIZE (inches)				
		1/8	5/32	3/16	7/32	1/4
		#4	#5	#6	#7	#8
50	21.7	2.17	3.40	4.88	6.65	8.68
60	26.0	2.38	3.70	5.35	7.28	9.51
80	34.6	2.75	4.28	6.18	8.40	11.0
100	43.3	3.07	4.80	6.91	9.40	12.3
120	52.0	3.36	5.25	7.56	10.3	13.4
150	65.0	3.76	5.88	8.95	11.5	15.0
200	86.6	4.34	6.78	9.77	13.3	17.4
250	108	4.86	7.58	10.9	14.9	19.9
300	130	5.32	8.30	12.0	16.3	21.3
400	173	6.14	9.58	13.8	18.8	24.5

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

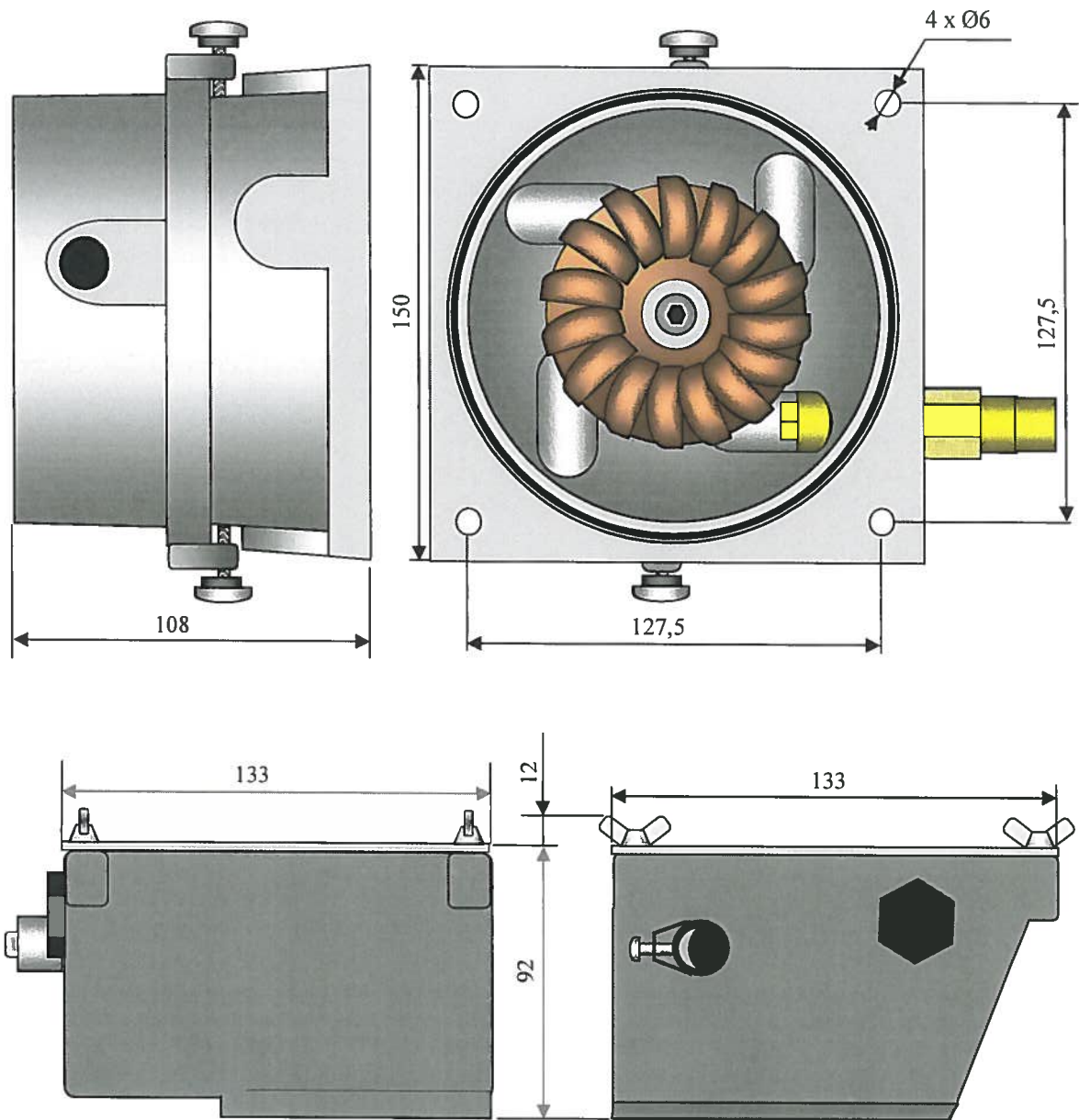
Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

Flow US GPM	Pipe Diameter, Inches										
	1	1.25	1.5	2	2.5	3	4	5	6	8	10
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	0.02				
22	12.6	3.77	1.96	0.67	0.25	0.10	0.02				
24	14.8	4.42	2.32	0.78	0.30	0.12	0.04				
26	17.2	5.13	2.65	0.90	0.35	0.14	0.05				
28	19.7	5.89	3.04	1.04	0.41	0.16	0.05				
30	22.4	6.70	3.45	1.17	0.43	0.18	0.05				
35		8.90	4.64	1.56	0.62	0.23	0.07				
40		11.4	5.89	1.98	0.78	0.30	0.09	0.02			
45		14.2	7.34	2.48	0.97	0.37	0.12	0.04			
50		17.2	8.92	3.01	1.20	0.46	0.14	0.04			
55		20.5	10.6	3.59	1.43	0.55	0.16	0.05			
60		24.1	12.5	4.21	1.66	0.64	0.18	0.07	0.02		
70			16.6	5.61	2.21	0.85	0.25	0.09	0.03		
80			21.3	7.18	2.83	1.08	0.32	0.12	0.04		
90				8.92	3.52	1.36	0.39	0.14	0.07		
100				10.9	4.28	1.66	0.48	0.18	0.07	0.02	
150				23.2	9.06	3.50	1.04	0.37	0.16	0.05	
200					15.5	5.96	1.75	0.62	0.28	0.07	0.02
250					23.4	9.05	2.65	0.94	0.42	0.12	0.05
300						12.6	3.73	1.34	0.58	0.16	0.05
350						16.8	4.95	1.78	0.76	0.21	0.07
400						21.5	6.33	2.25	0.97	0.28	0.10
450							7.87	2.81	1.20	0.32	0.12
500							9.55	3.41	1.45	0.42	0.14
550							11.4	4.07	1.75	0.48	0.16
600							13.4	4.78	2.05	0.58	0.18
650							15.5	5.54	2.37	0.67	0.23
700							17.8	6.37	2.71	0.76	0.25
750							20.3	7.22	3.10	0.86	0.30
800								8.14	3.50	0.97	0.32
850								9.11	3.89	1.08	0.37
900								10.1	4.32	1.20	0.42
950								10.8	4.79	1.34	0.46
1000								12.3	5.27	1.45	0.51

PIPE FRICTION LOSS Polyethylene SDR - Pressure Rated Pipe

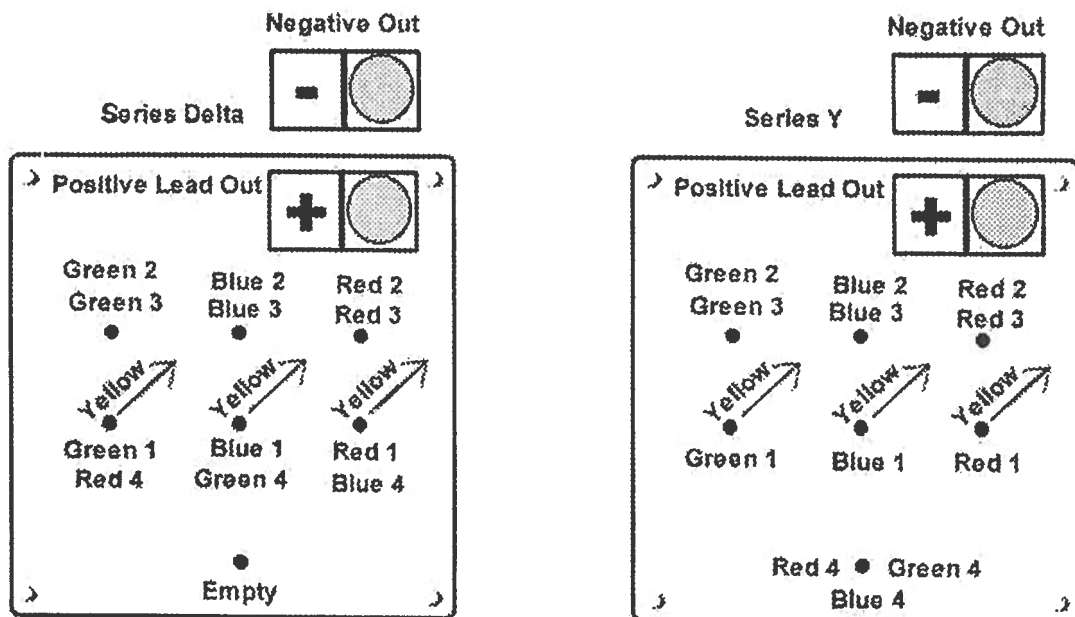
Pressure Loss from Friction in Feet of Head per 100 Feet of Pipe

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
300								18.4



WIRING DIAGRAMS

These diagrams represent the two possible combinations of output wiring. They are in order of potential. Series Delta produces higher current and lower voltage while Series Wye produces higher voltage and lower current.

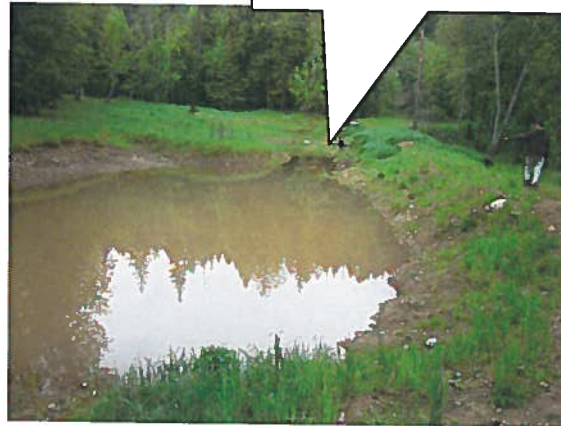


NEW-CURRENT LIMITING

The Water Baby is now supplied with current limiting devices that prevent overloading of the machine. These are located in the junction box between the series connections that are provided between the #2 and #3 wires of each phase. This will limit the output current of the low voltage (12 & 24 volt) machines to about 15 amps for the WYE connection and 26 amps for DELTA. For the high voltage (48 & 120 volt) machine, the limits will be about four amps for WYE and 6.5 amps for DELTA. If the machine exceeds these ratings, the output will fall as the machine protects itself. When the overload condition is removed and the devices cool, normal operation can be restored.

PHOTOGRAPHER AND DATE OF PHOTOS DANIEL A NELSON 5/23/2013

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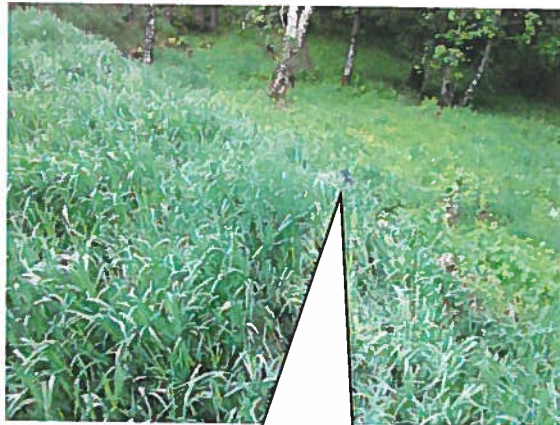


Overflow back to channel

The photo above shows the pond used to store water for the power plant. This pond sits in a draw, so there is no designated stream channel. This pond simply captures runoff water from the hill side.

The photos below show the emergency overflow for the pond. It is an ten inch pipe through the dam that discharges into the meadow. You can also see an overflow to drainage where any excess water can flow back to drainage channel.

Emergency overflow pipe.



Outlet of Emergency
Overflow Pipe.

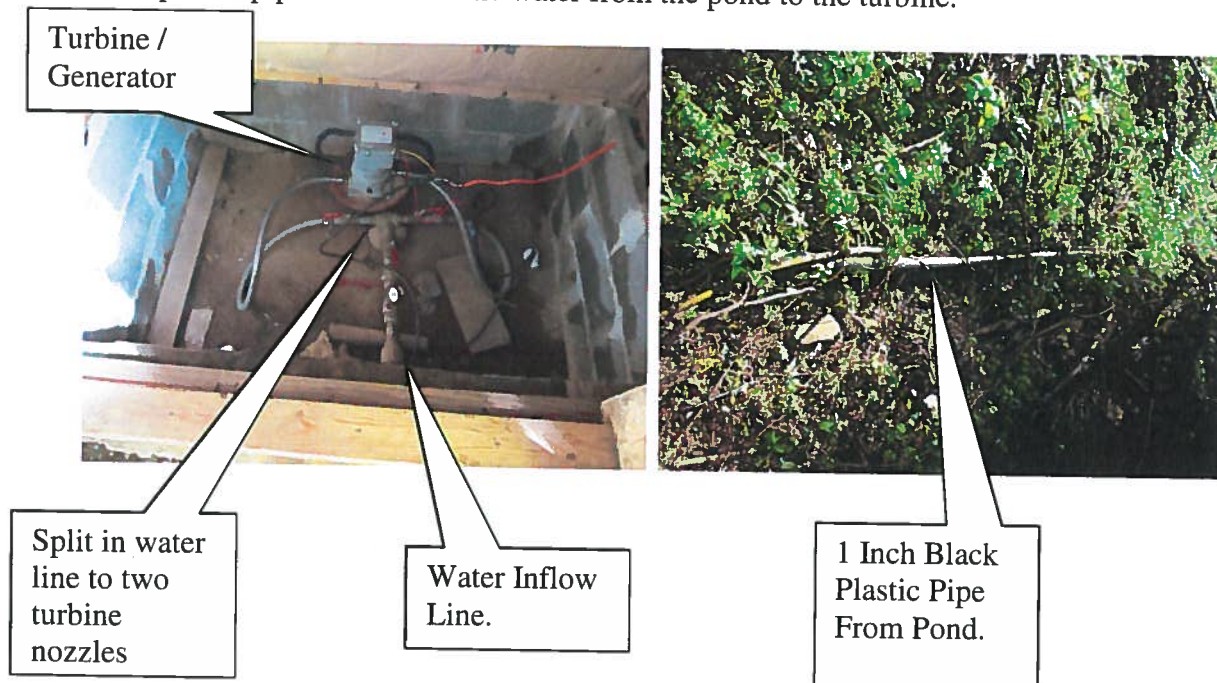
PHOTOGRAPHER AND DATE OF PHOTOS DANIEL A NELSON 5/23/2013

FILE NUMBER 96-9438



The photo above left shows the intake structure that collects the water in pond and delivers it down to the power plant. The photo above right shows the pipe traveling down to the power plant. This picture was taken on the pond's dam.

The photo below left shows the power plant. It is a Water Baby power generation. This unit can use up to 1-4 nozzles to operate the turbine. You can see in the photo that the intake from the pond splits into two lines and enters the turbine on opposite sides. This unit uses two nozzles to operate the system. The photo below right shows the one inch black plastic pipe that carries the water from the pond to the turbine.



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These photos show the battery packs that store the energy that the solar and the hydro plant produce.

This system uses both hydropower and solar power to provide the electricity needed to operate the home. Both systems are connected into a main control panel shown below. The solar power panel connects into the main panel that distributes the power.

