MANUAL

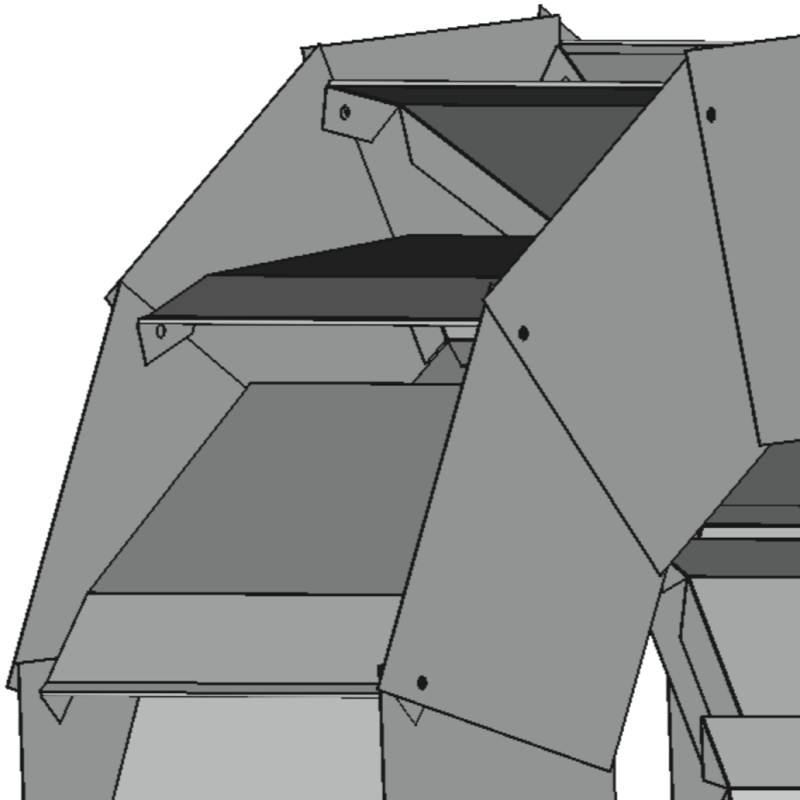
Estimation of the water flow rate

Overview:

Introduction

Method I: Flow speed estimation

Method II: V-notch weir



Introduction

The dimensioning of the waterwheel system is based on two main parameters found at the site: the fall height H [m] (also called head) and the water flow rate Q [l/s]. This manual provides a guide on ***how to measure the available water flow rate at the site using two methods.***

Method I: Flow speed estimation

- **simple** procedure without any manufacturing process
- requires a steady flow in a channel
- **scalable**
- **less accurate** than V-notch weir but good approximation

Method II: V-notch weir

- **cheap** to manufacture
- designed for a steady water flow in an **open channel** without slope
- **scalable** – the same concept is applied in different sizes depending on the available water flow rate (between 20 and 100 l/s)
- **accurate** – provides a better head measurement than rectangular weirs

For both methods, it is assumed that there already exists an intake and channel at the site. If not, follow the respective instructions in the manual for the periphery components.

Example V-notch weir

Method I: Flow speed estimation

Tools needed for the flow speed estimation

Metre rule

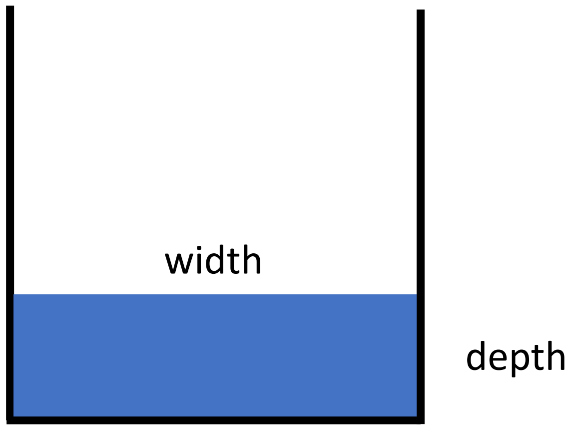
Computer and internet

Smartphone or camera

<u>1. Step: Estimate water flow area</u>

Tools needed:

- Meter rule



Area = width x depth

Steps

1. **Measure** the channel width with the meter rule at as many locations along your channel as possible. Calculate the average channel width from your measurements.

2. **Measure** the water depth in your channel at as many locations along your channel as possible. Calculate the average water depth from your measurements.

3. **Calculate** the water flow area in your channel using the formula on the left. Scale your result into m^2.

2. Step: Estimate water flow speed

Tools needed:

- Meter rule
- Camera or smartphone
- Computer

Tip: Use a high resolution (1020p and high frame rate (50fps) camera for more precise measurements.

Steps

1. **Mark** one meter of the channel with a pen. Choose the segment were the water flow is the less turbulent. (Mark the 0 and 1 m)

2. **Set up** your camera or smartphone so that you can record that entire meter of the channel.

3. **Start** recording and throw a leaf or any floatable and good recognizable small object into the channel at around 30 cm upstream of the first mark. Stop recording once the leaf passes the second mark.

4. **Repeat** this process 20 times with different recordings.

5. **Use** the video analysis software Coach's Eye Free and determine the time that the leave requires to go from the first to the second mark.

6. **Divide** 1 meter by the previously determined time in seconds and you will get the flow velocity.

7. **Repeat** this process with all the recordings and calculate the average flow speed.

3. Step: Calculate the average water flow rate Q

Tools needed:

- none

Steps

1. **Multiply** the average water flow area times the average water flow velocity to get the average water flow rate Q in m^3/s (Q = A x v).

2. **Convert** the water flow rate unit to l/s by multiplying the m^3/s times 1000. (If needed)

Congratulations!
You have measured the water flow rate of your system.

Method II: V-notch weir

Tools needed for the manufacturing of the V-notch weir

Metal scissors and galvanized steel sheet (1mm)

Metre rule and square

Hammer and shovel

Smartphone and internet

Optional

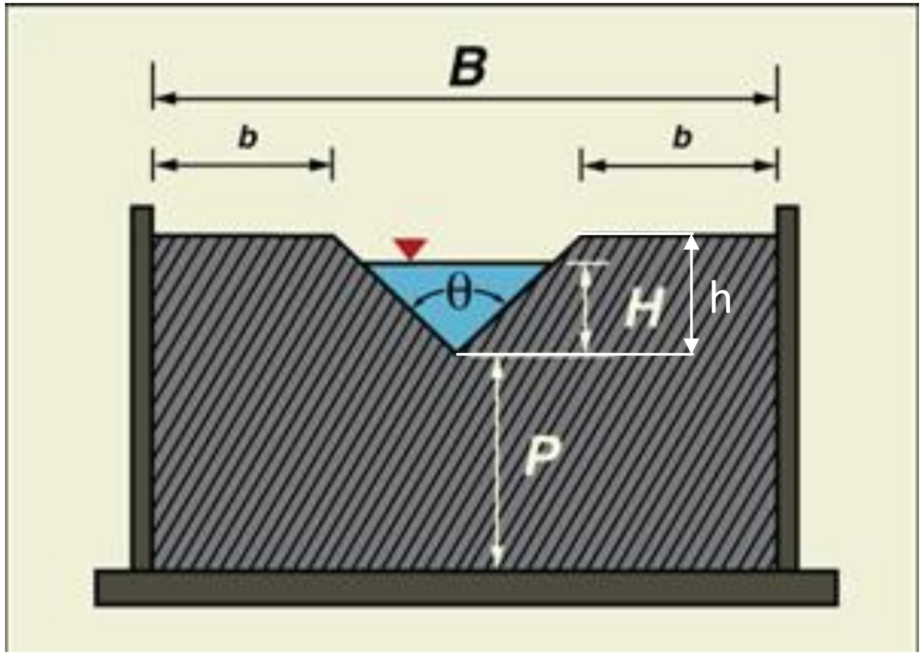
Angle grinder, manual arc welder, galvanized angle profile and galvanized steel sheet (5mm)

V-notch weir parameters

The water flow rate calculation using the V-notch weir can be performed for fully (H/B ≤ 0.2) or partially (H/B ≤ 0.4) contracted weirs. **This manual focuses on partially contracted weirs** given their smaller size. A complete explanation as well as the method for fully contracted weirs can be found under: ponce.sdsu.edu/onlineveenotchdescription.html

<u>Parameters of a V-notch weir:</u>

- **B [cm]:** Width of the weir and approach channel
- **b [cm]:** Width of the weir shoulders
- **H [cm]:** Head (water depth above the crotch)
- **h [cm]:** Distance from crotch bottom to weir shoulders
- **P [cm]:** Height of the crotch from channel bottom
- **Θ [degrees]:** Notch angle (angle of the "V")
- **t [mm]:** Thickness of the weir at the "V"



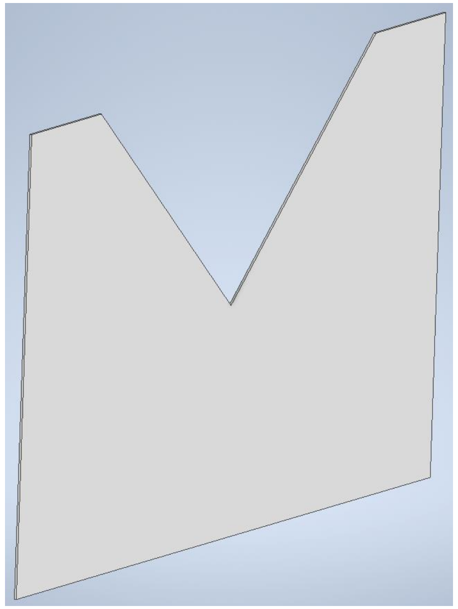
For this method (partially contracted weirs), the notch angle Θ is always 90°

V-notch weir parameters

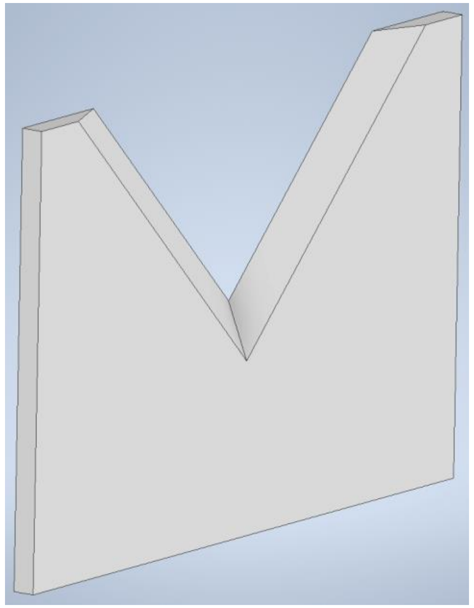
<u>Thickness of the weir t:</u>

It doesn't matter how thick the weir is **except where water flows over the weir through the “V“.**
You want to avoid having water cling to the downstream face of the weir, which is achieved with one of these two options:

1. The weir thickness at the “V“ is between 0.8 mm and 2 mm
2. The weir thickness at the “V“ is greater than 2 mm and the downstream edge of the V is chamfered at an angle greater than 45° (60° is recommended)



Weir with t=2mm



Chamfered weir with t=20mm

This manual assumes that t < 2mm

Rules for validity

The following rules must hold so that the water flow estimation can be performed:

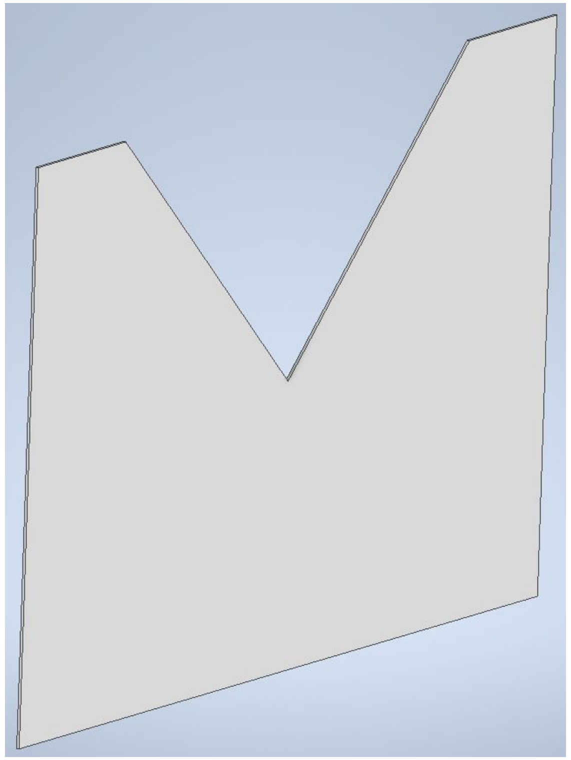
1. Water doesn‘t cling to the downstream surface of the weir (see previous slide)
2. Ratio H/B is between 0.2 and 0.4 → partially contracted weir
3. Ratio P/B is smaller than 0.6
4. Ratio H/P is smaller than 1.2
5. Θ is 90°
6. Water surface downstream of the weir is at least 6 cm below the bottom of the “V” to allow a free flowing waterfall
7. The bottom of the “V” is at least 10 cm above the bottom of the incoming channel
8. If the head over the crotch is smaller than 18.3 cm or bigger than 34.6 cm (using the respective weir size), the water flow is too small/too big for this waterwheel system

By following this manual, you are making sure that all rules are kept

1. Step: Manufacturing of the V-notch weir

Tools needed:

- Metal grinder or metal scissor
- Pen and square
- Metal sheet (1-2 mm thickness)



Steps

1. **Draw** the shape of the V-notch weir on the metal sheet. Use the measurements for Size 1 provided in the table.

2. **Cut** the shape of the weir with the metal grinder/scissors.

Size	B [cm]	Θ [°]	b [cm]	P [cm]	h [cm]	H [cm]	Q [l/s]
1	60.3	90	6.05	20.1	24.1	18.3 – 24.1	up to 40
2	70.8	90	7.1	23.6	28.3	24.1 – 28.3	up to 60
3	79.3	90	7.95	26.5	31.7	28.3 – 31.7	up to 80
4	86.5	90	8.65	28.9	34.6	31.7 – 34.6	up to 100

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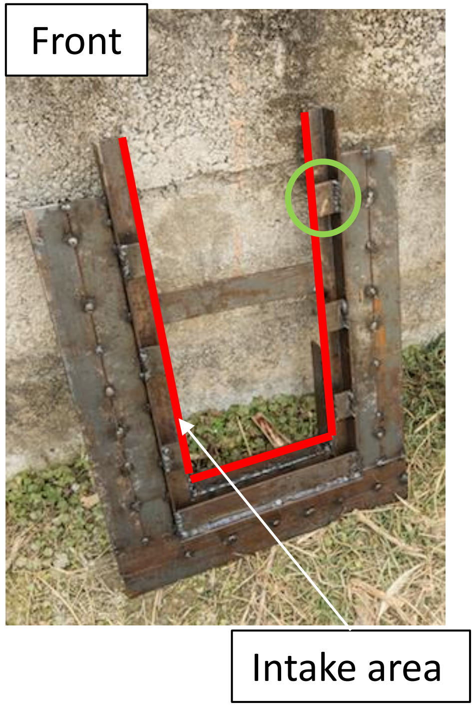
If you know/believe that your water flow rate is higher than the one from size 1/2, choose the next size.

2. Step: Manufacturing of the frame (optional)

Tools needed:

- Flat steel sheet (5 mm)
- Galvanized angle profile (5 mm)
- Angle grinder
- Manual arc welder



Steps

1. **Define** the dimension of your frame based on the width and height of the V-notch weir.

2. **Cut and weld** the angle profiles to create the frame (marked with red).

> Add 3 small flaps on each side of the front of the frame so that the V-notch weir can slide in (marked in green).

3. **Cut and weld** 5 cm of flat sheet to the sides and bottom of the frame to fix the frame to the soil.

4. **Add** some flat sheet between the vertical walls of the frame for reinforcing.

2. Step: Drive the V-notch weir (or frame if manufactured) into the soil

Tools needed:

- Shovel
- Hammer

Steps

1. **Drive** the gate into the soil were the water flow is the less turbulent in your channel. The weir/frame should be placed in the middle of the channel.

The turbulence of the water flow in the channel should decrease in downstream direction. Choose a suitable place as downstream as possible where you can place your frame or weir.

(If frame is used)

2. **Slide** the V-notch weir into the frame.

4. Step: Measure head H

Tools needed:

- Meter rule

Steps

1. **Open** the intake and let water run through the channel and weir.
The system should look like in the picture on the left.

If water flows over the weir shoulders, the weir size is too small!
Repeat the process from Step 1 with the next bigger size.
Remember that the channel must have the same width as the weir.

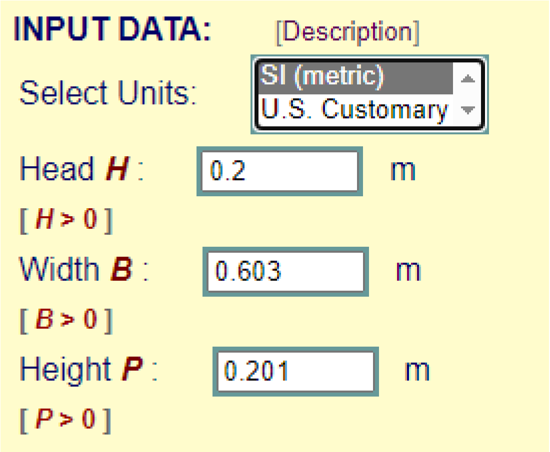
2. **Measure** the water depth at the crotch.
It should be in the range of H for your chosen weir size (see table).

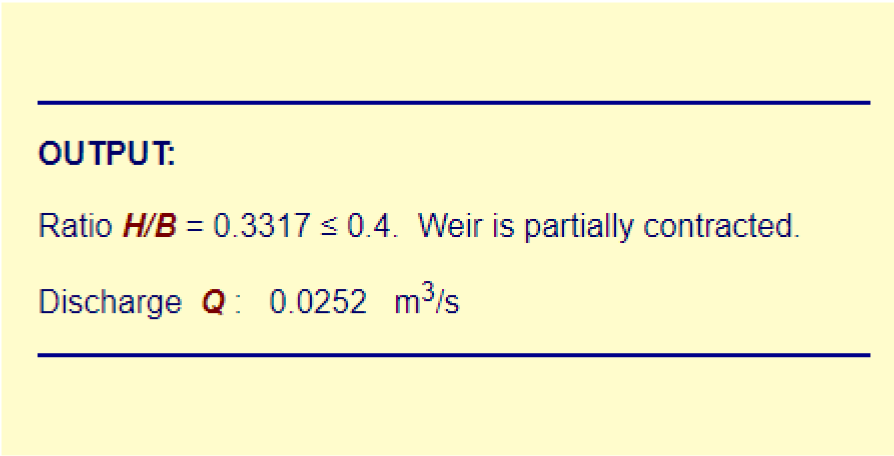
Size	H [cm]	Q [l/s]
1	18.3 – 24.1	up to 40
2	24.1 – 28.3	up to 60
3	28.3 – 31.7	up to 80
4	31.7 – 34.6	up to 100

5. Step: Calculate water flow Q

Tools needed:

- Computer or smartphone and internet





Steps

1. **Go** to ponce.sdsu.edu/onlineveenotch2.php and input your data in the input boxes.

> 1. Check the box with the “SI (metric)” units.
> 2. The inputs for H, B and P have to be in meters (ex. 0.201).

2. **Click “calculate”** and check if ratio H/B is between 0.2 and 0.4. The program should confirm that the “weir is partially contracted”.

3. If no warning is given, **read** the water flow Q from the output Q is given in m^3/s → multiply by 1000 for l/s.

> **Congratulations!**
> You have measured the water flow rate of your system.

4. Close the intake gate, remove the V-notch weir and frame and continue with the instructions of the waterwheel.

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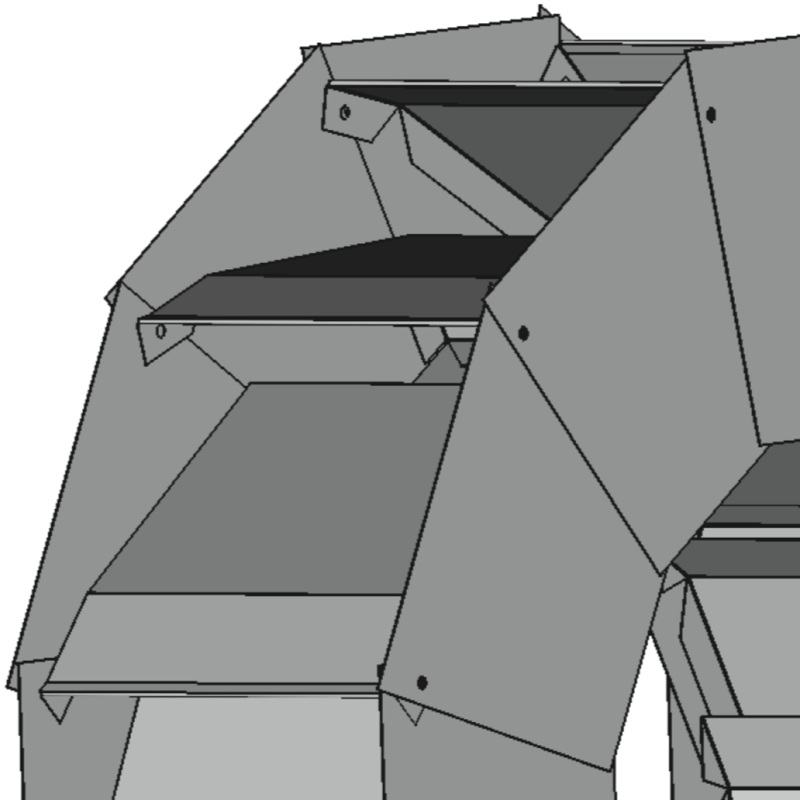

NEPAL WATERWHEEL PROJECT