

## Lab 11: Flooding I --- Understanding the Workings of Streams

### Introduction

Floods are a natural part of a stream's development cycle. Small floods occur on almost a yearly basis, whereas large floods may happen on once a decade or perhaps once a century. For thousands of years, humankind adjusted their activities to the natural flooding cycles of the rivers and coasts they lived beside. Still, humans have tried to modify the behavior of streams to satisfy their own goals. In modern, times the scale of these modifications have become truly astounding. Yet, while the human costs of floods have decreased in developed nations, the cost in terms of property loss continues to climb. Indeed, it is now apparent that many of the modifications humans make to streams have increased the frequency and magnitude of flooding. Clearly, a better approach to flooding requires a sound understanding of the geologic processes of streams.

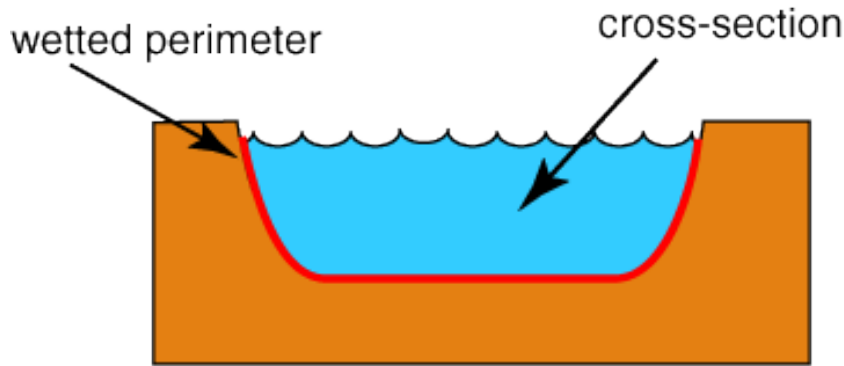
### Stream Velocity & Channel Characteristics

The velocity of a stream is a complex function of interacting factors:

- **stream gradient:** the ratio of the distance that a stream falls vertically to the horizontal distance traveled. The horizontal distance traveled is measured along the channel of the stream. For meandering streams, this distance can be significantly longer than the straight-line distance separating two points. All other factors being equal, the steeper the gradient, the faster the water in a stream will flow.
- **width and depth of the channel:** friction along a channel wall slows moving water. Because they have a greater area of water in contact with their banks, wide shallow rivers experience more friction than narrow deep ones and have lower velocities. The lack of friction in the center of a stream allows water farthest from the stream walls to travel faster than that near the banks or bottom.
- **roughness of the channel bed:** rocks and boulders are obstacles to stream flow. Thus, a stream with a rocky bed will have a slower velocity than a similar stream with a smooth bed.

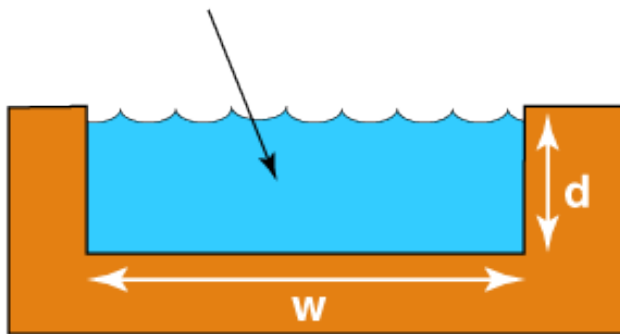
### Cross-section

The width and depth of a channel are important in determining the behavior of a stream. Given these quantities and knowledge of the geometric form of the channel bed, two important parameters of stream flow, the cross section and the wetted perimeter, can be calculated. The **cross section** of a stream is simply the area occupied when it is cut by a plane perpendicular to the channel.



For a rectangular channel, the cross section is simply the width times the depth.

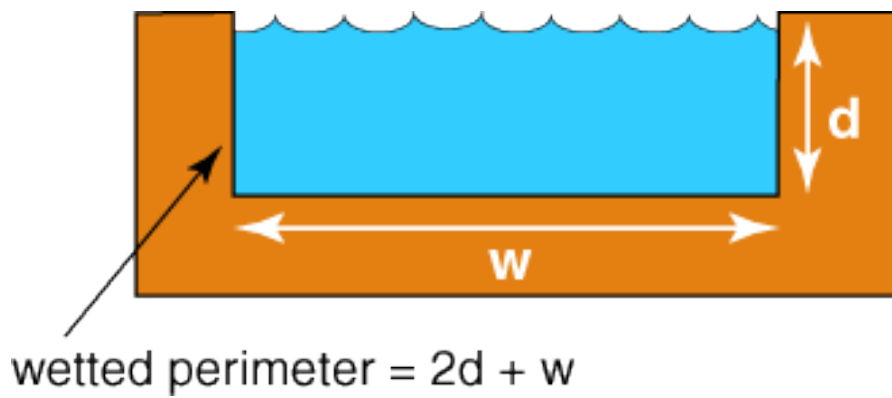
cross-section =  $w \cdot d$



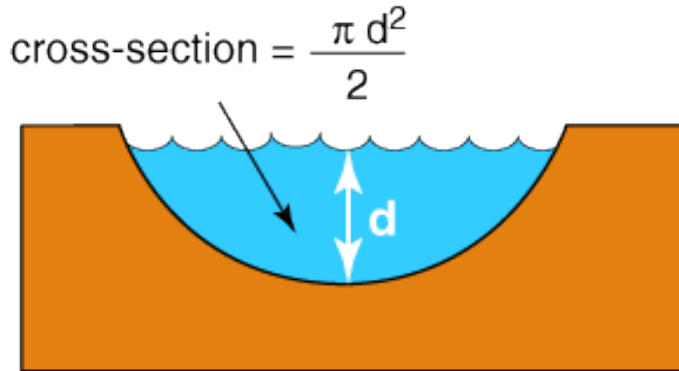
For a semi-circular channel, the cross section is  $0.5(\pi)r^2$ .

### Wetted Perimeter

The **wetted perimeter** is a measure of the amount of surface contact between the water in a stream and its channel. It is calculated from the width and depth of the channel and is determined by the geometric shape. For a rectangular channel, the wetted perimeter is simply the width plus twice the depth (the two sides).



If the channel shape is semi-circular in outline and the radius of the channel is  $r$ , the wetted perimeter is half the circumference ( $2 \cdot (\pi) \cdot r$ ):



### Manning Equation

The relationship between stream velocity and cross section, wetted perimeter, gradient and bottom friction is complex. Several equations have been used to describe this relationship. One, the **Manning equation**, has the following form:

$$\text{velocity} = \frac{\left( \frac{\text{cross section}}{\text{wetted perimeter}} \right)^{\frac{2}{3}} \cdot \sqrt{\text{gradient}}}{\text{frictional coefficient}} = \frac{\left( \frac{A}{wp} \right)^{\frac{2}{3}} \cdot \sqrt{s}}{fc}$$

where  $A$  is cross section,  $s$  is gradient or slope, and  $fc$  is the frictional coefficient. The frictional coefficient is a measure of the roughness of the bed and varies from about 0.1 to 1.

### Discharge

One means of measuring the energy of a stream is its discharge. **Discharge** is the amount of water that flows through a channel in a specified amount of time. It is measured at a particular point along a stream and expressed as  $m^3/s$ . Discharge, cross section, and stream velocity ( $v$ ) are related by the following equation:

$$\text{discharge} \left( \frac{m^3}{s} \right) = \left[ \text{cross section} (m^2) \right] \cdot \left[ \text{velocity} \left( \frac{m}{s} \right) \right] = A \cdot v$$

Because the water in the main stream is continually added to be the tributaries, discharge increases downstream. To handle this increase, stream channels become deeper and wider with a corresponding increase in stream velocity (the cross sectional area increases greatly with limited increase in wetted perimeter).

## Reference

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