Stream and Watershed Ecology

Susan Bolton
Bloedel 244
sbolton@uw.edu

Stream and Watershed Ecology

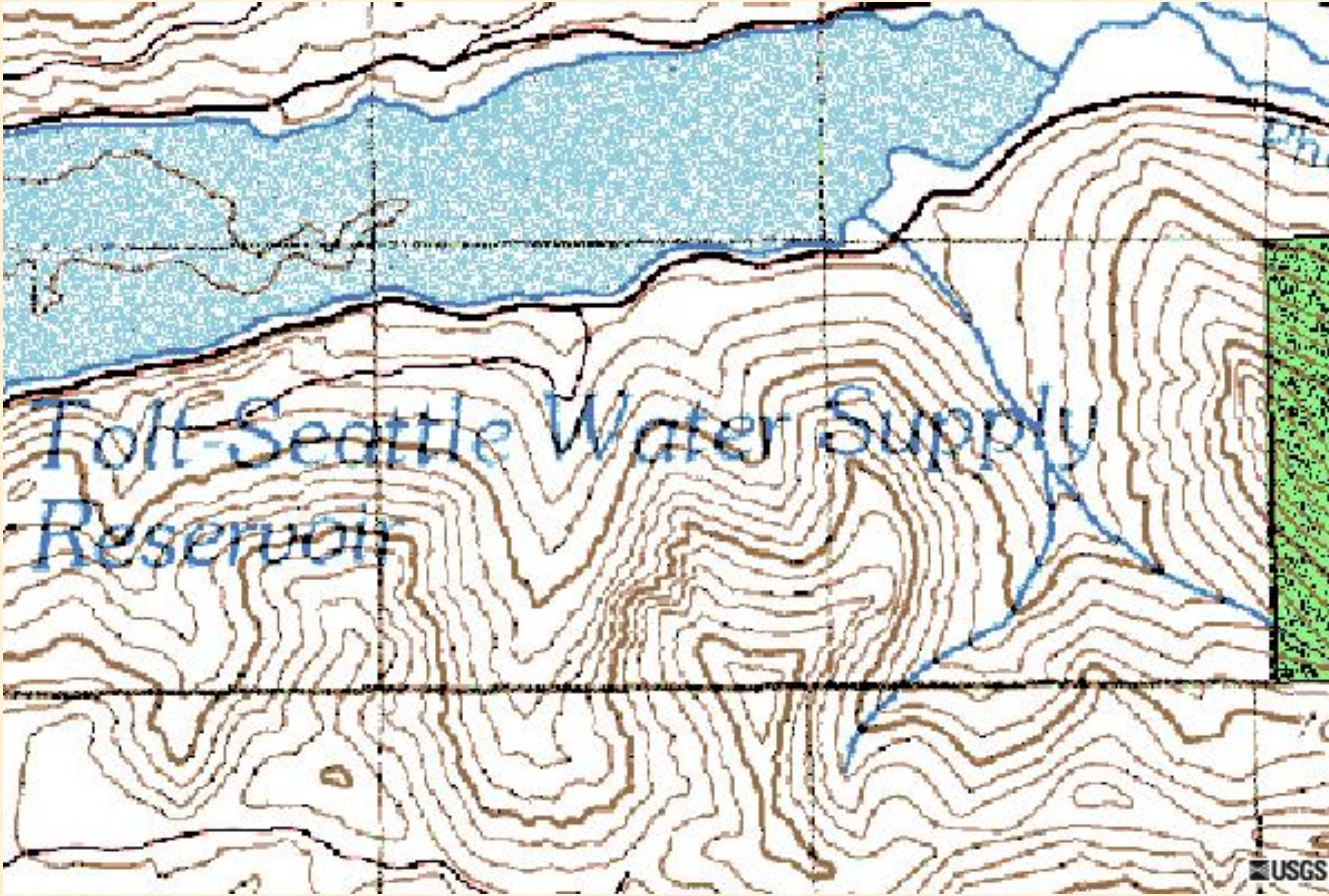
- Ecology is the interaction of the biotic (living) environment and the abiotic (non-living) environment
- In this module we will learn about important stream habitat-forming processes and how to do a quick assessment of these processes
- More specifically students will learn:
  - what a watershed is,
  - who typically collects data,
  - what kinds of data are typically collected
  - how to collect and analyze some types of data
  - human effects on streams and hydrology

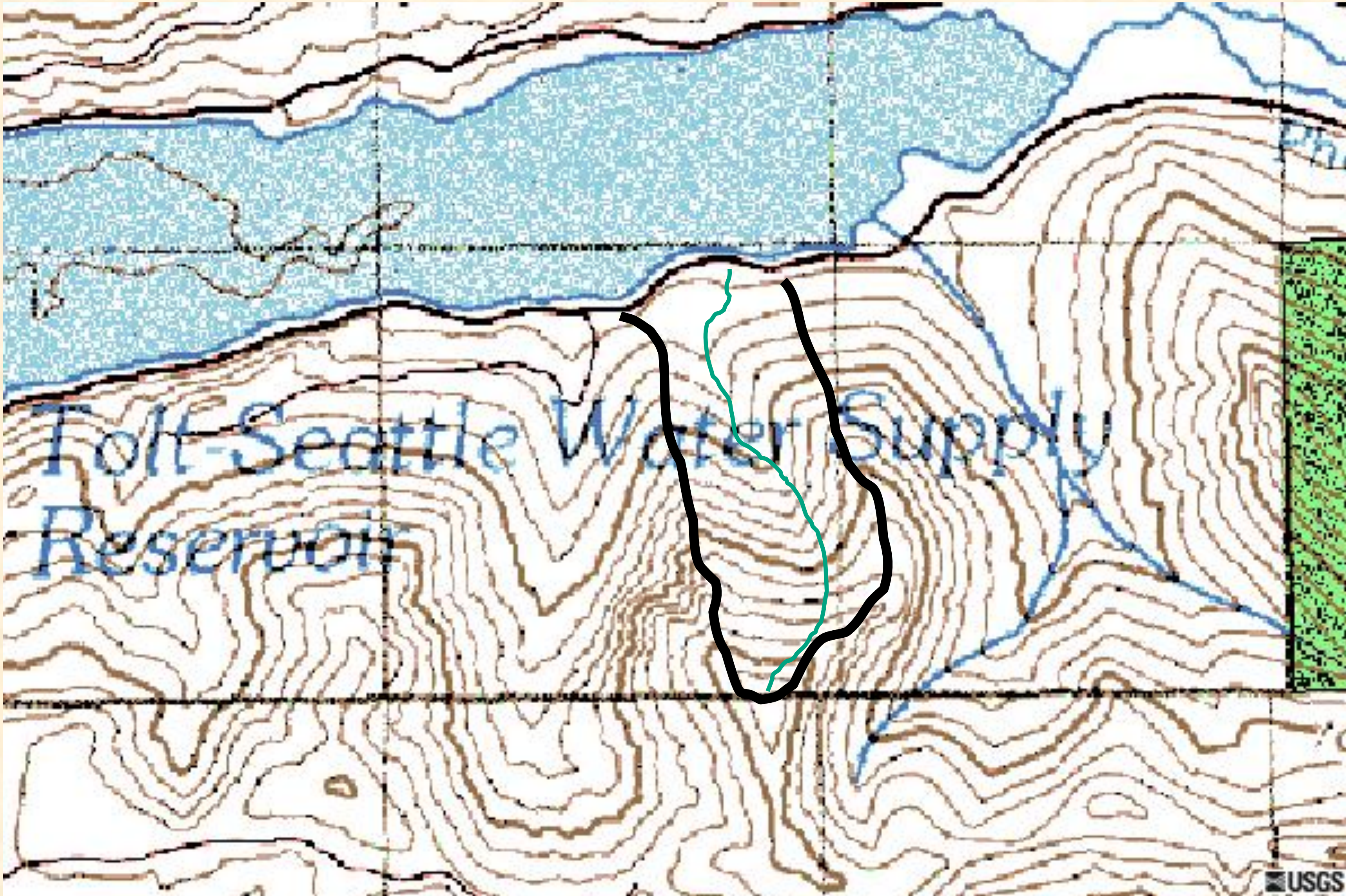
Learning Objectives

- What is a watershed?
- Who measures water and watersheds?
- What do they measure?
- How do they measure and analyze it?
- Human effects and management of watersheds

What is a watershed?

- The land area that drains into a selected stream point or water body
- Can by very small or very large
- Called catchments in the rest of the world
- Usually based on surface topography- subsurface features may not mimic surface ones as far as drainage is concerned


Tolt-Seattle Water Supply
Reservoir
USGS


Tolt-Seattle Water Supply
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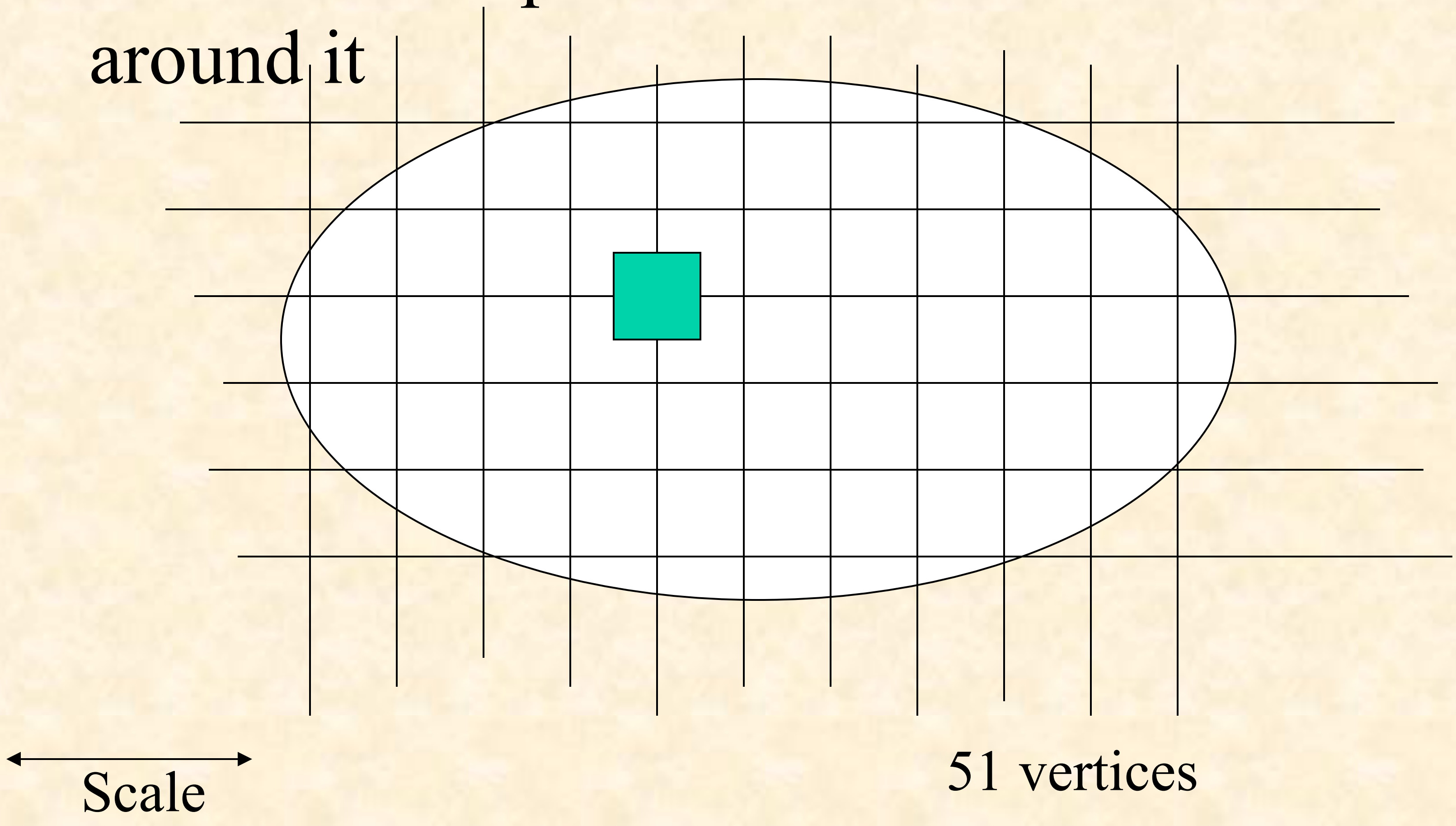
USGS

Graphic method of measuring area

Count the vertices within the area

- Each vertix represents the center of the area around it



Graphic method for area

- Trace your watershed on vellum or other transparent paper
- Lay the area over gridded graph paper
- Count the number of vertices
- Use the scale on your map to figure out how much area one square of your graph paper represents
- Multiple the area of one square by the number of vertices you counted

Other measurement methods

- Can trace, cut and weigh your watershed
- Can trace your watershed using a planimeter
- Can use GIS or other electronic methods if you have the data layers
- Can do a site survey with a level and rod or GPS

Watershed areas

- Area is a basic piece of information that one needs for many purposes, e.g.,
  - Trees /area
  - Runoff / area
  - Soil nutrients / area
  - Watershed area defines the area that delivers water, sediment, organic matter and nutrients to a water body

Who measures watersheds?

Who measures water and watersheds?

USGS- US Geological Survey
USBoR – US Bureau of Reclamation
USACOE – US Army Corp of Engineers
USFS – US Forest Service
NRCS – National Resources Conservation Service
USEPA – US Environmental Protection Agency
USFWS – US Fish and Wildlife Service
NOAA – National Oceanic and Atmospheric Administration
- NMFS – National Marine Fisheries Service
- NWS- National Weather Service

TRIBES
Cities, counties, states, schools

Watershed assessment methods

- ***Many of the organizations we mentioned the first week of class use some sort of watershed assessment technique to characterize landscapes***
  - Each organization has slightly different procedures.
  - There are many examples on the web, e.g., any of the 62 Washington state WRIA (Water Resource Inventory Area)
    - http://www.ecy.wa.gov/services/gis/maps/wria/wria.htm
  - WA Dept of Natural Resources (DNR)
    - http://www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesHCP/Pages/fp_hcp.aspx

Watershed assessment methods

- ***Hydrologic regime***
  - Analyze stream flow records for changes in **peak flows** (maximum), **flow durations** (how long a flow lasts), **base flows** (normal low flow), etc.
  - Compare flow records with precipitation data
  - Assess connectivity changes in watershed, e.g. dams, diversions, levees, impervious area

Watershed assessment methods

- ***Organic matter input processes***
  - Assess riparian and floodplain forest/vegetation conditions
  - Identify current and historic fire return patterns

    PNW data source on fire history

    www.fs.fed.us/pnw/fera/research/climate/fire_history.shtml

Watershed assessment methods

- ***Nutrient input processes***
  - Assess background inorganic inputs based on geologic and soils maps
  - Assess inputs from anthropogenic sources such as dryfall and wetfall deposition
  - Point and non-source inputs
  - Current or former seasonal inputs such as spawning fish and leaf fall

Watershed assessment methods

Sediment supply and erosional processes

- Quantify landslides and estimate sediment budgets
- Assign landslide hazard ratings to roads and hillslopes
  - DNR http://www.dnr.wa.gov/BusinessPermits/Topics/LandslideHazardZonation/Pages/fp_lhz_review.aspx
  - Seattle http://www.ecy.wa.gov/programs/sea/landslides/maps/maps.html
- Map surface erosion areas such as unpaved roads, bare areas, construction zones

Watershed assessment methods

- ***Light and heat inputs***

  - Assess current and historical shade/canopy conditions in stream and floodplain
  - Assess current and historic turbidity levels in streams

What do we typically measure in streams and watersheds?
General categories

Land cover/land use, e.g. vegetation,
impervious area

Physiography – soils, geology, topography

Climate – precipitation, temperature, wind, humidity, streamflow, etc.

Examples of more specific measurements related to stream ecology

- Precipitation
- Organic input to streams – LWD
- Nutrient input to streams- leaves, salmon
- Sediment input to streams
- Light and heat inputs to streams
- Biological communities in or adjacent to streams
- Streamflow – quantity, timing, duration and quality
- Channel characteristics –
  slope, bank full width, substrate, pools, riffles

What do we want to know about precipitation?

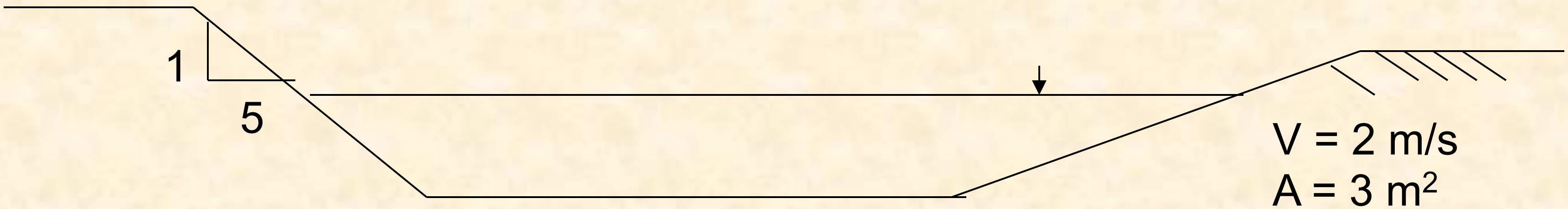
- Quantity (how much)
- Intensity (rate) (how much over how long)
- Temporal variation
- Spatial variation
- Form (solid, liquid)

Precipitation gage

What do we want to know about stream channels?

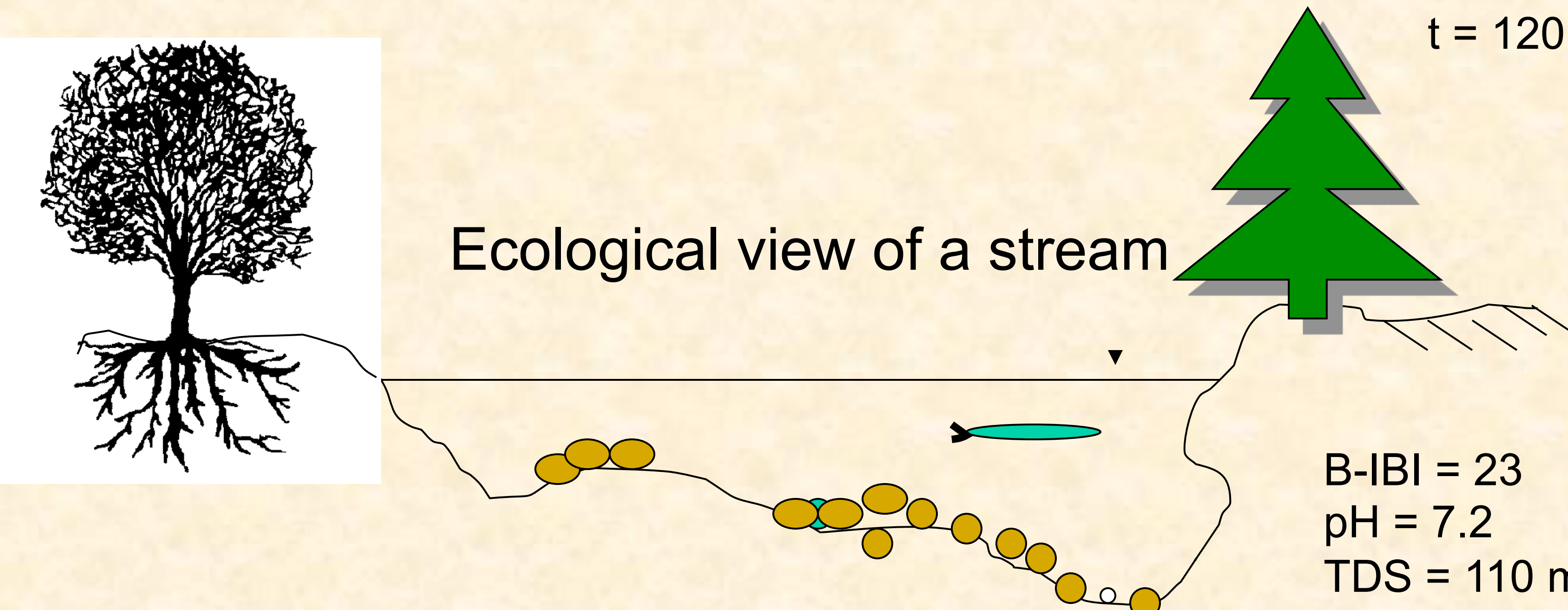
- Slope
- Width
- Type
- Substrate
- Form

Engineering view of a stream



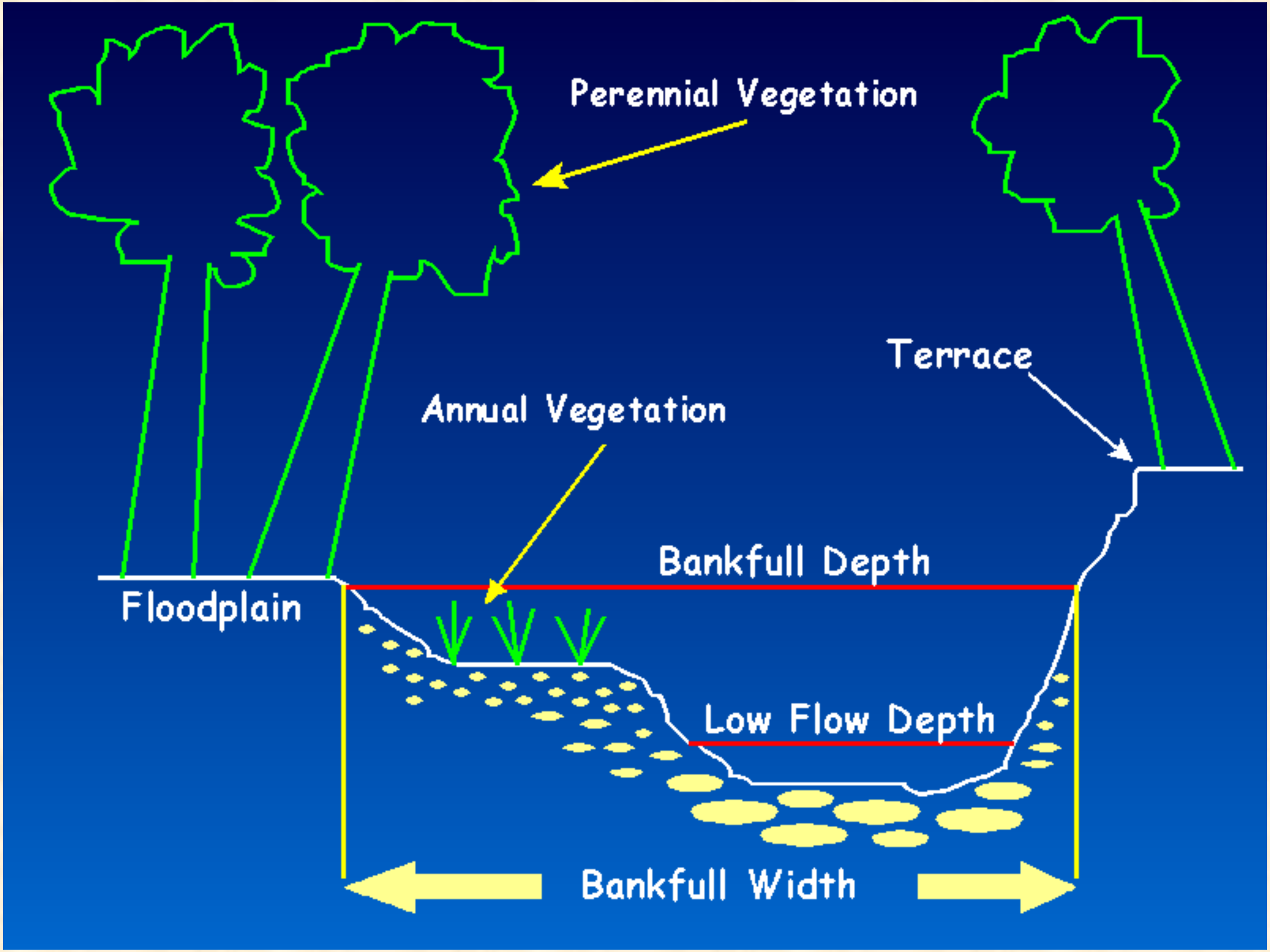
V = 2 m/s
A = 3 m^2
n = 0.04
t = 120 N/m^2

Ecological view of a stream



B-IBI = 23
pH = 7.2
TDS = 110 mg/l
DO = 8.3 mg/l
D_{50} = 10 cm

Adapted from Gordon et al. 1992



Slide by Jeff Grizzel

Bankfull Width

- Why Is It Important?
  - Water typing system dependent on bankfull width (Type F waters)
  - Riparian Management Zones begin at bankfull channel edge
  - RMZ Inner Zone width is dependent on bankfull width
  - Bankfull width is used in determining appropriate culvert sizing
- How Is It Defined?
  - Lateral extent of water surface elevation at bankfull depth; bankfull depth is water surface elevation required to completely fill the channel to a point above which water would spill onto the floodplain

Slide by Jeff Grizzel

Water types in Washington

- S – shorelines
- F – Fish bearing
- Np – Non fish bearing but perennial flow
- Ns – Non fish bearing, only seasonal (intermittent) flow

www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesApplications/PermitPages/fp_watertyping.aspx

Discharge Measurement

Slide from U. Mass. Boston

How do we measure how much water is in a stream?

- Volumetric measurements-
  - Works for very low flows, collect a known volume of water for a known period of time

    Volume/time is discharge = Q
- Cross-section/velocity measurements
- Dilution gaging with salt or dye
- Artificial controls like weirs

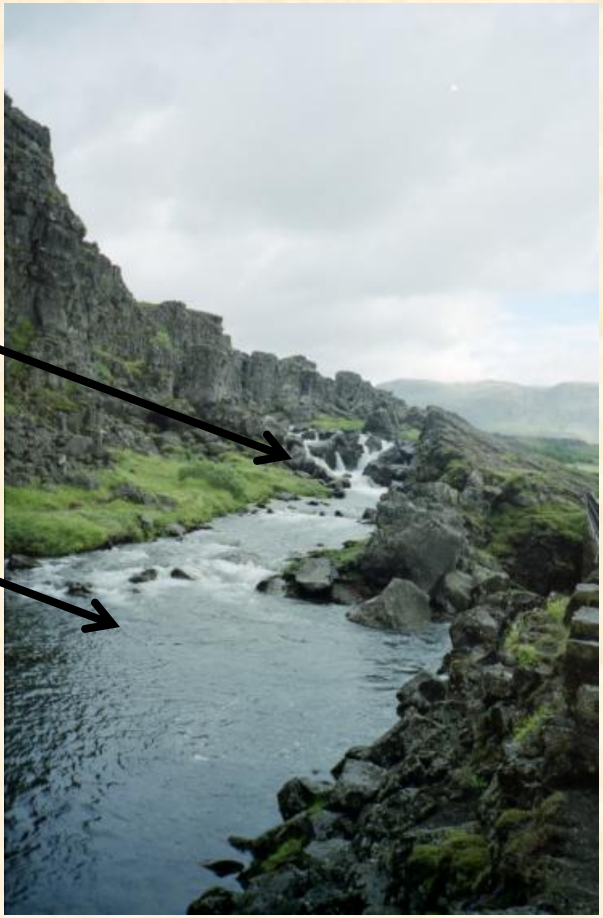
Velocity – Area Method of discharge measurement

By measuring the cross-sectional area of the stream and the average stream velocity, you can compute discharge

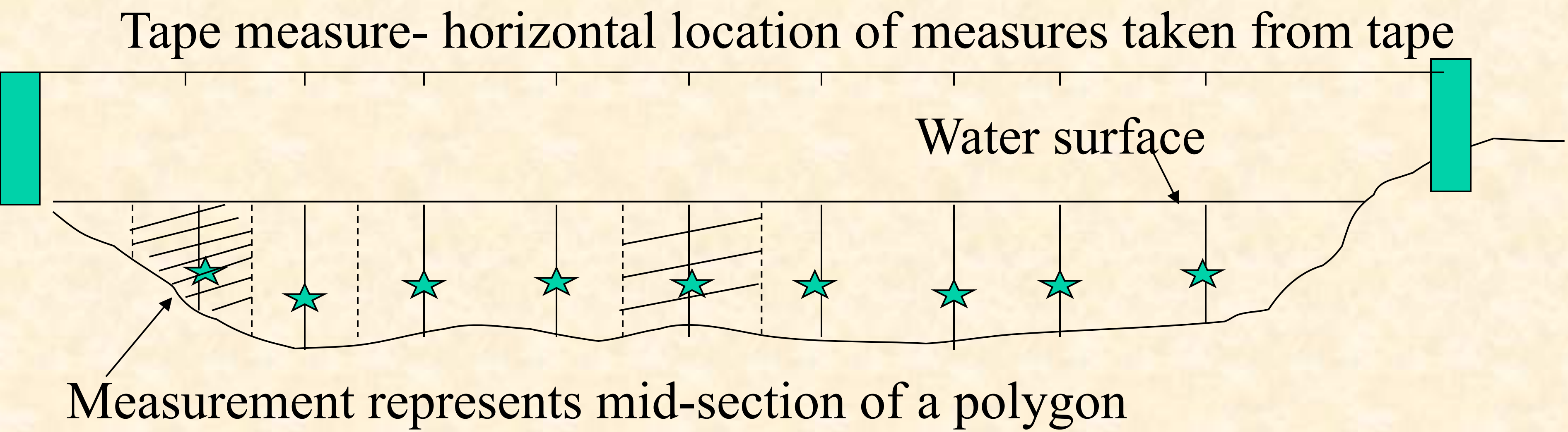
This is a continuity of mass equation

$Q = VA$ units are L^3/t (volume / time)
= discharge

Where Q is discharge
V is velocity
A is wetted cross-sectional area
and depth = width x depth



Velocity – Area method of discharge measurement

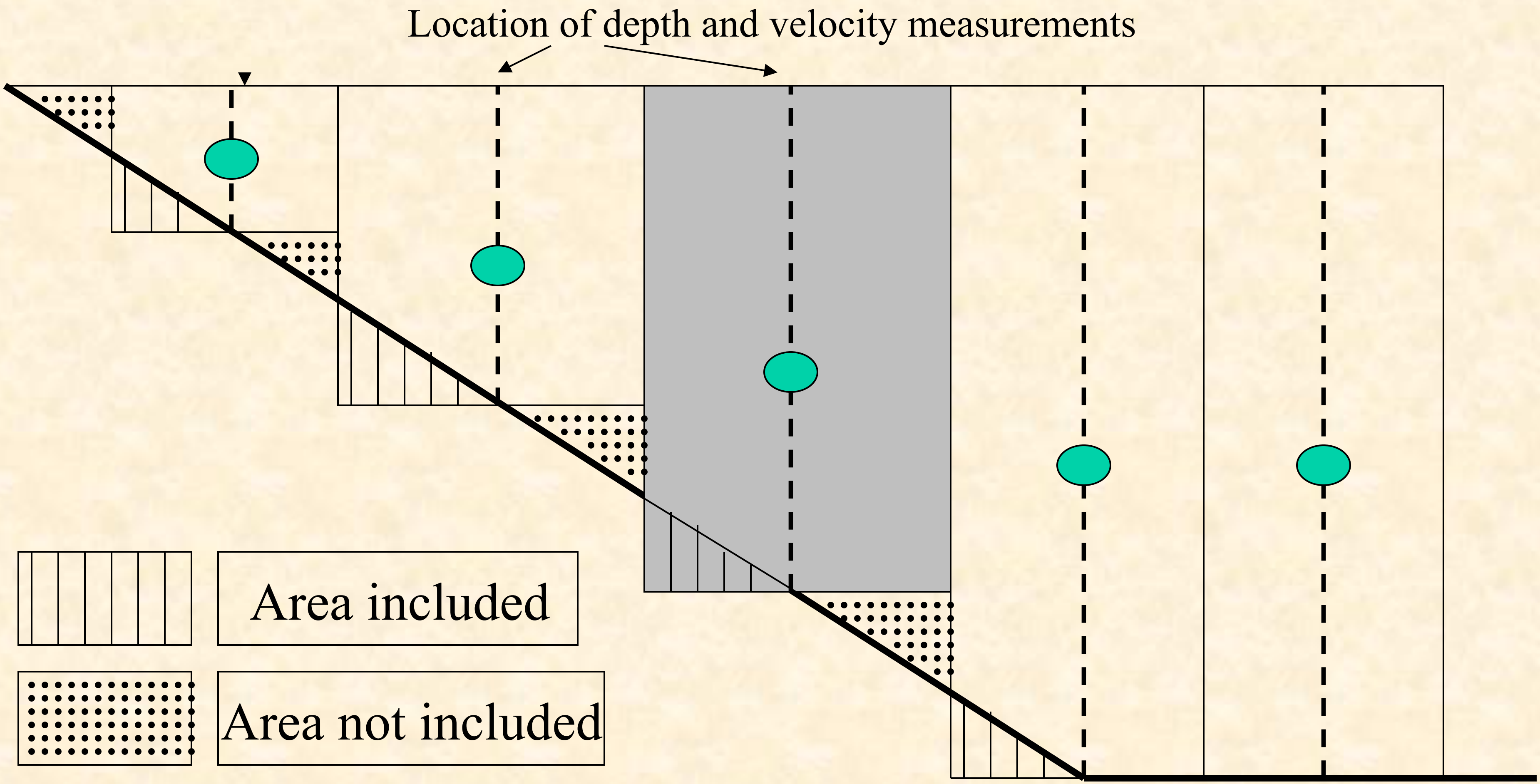


★ Velocity measured 0.6d from water surface (0.4d from bottom)

Record **x** value (tape value), **y** value (water depth at measurement site, and **velocity** at 0.6d (you will have 3 values recorded at each spot)

Photo from Black Hills State University

Mid-point method of calculating discharge (Q)



Key Assumption: Over estimation (area included) = Under estimation (area not included), therefore cross-section area is simply the sum of all the sections (rectangles), which is much easier than taking the integral! **However, the hypotenuse of each over-under estimation triangle can be used to calculate the wetted perimeter.**

How many subsections?

- Subsections should be at least 0.3 feet or ~0.1 m wide
- Each subsection should have 10% or less of total discharge (i.e., if flow is deep and fast measurements should be closer together and if flow is shallow and slow they can be farther apart)
- Number of subsections should be doable in a reasonable amount of time!

Equation for computing subsection discharge - q_i

Equation for computing q in each subsection

X = distance of each velocity point along tape

Y = depth of flow where velocity is measured

V = velocity

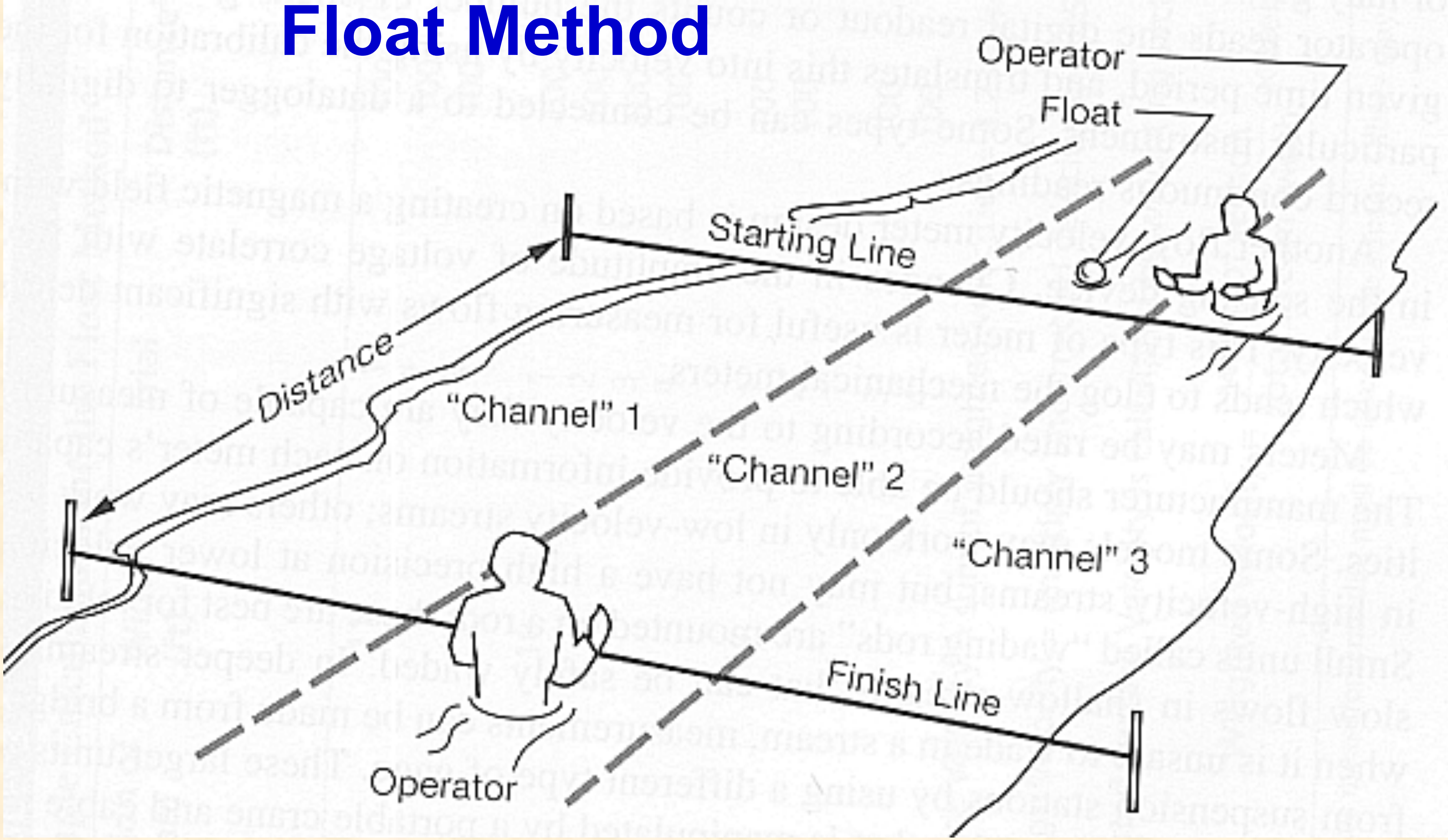
$$q_i = y_i \times v_i \times \left(\frac{x_i - x_{i-1}}{2} + \frac{x_{i+1} - x_i}{2} \right)$$

$$Q = \text{total discharge} = \text{sum of } q_i = \sum_{i=1}^{n} q_i$$

Float method of discharge measurement

- Gives reasonable estimates when no equipment is available
- Use something that floats that you can retrieve or is biodegradable if you can't retrieve it
  - E.g. oranges, dried orange peels, tennis balls, leaves, twigs

Float Method



surface velocity = distance / time

average subsurfacevelocity ~ (0.8*surface velocity)

Float method of velocity measurement

Three people are needed to run the float test. One should be positioned upstream and the other downstream a known distance apart, one in the middle to record data.

The upstream person releases the float and starts the clock and the downstream person catches the float and signals to stop the clock. The recorder writes down the time of travel of the float.

Velocity is the distance traveled divided by the time it takes to travel that distance. Velocity = distance/time

You should conduct at least 3 float tests and take an average velocity. This gives you surface velocity which is <u>NOT the same as average subsurface velocity</u>

With an estimate of cross-sectional area, discharge can be computed as Q = VA where V is average *subsurface* velocity (need to use correction factor)

Channel Substrate

- Substrate size (particles that line the channel) is an important component of habitat
- Substrate size is important for fish habitat and macroinvertebrate habitat
- Changes in land use/land cover can change substrate size distributions

Substrate categories

1. Sand, silt, clay. <0.25" or <0.8 cm (*smaller than pea size*)
2. Gravel. 0.25" -1" or >0.8-2.5 cm (*pea to golf-ball size*)
3. Large Gravel. >1" - 3" or >2.5-7.5 cm (*golf-ball to baseball size*)
4. Small Cobble. [>3"-6" or >7.5-15 cm (*baseball to cantaloupe size*)
5. Large Cobble. >6"-12" or >15-30 cm (*cantaloupe to basketball size*)
6. Small Boulders. >12"-40" or >30cm-1.0 m (*basketball to car-tire size*)
7. Large Boulders. >40" or >1.0 m (*greater than car-tire size*)
8. Bedrock

Substrate expectations

- Pools usually have finer substrates
  - Velocity in pools is slower and finer particles settle out
- Riffles usually have coarser substrates
  - Velocity in riffles is faster and finer particles are swept downstream

Examples of organisms used as bioindicators

Large mouth bass

Muskellunge

Midge

Caddis fly

Stonefly

Mayfly

Riffle beetle

Photos from www.epa.gov/bioindicators/html/photos_fish.html and www.epa.gov/bioindicators/html/photos_invertebrates.html

Aquatic Invertebrates

- Stream invertebrates are frequently used as bioindicators
- Benthic index of biotic indicator (B-IBI) uses numbers and species of aquatic invertebrates to assess stream condition

What will we do in the field on Tuesday and Wednesday?

- Go to a small stream at St. Edwards State Park (weather permitting):
  - Discuss low flow measurement issues
  - Assess light, sediment, water, organic and nutrient inputs
  - Look for aquatic insects

- Go to a larger stream (Juanita Creek) and take velocity cross-sections in order to compute total flow volume (discharge): using two different methods **!!Please read the procedures before lab!!**

- Evaluate substrate, look for aquatic insects

- Everyone needs to be dressed appropriately for the weather and for standing in water (we have some hip waders)

- **We will leave the C-10 parking lot at 12:30 sharp!**