Sediment Trap Efficiency

Objectives and expected significance

The objective of this parameterization experiment is to determine the efficacy and efficiency of a commonly used best management practice (BMP) in the logging industry: sediment traps. Using a rapid and inexpensive experiment, we will develop an efficiency curve—a relation of the fractional reduction in sediment flux to how full the sediment trap is—that can be used to inform landowners whether and when these BMP are performing in the expected manner.

Background and motivation

Sediment traps are ubiquitous in industrial lands. A typical sediment trap is dug out by an excavator at the end of a ditch line as a final treatment of water quality before sediment-laden water from the road and ditch line is released to a water body. The traps vary in size but, on average, are approximately 4 cubic feet. The Washington Department of Natural Resources Forest Roads Guidebook (2018) states that sediment traps must be frequently monitored and maintained to keep them functioning properly.

As common as sediment traps are, though, few data are available regarding their efficacy. Fortunately, the basic principle governing the behavior of sediment traps is the settling of particles (i.e., sediment) as the velocity of water is temporarily slowed (see figure 1). Conceptually, this design base contrasts particle-settling-time versus water-residence-time. While such a design could be tested in a real ditch with trials over the course of several years, a more cost-effective approach can be used for bounding expected performance in a lab-like setting. We propose a more active experimental format to test the performance of this treatment rapidly and inexpensively.

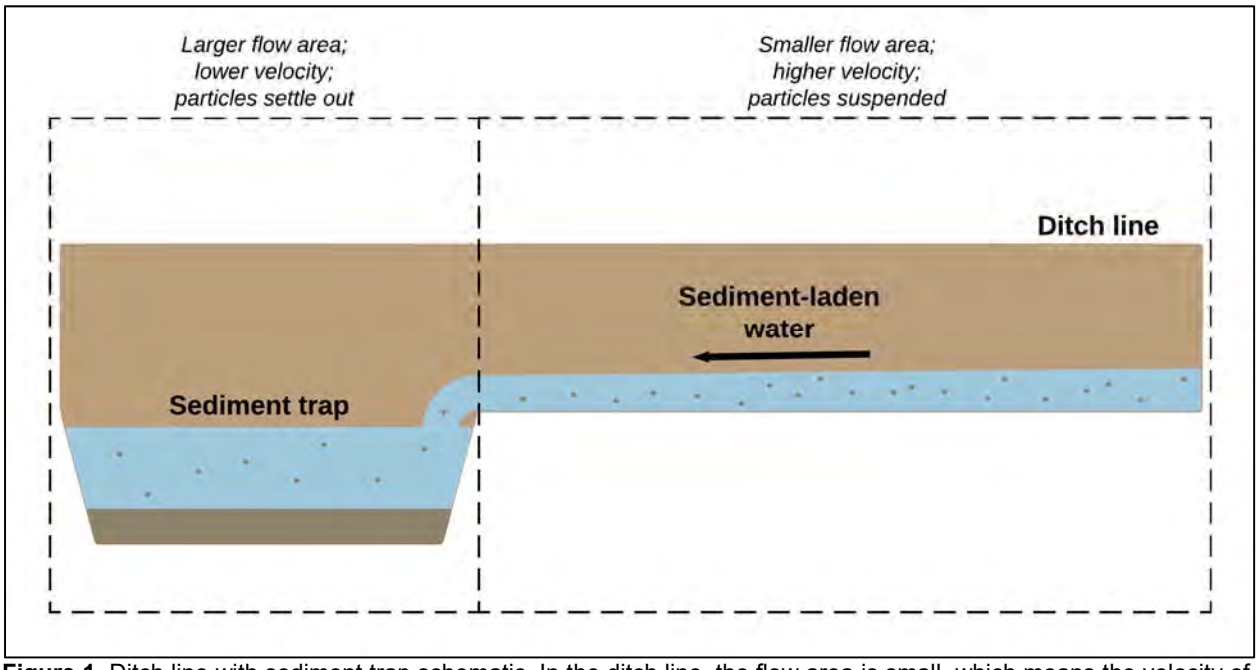

Figure 1. Ditch line with sediment trap schematic. In the ditch line, the flow area is small, which means the velocity of the sediment-laden water is high. Once this water hits the sediment trap, the velocity decreases because the flow area increases, thus allowing the sediment particles to settle out.

Experimental setup

This experiment is set to take place in Spring 2021 and will be conducted in a location with readily available water and capacity to weigh sediment*.

The basic design is shown in figure 2. We will use half of an oil barrel on its side as the sediment trap (approx. 25 gallons or 3.3 cubic feet). The half-barrel and a surrounding catch basin will be set nearly level with a 10- to 15-foot length of double-wall, 18-inch plastic culvert acting as a flume set on a 3% grade feeding it. The culvert will be fed water by a sediment-free water source (e.g., a portable fire pump). Pre-sieved sediment (from two sources—one from each lithology in the Major Experiment, volcanic and siltstone) will be shoveled into the flume for the water to carry to the trap. Outlet water from the trap will be caught in the catch basin. The sediment trap/catch basin combination will be weighed using either a hanging scale or a ground scale—whichever is deemed more viable once the experiment setup is created.

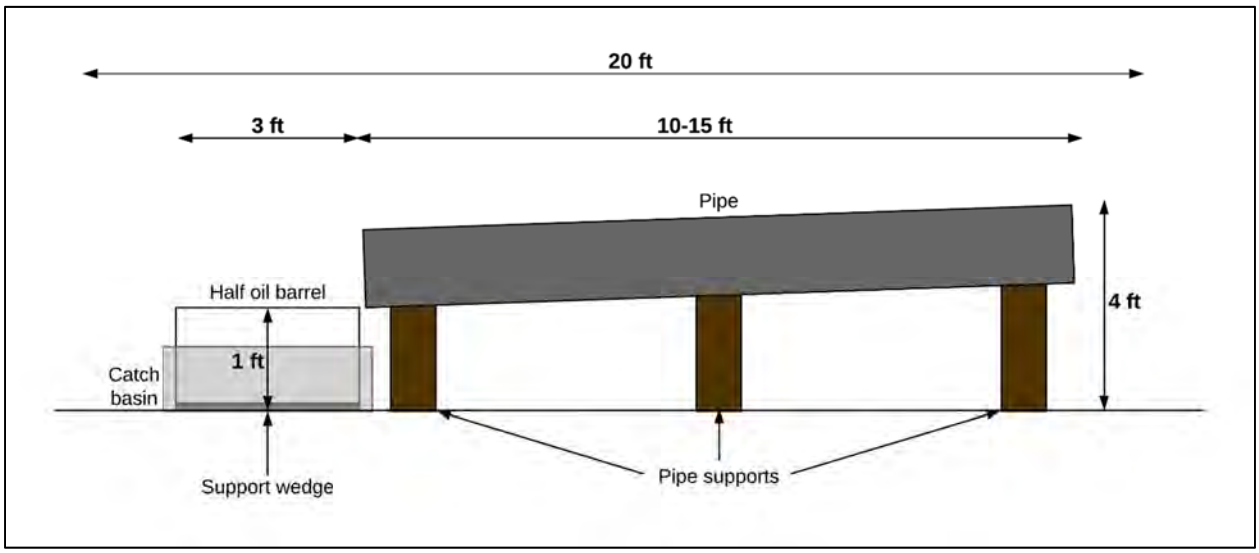

Figure 2. Experimental setup schematic.

Approach

1. Prior to running any water
    a. Sieve sediment from each source to obtain fraction of sediment finer than 2 millimeters
        i. We expect each source to have strong contrasts in clay/fine silt content and, thus, different grain size distributions (GSD)
        ii. We will need approximately 1 cubic yard of sieved sediment from each source
2. Experimental runs will be carried out for each GSD at the 85th percentile flow rate (i.e., a fairly high flow rate during which we expect to see sediment moving)
    a. Shovel sediment (0.5 cubic yard per run) in by hand while water is running
        i. Try to maintain constant feed rate
    b. Weigh sediment trap continuously throughout experimental run
        i. Use either a hanging scale or a ground scale to weigh the catch basin/sediment trap
    c. Flow rate: 64 gal/min
        i. This rate reflects the 85th percentile flow rate expected for an 80-meter road segment (based on a simple hydrologic calculation for 10-minute precipitation intensity)
    d. Each run will be carried out until we have routed 0.5 cubic yards of sediment through the system
        i. 2 runs per GSD at 85th percentile flow rate
        ii. 4 runs total

*Most likely the Rayonier Pacific Resource Unit in Forks, WA.

3. After experimental runs (more details in Analysis)
    a. Weigh the sediment trap
    b. Particle size analyses for the input soils and trapped sediment

Analysis

This experiment will give us data regarding sediment trap efficiency both instantaneously and over time. During the experimental runs, the sediment trap will be weighed continuously, which will give us an idea of how much sediment is held within the trap at any given time. These data will enable us to construct an efficiency curve—a plot of the ratio of trapped mass to the total mass over time—to see how the trap's efficiency changes over time.

At the end of the experiment, the sediment in the trap will be weighed to give us an estimate of the trapped mass. The total mass—the mass of the sediment placed in the flume—will be based on the weight of the sediment along with the moisture content taken from 5 samples (placed in soil tins for lab analysis). The ratio of the trapped mass to the total mass is the sediment trap efficiency over time. This piece of the analysis will allow us to inform landowners when to empty their traps (i.e., empty the trap once it has hit 75% capacity to ensure continuous operability).

Additionally, particle size analysis will be done on the input soils and trapped sediment to calculate the trap efficiency by particle size range. This will allow results to be extrapolated to other soils with different particle size distributions. These particle sizes will also be compared to the observed particle sizes of sediment from the Major Experiment to estimate sediment trap efficacy.

Equipment

- 10-15 feet of 18 in. diameter pipe on 3% grade
- Pipe supports
- Half an oil barrel
- Support wedge (for oil barrel stability)
- Catch basin
- Weighing apparatus
- Sieved sediment from each lithology
    - Approximately 1 cubic yard per lithology
- Water pump

References

Forest Roads Guidebook, 3rd ed. WADNR, Olympia, WA, USA, 2018.