A Battery Powered Proportional Stream Water Sampler

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Abstract. A stream water sampler was designed and tested to sample water from a stream at a rate proportional to the streamflow rate. A composite of samples taken in this manner is an estimate of the mean concentration of constituents carried by the stream while the sample was collected. The instrument is suitable for estimates of transport of suspended or dissolved constituents in small streams. The sampler can be built for under $1000.

INTRODUCTION

Sampling for water quality in small upland streams has always been a problem. Streams rise and fall rapidly during the storms that produce the largest portion of the sediment and dissolved constituents. The logistics of sampling these runoff events by hand is difficult, and after the samples are analyzed the job of interpreting the data may be even more difficult. The Pacific Northwest Forest and Range Experiment Station recognized these problems and developed a proportional stream water sampler.

Yield is one useful statistic for measuring the rate that materials move from the land into the stream. An instrument was designed that sampled for yield by pumping samples of constant volume from the stream at a rate proportional to the streamflow rate. The advantages of this design approach were (1) the intake velocity from the stream was standardized; (2) trash clogging at the intake pipe from the stream was minimized by a short pumping time; and (3) the short pumping time helped hold power drain within the power supplying capacity of wet cell batteries. In addition, this sampler design could simplify data analysis. An annual estimate of yield of each constituent can be made from laboratory analysis of 12 to 48 composite samples. Since the constituent concentration of each composite sample is an estimate of the mean concentration in the stream over the collection period, yield is simply the product of volume flow of water, the mean constituent concentration, and a suitable constant to equalize the units of measurement.

SAMPLER DESIGN

The following example explains the design of the proportional sampler. The expected maximum peak flow from a watershed, 8 cfs, is divided into 20 volumetrically equal classes of 0.4 cfs each. If one sample is taken in a base time of 10 hours in the lowest flow class and the number of samples progressively increases to 20 at the highest class, proportionality is achieved. The sampling rate for each class is the number of minutes in the base time (10 hours) divided by the number of samples assigned to each flow class.

Major components of the sampler are the streamflow sensing unit, timing control box, and sample trap as shown in Figure 1.

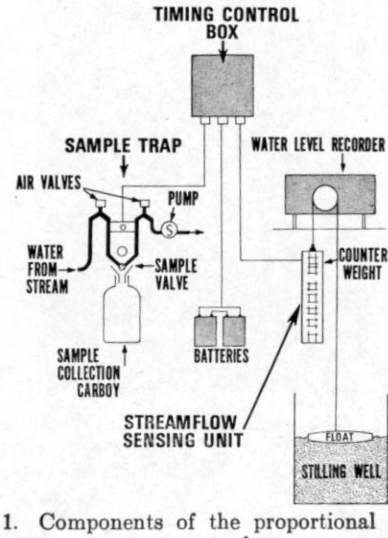

Fig. 1. Components of the proportional stream water sampler.

The streamflow sensing unit divides the expected range of flows into classes of equal volume flow (cfs). This unit is mechanically coupled to the water level recorder in a gaging station. The counterweight for the water level recorder moves in a guide behind a series of magnetic switches. The switches are spaced along the guide at the limit of each streamflow class (Figure 2). Magnets attached to the counterweight open and close the switches when there is a change in streamflow.

The timing control box provides the required time interval between samples for each streamflow class. Two stepping switches provide the timed intervals and are connected in cascade so that the first switch counts each pulse from a timing clock while the second switch counts the number of revolutions made by the first switch. The stepping switches are driven by a clock timer at 1.5-minute intervals. Because the counting system provides for sampling at multiples of 1.5 minutes, the time between samples varies somewhat from the calculated values. The small timing errors resulting from this approximation do not exceed 2.3% and average ½%. This unit can be constructed from off-the-shelf items.

The sample trap is the container for each sample pumped from the stream and composited in the carboy (Figure 3). Function of the sample trap is controlled by a multi-cam cycling timer in the timing control box. The timer starts

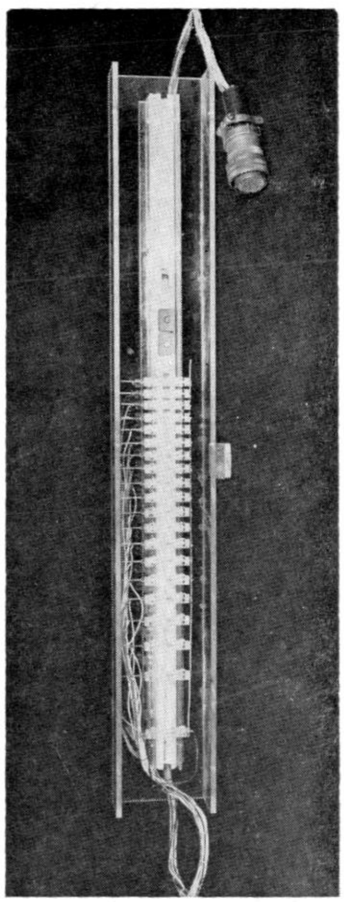

Fig. 2. The streamflow sensing unit divides the expected range of streamflows into 20 classes of equal volume flow. The counterweight on the water level recorder slides in a teflon guide. Magnetic switches are opened and closed by magnets on the counterweight with a change in streamflow.

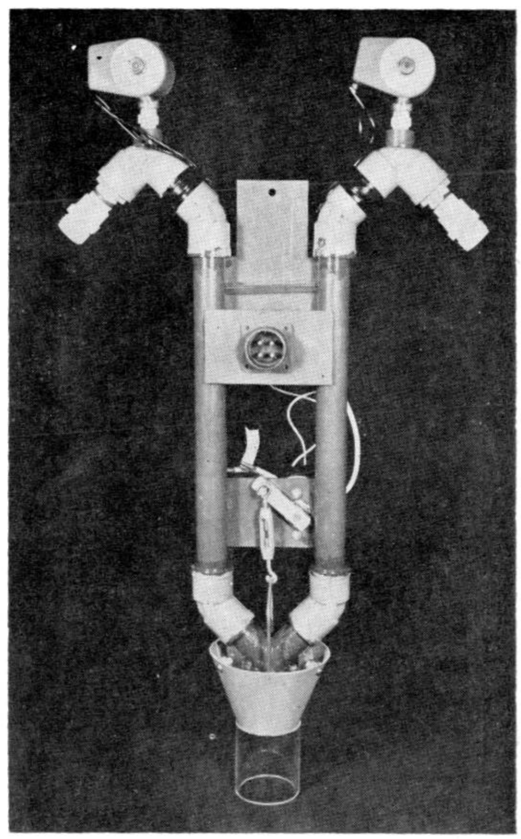

Fig. 3. The sample trap is equipped with air valves mounted on the top. A rotary solenoid operates the drain valve. The funnel fits a widemouth polyethylene carboy. Plumbing system from the stream attaches to the nylon hose connections. The trap is constructed of PVC pipe and fittings.

upon completion of a timed interval corresponding to the streamflow rate. For example, samples would be taken at hourly intervals for as long as streamflow remained within the 3.6 to 4.0 cfs class. Sample taking begins with pumping of water from the stream through the trap. When the pump stops, air valves open, venting the trap to atmospheric pressure. Then a teflon ball valve opens, and the sample drains into the carboy.

The proportion of streamflow collected is determined by the volume of water in the sample trap and the rate that the counting system (cascaded stepping switches) is advanced. A sample trap volume of 0.32 liter and a 1.5-minute timing cam are used for intensive sampling of streams for estimates of nutrient loss. Sample carboys are emptied weekly to biweekly at this sampling rate. Where less intensive sampling is required, we use a 3.75-minute cam. At this slower sampling rate, 5-gallon carboys are removed at monthly intervals. These combinations of sample trap volume and timing interval are satisfactory for streamflow conditions of small headwater streams in western Oregon. Sample volume and time may be varied to meet requirements imposed by access, regional stream hydrology, and objectives of the particular study. For example, in regions where extremely rapid stream rises are common, the sampling rate may be increased and the sample trap volume reduced proportionately to prevent overflow of the sample carboy.

Power for the sampler is supplied by two 12-volt automotive batteries connected in series. Batteries are charged at intervals of one to two months depending on streamflow and sampling rate.

All three components of the sampler can be built for under $1000.

ONE INSTALLATION IN THE WESTERN CASCADE RANGE

The installation shown in Figure 4 is part of a study of sediment and nutrient loss resulting from the harvesting of an old growth Douglas

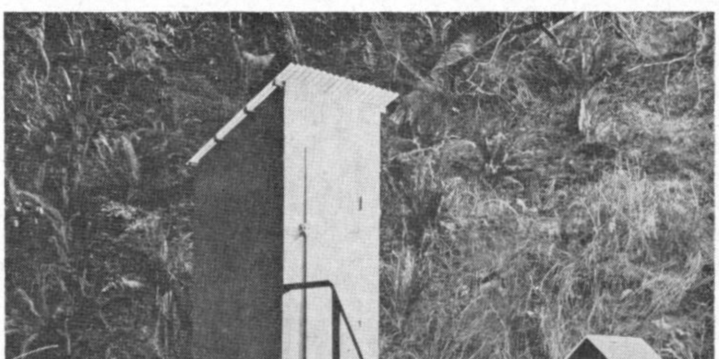

Fig. 4. A proportional water sampler samples streamflow from a 20-acre control watershed, part of a nutrient loss experiment. The study is located on the H. J. Andrews Experimental Forest 50 miles east of Eugene, Oregon.

fir forest on a 25-acre watershed. Samples are pumped from the box below the 2-foot stainless steel H-flume at an intake velocity of 5 feet per second. Suspended matter in the stream is mixed by turbulence in the box. Sample trap and pump are mounted in the small house in the right side of the picture. A propane pilot burner prevents freezing during cold weather. The other components of the sampler are mounted inside the gage house.

Five samplers are now operating on western Oregon streams: two at the H. J. Andrews Experimental Forest and three at the Bull Run City of Portland Watershed. Further details are available on request from the Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, P. O. Box 887, Corvallis, Oregon 97330.

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