HYBRID PASSIVE/AUTOMATED FLOW PROPORTIONAL FLUID SAMPLER

RELATED APPLICATIONS

This application follows from Provisional Application Ser. No. 60/194,964, filed on Apr. 5, 2000.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to devices for obtaining samples from moving fluids, such as rivers, streams, pipes, sewers, or irrigation canals.

Water sampling is essential to proper development and management of water and land resources. The need for a clear understanding of the effects of hydro-geomorphologic processes has become increasingly important. Processes such as erosion and fluvial transport of sediment and other associated constituents ("loads"), require accurate measurement of sediment and constituent content within bodies of water. Stream flow and constituent loads are the most important data collected for such an analysis and require flow measurements and water quality sample collection for determining representative concentrations of the constituents of interest. Some of the constituents of interest are suspended solids, phosphorous, nitrogen, and heavy metals. But, natural environmental factors such as geology, soils, climate, runoff, topography, drainage area, and ground cover make obtaining samples and data challenging. For example, in remote forests areas it has become important to monitor runoff to streams and rivers to determine the effects of logging, but obtaining reliable test samples is difficult.

Current monitoring of the hydro-geomorphic processes in stream locations is conducted either by "grab sampling" or by automated samplers. Manual grab samples, which usually provide accurate samples and flow measurements, have the disadvantages of requiring frequent trips to the test site and providing no guarantee of sampling during a runoff event. Current automated devices are versatile in that they are capable of sampling on a programmable time basis or a proportional stream flow basis, and therefore are able to sample during runoff events. Some of the major disadvantages of automated samplers are that they are expensive, use substantial power and require frequent battery charging or expensive and complicated alternative power supplies. Owing to the need to re-charge batteries, automated samplers require frequent attention, which is difficult to provide in remote locations. Moreover, owing to the automated samplers' expense and complexity, users are reluctant to leave them unattended in remote locations, for fear they will be stolen or vandalized. Consequently, there is a need for a simple, inexpensive, flow-proportional sampler that can obtain accurate samples.

To obtain samples and data, and to test and monitor moving fluids, such as streams, there is a need for a sampler that can take adjustable volume samples or samples based on volume or flow-based settings, and that can collect composite or discrete samples. To obtain useful samples, it is critical that samples taken at different times be comparable. For example, in sampling a moving stream over the course of several weeks or seasons, the samples must be taken in proportion to the speed of the stream, which will fluctuate, in order to compare concentrations of sediments or contaminants during dry and wet periods. Without such proportional sampling, samples taken at different times under different stream flow speeds will not be comparable. Thus, flow proportional sampling results in few samples taken during

low-flow ("baseflow") conditions and many samples during stormy conditions. This flow proportional sampling provides an accurate hydrograph which can be used to correlate constituent loads in relation to stream flow.

The present invention provides a flow proportional fluid sampler that pumps out a sample at a rate directly related to the flow speed. By linking pump speed to flow speed, samples taken during different fluid flow speeds are comparable. To accomplish this, a propeller or turbine is placed in the fluid to be sampled. The flow of the fluid drives the turbine. A pump is driven mechanically by the turbine. The pump draws a sample from the fluid and pumps it to a sample container. Since the turbine powers the pump, this system does not require an external power source to drive the pump. Since the pumping rate is directly related through the turbine to the fluid's speed, there is no need for a separate mechanism to proportion the rate of sample collection to fluid speed. The present invention also provides a very simple electrical sensor to measure the speed of the fluid being tested, which may be recorded as part of the sample data. The present invention also provides a sample collection system to distribute and store samples taken at different times.

2. Discussion of the Prior Art

Sediment studies require frequent collection of suspended sediment at a test site. Site location, flow conditions, frequency of collection, and operational costs frequently make collection of sediment data by manual grab methods impractical. As a result several organizations, such as Federal Interagency Sedimentation Project (FISP), and United States Geological Survey (USGS), accompanied by commercial companies, have developed and evaluated several models of automated samplers. The USGS has identified seventeen optimum criteria for Automatic Pumping-Type Samplers in USGS Open-File Report 86–531, by Edwards and Glysson (1988):

1. Isokinetic sample collection if intake is aligned with approaching flow.
2. Suspended-sediment sample should be delivered from stream to sample container without a change in sediment concentration and particle-size distribution.
3. Cross contamination of sample caused by sediment carry-over in the system between sample-collection periods should be prevented.
4. Sampler should be capable of sediment collection when concentrations approach 50,000 (mg/l) and particle diameters reach 0.250 mm.
5. Sample-container volumes should be at least 350 ml.
6. The intake tube inside diameter should be ⅜ or ¾ inch, depending upon the size of the sampler used.
7. The mean velocity within the sampler plumbing should be great enough to ensure turbulent flow (Reynolds number greater than 4000 to ensure turbulent flow).
8. The sampler should be capable of vertical pumping lifts to 35 feet from intake to sample container.
9. The sampler should be capable of collecting a reasonable number of samples, dependent upon the purpose of sample collection and the flew conditions.
10. Some provision should be made for protection against freezing, evaporation, and dust contamination.
11. The sampler-container tray unit should be constructed to facilitate removal and transport as a unit.
12. The sampling cycle should be initiated in response to a timing device or stage change.