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TECHNICAL NOTE

AN INTEGRATED SYSTEM FOR AUTOMATIC COLLECTION OF FLOW AND SUSPENDED SEDIMENT DATA

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INTRODUCTION

The collection of suspended-sediment data during floods at many river sites is hampered by their remoteness. Very often, by the time field parties receive flood warnings, organise equipment, and arrive on site, the flood has peaked and is receding. Even then, work priorities commonly allow time for only one series of measurements before the field party must move on to the next site. Recording the suspended sediment yield of a catchment throughout individual floods manually is thus frequently impractical.

The technology for obtaining a continuous flow record, using automatic water-level recorders, is now well established. The technology for automatic and continuous monitoring of suspended-sediment concentration is still being developed. Several types of automatic pumping samplers are currently available to provide a discontinuous record of concentration. They sit beside the flow and pump up a sample of water at fixed or variable time intervals. While the point concentration at the sampler's intake may not be representative of the mean concentration across the flow, a qualitative concentration record is still obtained and a point/mean concentration relationship can be derived by comparing point-sample concentrations with manually collected depth-integrated concentrations. Most of these automatic samplers were developed primarily for water-quality sampling purposes in artificial channels (e.g., urban sewers) and are only moderately suited for sampling from rivers. They usually possess the ability to either sample at regular time intervals or to sample flow-proportionally when a nearby flow-totalising meter signals electronically that a certain volume of flow has passed by. Because suspended-sediment concentration in rivers usually changes fastest at high flows, some form of flow-proportional sampling is obviously better than simply sampling at fixed time intervals. The use of flow-totalising meters in rivers is uncommon, however, since they must be pre-programmed with a simple and constant stage-discharge rating relationship, something that is often impossible to achieve in a natural river channel. This note presents a system wherein approximate flow (actually stage)-proportional sampling control for an automatic sampler is provided from a modified Stevens 7001 digital water-level recorder, an instrument in common use at hydrological sites throughout

New Zealand. The sampling control instrumentation is housed in the Stevens recorder and in a separate control box. It can be connected by a single lead to any standard automatic sampler that has the facility to accept an externally-generated sampling trigger signal. In our system, the lead plugs into the "Flow" terminal on the control box of a Manning S4040 automatic sampler.

DESIGN AND OPERATION OF THE UNIT

Attributes of an Integrated Flow and Sediment Recorder

At remote hydrological sites where records of water discharge and suspended-sediment concentration are required, the automated instrument must do the following:

1 continuously sample the water level to provide a time-stage record,
2 collect water samples throughout floods at pre-selected rates which vary according to the water level,
3 record the time each sample was taken, and
4 not sample when the flow is low.

In addition, the instrument must be portable, battery-powered, robust, weather-proof, and reliable — requiring servicing only fortnightly or even monthly.

Water-Level Record

The normal operation of the Stevens recorder remains unchanged: at fifteen-minute or six-minute intervals the water level is punched onto a time-calibrated chart.

Sampling Control

The sampler operates as an event sampler whose frequency is determined by time switches according to stage height. Sampling is controlled by having different sampling rates for four intervals of stage. At low stages, the sampler does not sample at all. At medium, high and flood (very high) stage ranges, the sampling rate can be set to 0, 1½, 3, 6, 12 and 24 hour periods from three switches on the time control box. Any combination of sampling rates can be used, but normally sampling intervals are set so that sampling becomes more frequent at a higher stage range. Stage settings that will result in a semi flow-proportional sampling schedule can be deduced from the stage-discharge rating of the particular site. The no-sampling-at-low-stage operating mode renders the sampler (but not the water-level recorder) inert during periods of low flow when the water is expected to be clear. However, if low flow sampling should be desired, the no-sampling mode can be effectively eliminated by setting the "low" stage range at zero stage.

The stage ranges are pre-set mechanically on the Stevens recorder. The changing water-level rotates a threaded shaft in the recorder, and a threaded metal receiver is moved along this shaft. Two microswitches (dividing the medium, high, and flood ranges) are mounted on either side of the travelling block and are closed (or opened) as the block moves past two offset cams (Fig. 1). A third microswitch (dividing the low and medium ranges) is mounted on the recorder chassis and is closed simply by the block passing beneath it. As the water-level rises, the block travels along the threaded shaft in the direction of the pulley cog, each microswitch is opened in turn, and the sampling control passes successively from low to medium to high to flood sampling modes. The positions of the microswitches and cams are adjustable and help to determine just what water levels define each stage range. By disengaging the spring-loaded threaded shaft from the float pulley cog, the low/medium stage boundary can actually be set at any stage value, low or high. The high and flood stages can subsequently be set by shifting the positions of the cams. Although it was not the case with our system, cam adjustment could be facilitated by threading the cam shafts through the recorder chassis wall (Fig. 1).

The microswitch contacts provide either 0 or 1 levels to the CMOS logic gates into which they are wired. A trigger is given to the sampler when the sample-time interval for a particular microswitch (stage height) has expired. The time signals are obtained from the recorder's punch motor which can be operated at six-minute or fifteen-minute intervals by a special timer developed in the Ministry of Works and Development. As this is normally set to fifteen minutes a divide-by-three network yields electronic signals at $1\frac{1}{2}$ hour intervals. These are further divided by five stages of a seven stage binary divider, to yield intervals up to 24 hours. If desired, the six-minute setting of the timer will decrease these times by a factor of 2.5.

To record a sampling event, the sampling trigger signal also triggers a servo-powered marker pen which inscribes an arc on the time-calibrated punched-paper tape of the recorder. As its trace is light the pen may be

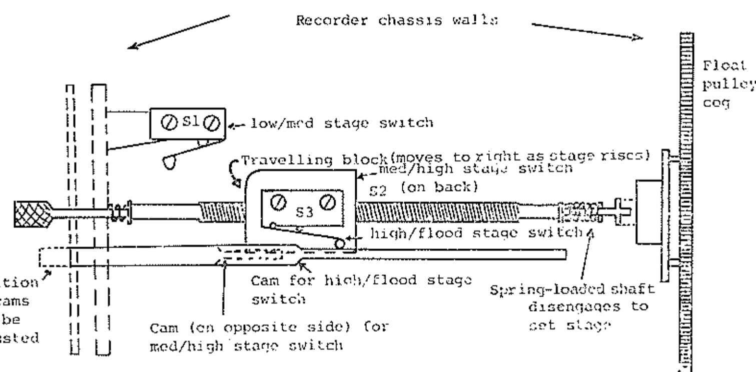

FIG. 1—Sketch of stage proportional sampling control mechanism for STEVENS 7001 water-level recorder. Stage intervals are adjusted by altering:

(1) Positions of cams (for high and flood stages).
(2) Position of travelling block on threaded shaft — by disengaging spring loaded shaft from pulley cog (for low and medium stages). Note S1 is the low/medium, S2 the medium/high, and S3 the high/flood stage microswitch.

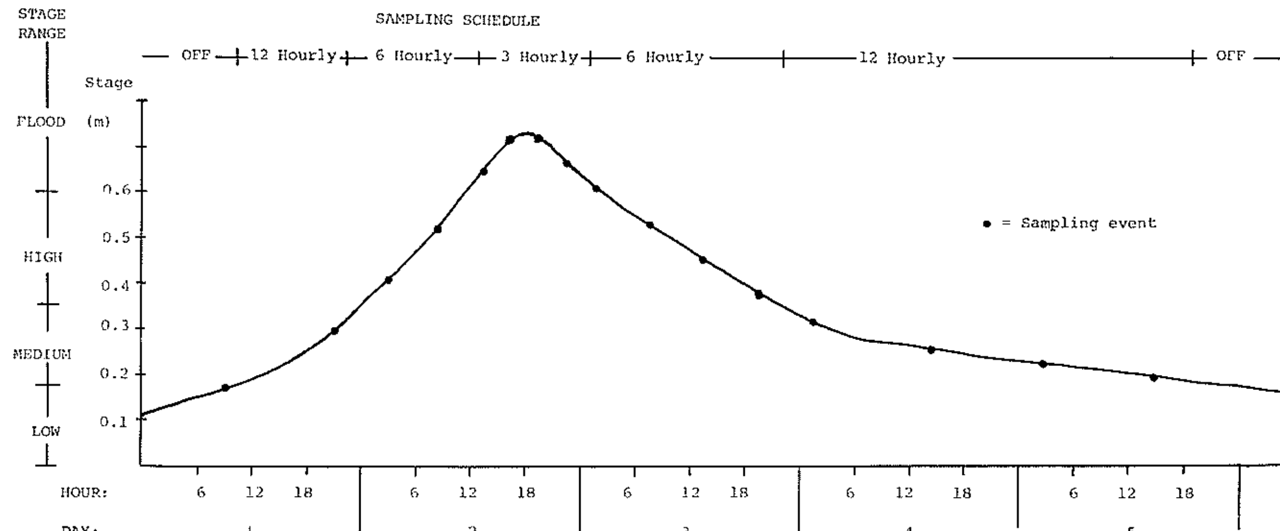

FIG. 2—Sampling record for a test hydrograph when sampler was programmed to sample 12 hourly in medium stage range (0.18 to 0.35 m), 6 hourly in high stage range (0.35 to 0.60 m), and 3 hourly in flood range (higher than 0.60 m).

programmed to repeat its sweep: for example, on our device a suitably visible event mark is produced from three sweeps of the pen. Up to nine sweeps per event mark may be pre-programmed.

Three metal boxes house the CMOS circuitry. Two are fixed inside the Stevens recorder, one for marker pen motor drive control and the other for microswitch logic gating. The third box is external and contains the timing circuitry. In our system, a double-wire lead connects the Stevens recorder to the Manning sampler, plugging into the sampler's control box at the port normally provided for flow-proportional control from a Manning flow totaliser. This results in the time control circuitry in the Manning control box being by-passed and requires no modification to the sampler whatsoever.

The modified Stevens recorder is powered by a 2.5 Ah, 12 V rechargeable sealed lead-acid cell, which provides two months of normal operation before recharging.

SUMMARY AND DISCUSSION

The system described requires mechanical and electronic modifications to a standard Stevens stage recorder. The modified recorder provides sampling control for a standard, unmodified, automatic suspended-sediment sampler. Sampling is scheduled by a combination of both time control and stage control, which can be adjusted, if required, to provide approximately stage-proportional sampling control. This allows the sampler to sample throughout a flood, but to take more frequent samples about the flood peak. At lower flows, between floods, the sampler can be made to sample much less frequently or not at all (Fig. 2 shows the sampling record obtained for a test flood). This system has some advantages over others wherein sampling is triggered at fixed intervals of stage change. For example, it allows frequent sampling when there are rapid changes in suspended-sediment concentration, but comparatively small changes in stage. Generally, the availability of selectable time control for three adjustable ranges of stage provides flexibility of application.

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