REPORT PP

THE US D-96: AN ISOKINETIC SUSPENDED-SEDIMENT/WATER-QUALITY COLLAPSIBLE-BAG SAMPLER

ADDENDUM – II

THE US D-96-A1: A LIGHTWEIGHT VERSION OF THE US D-96

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INTRODUCTION

The Federal Interagency Sedimentation Project (FISP) designed, tested, and currently supplies a collapsible-bag depth-integrating isokinetic sampler for the collection of suspended-sediment/water-quality samples. The sampler is designated the US D-96 (patent number 6,216,549 B1). A report (FISP Report PP) describing the development and testing of the sampler is available on the FISP internet site (http://fisp.wes.army.mil). The US D-96 weighs 130 pounds (lbs). Instructions for use of the sampler are available on the site. Results of a comparison test between the hydraulic efficiencies using different bag compositions are reported in Report PP Addendum I, which is also available on the FISP internet site.

Reports about the operation and usefulness of the US D-96 from field personnel have been very favorable. Most users are deploying the sampler with a hand-crank reel and relate that it is tiresome to crank. A lighter weight sampler would be easier to hand-crank and could be used in stream flow velocities where the heavier US D-96 would not be required. By manipulation of the material used in the US D-96, an 80 lb version of the sampler was fabricated and tested for stability and drift angle. The lighter version is designated the US D-96-A1 in accordance with previous FISP nomenclature. The recommended stream velocity range for the US D-96-A1 is 2 to 6 feet per second (ft/sec). The US D-96-A1 is plastic coated, as is the US D-96, to facilitate water-quality sampling.

US D-96-A1 DESCRIPTION

The US D-96 is fabricated with a bronze top, an aluminum bottom, an aluminum nose with an attached plastic tray, and a plastic tail section. The sampler weighs approximately 130 lbs. Sampler weights that could be obtained using various combinations of materials for the sampler parts were calculated. Making the top section aluminum and the bottom section bronze, and leaving the other parts unchanged resulted in a sampler that would weigh approximately 80 lbs. FISP fabricated a prototype sampler using this material combination and designated it the US D-96-A1. It should be noted that the US D-96-A1 is dimensionally the same as the US D-96 and uses the same nozzles, nozzle holders, and bags. The only difference is the weight. The US D-96-A1 is plastic coated to facilitate water-quality sampling.

STABILITY TEST

The prototype US D-96-A1 was balanced in the FISP calibration flume. The sampler was towed with a boat in a lake at velocities of 3 to 10 ft/sec. The stability of the sampler was observed and recorded using the underwater video system described in Report PP. A streamer was attached to the hanger bar above the sampler so the horizontal attitude of the sampler could be determined. The sampler tracked in a straight line and remained stable at 10 ft/sec velocity. Higher velocities were not tested because of the severe drift angle of the sampler.

DRIFT ANGLE TEST

FISP conducted tests to determine the drift angle of the US D-96-A1while being towed by a boat. The drift angle of a towed sampler is not exactly the same as a sampler deployed in a stream due to the velocity distribution in a stream vertical. When towed in a lake, the entire wetted cable and sampler are subjected to the same velocity and force. In a stream vertical, the force varies along the wetted cable based on the velocity distribution in the stream. However, the information derived from tow tests should give the user a good indication of the expected drift angle. The crane on the FISP research boat was fitted with a bridge crane protractor. The distance from the crane boom to the water surface is approximately 8 ft. The sampler was towed at velocities from 2.5 to 10 ft/sec and cable lengths from 10 to 60 ft, measured from the water surface. Water depth limitations in the lake prevented testing longer cable lengths. Figure 1 shows the measured drift angles for cable lengths of 10, 20, 30, 40, 50, and 60 ft at velocities from 2.5 to 10 ft/sec. The maximum theoretical depth for the sampler with a 5/16-in diameter nozzle is 39 ft, and with a 1/4-in diameter nozzle is 60 ft. Most streams are less than 60 ft deep, therefore results presented in figure 1 should give the user a good indication of the drift angle for most field situations. Figure 2 shows the drift angle for various wetted cable lengths for velocities of 2.5, 4.8, 6.75, 8.7, and 10.5 ft/sec. It is apparent from the two figures that the drift angle of the sampler will be the controlling factor in the limitation of its use. A comparison of the drift angle results for the US D-96-A1 to the drift angle results for the US D-96 (Report PP) show that the lighter US D-96-A1 drifts roughly twice as much as the heavier US D-96.

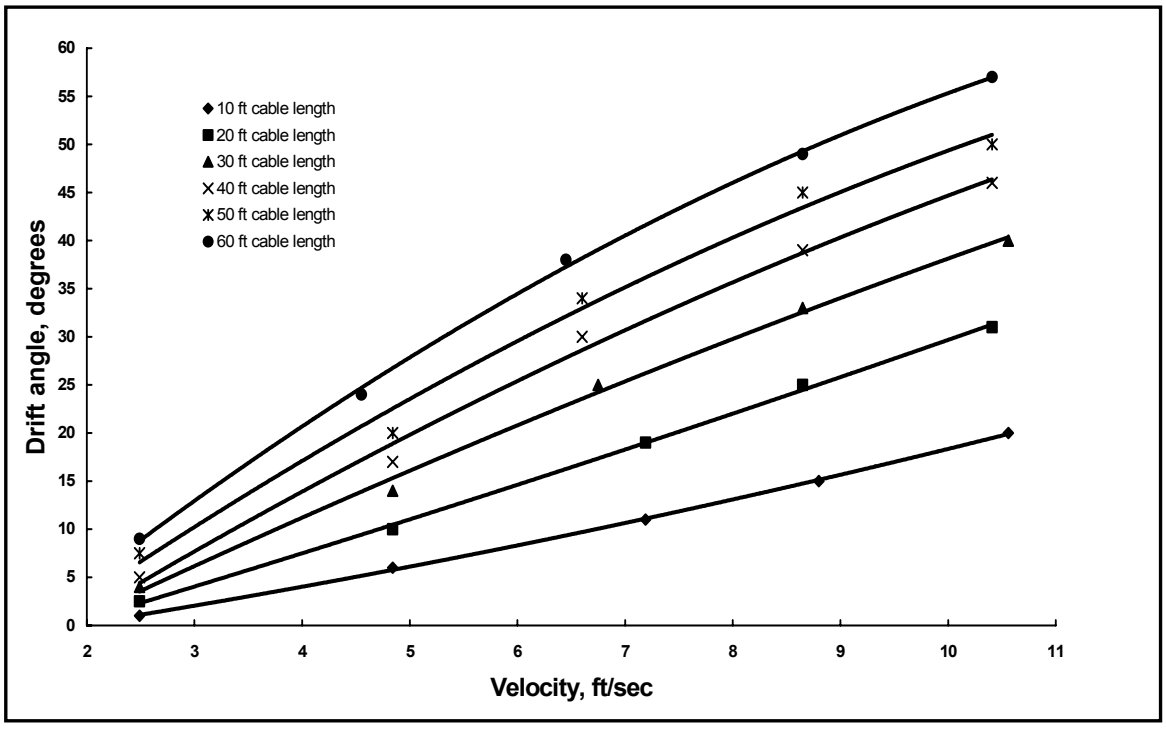

Figure 1-- Drift angle for various wetted cable lengths

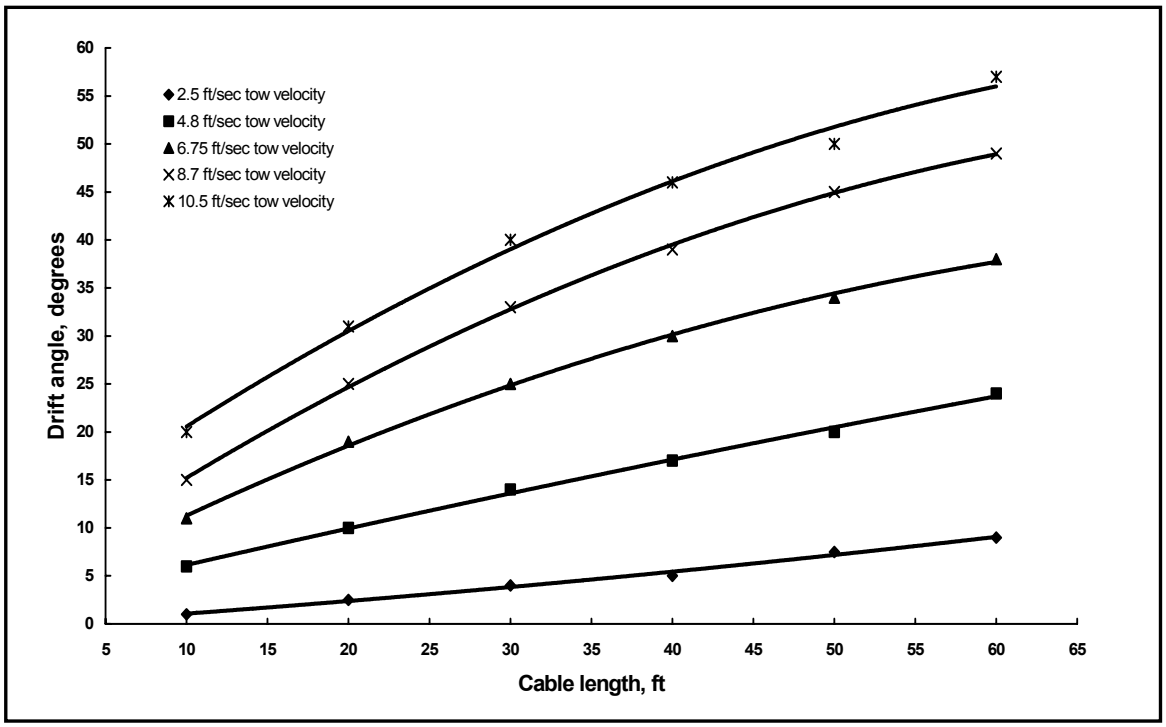

Figure 2-- Drift angle for various constant velocities

FIELD EVALUATION

FISP fabricated five US D-96-A1 samplers for field evaluation by several USGS field offices. One sampler was used at several locations in Alaska. Personnel with the Grand Canyon Monitoring and Research Center used two samplers on the Colorado River. One sampler was used at two locations on the Mississippi River in Iowa, and one on the Sacramento River in California. Operating instructions, a field data form, and an evaluation questionnaire were sent with each sampler. The samplers were deployed in stream velocities of 2 to 7 ft/sec and stream depths up to 35 ft. No problems were identified in the field evaluations that would prevent the use of the sampler. Those who had been using the heavier US D-96 were very pleased with the lighter weight US D-96-A1 for use with a hand-crank reel.

OPERATING LIMITATIONS

Depth

The maximum theoretical depth at which the US D-96-A1 can be used is 110 ft with a 3/16-in diameter nozzle, 60 ft with a 1/4-in diameter nozzle, and 39 ft with a 5/16-in diameter nozzle. The maximum theoretical depth is determined using a 3 L sample volume, the internal cross-sectional area of the nozzle, and a maximum transit rate ratio of 0.4. The maximum practical

depth in field use depends on stream conditions. The maximum depth may be reached at low to medium velocities, but probably is not practical at high velocities due to the drift angle.

Stream Velocity

The minimum stream velocity at which the US D-96 and the US D-96-A1 samplers will collect an acceptable isokinetic water-sediment sample is 2 ft/sec (Report PP). The upper stream velocity limitation in field practice depends on stream conditions, not hydraulic efficiency. For example, the sampler could be used at a certain velocity in a shallow stream but may not be practical at the same velocity in a deeper stream. The drift angle of the sampler most likely will be the limiting factor in its use. Based on the information presented in figures 1 and 2, the recommended upper velocity limit for the US D-96-A1 is approximately 6 ft/sec, which is about half that of the heavier US D-96. Safety and the operating platform should always determine the upper velocity limit for which any sampler should be deployed.

Transit Rate

The US D-96-A1 is not subject to the same transit rate limitations of rigid bottle samplers. The minimum transit rate is one at which the sample volume does not exceed 3 L. The maximum transit rate is 0.4 times the stream velocity, which is due to the apparent approach angle of the nozzle as the sampler moves vertically in the stream. The transit rate should never exceed 0.4 times the stream velocity. Transit rates can be calculated using the tables and instructions in the Operating Instructions for the sampler.

Unsampled Zone

The unsampled zone for the US D-96-A1 is 4 in. This zone is the distance between the center-line of the nozzle and the bottom of the sampler. Care should be taken if the sampler is allowed to touch the bottom of the stream so that unconsolidated material is not overly disturbed, possibly biasing the sample.

CONCLUSIONS

A lighter weight version of the US D-96 was devised by FISP. By changing the composition of sampler parts, as 80 lb version was fabricated. The sampler was designated the US D-96-A1. The US D-96-A1 was tested for stability and drift angle, and evaluated by several field offices. The sampler should be useful in stream velocities of 2 to 6 ft/sec. The sampler was very popular with those who evaluated it in the field. The US D-96-A1 should be a very useful addition to the FISP's suite of depth-integrating samplers.