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14. ABSTRACT
The purpose of this report is to summarize briefly the history of the Surface Water Research project since its inception in 1952, the work accomplished, and the problems encountered. In general, each topic is discussed under two periods of time: 1952-1963, when projects were confined to the Helmand River Valley and was entitled "Helmand Surface Water Investigations (306-12-021, 306-M-12-AD and 306-AC-12-AD5)," and 1963-1969 when activities were expanded to cover most of Afghanistan and title was changed to "Surface Water Research (306-11-190-002)".

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

A PROPOSED SEDIMENT DATA COLLECTION PROGRAM FOR AFGHANISTAN

by George Porterfield

Prepared by the U.S. Geological Survey in cooperation with the U.S. Agency for International Development

Kabul, Afghanistan

Administrative Report

June 1967

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TABLES

A PROPOSED SEDIMENT DATA COLLECTION
PROGRAM FOR AFGHANISTAN

by George Porterfield

INTRODUCTION

On March 9, 1967, the author was detailed for 90 days to study sediment problems in Afghanistan, make recommendations for a sediment program, train personnel in collection of sediment data, and set up laboratory facilities and train personnel in the use of these facilities.

Visiting the many gaging stations, preparing laboratory facilities, and training personnel in the 90 days was a large undertaking and would not have been possible without the complete cooperation and assistance of Messrs. Mohammedi and Isaqh of the Water and Soil Survey Department (WSSD) of the Ministry of Agriculture and Irrigation, Royal Government of Afghanistan. Special thanks to Mr. Khaliq of the Kandahar Office who furnished equipment and assistance, and to Mr. Dilshod of the Kabul office who accompanied me on all trips, spent many hours in the laboratory, and acted as friend and interpreter.

This preliminary report is not complete; it includes only a summary of the activities and makes recommendations for a sediment program.

THE SEDIMENT PROBLEM

Sediment transported by streams even in small quantities may adversely affect some projects and in large quantities will affect almost all hydrologic projects in either design, cost or maintenance. Thus, for planning purposes an adequate amount of basic data should be collected to determine the volume and nature of the sediment load of the stream on which the project is proposed.

The physical and economic life of a reservoir is affected by the accumulation of river-borne sediments. Lacking adequate design data reservoirs are usually built at the most advantageous and economical sites, and the loss of a reservoir to excessive sedimentation may require construction of a new reservoir at a less desirable location and a higher initial cost. Sediment usually accumulates in the upper part of the reservoir; this adversely affects the power-generating capability and will require operation at successively higher water levels and this in turn increases evaporation. Also, deltas are formed which not only provide a growing place for water-wasting phreatophytes, but may increase the backwater effect and cause flooding upstream from the reservoir.

The sediment load of the stream is reduced in the reservoir, and the nearly sediment-free water released tends to scour the downstream channel and cause damage to control structures and stream banks, and the erosion of productive farm land. Sediment damage can increase maintenance costs of irrigation canals, power generating turbines, and water-treatment facilities, and can adversely affect wild-life habitat.

PREVIOUS RECORDS

Very little sediment data is available for Afghanistan streams. Some data was obtained in the Kabul River basin by the Russian Hydraulic Expedition during 1957, 1962, and 1963. The West German Hydrologic Mission operates stations in the Kabul and Kunduz River basins and since April 1965 has obtained sediment samples with each routine water discharge measurement. During 1967, extra measurements and samples were obtained during periods of high water. The samples were collected in a small-mouth, one-liter bottle about a foot below the water surface and at the point of maximum velocity in the stream cross section. The stations operated by the West German Hydrologic Mission are listed in Table 1.

Table 1.—Stations operated by the German Hydrologic Mission

Location	Tributary
KABUL RIVER BASIN	
Unnari	Kabul 1/
Pul-i-Kama	Kunar
Asmar	Kunar
Caghasaray	Darya Pech
Barikot	Basgal 1/
Kalata	Surgh Ab 1/
Darunta	Kabul
Pul-i-Qanghai	Laghman
Naghlu	Kabul
Shukhi	Panjshir
Gulbahar	Panjshir
Omars	Panjshir
Pul-i-Asawa	Ghorband
Boche Lala	Salang
Tangi Garu	Kabul
Sang-i-Nawesta	Logar
Sekhabad	Logar
Kajaw	Logar
Pul-i-Sokhta	Paghman
Tangi Saydan	Kabul
Maydan	Kabul
(Unnamed)	Tagaw
Gulbahar	Shator
KUNDUZ RIVER BASIN	
Char Dara	Kunduz
Pul-i-Cugha	Talugan
Pul-i-Bangi	Bangi
Pul-i-Alcin	Talugan
Pul-i-Khumri	Kunduz
Doshi	Andarab
Pul-i-Kundasang	Kunduz
Doab	Kunduz
Doab	Bamyan 1/
Bamyan	Bamyan
Tangi Fahkar	Talugan 1/

1/ Proposed.

EQUIPMENT AVAILABLE

In addition to regular stream-flow measuring equipment available at the WSSD, special field equipment for the collection of suspended-sediment samples included 5 DH-48 hand samplers, 5 D-49 suspended samplers and 2,000 pint sample bottles.

The Darulaman Laboratory, located at the German Hydrologic Mission, was made available to the sediment section. This laboratory was originally equipped to make only bacteriological and chemical water analyses. Many of the items needed, however, for a sediment laboratory were available such as analytical balances, vacuum pumps, filtration equipment, and special glassware and pipettes. In addition, surplus soil testing equipment from the 025 project (USAID) was made available. This equipment included hydrometer jars, triple-beam balance, 8-inch sieves, a rotap, soil dispersion mixer, wash bottles, sample splitters, oven and transformers. Considerable time was spent getting this equipment into operating condition, including cleaning and optical analytical balance, drying out the desiccant, and rebuilding the oven.

WORK ACCOMPLISHED

Reconnaissance trips were made to most major river drainage basins and surface water gaging stations. Sediment samples were taken at each station visited and analyzed in the Darulaman Laboratory of the WSSD. Although the laboratory work progressed very slowly at first because of equipment problems and the necessary time spent training laboratory personnel, the tempo increased rapidly after several weeks. All samples were analyzed to determine total suspended-sediment concentration and, as a training exercise, many samples were analyzed for particle size.

Office work included computation of suspended-sediment concentrations and particle-size analysis, and the training of personnel in computation theories and procedures. Considerable time was also spent discussing sampling procedures and theories and computing sampling centroids for several gaging stations. Insufficient office time remained to prepare a comprehensive account of the 90-day detail and this report was prepared primarily to expedite the establishment of the sediment program. A consultation will be held with USGS/Washington concerning a more comprehensive and formalized report.

FINDINGS

Data collected and analyzed during this study period are shown in Table 2. Fortunately, many suspended-sediment samples were obtained during periods of high water and during or immediately following a rain storm. These samples show large concentrations of sediment, but these concentrations are probably significantly less than what could be expected during a historic flood of 20, 50, or 100-year frequency.

The concentration data in Table 2 is the mean suspended concentration in the stream if a bridge of cableway was available for sampling or if the samples could be obtained by wading across the stream. At all other sites a dip sample was taken near the bank. The dip samples do not give the mean suspended-sediment concentration but are indicative of the magnitude of sediment transport.

Table 2.—Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters 0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000	Method of analysis	Specific cond. (micromhos)
HELMAND RIVER BASIN																	
Arghandab River above Arghandab Reservoir																	
4-21-53	1500			13	(Dip, small mouth bottle)												340
4-1-67	1430	11		2,320	(From cableway, D-49)					34	48	64	96	100		S,N,	185
4-24-67	1630			2,500	6	12	24	34	48	51	60	78	97	100		P,S, W,M,	235
Arghandab River below Arghandab Reservoir																	
5-3-53	1530		1,200	186	(Dip, small mouth bottle)												320
4-2-67	1450	13		a 20	(Dip, DH-48)												
Arghandab River at old highway bridge near Kandahar																	
3-28-67	1730	17		a 2	(By bridge boom, D-49)												265
Arghandab River near Qala Bist																	
3-28-67	1100	16		2,730	(Cableway, D-49)					97	98	100				S,N,	900
Helmand River below Kajakai Reservoir																	
3-27-67	1115	11	3,030	36	(Cableway, D-49)												260
5-28-53	0710		7,570	7.28	(Cableway, dip, small mouth bottle)												275
Helmand River near Chahar Burjak																	
2-28-53	1600	21	2,960	262													820

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

a Concentration approximate, Analytical Balance not cleaned.

Table 2.--Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment-Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters 0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000	Method of analysis	Specific cond. (micromhos)
	Helmand River at Darweshan																
3-26-67	1530	15	7,100	5,030	(Cableway, D-49)					86	87	89	100			S,N,	1,100
	Helmand River at Dehraout																
5-14-53	1320		11,500	368	(Dip, small mouth bottle)												310
3-30-67	1250	13		301	(Cable, D-49)					84	92	96	100			S,N,	
4-22-67	1245			4,270	(Dip, DH-48)												
	Morcha River near Tirin																
3-31-67	1000	8	800 (est)	27,700	(Dip, DH-48)												190
	Tarnak River near Kalat																
4-25-67	1315			2,220	(ETR)					98	98	99	100			S,N,	
	Tirin River at Dehraout																
3-30-67	1510	14		4,770	(Dipped by hand)												
4-22-67	1600			2,140	(Dip. DH-48)												
	Tirin River at Oruzgan																
4-23-67	1715			2,980													280
	Unnamed tributary near Tirin (on Dehraout road)																
3-31-67	1200	8		31,000	(Dip, DH-48)												

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Table 2.-- Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment--Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters											Method of analysis	Specific cond. (micromhos)
					0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000		
[illegible]	Tirin River on Oruzgan road (upstream from Tirin)																
4-23-67	1300			3,160	(Dipped by hand)												
	Unnamed tributary to Tirin River in Morcha Pass																
3-31-67	0900		0.1 (est)	2,430	(Dip, DH-48)												
	Carabagh River at Kabul-Kandahar highway south of Ghazni																
4-25-67	1530			23,800	(Dipped by hand)												
KABUL RIVER BASIN																	
	Kabul River at Guzargah																
4-27-67	1610			6,640	(Dipped by hand from surface in mason jar)												245
4-29-67	1455	11		3,420	(Dip, DH-48)												
	Kabul River at Horton Bridge																
4-27-67	1615			10,600	(Dipped from surface in mason jar)												235
4-29-67	1500	13		3,800	(Dipped from surface in mason jar)												270
4-29-67	1500	13		4,240	(Dip, DH-48												
	Kabul River at Tangi Saydan																
4-25-67	1830			1,170	(Dip, DH-48)												

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Table 2.--Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment--Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters											Method of analysis	Specific cond. (micromhos)
					0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000		
	Paghman River at Pul-i-Sokhta																
4-27-67	1600			24,500	(Dipped from surface in mason jar)												225
4-29-67	1440	17		12,830	(Dip; DH-48)												
	Logar River near Kabul																
5-7-67	1730			1,050	(Dip, DH-48)												470
	Salang River near Charikar																
5-8-67	1345	12		586	(Dip; DH-48)												
	Gherband River below Gherband at bridge																
5-2-67	1300			5,020	(ETR)					66	74	85	98	100		S,N,	410
	Kabul River at Tangi Garu																
6-26-67	1500			162	(ETR)					57	63	74	100			S,N,	1,100
6-29-67	1130			236	(ETR)												860
KUNDUZ RIVER BASIN																	
	Andarab River near Doshi																
5-8-67	1645	19		2,745	(Dip, DH-48) (at gage)												
5-8-67	1630	19		11,050	(Dip, DH-48) (4 miles above gage)												

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Table 2.--Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment--Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters											Method of analysis	Specific cond. (micromhos)
					0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000		
	Gowkush River at Khanabad																
5-9-67	1100	22		18,700													1,200
	Khanabad River at Pul-i-Alcheen near Kunduz																
5-9-67	0830	21		1,040	18	21	32	44	65	80	92	98	100	(ETR)		P,S, W,M,	840
	Kunduz River at Chardara																
5-9-67	0745	21		847	(Dip, DH-48)					84	89	94	100			S,N,	
	Farkhar River at Pul-i-Chugha																
5-9-67	1200	22		6,170	(Dipped from surface in bottle)												
	Darya-i-Surkhab below Ishpushta																
5-1-67	1700			317	(Dip, DH-48)												
KOKCHA RIVER BASIN																	
	Kishm River near Kishm (Meshed)																
5-10-67	1230	17		2,920	(Dip, DH-48)												
	Kokcha River near Kishm above confluence with Kishm River																
5-10-67	1420	15		17,200	(Dip, DH-48)												185

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Table 2.--Determinations of suspended-sediment discharge and particle-size analysis cf suspended sediment--Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment Percent finer than indicated size, in millimeters 0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000	Method cf analysis	Specific cond. (micromhos)
BANDE AMIR RIVER BASIN																	
	Balkh River at Pul-i-Mamokri (Mazar-i-Sharif)																
5-28-67	1700			3,020	(Dip)												
	Balkh River at Chesme Shefa (Mazar-i-Sharif)																
5-28-67	1200			2,670	(Dip)												
HARI RUD BASIN																	
	Kcwgan River near Langar																
4-18-67	1220	15		2,580	(Cable, D-49)					78	86	92	99	100		S,N,	420
	Hari Rud at Pul-i-Pushtocn																
4-16-67	1215	17		858	(Bridge boom, D-49)					81	87	96	[illegible]			S,N,	
4-19-67	1845			1,820	(Dip, DH-48)												
	Hari Rud near Tagaw Gaza																
4-17-67	1215	13		1,130	(Cable, D-49)					70	81	91	99	100		S,N,	
	Unnamed tributary to Hari Rud east cf Obeh																
4-17-67	0940	13		8,590	(Dipped by hand)												

(Method cf analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

Table 2.--Determinations of suspended-sediment discharge and particle-size analysis of suspended sediment--Continued

Date	Time	Water temperature (°C)	Discharge (cfs)	Mean concentration (ppm)	Suspended sediment: Percent finer than indicated size, in millimeters											Method of analysis	Specific cond. (micromhos)
					0.002	0.004	0.008	0.016	0.031	0.063	0.100	0.200	0.500	1.000	2.000		
HARUT RIVER BASIN (ADRASKAND)																	
Adraskand River near Adraskand																	
4-15-67	1710	14		1,040	(ETR)					63	72	83	98	100		S,N,	
4-19-67	1015			2,170	(Dip, DH-48)												
Rude Gaz near Adraskand																	
4-15-67	1740	13		1,660	(Dip, DH-48)												
FARAH RUD BASIN																	
Farah Rud near Pechitangi																	
4-15-67	1145	17		634	(Dip, DH-48)												276
Malmand Rud near Shawalat																	
4-14-67	1715	19		185	(ETR)					89	96	99	100			S,N,	
INDUS RIVER BASIN																	
Tongi River at Domundi																	
6-18-67	0930	20		210	(ETR)					76	82	88	100			S,N,	675

(Method of analysis: P, pipet; S, sieve; N, in native water; W, in distilled water; C, chemically dispersed; M, mechanically dispersed; V, visual accumulation tube)

RECOMMENDATIONS

Station Classification

The more frequently samples are obtained the more accurate the sediment load can be computed, and because a large percentage of the annual sediment load may be transported during a few days each year frequent sampling is required for stations on important streams and at project locations. For convenience and to describe the sampling frequency at a station it is recommended that sediment stations be classified as daily record stations, partial record stations, and periodic record stations.

A daily record station is defined as a station where a sufficient number of samples are collected to define a continuous concentration curve of sufficient accuracy to compute daily sediment discharges. Thus, during periods of rapidly changing water discharge and sediment concentration, samples may be needed several times each day; but during periods of low and relatively clear flow samples may not be required more often than twice weekly.

A partial record station is defined as a station where a sufficient number of samples are collected during the runoff, or storm season to define a continuous concentration curve and compute daily sediment discharges for that period. Periodic samples only are obtained during the low flow season. This type of sampling is suited to streams that have all, or most all, of the runoff during a short snowmelt or rainy season and for the remainder of the year have a relatively low clear flow, or no flow. A partial record station provides a good record at lower cost than a daily record station and may be applicable to many streams in Afghanistan.

A periodic record station is defined as a station where samples are collected during each visit by the engineer or technician. Thus, a sample is obtained at each routine visit and, more important, a sample is obtained at each special visit during periods of high flow.

The recommended classification for each proposed station is given in Table 3.

Table 3.--Proposed sediment data collection stations

	Station	River basin	Classification
1.	Helmand River near Ghizao	Helmand	Periodic
2.	Helmand River above Kajakai Reservoir	Helmand	Daily
3.	Tirin River at Dehraout	Helmand	Daily
4.	Arghandab River near Mizani	Helmand	Periodic
5.	Arghandab River above Arghandab Reservoir	Helmand	Daily
6.	Arghastan River near Kandahar	Helmand	Periodic
7.	Tarnak River near Kalat	Helmand	Periodic
8.	Khash River at Dilaram	Khash	Periodic
9.	Malman River near Shawalat	Farah	Periodic
10.	Farah River at Petchi Tangi	Farah	Periodic
11.	Farah River at Daulatabad	Farah	Periodic
12.	Farah River near Porchaman	Farah	Periodic
13.	Ghor River near Porchaman	Farah	Periodic
14.	Adraskand River at Adraskand	Adraskand	Periodic
15.	Hari River at Tagao Gaza	Hari	Daily
16.	Kowgon River at Langar	Hari	Periodic
17.	Hari River near Obey	Hari	Daily
18.	Shirin Tagao River near Maimana	Shirin Tagao	Periodic
19.	Shirin Tagao River near Daulatabad	Shirin Tagao	Periodic
20.	Bande Amir River near Kasendeh	Balkh	Periodic
21.	Balkh River near Chasma Shafa	Balkh	Periodic
22.	Samangan River at Haibak	Samangan	Periodic
23.	Kunduz River at Char Dara	Kunduz	Periodic
24.	Taluqan River at Pul-i-Cugha	Kunduz	Periodic
25.	Taluqan River at Pul-i-Alcin	Kunduz	Periodic
26.	Warduch River near Barak	Kokcha	Periodic
27.	Kokcha River above Warduch River	Kokcha	Daily
28.	Mashad River near Mashad (Kishm)	Kokcha	Periodic
29.	Kokcha River above Mashad River	Kokcha	Daily
30.	Bangi River near Pul-i-Bangi	Kunduz	Periodic
31.	Logar River near Kabul	Kabul	Periodic
32.	Kabul River at Tangi Garu	Kabul	Daily
33.	Panjshir River at Shukhi	Kabul	Periodic
34.	Ghorband River at Pul-i-Asawa	Kabul	Periodic
35.	Kabul River below Panjshir River	Kabul	Periodic
36.	Shator River near Gulbahar	Kabul	Periodic
37.	Laghman River near Pul-i-Qanghai	Kabul	Periodic
38.	Kunar River near Asmar	Kabul	Periodic

Procedures

The operation of a daily record station or partial record station requires the services of a contract observer or gage keeper. This man must be carefully trained and instructed in sample collection and collects samples daily or as frequently as instructed. The engineer or technician visits the station at routine intervals, obtains samples himself to verify the accuracy of the observer's work, picks up the observer's samples for delivery to the laboratory, and leaves a fresh supply of sample bottles.

An example of sampling instructions for engineers and observers in the USGS California District are given in Appendix A. The observer instructions, G and H, would be applicable to a partial record station in Afghanistan. However, the dates denoting periods of low flow and storm runoff are different than those experienced in Afghanistan and should be modified to fit local conditions.

Two methods of sampling suspended sediment are in general use: the centroid method and the equal transit rate (ETR) method. Both methods are described in detail in the Inter-Agency Committee on Water Resources Report No. 14 (1963). Each sediment sample consists of several sub-samples collected in individual bottles. The recommended number of sub-samples per sample for the ETR method is four. The samples should be analyzed according to methods described by Guy (1960) and the records computed as described by Porterfield (1967). The latter reports are not available to the public at present and are for administrative use only.

The DH-48 and D-49 depth-integrating samplers used to collect these samples obtain an average suspended-sediment concentration from the surface of the stream to near the bottom of the stream. Near the bed, and in the bed, the material is not sampled and the sediment discharge in this unsampled zone must be computed by one of several bed-load formulae (Myer-Peter and Muller, 1948), or by a total-load procedure (Colby and Hembree, 1955). Detailed instructions for use of the DH-48 and D-49 samplers, and for the collection of samples by the ETR method are given in Appendixes B,C, and D.

In general, the suspended discharge represents the major portion of the transported sediment, but the actual ratio of suspended load to total load varies considerably with time and space and is a function of channel geometry, slope, turbulence, and particle size of the suspended and bed material. Many streams investigated in Afghanistan have gravel and cobble beds and the suspended load should approach total load at velocities slower than that required to move the bed material. At faster velocities, considerable large material moves in the bed and a computation of bed-load transport should be made for higher stages to supplement suspended-sediment load samples. Several streams investigated have beds of fine to medium sand and a suspended load sample in these streams will not represent total load at medium or higher stages. Thus, total load measurements (Colby and Hembree, 1955, and Colby and Hubbell, 1961) are needed during high stages at these stations to supplement the suspended-sediment load.

Because most sediment is transported in a very short period, usually on rising and peak stages, care should be exercised in any sampling program to obtain sufficient data during flood events to accurately compute the sediment load. In addition, samples should be collected at sufficient frequencies to define the sediment concentration at all stages of stream flow. The more accurate the record needed, the more frequently samples should be collected. There is no fixed relation between stage or water discharge and sediment concentration, and to determine the exact concentration in time or space an actual sample is required.

The determination of the particle size of the suspended sediment and the bed material is an important phase of any sediment study. A knowledge of the particle size being transported is needed for use in all suspended-sediment and bed-load transport formulae, and to convert sediment data from tons per day to volume. Detailed instructions for making particle-size analyses is given in the Inter-Agency Committee on Water Resources Report No. 4 (1941).

Organization

A list of recommended stations and sampling frequencies are given in Table 3. This is a minimum number of stations for a basic program and should be expanded as personnel, equipment, and laboratory facilities become available. The network should include at least one daily or partial record station and one periodic record station for each major basin, a daily or partial record station for each active or potential project area, and a periodic record station for reconnaissance data in intermediate and minor basins where hydrologic projects may be developed in the future.

Of the 38 listed stations, 8 are suggested as daily record stations. Operation of these 8 stations on a daily basis may be impractical at this time because of a shortage of personnel and equipment. In that event, they should be operated as partial record stations.

Each daily station must have a local observer trained to take samples, a month's supply of sample bottles, and a set of sampling equipment which can be left at the gaging station.

Because of the apparent high rate of silting of Kajakai and Arghandab Reservoirs, sediment stations should be established at the inflow stations as first priority. Second priority should go to stations in the high sediment rate areas and sites of future projects in the Farah, Hari, Shirin Tagao, Kokcha, and Kabul River basins. A high priority should be given to a daily record station on the Kabul River at Tangi Garu. This station will furnish valuable hydrologic data and also serve as a model station to train personnel in routine collection of sediment data.

The sampling program operated by the German Hydrologic Mission in the Kunduz and Kabul River basins (Table 1) should be continued. These stations are sampled routinely at present and should be sampled as frequently as possible during the spring runoff.

The WSSD should appoint a supervisor responsible for the sampling program. His duties would be to train personnel in the collection of samples, monitor the number of samples taken by each crew to assure adequacy of sampling, and assure that samples are brought to the laboratory. He would be responsible for training crews as to the best way to handle and store samples to prevent breakage during transportation and freezing during the winter. Proper design of sample cases can keep losses during transport to a minimum.

The program supervisor would also be responsible for the training of laboratory technicians, accuracy of laboratory analyses, and assurance that an adequate number of particle-size analyses are made for each station. He should check all computations and prepare the data for filing and publication.

In general, the data in Table 2 and observations made in the field by the author indicate a large sediment potential in most streams in Afghanistan, at least in the lower reaches. Sediment data should be obtained in every basin for hydrologic purposes and detailed data obtained at locations where projects are planned.

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UNITED STATES
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Engineers Sediment Sampling Instructions
Daily Sediment Stations

Sediment stations are visited by the field engineer at routine intervals and during flood flows.

Routine Visits are made at intervals of from four to six weeks and are for the purpose of obtaining check samples, visiting observer, picking up the samples collected by the observer, inspecting equipment, and obtaining samples for particle-size analysis.

Check samples should be collected during each routine visit to the station and occasionally during flood flows. Sufficient check samples should be obtained each year to cover the range in stage. The purpose of these is to relate the concentration obtained from the observers' samples to the true concentration in the cross section. This is necessary because the observer samples only a few verticals in the cross section (3 verticals from a cable and one vertical from a box installation) and usually these few verticals are insufficient to define the true concentration.

Check samples may be obtained by different methods at various stations because of the different equipment available and the characteristics of the stream; however, the purpose of check samples remains the same regardless of the method used. Different techniques are used for each of the following cases:

1. Observer samples from box and engineer samples from cable, bridge, boat or wading.

2. Observer and engineer sample from cable.

3. Observer and engineer sample from wading section.

The procedure generally used for check samples is as follows:

A. Observer samples from box installation.

1. Obtain sample using sampler in box. This sample is analogous to reading the gage prior to making a discharge measurement.

2. Obtain set of samples, 5-9 verticals, from cable, bridge, wading or boat.

Following are step-by-step instructions for the procedure to be followed on a flood visit to an observer-operated station:

1. Upon arriving at station, take sample (2 bottles) at the box. If there is no box, and you are to make a discharge measurement from cable or bridge, set up sampler and take at least 3 bottles.

2. Contact observer, make sure he is sampling the storm. Give observer specific instructions on how the remainder of the storm should be sampled - two a day, morning, and evening, until the water has receded, when he will return to his regular sampling frequency.

3. If, for some reason, observer is not able to sample, try to obtain an alternate for the observer, or arrange your schedule to sample the storm yourself. You will need at least three samples well spaced to cover the rising stage with the last one near the peak, plus two or more samples on the falling stage.

4. If observer is covering storm, and you do not plan to make a discharge measurement, go on to next station.

5. If you make a discharge measurement, and time permits, get a cross-section sample, or at least another set from the box, after completing measurement.

Periodic stations with no observer.

The stations you visit will be assigned by your supervisor, on the basis of a pre-determined priority. The objective is to get coverage on two or three storms each year at each station. This requires that samples be taken through the rising and falling stages, at regular intervals; 3 or more on the rising stage, and 2 or more on the falling stage.

Particle-size samples are special samples collected in separate bottles for particle-size analysis and usually are obtained each time a check sample is obtained; but, because of the unusual seasonal distribution of rainfall in Afghanistan a tailored sampling schedule is necessary for most streams.

A sample for size analysis is collected by obtaining duplicate bottles in each vertical when a check sample is collected. The bottles should be labeled Ia, Ib, etc., 2a, 2b, etc., and the information needed by the laboratory recorded on the sediment station inspection form. This information should include the number of bottles collected in each vertical for the check sample and the number bottles collected in each vertical for size analysis. These notes will assure proper laboratory handling. The number of bottles needed to obtain sufficient suspended sediment for size analysis varies from stream to stream and from day to day. In general, the amount of material needed is 3 to 5 grams. After some experience, the number of bottles per vertical required to get 3-5 grams of sediment can be estimated by observing the appearance of the stream and the amount of sediment in the first bottle of water collected in the cross section. This amount of sediment is usually present in 5 bottles (one bottle from each of five verticals) at high, very turbid flow, and 10 bottles at medium, moderately turbid flow. During low clear flow in the summer and fall, however, many bottles are required to obtain sufficient material for size analysis and, becuase of this, only two samples are collected during this period, one in May or June and one September - December.

A general schedule for collecting size samples follows. However, to get the maximum benefit from a minimum of samples, this schedule should be varied slightly to fit the flow pattern. A record of size samples collected each season should be maintained to insure that the required range of flow conditions was sampled.

Samples for size analysis should be obtained 6-9 times annually at each station:

1. October to January: One sample of low flow <u>prior</u> to start of rainy season.

2. February to May: Four to six samples during storms.

   a. One sample during rising stage on first or second storm.

   b. One sample near peak on second or third storm.

   c. One sample during falling stage.

   d. One sample during medium flow in January or February.

   e. On notably high runoff events repeat (a), (b), or (c).

3. June to July: One sample of low flow following storm season.

Flood samples are obtained to supplement the observer's samples and to assure definition of the concentration curve during periods of rapidly changing concentrations. Low flow sampling by the observer is generally adequate to define the low water curve but streams that rise rapidly may require samples each 1-2 hours. A flood sample collected at a critical time will not only significantly improve the quality of the record but will save time and effort when computing the record. A few extra samples taken during flood flow may save hours or days in office work.

When visiting a station to obtain flood samples:

1. Obtain samples on arrival using procedures outlined for observer, i.e. two bottles from box installation or three bottle cross section from cable.

2. Contact observer. Find out if he is sampling and if he will be available to sample remainder of storm. If he is available give him a sampling schedule based on your knowledge of the flood magnitude and recorder trace. If he is not available try to find an adequate substitute or sample yourself. If you must sample yourself then get the largest number of samples consistent with the priority of the stream for sampling and measuring. The latter decision is based on your knowledge of the quality of records and flood conditions in the area.

3. When a water discharge measurement is made a check sample should be obtained if time permits and the rate of change of discharge and concentration is not too great. Sufficient check samples should be made to define the relation of observer's sampling point to the true concentration at all discharges and concentrations. Remember, though, that the flood sampling is primarily to obtain sufficient samples to define the concentration curve and that a check sample is more accurate if obtained while the concentration is relatively constant.

4. Particle size analyses are made on sufficient samples to cover the range in stage. When a check sample is obtained during flood flow an extra bottle should be obtained in each verticle for particle size analysis. The procedure to collect size samples is described more fully under Routine Visits.

Special samples or measurements are obtained at many stations. These include turbidity measurements, chemical quality samples, bed material samples, and total sediment-load measurements. The "Station Notes" which lists sampling requirements at each station indicates which special samples are required. Procedures for obtaining special samples and measurements are covered in supplemental instructions.

UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Engineers' Sediment Sampling Instructions
Periodic Stations

Observer-operated periodic stations require a routine similar to that outlined in the Engineers' Sampling Instructions - Daily Stations, pages 1 through 3; except that during the low flow months the observer will not collect samples. Engineers' samples will therefore be collected during the regular visit to the gaging station, or any time a visit is made during high water.

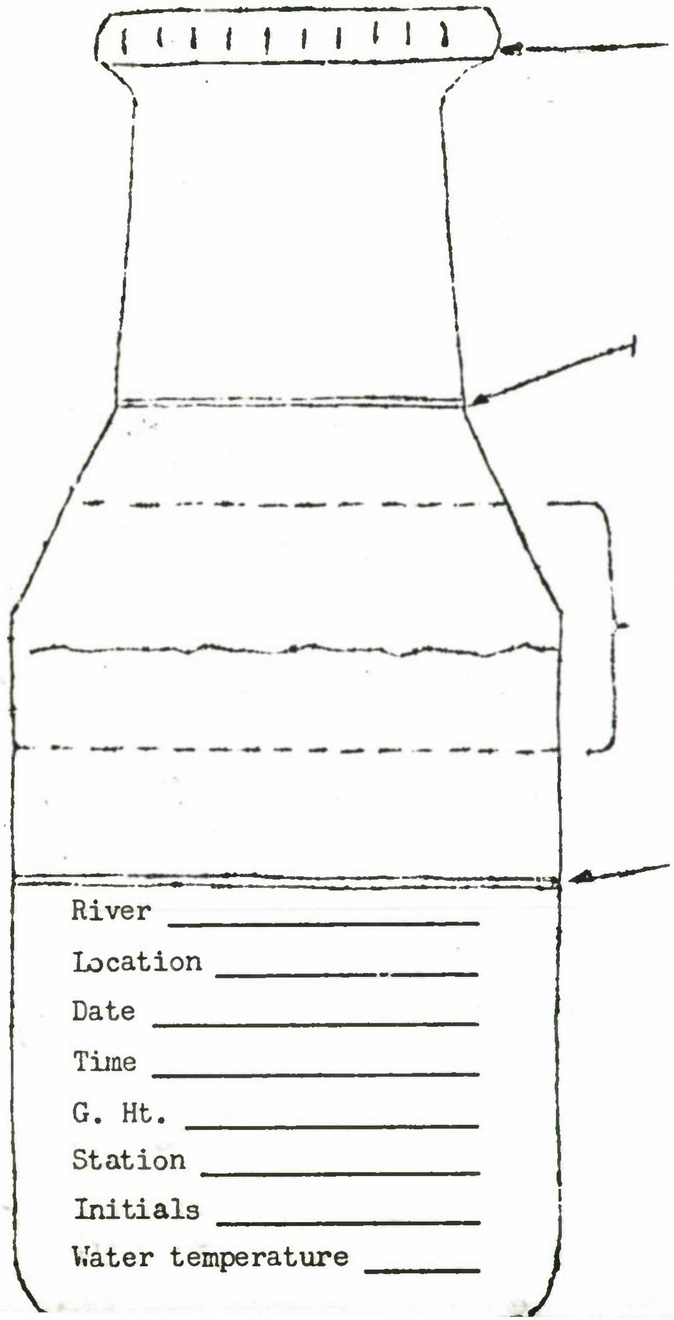
Periodic stations with no observer require the special attention of the field man, because the samples he takes are the only sediment data collected at the station. The objective is to collect routine low-water samples plus high-water samples during as many of the storm periods as possible. In addition, complete coverage should be obtained during two or three storm events each year.

Storm coverage requires that the field man sample throughout the high-water event, taking complete cross-section samples, with duplicate bottles for size analysis of the high-concentration samples. A minimum of 3 samples should be collected during the rising stage of the stream, with one sample near the peak stage and two or more samples during the falling stage.

Low-flow sampling consists of a cross-section, either an ETR sample if the stream can be waded, or an equal-centroid sample from bridge cableway.

U.S. Geological Survey, Water Resources Division

Station: ______________________ Date issued: ______________________



Mark month and date on top of cap.

Do not fill above this line. If you over-fill a bottle, throw the water out and obtain another sample in a clean bottle. <u>NEVER SPILL OR POUR OUT A PART OF A SAMPLE.</u> If you do, take a clean bottle and obtain another sample

A water level in this area has proven to give the best laboratory results.

Minimum amount of water that can be used

Time should be recorded to nearest five minutes

A copy to each observer and for each station

<u>High Water Sampling Procedure</u>

Begin sampling as soon as possible after water starts to rise.

Every ______ hours while water level continues to rise.

Get a sample as near as possible to the peak.

__________ daily while water level is going down.

______________________ until next rain storm.

If you are unable to sample for any reason, call field office collect at phone no.: __________ __________________.

Try to get some qualified person to sample for you.

INDEX TO OBSERVER INSTRUCTIONS

Symbol	Type Station
A	Daily - Box - No wading section
B	Daily - Box - Wading section
C	Daily - Cable - No wading section
D	Daily - Cable - Wading section
E	Periodic - Box - No wading section
F	Periodic - Box - Wading section
G	Periodic - Cable - No wading section
H	Periodic - Cable - Wading section

Instruction Type A

Station ______________________________

Date issued ______________________

Observer Sampling Instructions
Daily Station
Box Installation - No Wading Section

Each sample consists of 2 bottles collected with the large sampler stored in the box fastened to the bridge.

Frequency of Sampling - low water:

1. November through June: One sample daily.

2. July through October: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

REGARDLESS OF TIME OF YEAR, WHEN HIGH WATER OCCURS START HIGH WATER SAMPLING FREQUENCY.

Frequency of Sampling - high water:

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one late in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT THE WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Instruction Type B

Station ____

Date issued ________________________

Observer Sampling Instructions
Daily Station
Box Installation - Wading Section

Low water samples are collected with the hand sampler by wading in the vicinity of bridge or gage. Each sample consists of 3 bottles, one bottle taken near the center of the stream and one bottle about half way between the center and each bank.

Frequency of low-water sampling:

1. November through June: One sample daily.

2. July through October: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

REGARDLESS OF TIME OF YEAR, WHEN HIGH WATER OCCURS START HIGH WATER SAMPLING FREQUENCY.

High water samples are collected with the large sampler stored in the box fastened to the bridge.

Frequency of high-water sampling:

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ____________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one late in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT THE WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Station ______________________________

Date issued ______________

Observer Sampling Instructions
Daily Station
Cable Car Sampling - No wading section

Low water samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken near the center of the stream and one bottle about half way between the center and each bank. The station numbers (marks on cable) where samples should be taken will be given to you by the visiting engineer.

Frequency of low water sampling:

1. November through June: One sample daily.

2. July through October: Three samples weekly (Monday, Wednesday and Friday) unless otherwise instructed by the visiting engineer.

REGARDLESS OF TIME OF YEAR, WHEN HIGH WATER OCCURS START HIGH WATER SAMPLING FREQUENCY.

Highwater samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken from near center of stream and one bottle from halfway between the center and each bank.

Frequency of high water sampling:

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every _______ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one late in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Station ______________________________

Date issued ______________

Observer Sampling Instructions
Daily Station
Cable Car Sampling - Wading Section

Low water samples are collected with the hand sampler by wading in the vicinity of bridge or gage. Each sample consists of 3 bottles, one bottle taken near the center of the stream and one bottle about half way between the center and each bank.

Frequency of low-water sampling:

1. November through June: One sample daily.

2. July through October: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

REGARDLESS OF TIME OF YEAR, WHEN HIGH WATER OCCURS START HIGH WATER SAMPLING FREQUENCY.

High water samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken from near center of stream and one bottle from halfway between the center and each bank. The station numbers (marks on cable) where samples should be taken will be given to you by the visiting engineer.

Frequency of high-water sampling:

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ______ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one later in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Instruction Type E

Station ____

Date issued ______________________

Observer Sampling Instructions
Periodic Station
Box Installation - No wading section

Each sample consists of two bottles collected with the large sampler stored in the box fastened to the bridge.

Frequency of low water sampling:

1. December through June: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

2. July through November: None

Frequency of high water sampling:

December through June unless otherwise instructed by the visiting engineer.

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one late in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

<u>Instruction Type F</u>

Station ______________________________________

Date issued ____________________

Observer Sampling Instructions
Periodic Station
Box Installation - Wading Section

Low water samples are collected with the hand sampler by wading in the vicinity of bridge or gage. Each sample consists of 3 bottles, one bottle taken near the center of the stream and one bottle halfway between the center and each bank.

<u>Frequency of low water sampling:</u>

1. December through June: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

2. July through November: None

<u>High water samples</u> are collected with the large sampler stored in the box which is fastened to the bridge.

<u>Frequency of high water sampling:</u>

December through June - unless otherwise instructed by visiting engineer:

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take one sample per day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHANRGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Instruction Type G

Station ______________________________

Date issued ______________

Observer Sampling Instructions
Periodic Station
Cable Car Sampling - No wading section

Low water samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken near the center of the stream and one bottle about halfway between the center and each bank.. The station numbers (marks on cable) where samples should be taken will be given to you by the visiting engineer.

Frequency of low water sampling:

1. December through June: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

2. July through November: None

Highwater samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken from near center of stream and one bottle from halfway between the center and each bank.

Frequency of high water sampling:

December through June unless instructed by visiting engineer.

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take one sample per day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Instruction Type H

Station ____

Date issued ____________________

Observer Sampling Instructions
Periodic Station
Cable Car Sampling - Wading section

Low water samples are collected with the hand sampler by wading in the vicinity of bridge or gage. Each sample consists of 3 bottles, one bottle taken near the center of the stream and one bottle about halfway between the center and each bank.

Frequency of low water sampling:

1. December through June: Three samples weekly (Monday, Wednesday, and Friday) unless otherwise instructed by the visiting engineer.

2. July through November: None

High water samples are collected with the large sampler from the cable car. Each sample consists of three bottles, one bottle taken from near center of stream and one bottle from halfway between the center and each bank.. The station numbers (marks on cable) where samples should be taken will be given to you by the visiting engineer.

Frequency of high water sampling:

December through June unless otherwise instructed by the visiting engineer.

1. Take one sample as soon as possible after water level starts rising.

2. Take one sample every ________ hours (maximum 4 samples per day unless otherwise instructed) while water level continues to rise. Get a sample as near to the peak as possible.

3. When water level stops rising, or is falling, take two samples per day, one early in the day and one late in the day.

4. When flood flow has passed return to low-water sampling frequency, unless otherwise instructed by the visiting engineer.

5. Repeat this schedule for each storm.

IF YOU ARE UNABLE TO SAMPLE FOR ANY REASON: ILLNESS, VACATION, OR BUSINESS, OR IF YOU HAVE ANY QUESTIONS REGARDING SAMPLING, PLEASE CALL THE ENGINEER IN CHARGE OF YOUR STATION AT WATER AND SOIL SURVEY AUTHORITY IN KABUL. TRY TO OBTAIN A QUALIFIED SUBSTITUTE TO SAMPLE FOR YOU.

Appendix B

UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Operating Instructions For
US DH-48 Suspended-Sediment Hand Sampler

The hand sampler, US DH-48, was designed for depth-integration of suspended-sediment samples in shallow streams. With this instrument the operator takes the sediment samples while wading in the stream or, if more convenient, by operating from a low bridge. The sampler consists essentially of a streamlined aluminum casting, 13 inches long and weighing approximately 3-½ pounds, which encloses the sample container. The sampler is supported on the standard one-half-inch round wading rod used in stream gaging. (This wading rod is an item supplied by the U.S. Geological Survey and is available in 1 and 2-foot sections which are threaded for assembly to any desired length). Any alternate rod or pipe of desired size may be utilized to support the sampler provided appropriate end fittings are incorporated. A brass nozzle, threaded to permit hand assembly to the streamlined head, projects upstream and provides the intake passage for the sample.

Round pint milk bottles are used for sample containers. Pressure from a spring-tensioned operating rod, which is rotated by hand to bear upon the base of the sample bottle, holds and seals the bottle against a rubber gasket within the sampler head. The operating rod assembly can be removed from the recess provided at the rear of the sampler casting, and the pressure exerted by the operating rod can be adjusted by increasing or decreasing the compression on the operating spring. The axis of the sample container is inclined at an angle of 72-½ degrees to the vertical which permits sampling to within 3-½ inches of the stream bed. With the instrument oriented into the direction of flow (nozzle horizontal and pointed upstream) a continuous stream filament is discharged into the sample bottle during the period of submergence. The air displaced by the sample is ejected through the air escape vent tube projecting from the instrument alongside the head and oriented to discharge down-stream. A fixed static head differential of 11/16 inch between the intake and air exhaust facilitates sampling in low stream velocities and slack waters. Hand samplers are usually equipped with only the quarter-inch-diameter nozzle. However, nozzles with smaller bore may be employed if desired.

A clean bottle should be used for each separate sediment sample. At least one suspended-sediment sample is taken at each stream vertical selected in the cross section. In sampling operation, the intake nozzle is oriented upstream, directly into the current, and held in a horizontal position while the sediment sampler is lowered into the stream. Submerged obstructions directly upstream or adjacent to the sampler should be avoided to preclude interference with the stream filament approaching the intake nozzle. The sampler should be lowered at a uniform rate from the water surface to the bottom of the stream, instantly reversed, and then raised again to the water surface at a uniform but not necessarily an equal rate. Each filled sample bottle when removed from the instrument should be capped immediately and appropriately marked.

The hand sampler continues to take its sample in flowing water throughout the time of submergence, even after the bottle is completely filled. If the bottle becomes entirely full, the sample may not be representative and it should be discarded. Although the capacity of the sample container is about 470 cc., the tilt of the bottle is such that any sample containing more than 440 cc., or 5 in. of a water-sediment mixture in the bottle, may be in error. In order to provide sufficient sample for a laboratory analysis, the length of time the instrument remains submerged should be adequate to produce a sample volume greater than 375 cc. but not to exceed 440 cc. It is generally preferable to save an initial sample smaller than 375 cc but larger than 300 cc than to discard the sample on the spot and resample into the same bottle. Moreover, if the initial sample volume is considerably less than 300 cc, the stream vertical may be integrated a second time, or even a third time, each being additive to the same sample bottle. A minimum sample of 350 cc or 3 in. is suggested. However, sufficient latitude in minimum sample volumes should be permitted to obviate retaking a large number of samples.

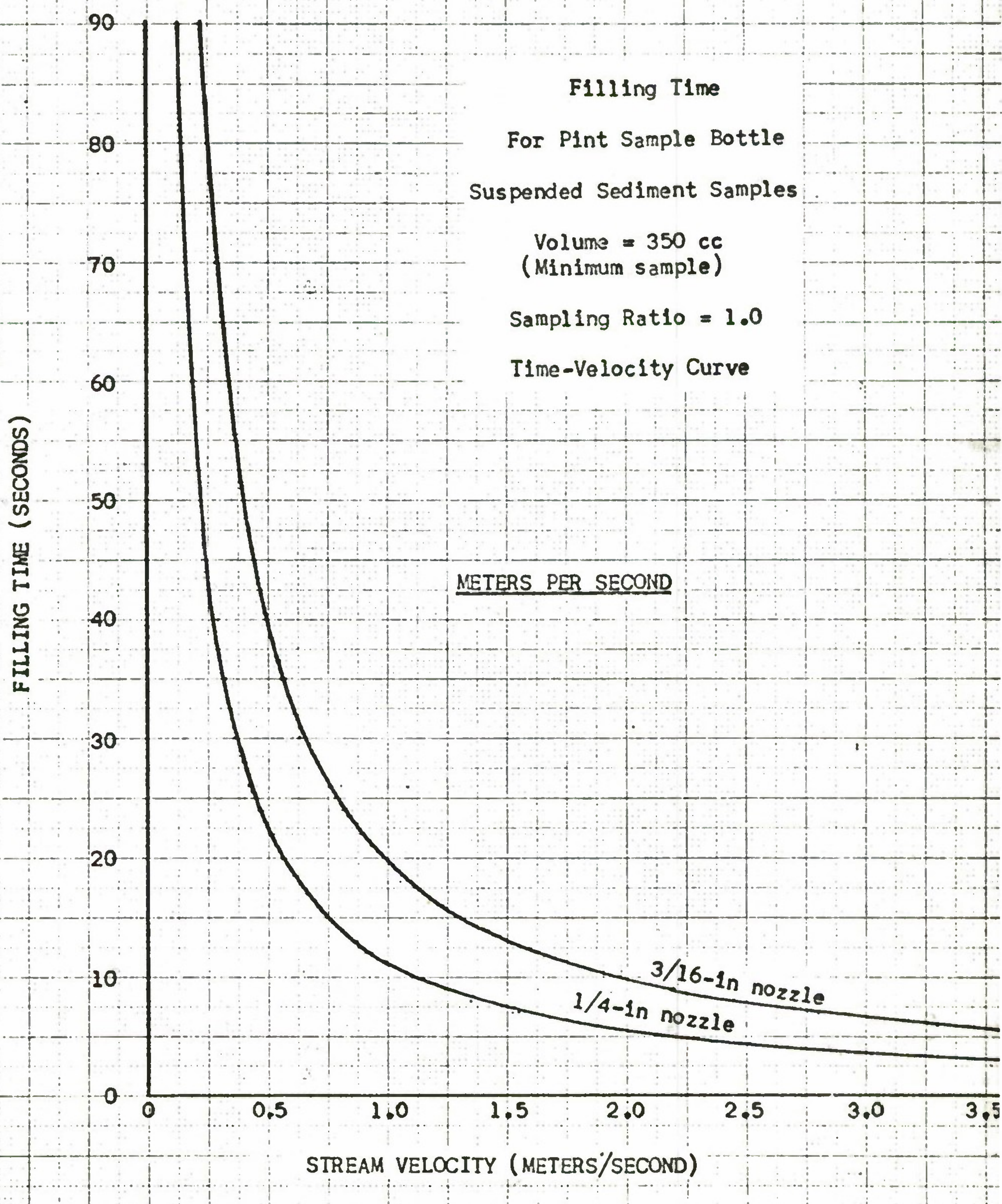
The volume of sample collected throughout any stream vertical is dependent primarily upon the mean stream velocity in that vertical, the size of the intake nozzle, and the time of submergence of the instrument. The operator must regulate the size of the sample accumulated by establishing the appropriate time period over which the sample is to be taken. Thus, the volume of the sample may be increased or decreased by varying correspondingly the sampling time. The attached graph shows the relation between stream velocity and filling time to produce samples 400 cc in volume for two different nozzle sizes. The volume, 400 cc, between the maximum and minimum sample suggested above, was arbitrarily selected for this illustration as permitting the greatest latitude in estimating stream velocities and depths. The filling time in seconds represents the total time of submergence of the instrument and includes the time involved in traversing the stream vertical in both the downward and upward direction. For example, if the mean velocity of flow in a stream vertical is 4 feet per second, the graph shows that a sediment sampler equipped with a quarter-inch-diameter intake nozzle will accumulate a sample 400 cc in volume in 10 seconds of submergence. If the sampler is lowered from the water surface to the stream bed at a uniform rate in 5 seconds, it should be raised at a uniform rate so as to break the water surface at the expiration of the next 5 seconds. The time of traversing the stream vertical need not be the same in both directions of travel. However, the rate at which the sampler moves vertically must remain uniform in each direction of travel. Thus, in the above example, the stream vertical could have been traversed at a uniform rate downward in 4 seconds and the sampler raised at a uniform rate upward to clear the water surface in 6 seconds, the total submergence period still being 10 seconds.

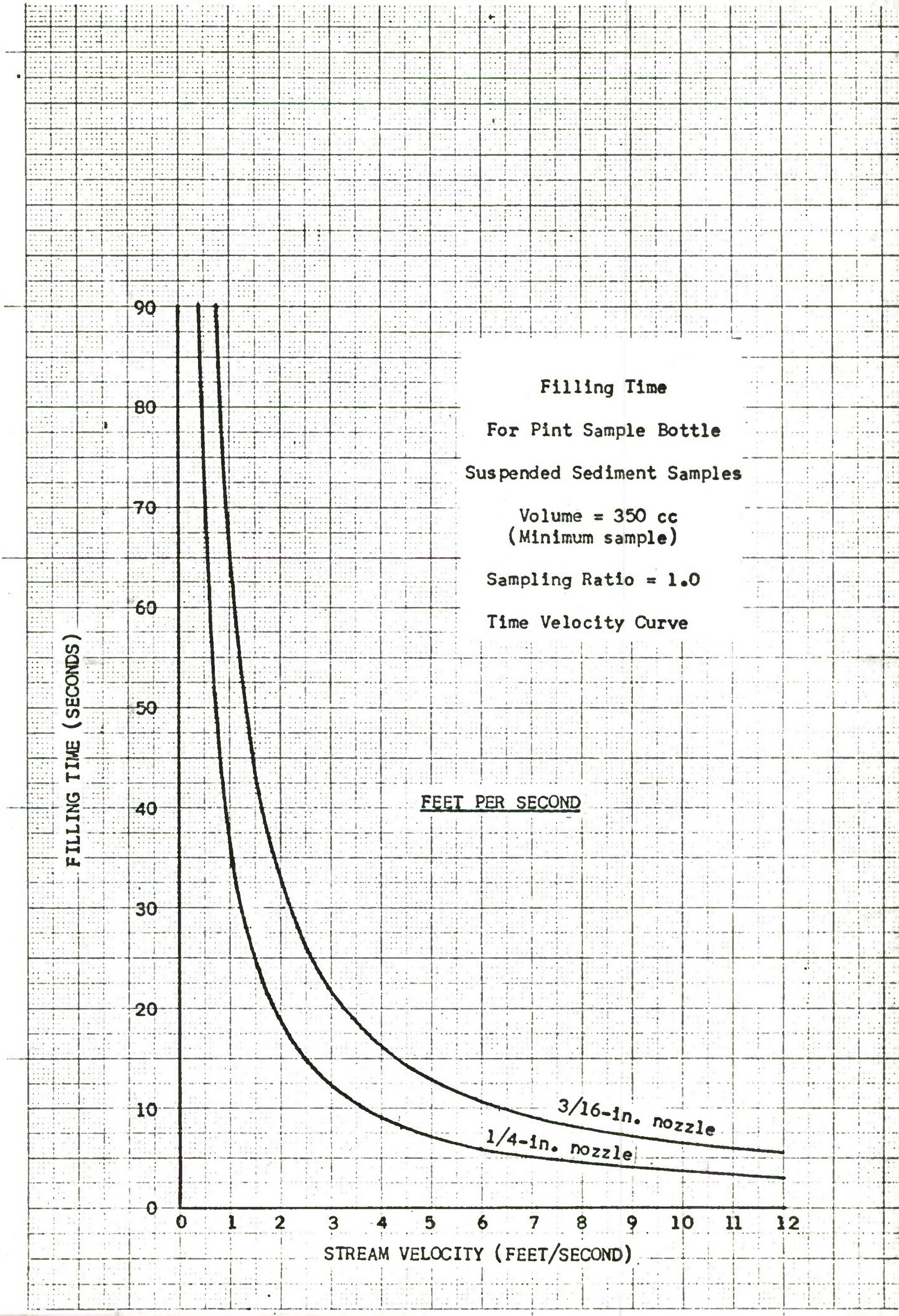
Adequate information and data to identify the sample and to satisfy the purpose of the investigation should be recorded at the time of sampling. The following items are suggested:

- Name of stream
- Location of the cross section
- Location of the vertical
- Stream depth covered by the sample
- Stage of the stream
- Date
- Time of day
- Identification of personnel
- Sampling time
- Water remperature
- Serial number of sample

A portion of the exterior face of the glass bottle may be etched or otherwise treated to provide a suitable surface for recording all the essential information for each sample. Before the bottles are reused they should be washed clean inside and outside to avoid contamination of future samples and to remove data referring to previous samples.

Pertinent information on depth-integrating samplers, development of the hand sampler, and sampling characteristics of suspended sediment samplers is presented in report No. 6 of the series on measurement and analysis of sediment loads in stream titled, "The Design of Improved Types of Suspended Sediment Samplers."


Filling Time
For Pint Sample Bottle
Suspended Sediment Samples
Volume = 350 cc
(Minimum sample)
Sampling Ratio = 1.0
Time-Velocity Curve
METERS PER SECOND
3/16-in nozzle
1/4-in nozzle
FILLING TIME (SECONDS)
STREAM VELOCITY (METERS/SECOND)
0
10
20
30
40
50
60
70
80
90
0.5
1.0
1.5
2.0
2.5
3.0
3.5



Filling Time
For Pint Sample Bottle
Suspended Sediment Samples
Volume = 350 cc
(Minimum sample)
Sampling Ratio = 1.0
Time Velocity Curve
FEET PER SECOND
3/16-in. nozzle
1/4-in. nozzle
FILLING TIME (SECONDS)
STREAM VELOCITY (FEET/SECOND)
0
10
20
30
40
50
60
70
80
90
0
1
2
3
4
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7
8
9
10
11
12

Appendix C

UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Procedure and suggestions for Taking Suspended Sediment Samples with US D-49 Samplers

The US D-49 suspended sediment sampler is a depth-integrating instrument designed for use in streams not more than about 15 feet in depth. The sampler has a streamlined body weighing about 62 pounds in which a round 1-pint milk bottle sample container can be enclosed. Tail vanes to orient the instrument into the direction of flow and an air escape passage are cast integrally. The head of the sampler is drilled and tapped to receive the threaded nozzles and mounted to permit access to the sample bottle cavity by releasing the catch and swinging the head assembly downward, away from the hanger bar support. Nine brass nozzles, three each with ¼ inch, 3/16-inch, and 1/8-inch diameter bore, threaded to permit hand assembly to the head, are supplied with the instrument. In use, the nozzle projecting from the head is oriented upstream directly into the current and the sampler is lowered from the water surface to the stream bed and raised to a position above the water surface. A stream filament, continuous during the period of submersion, is intercepted by the nozzle and discharged into the sample container securely contained and sealed within the bottle cavity of the sampler. During the collection of a water sediment sample, the air displaced from the bottle is ejected through the air escape passage which points downstream. The instrument provides a fixed static head differential of ½ inch to facilitate sampling in low stream velocities and slack waters.

Since the selection of the precise location of a suspended sediment sampling cross section is dependent upon local conditions and requires considerable background knowledge and special study as to objective, instructions on the appropriate procedure in selecting sampling stations will not be attempted here. Once having determined the sediment sampling station or cross section, sediment samples are usually taken at the various points across the stream determined by dividing the stream cross section into portions of equal flow volumes and taking one or more samples in each flow division. For further guidance in this respect see Report No. 8 in the series, Measurement and Analysis of Sediment Loads in Streams.

Current models of depth-integrating suspended sediment samplers continue to accumulate a sample in flowing streams throughout the period of submergence, even after the sample bottle has been filled. If the sample bottle becomes completely filled during a sampling operation, a representative sample was not obtained and the sample must be discarded. Samples must be collected in clean bottles and covered with suitable bottle caps to prevent contamination or loss of the sample after filling. Capacity of the bottle is about 470 cc., however, the bottle is inclined to the vertical to such a degree that any sample containing more than 440 cc. of water-sediment mixture may be in error. The period of submergence should be sufficient to produce sample volumes less than 440 cc. but greater than 375 cc. in order to obtain a sample large enough for a laboratory analysis. An initial sample less than 375 cc. but greater than 300 cc. is generally preferable to discarding the sample and re-sampling into the same bottle. However, if the initial sample volume is considerably less than 300 cc., the stream vertical may be integrated a second time, or even a third time, each being additive to the same sample bottle. A minimum sample of 350 cc. is suggested. However, sufficient latitude in minimum sample volumes should be permitted to obviate retaking a large number of samples.

The US D-49 suspended sediment sampler is best confined to use in stream depths of 15 feet or less, however, the instrument may be used to depths of 20 feet if necessity requires. The depths stated presume that the instrument is sampling throughout both the descending and ascending trips in the stream vertical. In general, the largest diameter nozzle that can be used within the operational limits of the equipment and personnel should be selected. However, a nozzle size should not be selected which would require transit rates that are too great to be handled conveniently. A transit rate which will produce a sample of not less than 350 cc. and not more than 440 cc. should be selected for stream depths less than 10 feet. Similarly for stream depths of 10 to 15 feet the sample obtained should approximate 380 to 440 cc., and 400 to 440 cc. for stream depths greater than 15 feet but not greater than 20 feet.

The size of the sample collected throughout any stream vertical is dependent primarily upon the stream velocity in the vertical and the duration of submergence of the instrument. Since the operator has no control over the stream velocities and depths encountered, he must regulate the size of the sample accumulated by selection of nozzle and establishing the appropriate time period over which the sample is to be taken. Thus, the size of the sample may be increased or decreased by varying correspondingly the size of the nozzle or the sampling time (total time of submergence of the instrument).

Attached hereto is a print containing curves representi, the relation between stream velocities and corresponding fil. times (time of submergence of the sampler) to produce samples 395 cc. in volume for the three standard nozzle diameters. It to be noted that the filling time in seconds represents the t. time of submergence of the instrument, the time involved in t. sing the stream vertical in both the downward and upward dire. Filling time curves plotted on the enclosure hereto will prov. acceptable sample volumes and will permit minor deviations fr. the total time of submergence without invalidating the sample. the sampling time curve with the stream velocity and determin. sampling time to secure a sample volume of 395 cc. for the res. nozzle sizes. Then, knowing the depth of the stream, select t. largest diameter nozzle which can be traversed conveniently th. out that depth. The rate of traverse in a stream vertical mus. remain constant throughout any one direction of travel.

Estimating the mean velocity of flow in a stream vertical 4 feet per second, a sediment sampler equipped with a $\frac{1}{4}$-inch d. intake nozzle will accumulate a sample of 395 cc. in volume of seconds of submergence. Then, the sampler must be lowered fro. water surface to the stream bed at a uniform rate in 5 seconds raised from the bed of the stream at a uniform rate to break t. water surface at the expiration of the remaining 5 seconds. T. time used in traversing the stream vertical need not be the sa. in both directions of travel. However, the rate at which the s. ler moves vertically in any one direction must remain uniform. in the above example, the stream vertical could have been trav. at a uniform rate downward in 6 seconds and the sampler raised uniform rate upward to clear the water surface in 4 seconds, a submervence period of 10 seconds. If the nozzle diameter sele. in the above example produced a vertical transit rate greater t. allowable for the stream depth to be traversed within the pres. time, a smaller diameter nozzle must be used.

A clean bottle is used for each separate sediment sample; at least one separate suspended sediment sample is taken at each stream vertical selected in the cross section. The sample is collected by submerging the sampler at a uniform rate from the water surface to the bottom of the stream and, by instantaneously reversing the direction of travel, the instrument is then raised at a uniform but not necessarily equal rate. Each filled sample bottle when removed from the instrument is immediately capped to prevent contamination and appropriately marked. Pertinent information for every sample should be recorded to include the following:

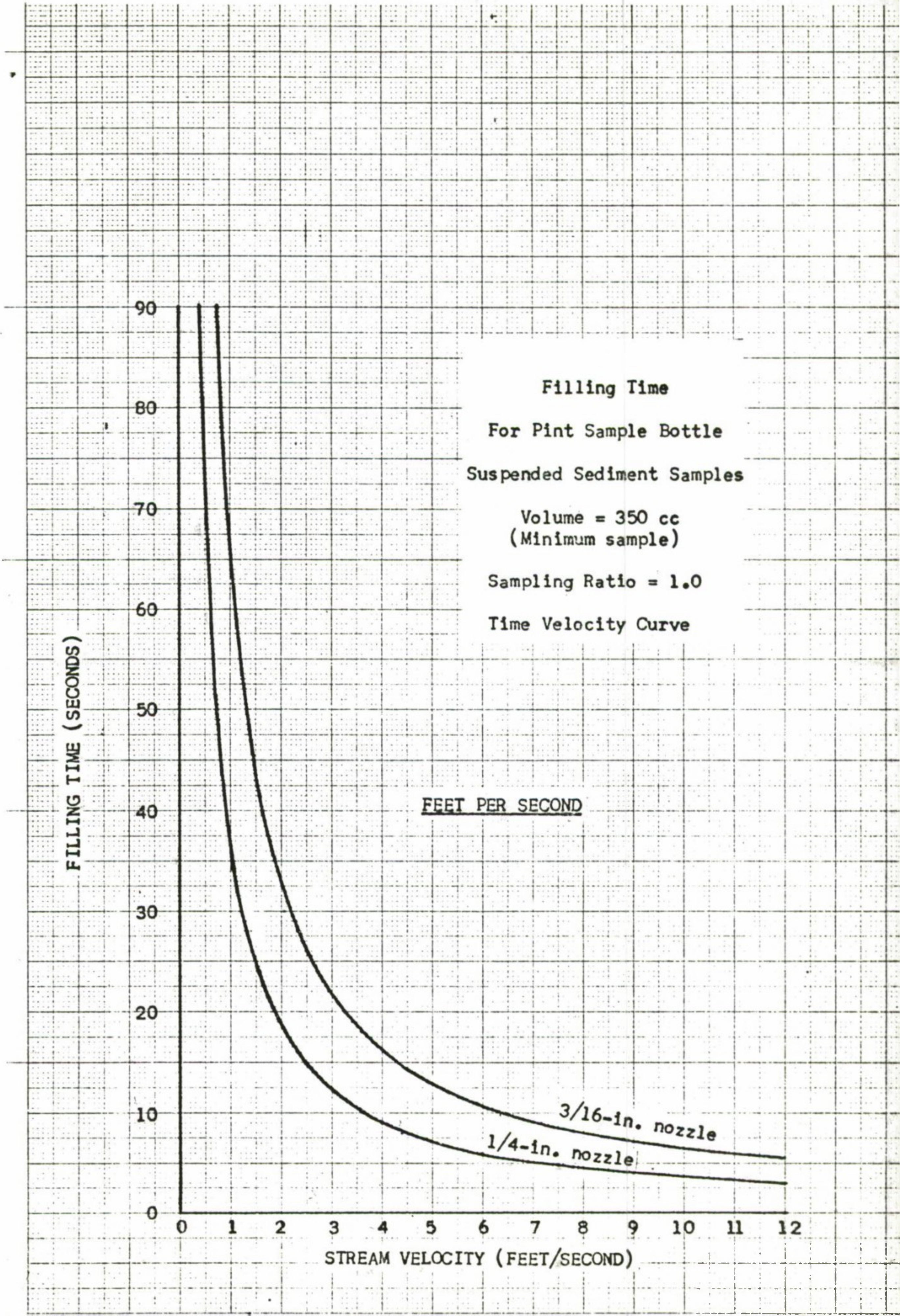
Name of the stream.
Precise location on the stream (vertical).
Location of the cross section.
The stream depth covered by the sample.
Stage of the stream (gage height).
Date.
Time of day.
Identification applied to sampling personnel.

In addition to the above, the following information may be useful also:

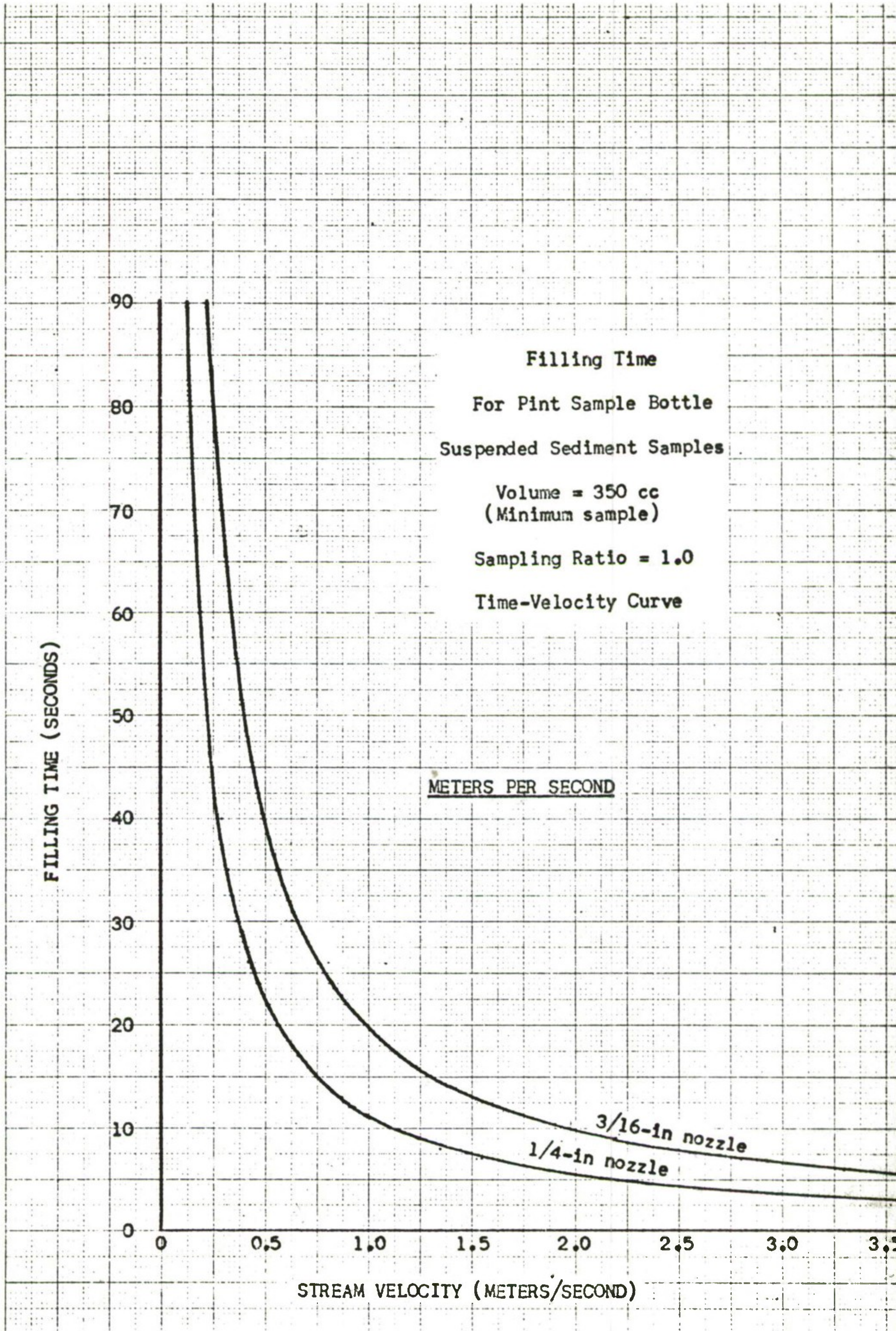
Sampling time (sampler submergence time).
Water temperature.
Coordination with sample groups.
Individual identifying sample number.

A portion of the exterior face of the glass bottle may be etched or otherwise treated to provide a surface suitable for recording all the essential information for each sample.

Methods of analyzing sediment samples are discussed in Reports No.s 4 and 7 of the series of reports on "A Study of Methods Used in Measurement and Analysis of Sediment Loads in Streams," sponsored by the Sub-committee on Sedimentation, Federal Interagency River Basin Committee.



Filling Time
For Pint Sample Bottle
Suspended Sediment Samples
Volume = 350 cc
(Minimum sample)
Sampling Ratio = 1.0
Time Velocity Curve
FEET PER SECOND
3/16-in. nozzle
1/4-in. nozzle
FILLING TIME (SECONDS)
STREAM VELOCITY (FEET/SECOND)
0
10
20
30
40
50
60
70
80
90
0 1 2 3 4 5 6 7 8 9 10 11 12



Filling Time
For Pint Sample Bottle
Suspended Sediment Samples
Volume = 350 cc
(Minimum sample)
Sampling Ratio = 1.0
Time-Velocity Curve
METERS PER SECOND
3/16-in nozzle
1/4-in nozzle
FILLING TIME (SECONDS)
STREAM VELOCITY (METERS/SECOND)
0
10
20
30
40
50
60
70
80
90
0.5
1.0
1.5
2.0
2.5
3.0

Appendix D

UNITED STATES GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

Suspended-sediment measurements by the Equal-Transit Rate Method

Low-flow discharge should be sampled with the DH-48 hand sampler by the equal-transit rate method (ETR). The hand sampler is used only when the flow is low enough to make a wading measurement.

The ETR sample is obtained by sampling a large number (10 or more) of equally spaced verticals with a constant transit rate. A sample bottle is placed in the hand sampler and successive verticals are sampled until the sample bottle is about 3/4 full. A second sample bottle is then placed in the sampler and the procedure continued until the entire stream is sampled. As only a few verticals may be sampled with the final sample bottle, the final bottle may be only partly filled. A transit rate should be selected so that three or more sample bottles will be filled with the water-sediment mixture.

The transit rate is the speed, or rate, that the sampler is lowered and raised in the stream. The slower the sampler is lowered and raised the faster the sample bottle is filled with water.

A fixed, or constant transit-rate should be used for each sediment measurement (or sample). Once the measurement is started the same rate should be used for all verticals and the rate should never be changed because the water gets deeper or faster toward the center of the stream. The purpose of this fixed rate is to allow more water to flow into the bottle in the deeper and swifter part of the stream than flows into the bottle from the shallow or slower part of the stream.

If the stream depth and width changes from day to day because of rain, or other reasons, the transit rate must be changed to obtain a sufficient amount of sample or to prevent the bottle from overfilling. The best transit rate is the speed that the sampler must be raised and lowered in the deepest and swiftest part of the stream so that two verticals will fill one sample bottle.

An example of an ETR measurement is as follows:

1. Determine the sampling verticals. Assume the stream to be 30 feet wide. (See figure 1).

   The stream should be divided into 10 or more equal parts. As the assumed stream width is 30 feet we can divide the stream into 10 equal parts by using 3 foot intervals (30 feet divided by 3 feet); or, we can divide the stream into 15 equal parts by using 2 foot intervals (30 feet divided by 2 feet); or, we can divide the stream into 30 equal parts by using a 1 foot interval; and so on.

   The sampling interval chosen for this example is 2 feet, which divides the stream into 15 equal parts. The first sampling vertical will be in the center of the first equal part ($\frac{1}{2}$ of the 2 foot interval), or 1 foot from the edge of water. The second sampling vertical will be in the center of the second equal part, or 3 feet from the edge of the stream. Likewise, each successive sampling vertical will be 2 feet past the vertical just sampled.

   Figure 1 shows the sampling verticals in the center of each of the 15 equal parts of the stream. The sampling verticals are 1 foot, 3 feet, 5 feet, 7 feet, 9 feet, 11 feet, 13 feet, etc. from the edge of water.

2. Determine the transit rate.

   The best transit rate is the speed that the sampler must be raised and lowered in the deepest and swiftest part of the stream so that <u>two</u> verticals will fill <u>one</u> sample bottle.

   The two verticals in the example (figure 1) in the deepest part of the stream are verticals 5 and 6. If the velocity of the stream at verticals 5 and 6 is estimated to be 2 feet per second and the depth of water is 2 feet, then the approximate transit rate to fill one bottle at verticals 5 and 6 is 0.4 foot per second. Thus the maximum speed which the sampler should be raised and lowered at all verticals is a little less than $\frac{1}{2}$ foot each second.

   The approximate transit rate was computed by multiplying the depth times the velocity and dividing by 10.

3. Obtain sample.

Place a clean sample bottle in the hand sampler and sample the first vertical using a transit rate of less than ½ foot per second. The first vertical is 1 foot from the edge of the water.

Next, sample the second vertical with the same transit rate used for the first vertical. The second vertical is 3 feet from the edge of water, or 2 feet further than the first vertical.

Continue to sample each successive vertical until the bottle is 3/4 full. The same transit rate used to sample the first vertical is used to sample each successive vertical, and each successive vertical is 2 feet further than the preceeding vertical. Replace full bottle with an empty sample bottle. Place a cap on full bottle and write all necessary information on front of bottle.

Continue to sample as described above until all verticals have been sampled. The completed measurement will result in three or more bottles of water. All the bottles of water from one measurement are usually referred to as a "set" of samples.

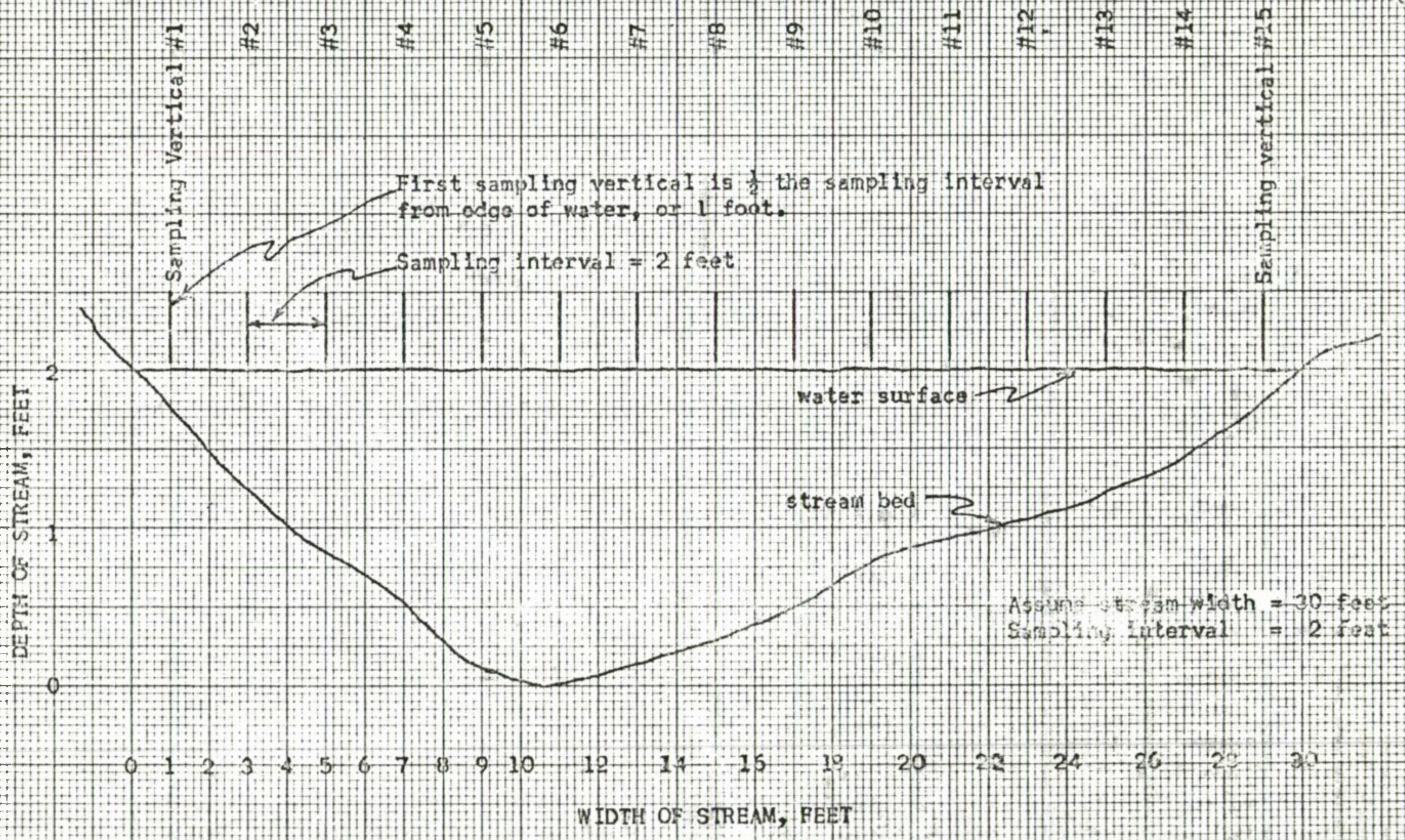


Figure 1.--Example of ETR measurement.