BASIC ENGINEERING SURVEYS FOR CONSERVATION PRACTICES TRAINING MODULE

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Natural Resources Conservation Service
Michigan

OBJECTIVE

This module is intended.to provide the participants with a basic understanding of engineering survey priciples applicable to conservation practices. These principles include the types of surveys, types of survey equipment, notekeeping and note reduction.

Upon completion of this module, participants should have reached the ASK Level 3, perform with supervision, for the following types of surveys performed with an optical level (self-leveling level); topographic, cross-section, profile and bench level circuit.

INSTRUCTIONS

At the end of each section there are questions to be answered. The questions are designed to give you feedback on your ability to accomplish the module objectives.

If you have difficulty in a specific area, contact your facilitator (module leader).

You will need a calculator in several sections of this module.

INTRODUCTION

We perform surveys to define the landscape that has a problem we are trying to solve or to define the landscape where we are installing a practice. The type of survey needed, the -accuracy required and the equipment to be used varies depending on the landscape and the practice to be installed. During the field survey section of this module, the participant and facilitator will spend time determining surveying needs with varying site conditions.

Section 1 - TYPES OF EQUIPMENT

There are several types of equipment used in surveying. We will be discussing only equipment that is typically used in NRCS work.

Survey Instruments

Total Station - is a laser level used to measure elevations, horizontal and vertical angles, and distances electronically. It has a computer that can be programmed to perform any type of survey and reduce survey data. It is a very complex instrument and generally will not be used by field office staff.

Transit - is an optical level used to measure elevations, horizontal and vertical angles, and distances. It can be programmed to perform any type of survey. We do not have many of these and generally will not be used by field office staff. For the type of surveys we normally perform, a transit due to its complexity would not be the instrument of choice.

Self-leveling Level - is an optical level used to measure elevations, horizontal angles and distances. It is one of the most frequently used instruments in the field office. It is used for performing bench level circuits, topographic surveys, cross-sections, profiles and construction layout/checkout. It automatically levels its line of site. It is simple, precise and quick. It is the most versatile survey instrument in the field office. You should become proficient at using this piece of equipment.

Laser Level - consists of a transmitter and receiver, it is used to measure elevations. You cannot measure distance or angles with the laser levels we have. It is also one of the most frequently used instruments in the field office. This instrument is very useful for construction layout/checkout.

For measuring field elevations a small laser receiver is mounted on a direct-reading survey rod. The user moves the receiver up or down the rod until a light or audible tone indicates the receiver is centered in the plane of laser light. The rod reading is taken directly from the rod, eliminating the need for someone to read the instrument.

Hand Level - is used for rough measurements of differences in elevation. The user stands erect and sights through the eyepiece, holding the tube in the hand and moving objective end up and down until the level bubble is centered on the fixed cross hairs. Hand level use seems to be on the decline, with laser levels located in all field offices.

However, hand levels can be useful in determining line of sight for setting up other survey instruments.

The Abney hand level has a graduated arc for reading percent of slope. To measure percent of slope lay a rectangular survey rod on the surface of the slope you wish to measure. Place the bottom side of the Abney level on the rod and move the arc adjustment indicator until the level bubble is centered on the cross hair. The measurement you obtain is in percent slope. The slope ratio (H:V) can be obtained from the percent slope, by dividing 180 by the percent slope (H = 180/percent slope, gives H:1 slope).

TRIPODS

All survey instruments are placed on tripods with the exception of hand levels. With the instrument in place tripods should be rough leveled, the plate. of the tripod should be horizontal.

SURVEY RODS

Survey rods or leveling rods are used to measure elevations. They are graduated in feet, tenths, and hundredths of a foot, with zero being at the bottom of the rod. The foot numbers are normally colored red. Numbers which denote tenths of a foot are normally black. The black strips are one-hundredth of a foot wide and are spaced one-hundredth of a foot apart. The top of each black strip is an even hundredth of a foot and the bottom is odd. Figure 1 shows a section of a rod.

Surveying rods may also be used to measure horizontal distances. This is called stadia and will be discussed in "measuring distance equipment".

MEASURING DISTANCE EQUIPMENT

Pacing - Measurement by pacing consists of counting the number of steps between two points. A natural stride or a pace can be used to determine your 'stride factor' or 'pace factor'.

Pacing may be used for approximate measurement when an error as large as 2 per-cent is permissible.

Taping - Taping is the method of measuring horizontal distances with a tape. This method is very accurate. When measuring distance on a slope be sure to keep tape level on the line being measured (see figure 3).

Stadia - The stadia method is a much faster way to measure distances than taping, and is sufficiently accurate for many situations. Stadia is accurate within a few feet under most conditions.

The equipment required for stadia measurements consists of a telescope with two extra horizontal hairs, called stadia hairs, and a survey rod. Self-leveling levels and transits have stadia hairs. One of the stadia hairs is above the center horizontal cross hair and the other is an equal distance below it.

To take a stadia measurement, observe through the telescope the interval in meters or feet on the rod between the two stadia hairs when the rod is held vertically on some point. This interval, called the stadia interval, is a direct function of the distance from the instrument to the rod. On most instruments the ratio of this distance to the stadia interval may be taken as 100 to 1. To determine the distance from the instrument to any given point, multiply the stadia interval by 100.

The distances obtained by the stadia method are as measured along the line of sight from the instrument to the rod. If the line of sight is on an appreciable grade, you will need to make a correction to obtain the true horizontal distance.

Section 1 - TYPES OF EQUIPMENT

QUESTIONS

1. What types of survey instruments listed in this module can be used for topographic surveys? Hint, must be able to measure horizontal angles and distance.

2. What field office instrument is the most versatile?

3. What would be your first choice of instruments to use for construction checkout of a grassed waterway, in a one person field office?

4. What is the stadia interval?

5. To determine distance using the stadia method you multiply the stadia interval by _____________ ?

6. Read and record the five cross hair settings on the rod in figure 1. The correct readings are shown on figure 2.

Section 2 - TYPES OF SURVEYS

Installation of all permanent practices used in soil and water conservation work require information regarding the relative elevation of designated points.

Common Terms

A **bench mark** (BM) is a point of known or assumed permanent elevation. Such points may be marked with a brass pin or a cap set in concrete, a lone metal stake driven into the ground, a specifically located point on a concrete bridge, culvert, or foundation, or similar objects that are not likely to be disturbed.

A **temporary bench mark** (TBM) is a point of known or established elevation usually provided for convenient reference in the course of surveys and construction when permanent bench marks are too far away or are inconveniently located. Such bench marks may be established on wooden stakes set near a construction project or on nails driven into trees. Bench marks on trees will have more permanence if set near the ground line where they will remain on the stump if the tree is cut and removed. When temporary bench marks are required to be maintained thru the winter, frost heave can be a big problem for stakes that are not placed below the frost line. Frost heave can move stakes up several tenths of a foot.

A turning point (TP) is a point on which the elevation is determined in the process of leveling, but which is no longer needed after necessary readings have been taken. A turning point should be located on a firm object, whose elevation will not change while moving the instrument setup. A small stone, fence post, temporary stake, or axe head driven firmly into the ground usually is satisfactory.

A backsight is a rod reading taken on a point of known elevation. It is the first reading taken on a bench mark or turning point. Backsights are sometimes recorded in the (+) column, because they are added to bench mark and turning point elevations.

A foresight is a rod reading taken on any point on which an elevation is to be determined. Only one backsight is taken during each setup; all other rod readings are foresights. Foresights are sometimes recorded in the (-) column, because they are subtracted from the height of instrument.

Height of instrument (HI) is the elevation of the line of sight. It is determined by adding the backsight rod reading to the known elevation of the point (BM, TBM, or TP) on which the backsight was taken.

Setting Up Levels

Before attempting to set up the level, be sure that the tripod wingnuts have been tightened. Be sure that after lowering the tripod legs to the ground the base plate of the tripod is relatively level by eye and that the tripod legs are spread at such an angle that the tripod is stable.

When setting a tripod on a slope, two of the tripod legs should be placed down slope and the remaining leg up slope.

For a level with four leveling screws, line up the telescope over one pair of leveling screws and center the bubble approximately, by turning screws in the opposite direction at the same time. The process should be repeated with the telescope over the other pair of screws. Continue this procedure until the bubble remains centered for any position of the telescope. The leveling screws should be tightened only. enough to secure a firm bearing.

For self-leveling levels with three leveling screws, turn the telescope until it is parallel with two of the screws. Bring the bubble to the center using the pair of screws and the third screw.

Adjust the cross hairs by turning the eyepiece.

Be sure that the rod reading is taken with the rod in the vertical position. When taking rod readings on bench marks and turning points rock the rod very slowly forward and backward over the center, using the bench mark or turning point as a pivot point.

On bench marks and turning points rod readings should be taken to the nearest hundredth of a foot. On routine ground shots rod readings should be taken to the nearest tenth of a foot.

When surveying near roads or during hunting season it is advisable to wear a florescent orange hunting vest.

Bench Level Circuit

A bench level circuit is run to determine the relative elevations of two or more bench marks. The circuit starts from a bench mark or from some point of assumed elevation. A bench level circuit is frequently run as a part of a profile, cross-section, or topographic survey.

On large projects, the bench level circuit should be run before all the other survey work, or much more work will be required to carry corrections through the survey notes if mistakes occur. Bench level circuits should always be "closed" on the starting point. That is, after the last bench mark is set, level lines should be run back to the starting point, unless the circuit can be closed on another proven point. The procedure for running a bench level circuit is as follows:

1. The level is set at a point between the starting bench mark and the next bench mark or turning point. Usually shots should not be taken over 400 feet. Keeping foresight and backsight distances approximately equal makes it possible to compensate for any adjustment errors in the instrument.

2. With the rod-person holding the rod on the bench mark (BM 1), the instrument-person takes a rod reading and records it as a backsight. The backsight rod reading is then added to the bench mark or assumed elevation to get the height of instrument (HI).

3. The rod-person then moves ahead and picks out a convenient point for a turning point (TP 1). The instrument-person takes a rod reading. on TP 1 recording it as a foresight. The HI minus the rod reading on TP 1 gives the elevation of TP 1.

4. The instrument-person then moves ahead and takes a backsight on TP 1. The elevation of TP 1 plus the backsight rod reading on TP 1 gives the new HI. The rod-person then moves ahead and picks a new tuning point (TP 2). The instrumentperson takes a foresight on TP 2.

5. After the elevation of the last bench mark has been determined, the survey crew runs levels back to the starting bench mark to "close" the circuit. In making the return, the instrument-person resets the instrument and uses the last bench mark as a turning point in closing the circuit.

6. After the final foresight on the starting BM is taken, the “error of closure” can be determined. This is the difference between the actual elevation of the BM and the elevation computed from the final foresight.

Ordinary survey accuracy should be attained in establishing bench marks, level circuits involving six or more instrument setups, and surveys for drainage, irrigation, large channels, and other major structural practices. Rough survey accuracy is adequate for level circuits of less than six instrument setups, for preliminary and reconnaissance surveys, and for surveys for such conservation practices as diversions, waterways, and small ponds (see figure 4).

The check for closure should be done in the field to find errors and reduce return visits to the field. The closure error should be checked by adding all the backsights and then adding all the foresights in the circuit. The difference should equal the error of closure.

Self-leveling instruments and laser levels are the most often used instruments for bench level circuits. Total stations are also used for these surveys.

Profiles and Cross Sections

The object of profile leveling is to determine the elevation of the ground at measured distances along a selected line, usually the centerline of a water course. These elevations can then be plotted on profile paper at selected scales so that studies can be made of grades, depths, and high and low spots, and so that estimates can be made of quantities of cuts and fills.

Cross sections are simply profiles usually taken at right angles to a base line such as the center of a road, ditch, gully, or other selected base line. Cross sections may be run along with profile levels, or they may be run after the profile line has been staked and profiles have been taken.

Normally the starting station for surveys involving streams, waterways, ditches and gullies should be located at the upstream end and proceed in the direction of flow. Drainage surveys commonly proceed upstream with increasing station.

It is recommended that the beginning station for a survey be called something other than 0+00 to prevent negative stations. 10+00 could be used as a starting station and if an addition station was required above the starting station, 1000 feet would be available without causing a negative station.

Normally the zero point (base line) of the cross section is the centerline of the gully, ditch or stream; however, it is not essential. In some cases, the zero point (base line) may be along the bank of a ditch. In any case, the zero of the cross section is on the base line. In the field notes the direction of the cross section should be indicated. It is standard practice to refer to “right” and “left” when facing (downstream) the direction of progressive station of the profile line.

Self-leveling levels and laser levels are the most often used instruments for cross sections and profiles. Total stations are also used for these surveys.

Topographic Surveys

Topographic surveys, to obtain ground relief data and locations of natural and constructed features, are the basis for many soil and water conservation projects.

Stadia surveys are the type most often used for topographic surveys. Stadia surveys usually consist of two parts: (1) the traverse, and (2) the taking of topography. The first is the horizontal control, and the second is the vertical control.

Horizontal Control - The field work in this survey consists of determining horizontal angles (azimuths) to points or objects and obtaining distances between points by stadia. The azimuth angle is always measured clockwise from the zero azimuth. On any given survey the position of zero azimuth should always be the same, usually north. The zero azimuth can be set by magnetic north with a compass or by visually estimating north using roads or fence lines.

It is very important to maintain horizontal control when making "turns" during stadia surveys. The most frequently used method for maintaining horizontal control is to have the rod person find a new instrument set-up point. The instrument-person should take a rod reading with stadia (distance) and azimuth. This will allow horizontal control to be maintained during plotting of the survey notes. When the instrument is moved to the new setup point, zero azimuth should be set north.

Stadia surveys should be tied to fence line, roads and buildings, whenever possible, as this facilitates plotting and orienting the survey.

Vertical Control - is maintained during a stadia survey using the same methods for bench level circuits.

Self-leveling levels and total stations are the most commonly used instruments for topographic surveys.

Construction Layout And Check-out

Construction layout surveys are surveys that are necessary to facilitate the construction of a practice. This type of survey is frequently a combination of a bench level circuit, profile and cross section survey.

Construction check-out surveys are surveys that are necessary to provide assurance that a practice was installed to proper elevation, grade and dimensions. These surveys are also a combination of other types of surveys.

Laser levels are the most frequently used instrument for construction layout and check-out.

Section 2 - TYPES OF SURVEYS

QUESTIONS

1. How is horizontal control maintained making “turns” during stadia surveys?

2. Are backsights added or subtracted from bench mark elevations to obtain the height of instrument?

3. When is it permissible to not close a bench level circuit?

4. On bench marks and turning points rod readings should bemade to the nearest _______ of a foot.

5. On routine ground shots, read the rod to the nearest _________ of a foot.

6. Zero azimuth is usually set to the __________ .

<u>Section 3</u> - NOTEKEEPING

The National Engineering Manual, Part 540 contains the policy on engineering survey notekeeping. Part MI540.03 states that “survey notes will provide the minimum information shown in the sample notes in Technical Release-62 and follow a format similar to TR-62 samples.

The sample notes in this module follow TR-62, with slight modifications based on years of experience.

It is suggested that you create sample notes for the type of surveys you use in your area and keep these in your field survey book. You may want to add any conversion factors you might find useful.

Bench Level Circuit

Figure 5 shows sample survey notes for a bench level circuit. At turning points, the foresight and elevation are on one line and the backsight and height of instrument are on the following line. A blank line is left between each turning point and bench mark. By putting the backsights and foresights on different lines it is easy to determine which was shot first. The blank line between turning points and bench marks makes notes easier to follow and allows room for bench mark descriptions on the adjacent page.

Topographic Survey

Figures 6 thru 8 show sample survey notes for a topographic survey. The column content is as follows:

< column - azimuth
B column - bottom cross hair (stadia)
M column - middle cross hair (rod reading)
T column - top cross hair (stadia) E column - elevation (HI - M)
D column - distance [stadia distance = (T-B)(100)].

Figure 9 is a plot of the topographic survey using the Michigan Engineering Programs.

Waterway and Structure Survey

Figures 10 thru 13 are the design survey notes for a waterway and structure. The type of surveys used are profile, cross section and bench level circuit. See figures 18 thru 22 for isometric views of the site.

Figure 14 is the construction layout survey notes for the waterway and structure.

Figures 15 thru 17 are construction check-out survey notes for the waterway and structure.

Section 3 - NOTEKEEPING

QUESTIONS

1. Where is the policy for survey notekeeping?

2. Why would you want to keep sample notes in your field survey book?

Section 4 - ANALYZING SITE CONDITIONS

To perform a survey there are some things you must be able to do that are obvious. You must be able to setup the instrument, take readings and keep survey notes. The most important tasks are performed before the survey instrument is ever setup, that is to determine what the problem is, what is causing the problem, formulate alternatives and then to decide what alternatives you are surveying for. Many times during the design phase you will find that the practice you thought would work best to solve a problem is not a viable alternative based on the site conditions that you have to work with. If you have performed a survey with only one type of practice in mind, you may be making another trip for additional survey data.

Analyzing site conditions is illustrated in figures 18 thru 22. Figure 18 shows a gully along a ditch bank. You should discuss the problem with the landowner to obtain his/her ideas. However, many times the landowner may not know what is causing the problem or what the problem is. You as the technical person must be able to recognize the problems and develop solutions. What are the problems on this site? How about gully erosion and unstable outlet. What is causing the problems on this site? Excess surface water is causing the problem. What are some alternatives for solving this problem? To control the gully erosion you might consider a water and sediment control basin up slope of the problem area or a grassed waterway at the problem area. To provide a stable outlet you will need some kind of grade stabilization structure (GSS). You might select a pipe drop structure, straight drop spillway, box spillway or a chute spillway. What alternatives you choose will decide the extent of your survey. Figures 19 and 20 show the alternatives that were chosen. What type of survey is needed for the solution shown in figure 20? Figure 21 shows a profile and cross-sections of the proposed waterway that are needed, as well as a cross-section at the structure site. Figure 22 shows actual stations and crosssection points.

Your survey must provide enough information to do the design and enough data to establish quantities. For a contractor to bid a job he/she will need reasonable quantity estimates.

You must develop the ability to recognize the problem to be solved and envision ways to solve it. Only then can you perform a good survey.

Section 4 - ANALYZING SITE CONDITIONS

QUESTIONS

1. An engineering survey must be able to provide enough information to and

2. You perform the survey first and then decide what type of practice will fit the site. (True of False)

Section 5 - CARE AND HANDLING OF EQUIPMENT

To set up an instrument and tripod, remove the tripod cap and place it in the instrument box for safekeeping. Blow dust and dirt particles from the tripod head before mounting instrument.

The sunshade should be used regardless of the weather.

When placing the instrument in the case, loosen the lower clamp screw and replace the objective lens cap on the telescope. After placing the instrument into the case, tighten the telescope clamp screw.

Do not lubricate instrument leveling screws.

Do not rub telescope lenses. These lenses are made of soft glass that scratches easily. Dust them with a clean, soft, camel's hair brush, or wipe them very carefully with a clean, soft cloth.

Never store a wet instrument in the case. Store equipment in a dry place.

Tripod screws should be loosened before storing.

Survey instruments should be carried in the instrument case in the cab of the vehicle, preferably on the floor or in a wellpadded equipment box. Rods should be in cases and carried where they will be protected from weather.

Section 5 - CARE AND HANDLING OF EQUIPMENT

QUESTIONS

1. What type of oil should be used on instrument leveling screws?

2. Tripod screws should be loose then tripod is stored. (True or False)

Section 6 - FIELD PRACTICE

Actual surveys, notekeeping, note reduction and survey plotting should be performed by participants with supervision from facilitator's (module leaders).

The following types of surveys should be performed:

- Bench level circuit
- Cross section
- Profile
- Topographic
- Construction layout/check out

Survey notes should be reduce and plotted by hand and using the "Michigan Engineering Programs".

Recommended Survey Types for Conservation Practices

PRACTICE	SURVEY TYPES
Agrichemical Containment Facility	Bench Level Circuit, Topo, Profiles and Cross Sections
Animal Trails and Walkways	Bench Level Circuit, Topo, Profiles and Cross Sections
Dike	Bench Level Circuit, Profiles and Cross Sections
Diversion	Bench Level Circuit, Profiles and Cross Sections
Fueling Facility, Above Ground Storage	Bench Level Circuit, Topo, Profiles and Cross Sections
Grade Stabilization Structure	Bench Level Circuit, Topo, Profiles and Cross Sections
Grassed Waterway	Bench Level Circuit, Profiles and Cross Sections
Heavy Use Protection	Bench Level Circuit, Topo, Profiles and Cross sections
Pond	Topo, Profiles and Cross Sections
Pumping Plant for Water Control	Topo, Profiles and Cross Sections
Recreation Land Grading and Shaping	Bench level circuit, Topo, Profiles and Cross Sections
Recreation Trail and Walkway	Bench Level Circuit, Topo, Profiles and Cross Sections
Roof Runoff Management	Bench Level Circuit, Topo, Profiles and Cross Sections
Spring Development	Bench Level Circuit, Topo, Profiles and Cross Sections
Streambank Protection	Bench Level Circuit, Topo, Profiles and Cross Sections
Stream Crossing and Livestock Access	Topo, Profiles and Cross Sections
Subsurface Drain	Bench Level Circuit, Topo, Profiles and Cross Sections
Surface Drainage, Field Ditch	Bench Level Circuit, Profiles and Cross Sections
Surface Drainage, Main or Lateral	Bench Level Circuit, Profiles and Cross Sections
Trough or Tank	Topo, Profiles and Cross Sections
Waste Storage Facility	Topo, Profiles and Cross Sections
Water and Sediment Control Basin	Bench Level Circuit, Topo, Profiles and Cross Sections
Wetland Restoration	Bench Level Circuit, Topo, Profiles and Cross Sections

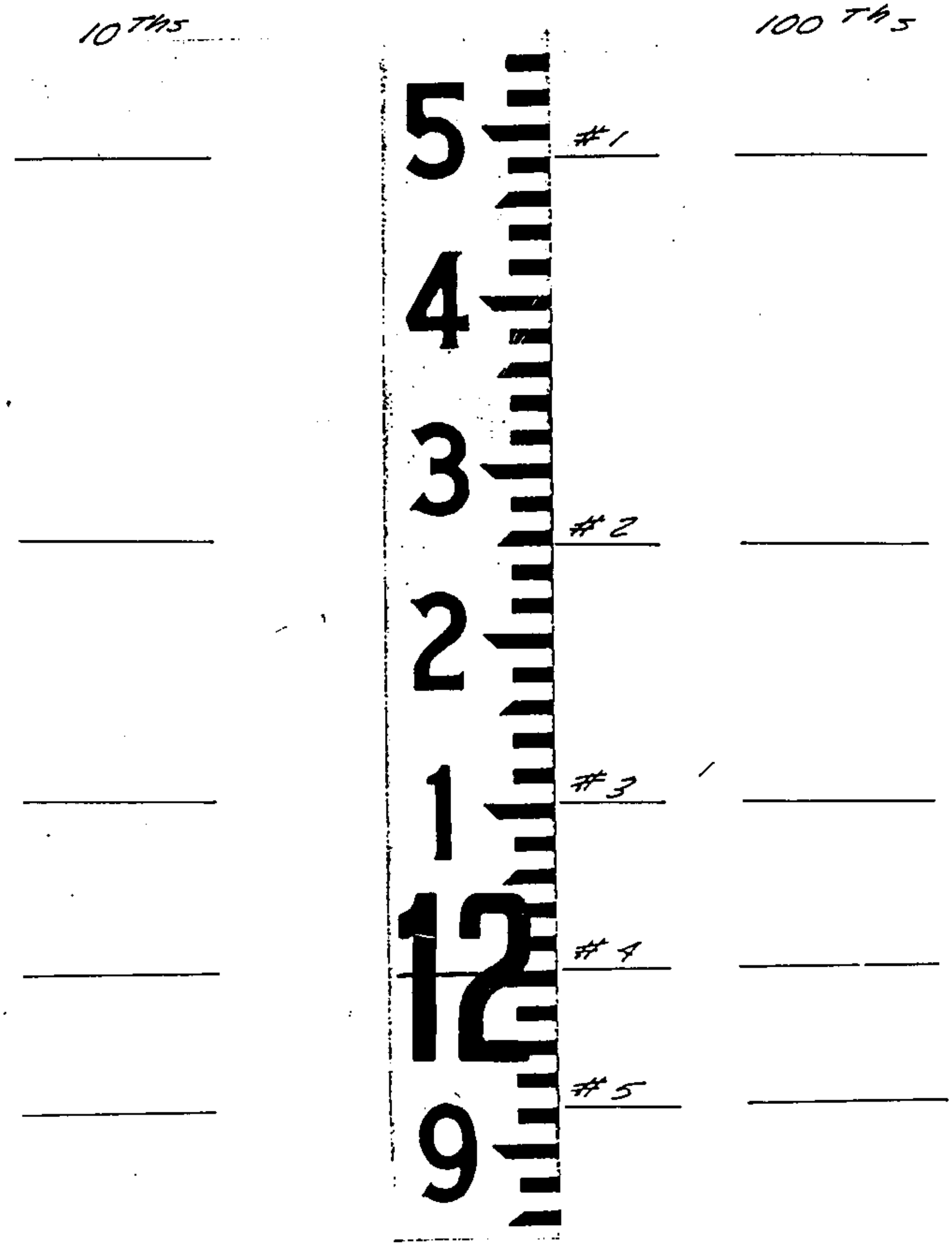


Figure 1

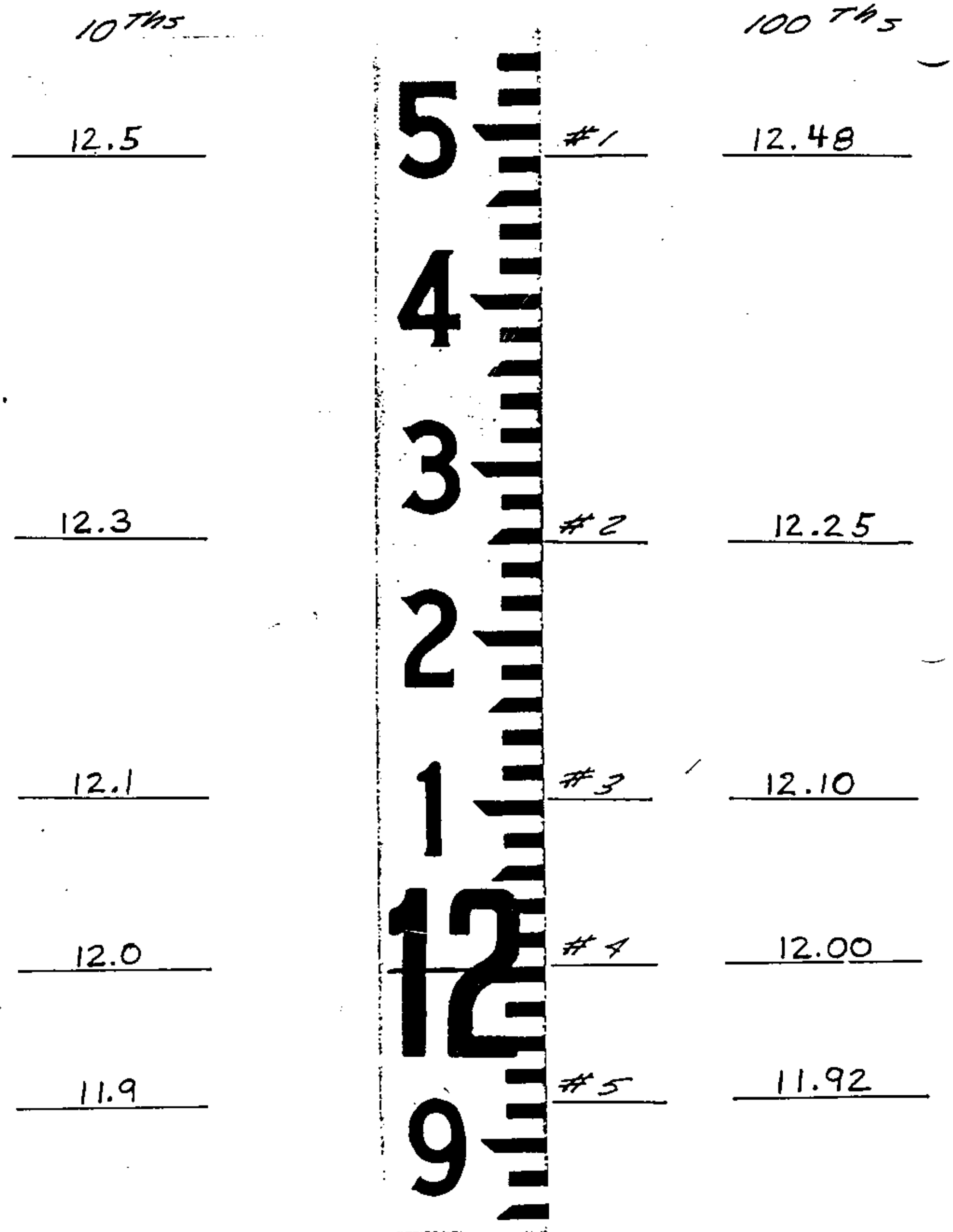

10ths
100ths
12.5
12.3
12.1
12.0
11.9
#1
#2
#3
#4
#5
12.48
12.25
12.10
12.00
11.92
5
4
3
2
1
12
9

Figure 2

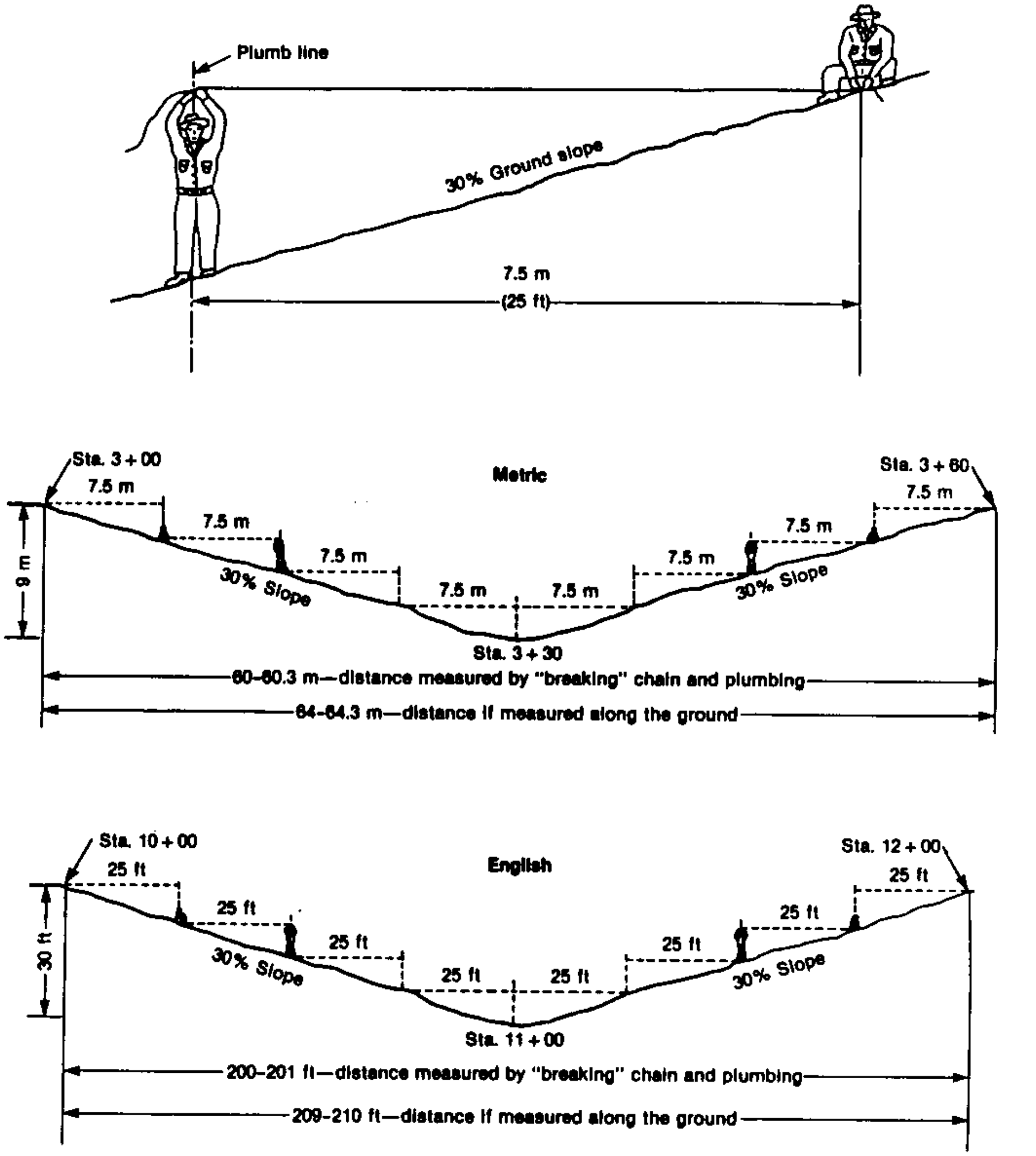

Plumb line
30% Ground slope
7.5 m
(25 ft)
Sta. 3+00
Metric
Sta. 3+60
7.5 m
7.5 m
7.5 m
7.5 m
7.5 m
7.5 m
7.5 m
7.5 m
8 m
30% Slope
30% Slope
Sta. 3+30
60-60.3 m—distance measured by "breaking" chain and plumbing
64-64.3 m—distance if measured along the ground
Sta. 10+00
English
Sta. 12+00
25 ft
25 ft
25 ft
25 ft
25 ft
25 ft
25 ft
25 ft
30 ft
30% Slope
30% Slope
Sta. 11+00
200-201 ft—distance measured by "breaking" chain and plumbing
209-210 ft—distance if measured along the ground

Figure 3

Type of survey		Ordinary surveys	Rough surveys
Triangulation:			
Maximum error of angular closure		1.0 minute $\sqrt{N}$	1.5 minutes $\sqrt{N}$
Maximum error of horizontal closure			
By chaining		1.0/5,000	1.0/1,000
By stadia		1.0/1,000	3.0/1,000
Traverse:			
Maximum error of angular closure		1.0 minutes $\sqrt{N}$	1.5 minutes $\sqrt{N}$
Maximum error of horizontal closure			
By chaining		1.0/5,000	1.0/1,000
By stadia		1.0/1,000	3.0/1,000
Leveling:			
Maximum error of vertical closure			
By level and rod	**Metric**	0.02 m $\sqrt{km}$	0.08 m $\sqrt{km}$
	English	.10 ft $\sqrt{M}$	.40 ft $\sqrt{M}$
By transit and stadia	**Metric**	.06 m $\sqrt{km}$	.20 m $\sqrt{km}$
	English	.30 ft $\sqrt{M}$	1.0 ft $\sqrt{M}$
Topographic:		The elevation of 90 percent of all readily identifiable points shall be in error not more than one-half contour interval. No point shall be in error more than a full contour interval.	

N is the number of angles turned.
M is the miles of levels run.
km is the kilometers of levels run.

Figure 4

NOTE ①

Sta.	+ B.S.	H.I.	− F.S. or ~~Grade Rod~~	Elev. or Planned Elev.	
TBM #1	3.26	103.26		100.00	
NOTE ②			NOTE ③		
TP #1			7.58	95.68	
	1.65	97.33			
TBM #2			2.38	94.95	
		CLOSE			
TBM #2	2.13	97.08		94.95	
TP #3			1.28	95.80	
	8.63	104.43			
		note ④			act =
TBM #1			4.41	100.02	100.00
	(15.67)		(15.65)		

• U.S. GOVERNMENT PRINTING OFFICE:1985-469-C36

SAMPLE ① ⊼ -- LASER
BENCH LEVEL CT. ∅ -- ANYONE
8/27/91

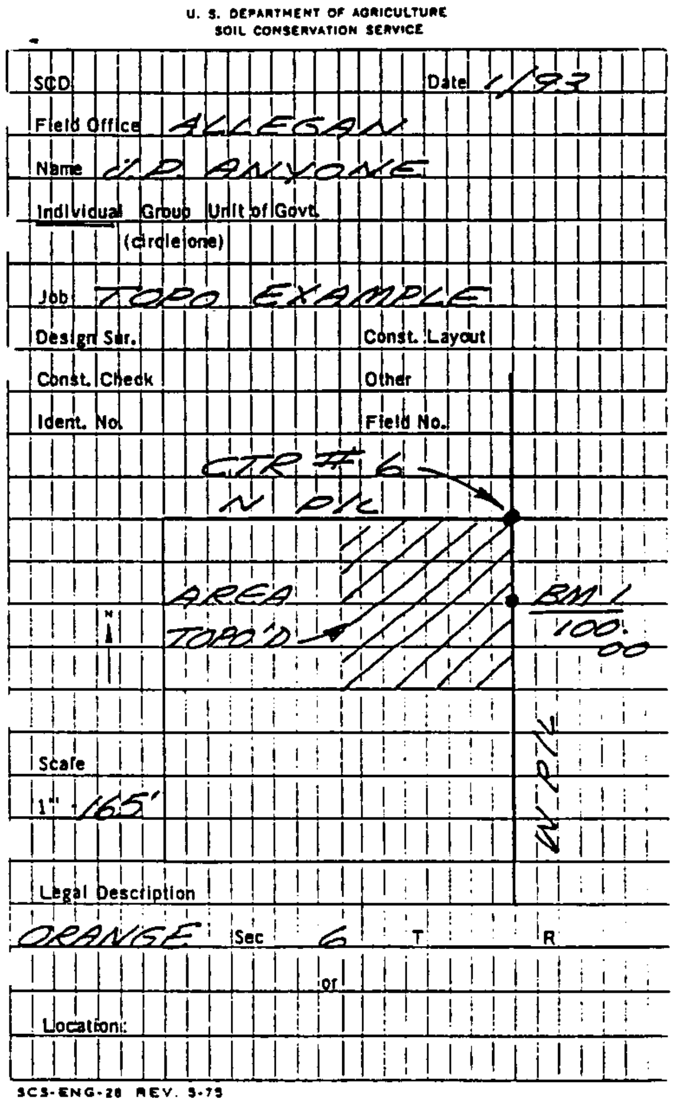
SCS DISK & SPIKE IN E SIDE 30" TULIP POPLAR IN W. P/L 275' S OF NW CORNER OF FARM. E FACE OF TREE MARKED W/ ORANGE PAINT.

"X" CHIPPED IN BELL - U.S. END OF 30" R/C LANE CULVERT IN N P/L 466' W OF E P/L.

notes

① shots on known elev's are always B.S. (back-sights) & are added to known elev. to obtain H.I. (Height of Instrument)
② T.P. = Turning point
③ shots on unknown elev's. are Foresights (F.S.) & are subtracted from H.I. to obtain the elev. of that point.
④ Checking into TBM to close a "Circuit" is an exception to note ①

Figure 5



U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SCD Date 1/93

Field Office ALLEGAN

Name J.P. ANYONE

Individual Group Unit of Govt.
(circle one)

Job TOPO EXAMPLE

Design Svr. Const. Layout

Const. Check Other

Ident. No. Field No.

Scale
1" = 165'

Legal Description
ORANGE Sec 6 T R
of

Location:

SCS-ENG-28 REV. 5-75

Figure 6

Sta.	B.S.	H.I.	F.S. or Grade Rod	Elev. or Planned Elev.	
BM#1	7.50	107.50		100.00	
∠	B	M	T	E	D
62° 30'	6.74	7.50	8.26	100.00	152
64° –	8.23	8.90	9.57	98.6	134
75° –	7.07	7.70	8.33	99.8	126
84° 30'	5.59	6.20	6.81	101.3	122
60° 30'	8.43	9.00	9.57	98.5	114
70° 45'	6.82	7.40	7.98	100.1	116
82° –	4.90	5.40	5.90	102.1	100
55° –	8.55	9.00	9.45	~~96.5~~ 98.5	90

* U.S. GOVERNMENT PRINTING OFFICE:1985-469-C36

J.P. ANYONE ① T-HAVEMAN
TOPO EXAMPLE ø-ANYONE
1/93

BM #1

NE CORNER OF BARN

NW CORNER OF BARN

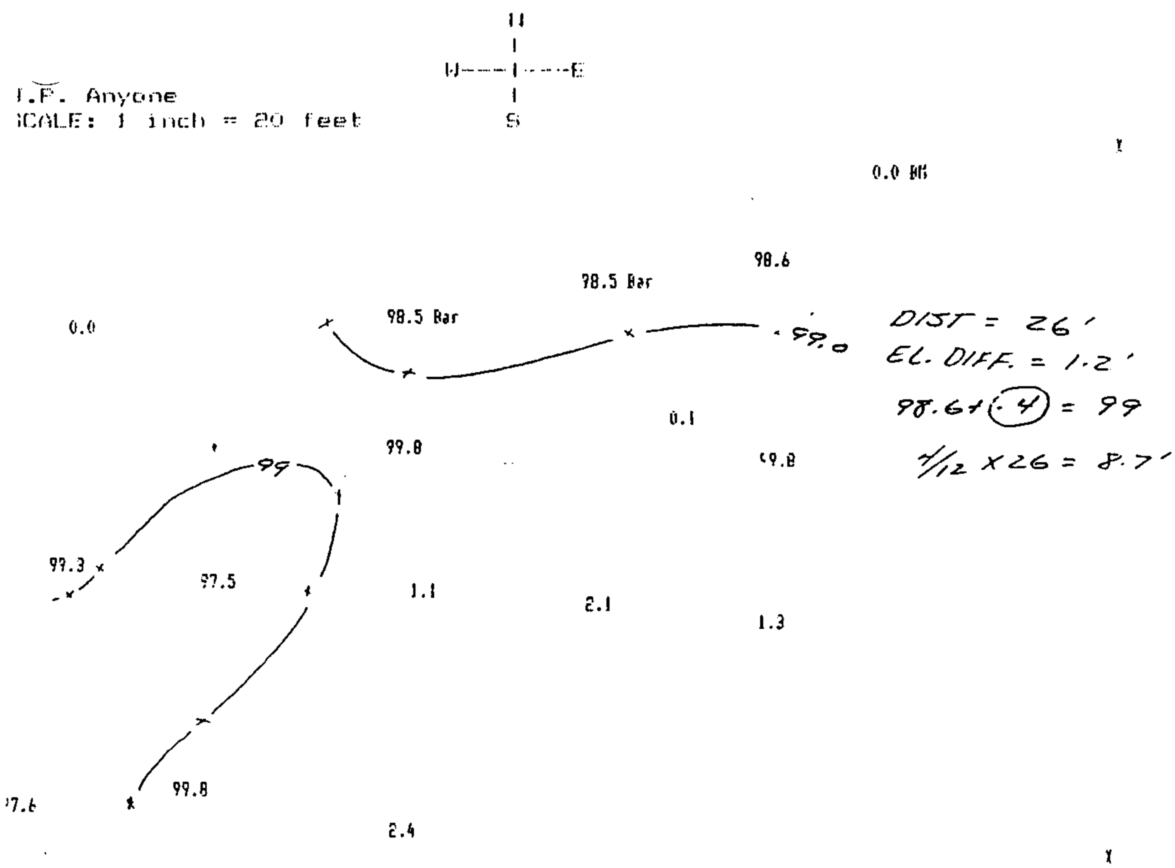
Figure 7

Station	B.S.	H.I.	F.S. or grade rod	Elev. or planned elev.	
		107.50			
L	B	M	T	E	D
65° 15'	7.29	7.70	8.11	99.8	82
78° 30'	6.01	6.40	6.79	101.1	78
101° 30'	4.72	5.10	5.48	102.4	76
72° —	9.73	10.00	10.27	97.5	54
102° —	7.46	7.70	7.94	99.8	48
33° —	7.20	7.50	7.80	100.0	60
58° 30'	8.02	8.20	8.38	99.3	36
115° 15'	9.76	9.90	10.04	97.6	28
BM 1			7.50	100.00	O.K.

SCS-ENG-29 (2-80) GPO : 1982 O - 369-952

Figure 8

OH-Ver 2.2 Page 1 Plotted 06/11/93



Computed overall length = 85 ft.

Figure 9

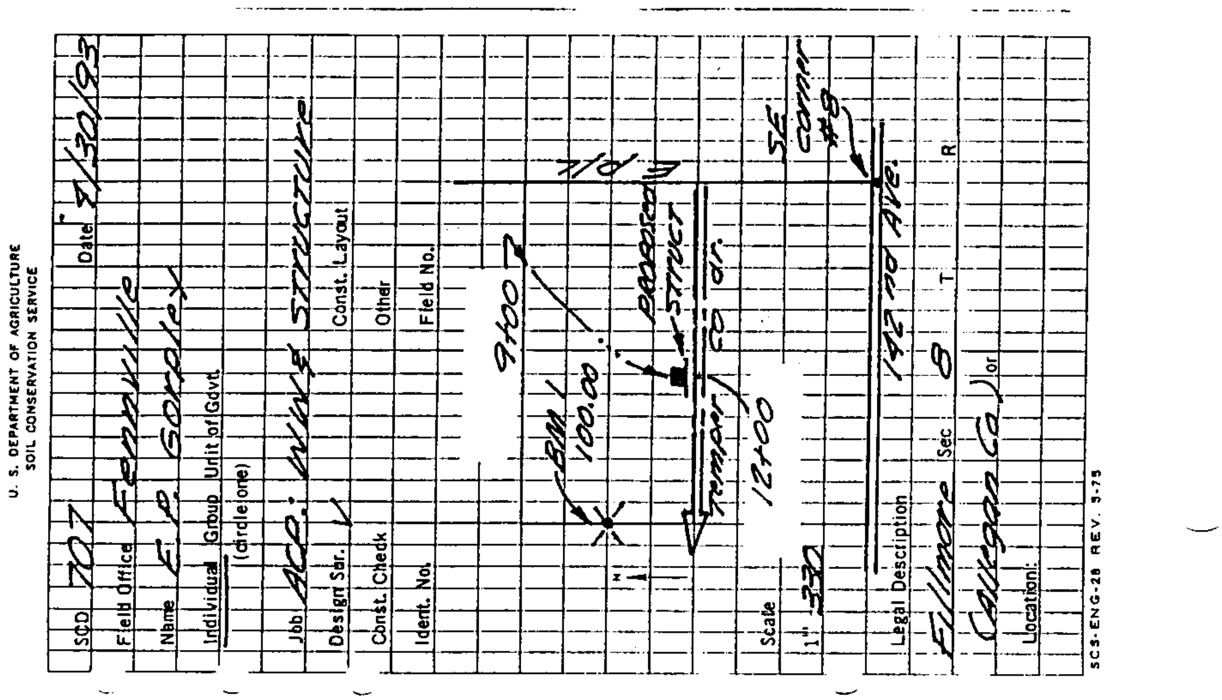

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SCD 707
Date 7/30/93
Field Office Fennville
Name
Individual Group Unit of Gdvt.
(circle one)
Job
Design Sar.
Const. Layout
Const. Check
Other
Ident. No.
Field No.
BM 1
100.00
9+00
12+00
Scale
1" = 330
SE corner #8
Legal Description
Ellmore
Sec 8
T
R
Location:
SCS-ENG-28 REV. 3-75

Figure 10

Sta.	B.S.	H.I.	F.S. or Grade Rod	Elev. or Planned Elev.
BM#1	5.13	105.13 (105.1)		100.00
12+00	Wooden lath w/ orange ribbon in ℄ of Temper Co drain.			
11+96				
11+93				
11+84	℄ of Wingwalls - prop. structure			

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E.P. Gorpley ① Ik - laser
ACP-WW, STT. ø - Haveman
des. survey
4/30/93

SCS disc & spike in E side 36" Beech Tree located 200' West & 160' North of gully outlet.

		97.6		
		10.5		
		95.1		
		10.0		
		96.6		
		8.5		
97.9	97.1	97.1	97.3	98.1
7.2	8.0	8.0	7.8	7.0
5'	3' LDS		3' RDS	8'
98.3	98.5		99.1	98.1
6.8	6.6		6.0	7.0
15'	25'		24'	14'

Figure 11

Station	B.S.	H.I.	F.S. or grade rod	Elev. or planned elev.	
		105.13			
		(105.1)			
11+50					
11+00					
10+50					
9+00	E	of	C.		
BM#1			5.12	100.01	

SCS-ENG-29 (2-80) GPO : 1982 O - 369-853

E.P. Gompley ②

~~Wat. Struct.~~

des. survey

7/30/93

100.1	100.1	99.1	99.9	100.1
5.0	5.0	6.0	5.2	5.0
18'	8'LDS		6'RDS	16'
100.3				100.3
4.8				4.8
28'				26'
		100.6		
		4.5		
	102.1	101.6	102.0	
	3.0	3.5	3.1	
	10'LDS		10'RDS	
		104.6		
		0.5		

0.01 out.

Figure 12

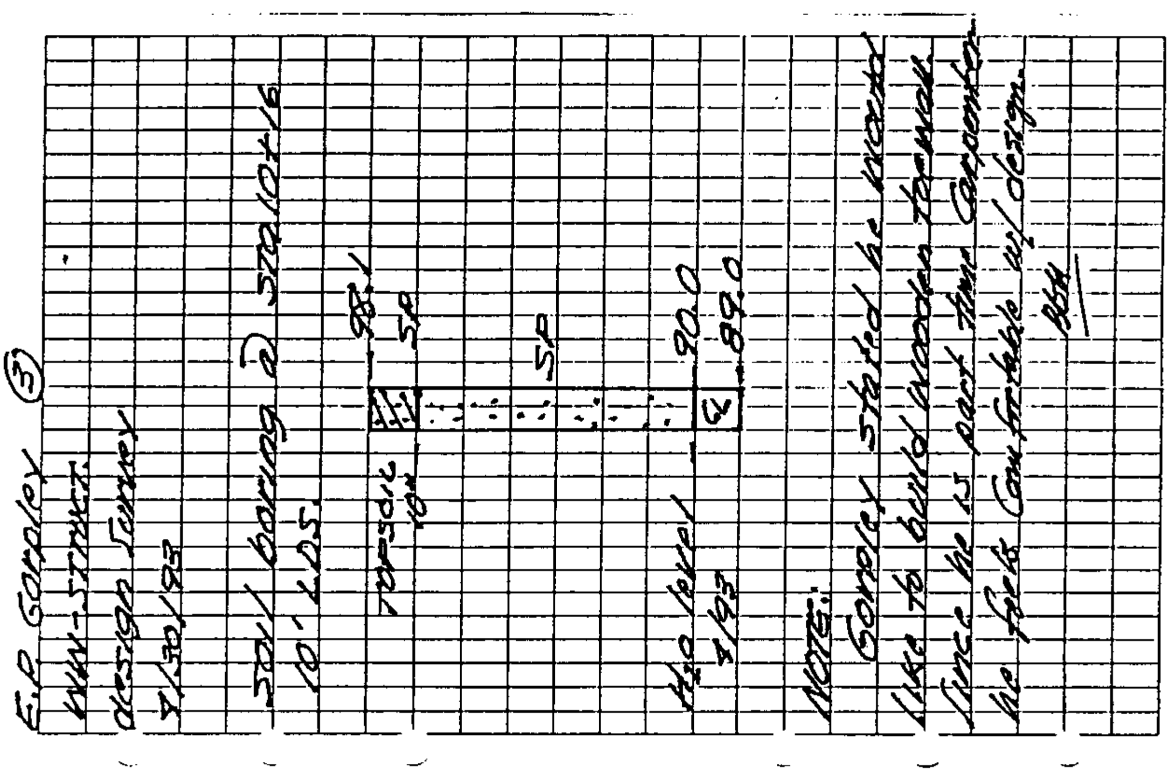
E.P. Gorpley
design survey
Soil boring @ STA 10+16
10' LDS.
Topsoil
SP
SP
H2O level
4/93
90.0
89.0
NOTE:
Gorpley stated he
like to build wooden
since he is part time
he feels comfortable w/ design.

Figure 13

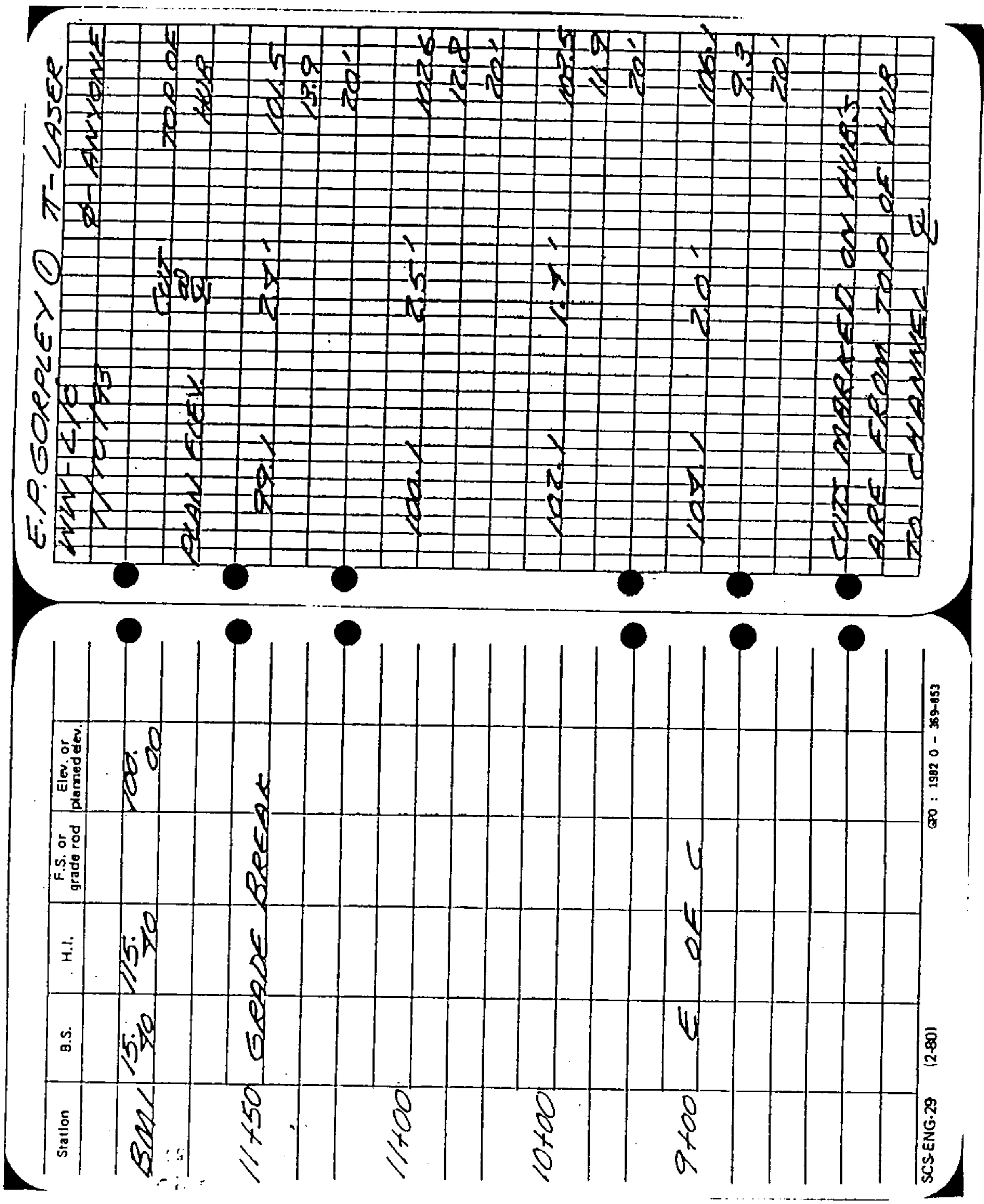
Station
B.S.
H.I.
F.S. or grade rod
Elev. or planned elev.
BM1
15.40
115.40
100.00
11+50
GRADE BREAK
11+00
10+00
9+00
E OF C
SCS-ENG-29 (2-80)
GPO : 1982 O - 369-853
E.P. GORPLEY ① π-LASER
WW-L/C
11/10/93
Ø-ANYONE
PLAN ELEV.
CUT @ ℄
TOP OF HUB
99.1
2.4'
101.5
13.9
20'
100.1
2.5'
102.6
12.8
20'
102.1
1.4'
103.5
11.9
20'
104.1
2.0'
106.1
9.3
20'
CUTS MARKED ON HUBS
ARE FROM TOP OF HUB
TO CHANNEL ℄

Figure 14

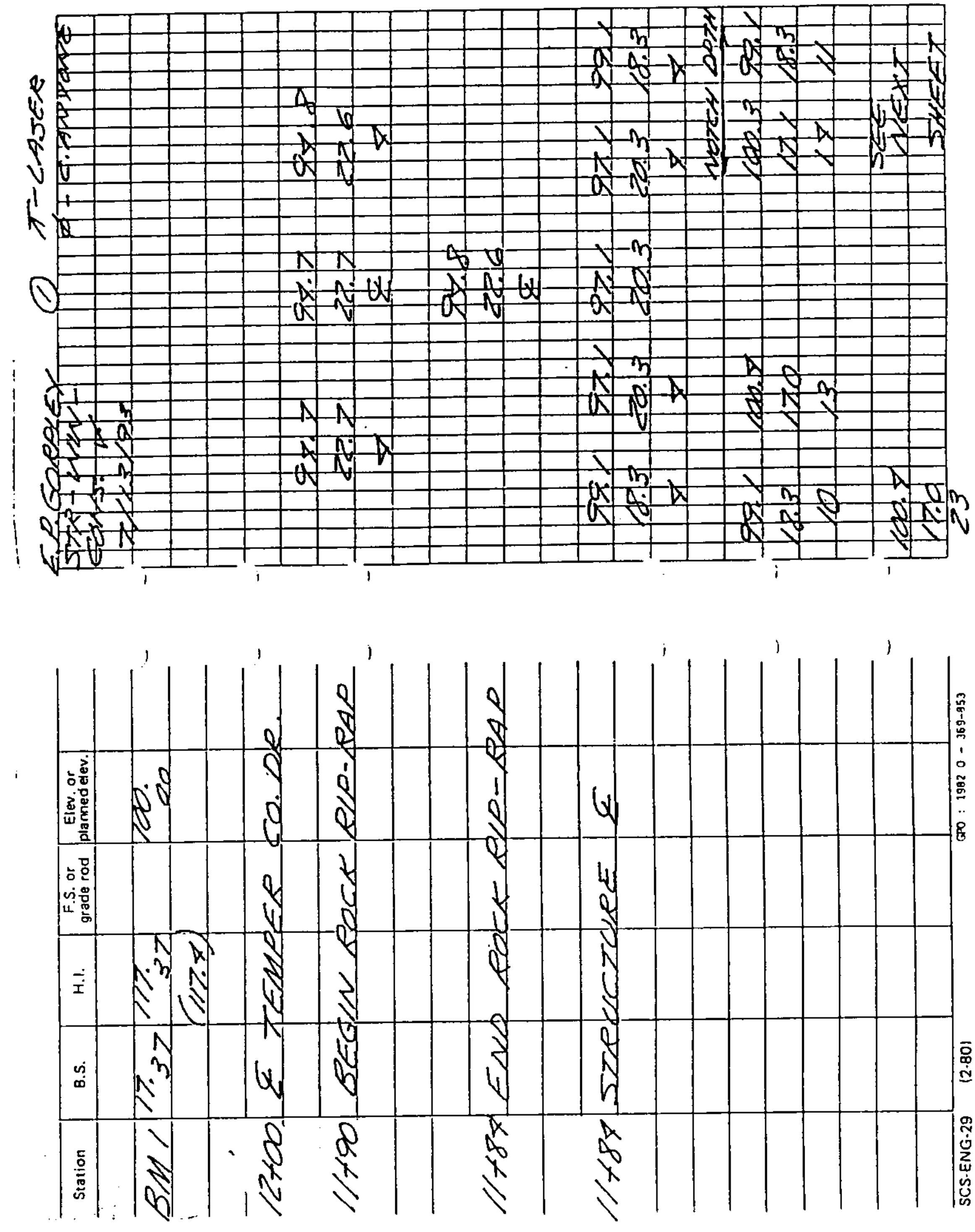
Station
B.S.
H.I.
F.S. or grade rod
Elev. or planned elev.
BM 1
17.37
117.37
(117.4)
100.00
12+00 ℄ TEMPER CO. DR.
11+90 BEGIN ROCK RIP-RAP
11+84 END ROCK RIP-RAP
11+84 STRUCTURE ℄
SCS-ENG-29 (2-80)
GPO : 1982 O - 369-953
E.P. GORPLEY
STR-LWW
CONS.
7/13/93
① T-LASER
∅ - C. ANTOINE
99.7 22.7
99.7 22.7 ℄
99.8 22.6
99.8 22.6 ℄
99.1 18.3
97.1 20.3
97.1 20.3
97.1 20.3
99.1 18.3
NOTCH DPTH
99.1 18.3 10
100.4 17.0 13
100.3 17.1 17
99.1 18.3 11
100.4 17.0 23
SEE NEXT SHEET

Figure 15

Station	B.S.	H.I.	F.S. or grade rod	Elev. or planned elev.	
11+84	℄ STRUCT - EMERG. SP.				

SCS-ENG-29 (2-80) GPO : 1982 O - 269-951

E.P. GORPLEY ②
STR. E WW
CONSTR. ✓
7/13/93

97.5
22.9
30'S

98.6
18.8
12'S

100.4 98.6 98.6 98.5
17.0 18.8 18.8 18.9
20 26 30 34

98.6
18.8
13'N

98.3
19.1
25'N

Figure 16

Station	B.S.	H.I.	F.S. or grade rod	Elev. or planned elev.	
		117.4			
11+50					
11+00	WATERWAY				
9+50	WATERWAY				

SCS-ENG-29 (2-80) GPO : 1982 O - 369-853

E.E. GORLEY (3)
STR. & WWY
ON STR. ✓
7/13/83

		99.1		
		18.3		
101.2	100.2	100.2	100.3	101.4
16.2	17.2	17.2	17.1	16.0
10	4		4	10
101.2				101.6
16.2				15.8
20				20
104.0	103.0	103.0	103.0	104.1
13.4	17.4	17.4	17.4	13.3
10	4		4	10

WATERWAY IS SEEDED &
MULCHED

Signature, title, date

Figure 17

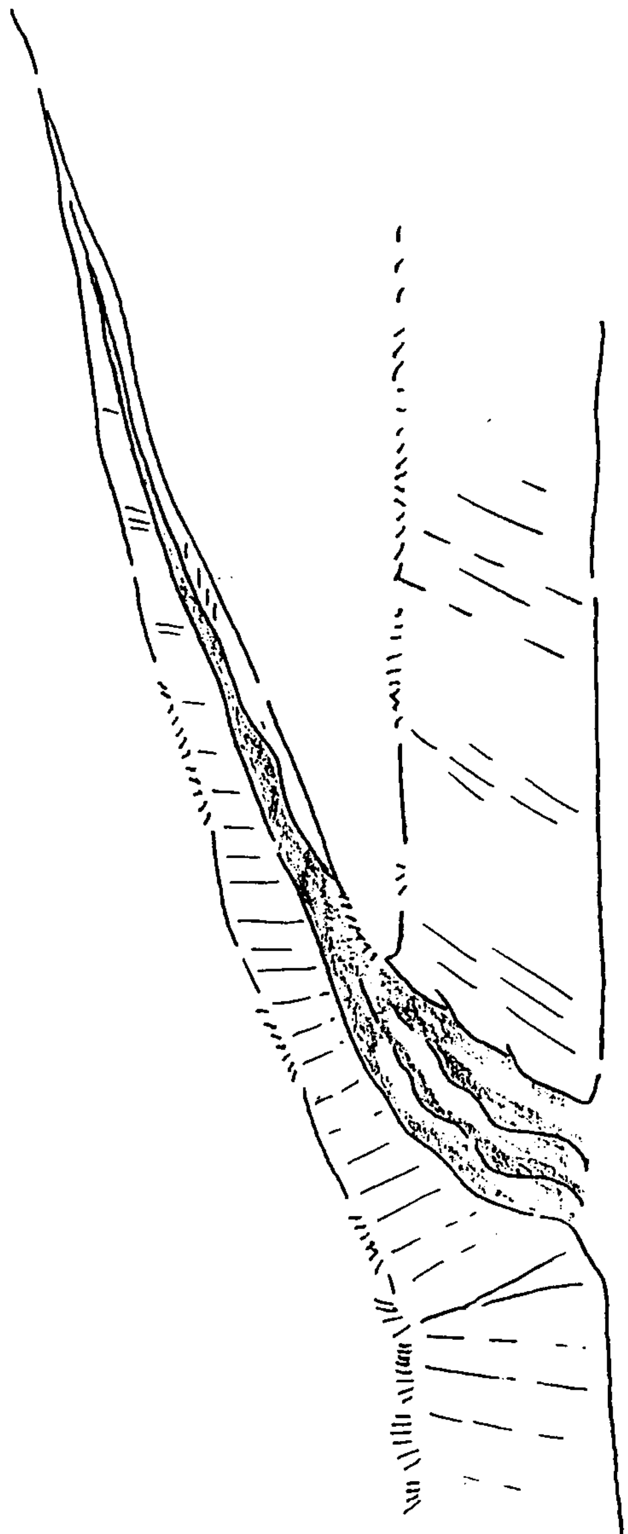

Figure 18

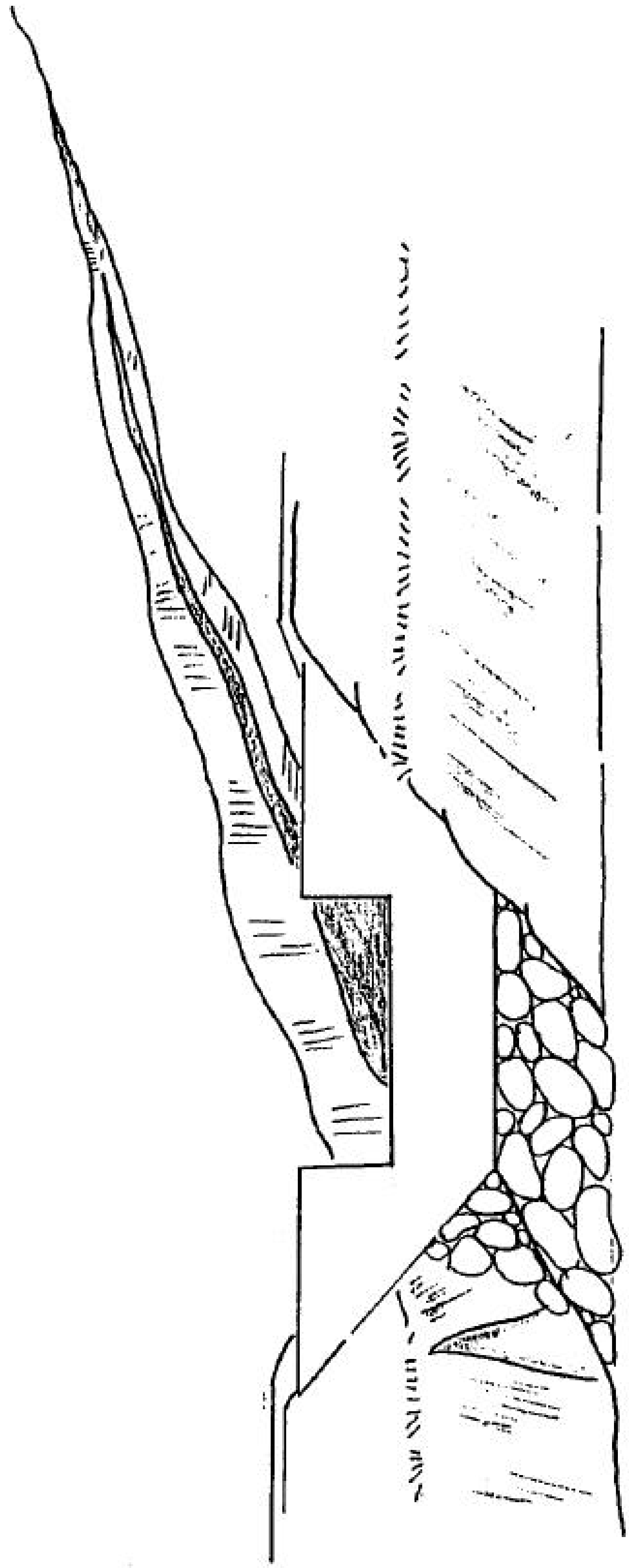

Figure 19

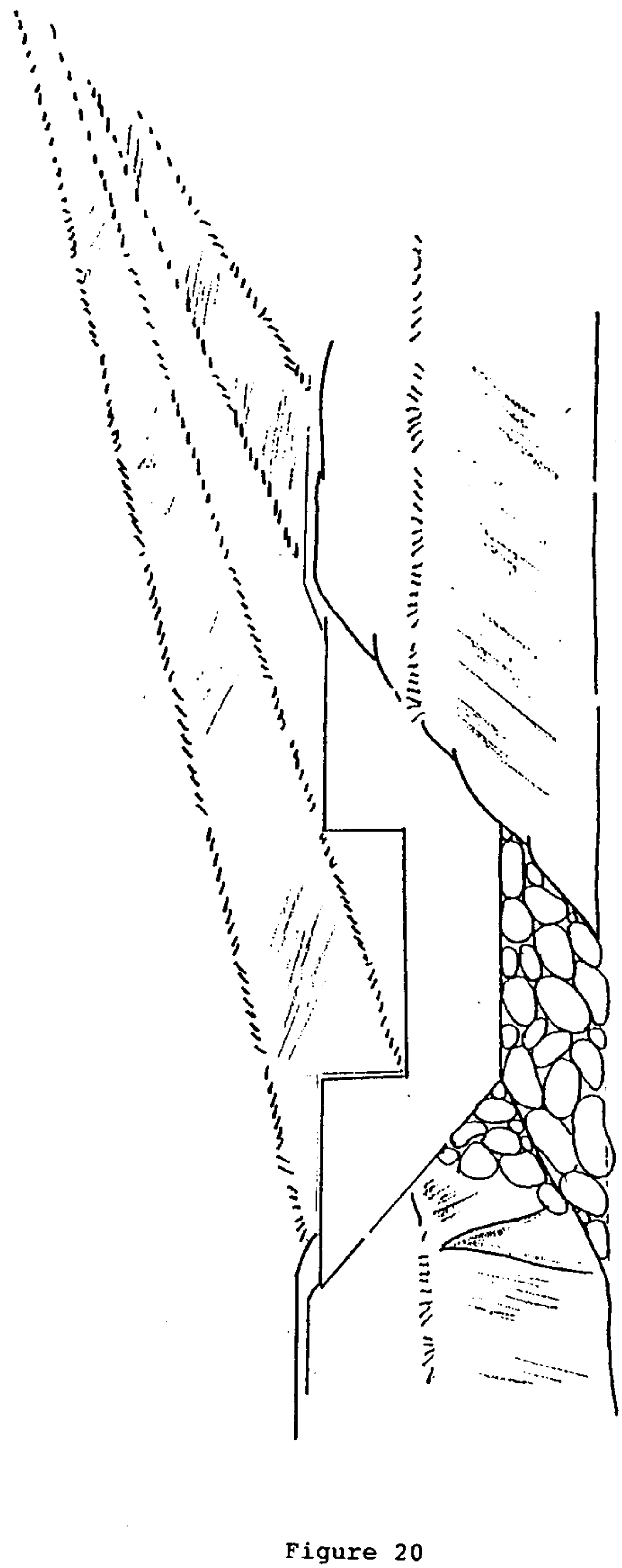

Figure 20

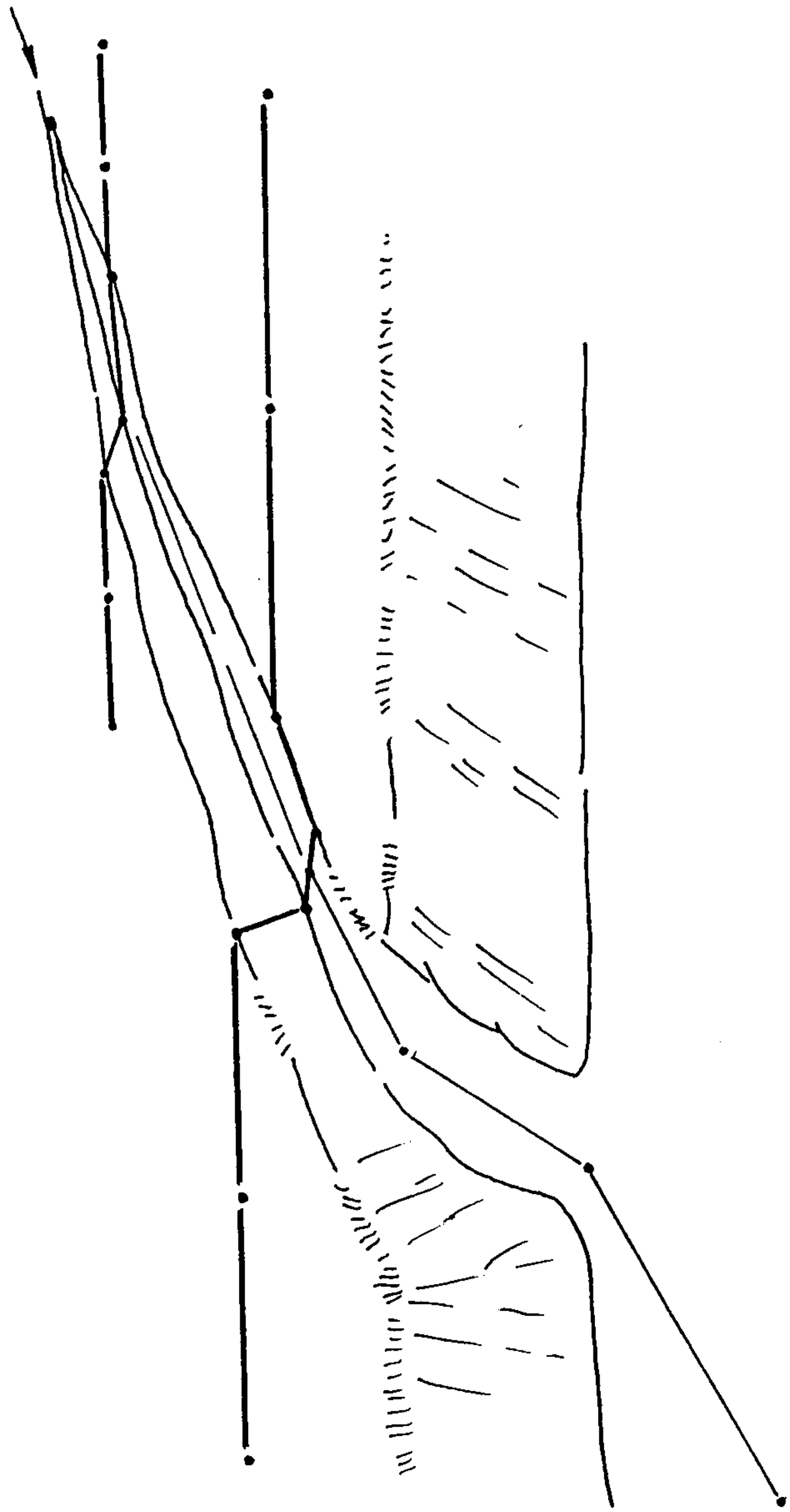

Figure 21

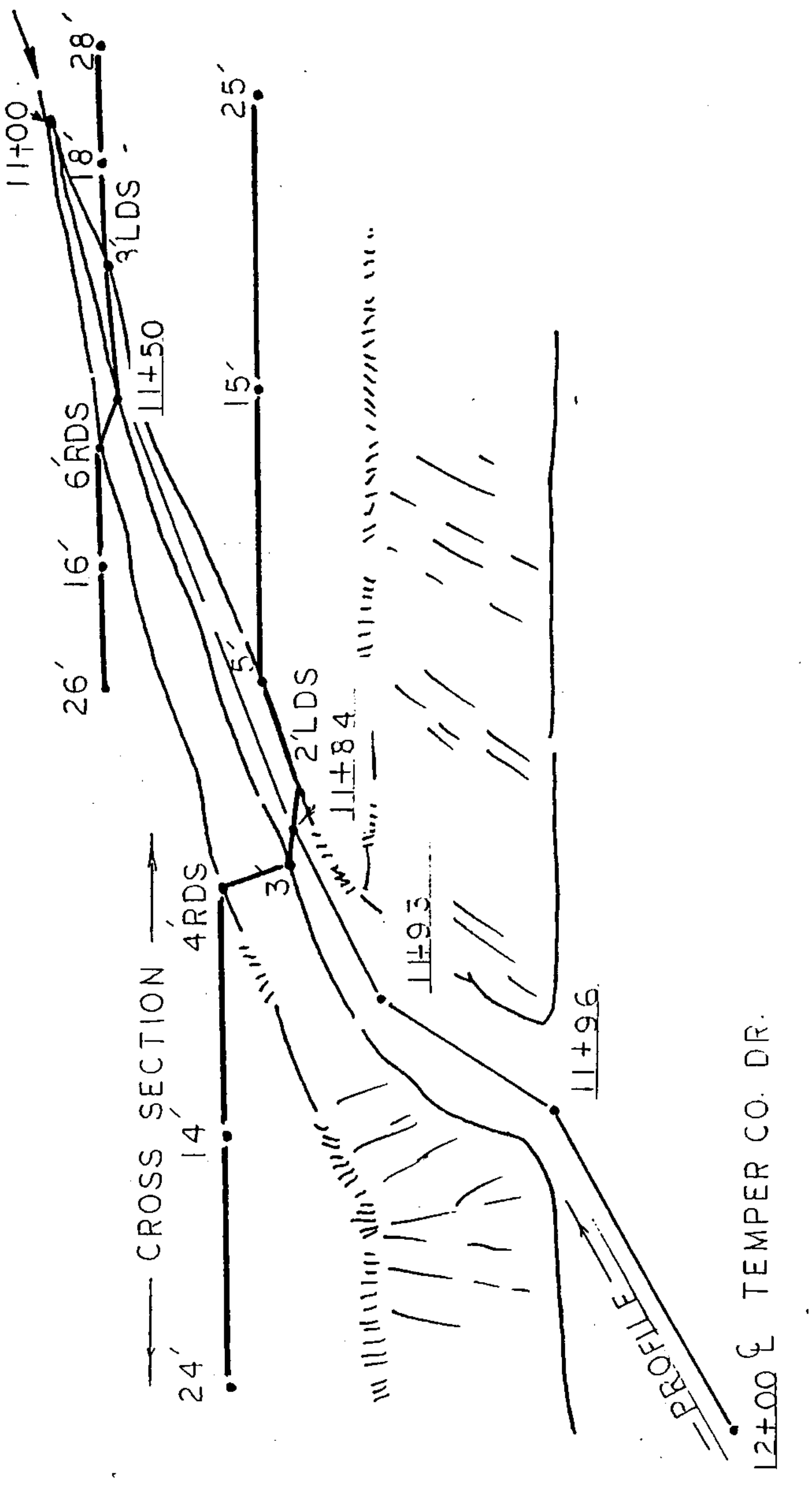
11+00
28'
18'
3'LDS
25'
11+50
15'
6'RDS
16'
26'
5'
2'LDS
11+84
3
4'RDS
11+93
CROSS SECTION
14'
24'
11+96
TEMPER CO. DR.
PROFILE
12+00 ℄

Figure 22