Instructions For Using
The AVOL-RULE

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INSTRUCTIONS FOR USING THE AVOL-RULE

TO DETERMINE END AREAS AND VOLUMES OF EARTHWORK

CONDITIONS: These instructions are for computing areas and volumes of earthwork from cross sections plotted on standard 10 x 10 cross section paper when the scale is 1" = 10'.

EXAMPLES: All figures are drawn to the scale of 1" = 10' and may be used as example problems to become familiar with the rule.

A. Principles of Operation

1. One method for determining end areas is to divide the section into triangles. The areas of the pairs of triangles having a common base (H) are computed and then added together to obtain the total area. Fig. 1 illustrates a section which has been divided at even intervals of distance (D) with heights H_1, H_2, H_3, H_4, H_5, H_6, and H_7. Triangles a, b, c, d, e, f, and so forth, are formed by the addition of the dotted lines.

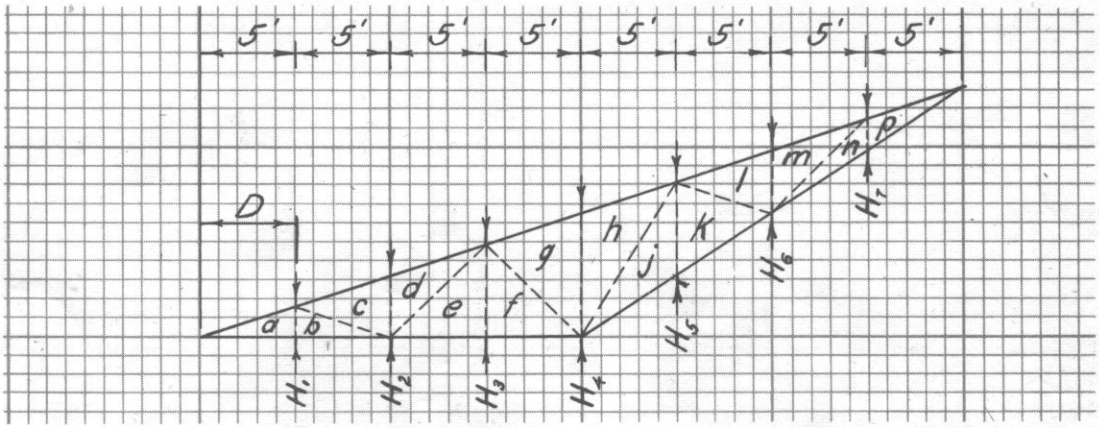


Fig. 1 — Scale 1" = 10' — Area = 132 sq. ft.

The area of this section is then determined as follows:

$$\text{Area a + b} = 1/2 \left[(D \times H_1) + (D \times H_1) \right] = 1/2\ (2DH_1) = DH_1$$

$$\text{Area c + d} = 1/2 \left[(D \times H_2) + (D \times H_2) \right] = 1/2\ (2DH_2) = DH_2$$

$$\text{Area e + f} = 1/2 \left[(D \times H_3) + (D \times H_3) \right] = 1/2\ (2DH_3) = DH_3$$

and so on until all pairs of triangle have been included.

Then the TOTAL AREA $= DH_1 + DH_2 + DH_3 + DH_4 + DH_5 + DH_6 + DH_7$

or TOTAL AREA $= D(H_1 + H_2 + H_3 + H_4 + H_5 + H_6 + H_7)$.

The AVOL-RULE has been designed to simplify this method of computing end areas. It provides a rapid, accurate means of adding the heights of the triangles and the area scale contains a multiplying factor of 5 so that the area is read directly in square feet when the distance (D) is equal to 5 feet.

2. Another concept of determining the end areas which can be applied to the AVOL-RULE is that of dividing the section into a series of rectangles of equal width. Fig. 2 illustrates this method. The area of this section is equal to the sum of the rectangles, or:

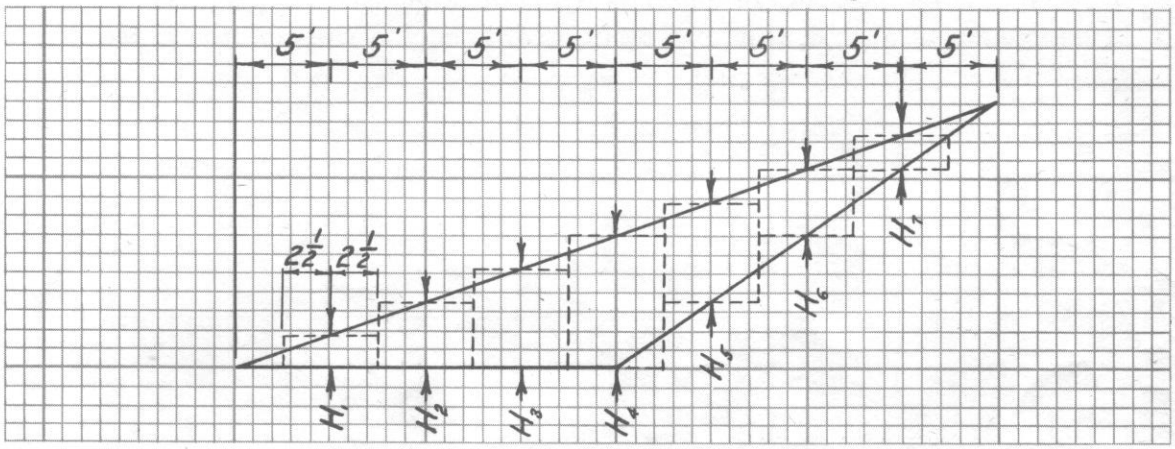
TOTAL AREA: $[(H_1 \times D) + (H_2 \times D) + (H_3 \times D) \ldots \text{etc.}]$

Since the distance (D) is equal in all the rectangles, it can be factored out to give

TOTAL AREA = $D(H_1 + H_2 + H_3 + H_4 + H_5 + H_6 + H_7)$.

The AVOL-RULE provides a rapid, accurate means of adding the heights (H) of the rectangles. The multiplying factor of 5 which is constructed into the area scale permits reading the area directly in square feet when the distance (D) is equal to 5 feet.

It may be noted in Fig. 2 that the small triangles which have been included outside the section just balance those triangles which were not included within the section.



B. How to Determine Area Fig. 2 — Scale: 1" = 10' — Area = 140 sq. ft.

The following steps describe how the end area of Fig. 3 is computed using the AVOL-RULE:

1. Start at the bottom of height H_1 with the sliding pointer of the rule set at zero.
2. Hold the rule firmly in place with one hand and move the sliding pointer with the other hand to the top of height H_1.
3. Leave this reading on the rule and move the rule to the right a distance equivalent to 5 feet so that the sliding pointer is at the bottom of height H_2.
4. Hold the rule firmly in place and move the sliding pointer to the top of height H_2.
5. Continue this procedure until the heights H_3, H_4, H_5, H_6, and H_7 have been added to the rule.
6. Read the TOTAL AREA directly from the AREA SCALE on the rule.
7. Note that the top of the area scale reads 540 but that it reverses and can be read coming back down to a maximum value of 1080 at the bottom, In scaling large areas, after the top of the scale (540) has been reached, just continue adding the heights by moving the sliding pointer downward from the tops of the remaining heights. Read the area indicated by the larger set of figures on the area scale.

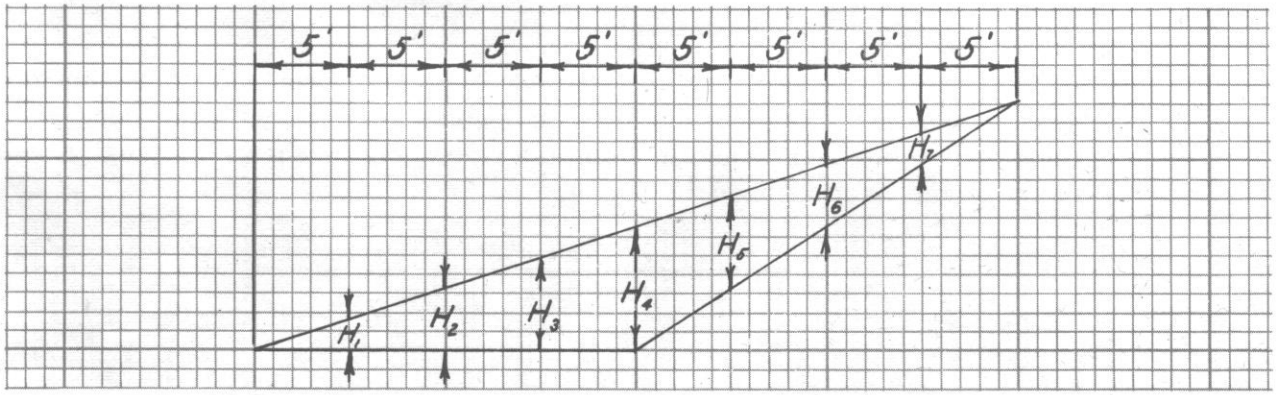


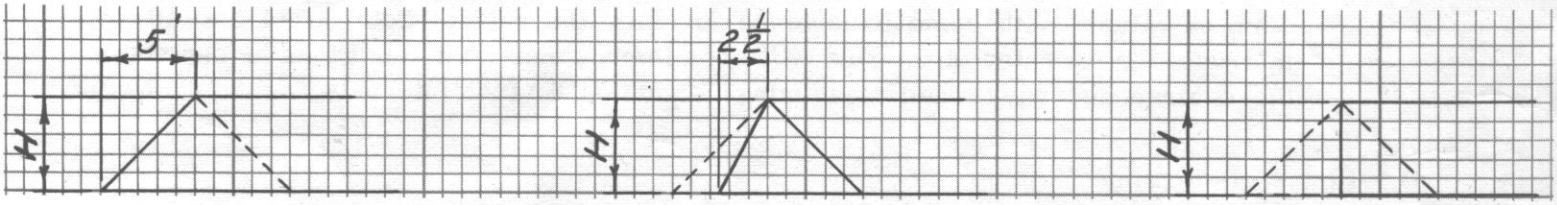
Fig. 3 — Scale: 1" = 10' — Area = 132 sq. ft.

C. Corrections

Some judgment is required by the operator of the rule in making minor corrections of "H" to get started on an even 5 foot interval due to irregularities in the section. However, when the heights "H" are taken at 5 foot intervals the errors introduced by scaling full "H" values are generally negligible except for very small sections.

1. Several of these corrections are shown when the triangle concept is used:

a. Ends of sections:



The dashed lines show the area measured when using the full "H" value.

b. A fill section is shown in Fig. 4. The errors in area when using full "H" values are shown cross-hatched. Although these errors are small and tend to cancel out, they can be compensated for by minor additions or subtractions to the "H" values as these are scaled with the pointer of the rule.

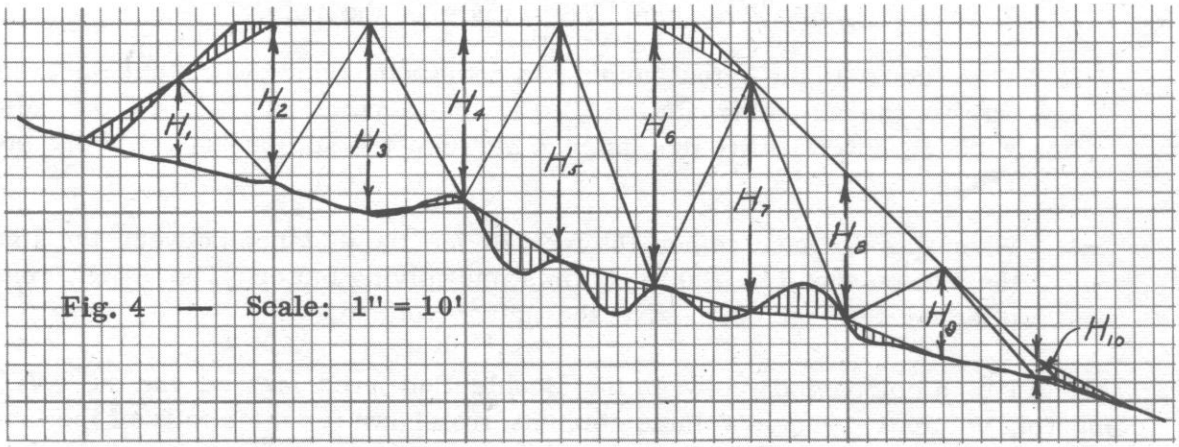


Fig. 4 — Scale: 1" = 10'

Area of Fig. 4 using full "H" values = 425 sq. ft.
Area of Fig. 4 using adjusted "H" values = 423 sq. ft.
(The difference in this case is negligible).

2. If the operator of the rule prefers to think in terms of rectangles he should sketch these in on several irregular sections to become familiar with the necessary corrections and to gain confidence in using the rule. Fig. 5 shows rectangles sketched in on the same section used in Fig. 4.

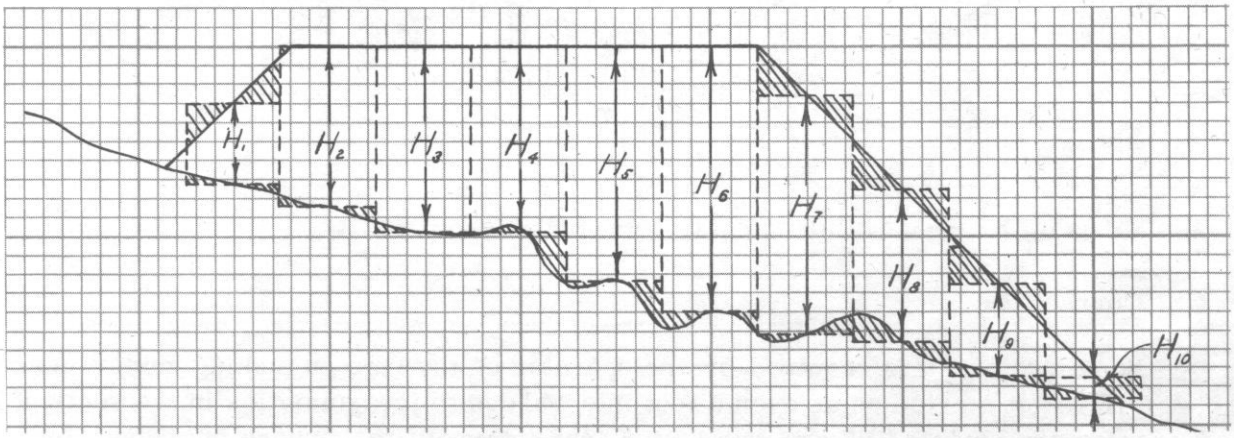


Fig. 5 — Scale 1" = 10'. Area of Fig. 5 using full "H" values — 425 sq. ft.

3. When end areas are large, or when the natural ground surface of a cross section is uniform, it is desirable to measure heights at 10 foot intervals rather than every 5 feet. When this is done the reading from the rule must be doubled to obtain the correct value. With some experience in using the rule at both 5 foot and 10 foot intervals the operator of the rule will soon learn under what conditions he can obtain the desired accuracy when measuring heights at 10 foot intervals.

D. How to Determine Volume

When using the AVOL-RULE, volumes of earthwork can be determined almost as readily as can areas of end sections. The following steps describe the operation for computing volumes:

1. Begin in exactly the same manner as in determining area by adding all the heights at 5 foot intervals onto the rule.

2. Read the volume from the "Vol." scale of the rule.

3. This figure is the actual volume in cubic yards for the distance between a point half way to the adjoining station BACK and a point half way to the adjoining station AHEAD, PROVIDING the distance between the station back and the station ahead is 100 feet.

4. When this distance is not 100 feet, divide the distance between the station back and the station ahead by 100 to obtain a multiplying factor. The AVOL reading is multiplied by this factor to give the actual volume.

Table I gives a comparison between the Double End Area Method and the AVOL Method for computing volumes. (Single volume columns are shown for simplicity of the table.)

When using the AVOL-RULE it is anticipated that the actual volumes will be recorded on the cross sections. The multiplying factor can be easily applied to the AVOL reading with a standard slide rule.

INSTRUCTIONS FOR USING THE AVOL-RULE

TO DETERMINE AREA IN ACRES

The instructions and principles of operation for measuring areas in acres are similar to those explained in the preceding pages applying to areas in square feet and volumes in cubic yards. The acre scale is on the left hand side of the AVOL-RULE.

Usually maps of land areas and many others are not plotted on cross section paper, so it is necessary to supply the cross section parallel lines with a parallel line over-lay. This over-lay is marked with parallel lines spaced one tenth inch apart with each fifth line marked heavier than the others. These lines are marked in one direction only preferably to be used perpendicular or approximately perpendicular.

It is well to place the parallel line over-lay over the area to be measured with one of the heavily marked or fifth lines on the left edge of the map. This eliminates the necessity of adjustment at the beginning of measuring as illustrated on page 4 paragraph C-2.

This acre scale is graduated to read direct when the scale of the map is 1 : 12,000 or 1" - 1,000', and when parallel lines are measured which are one tenth inch apart. On the general instruction sheet there is a table of multiplying factors which are to be used for other scaled maps and when parallel lines are measured other than one tenth inch apart as noted in the table.

TABLE I

METHOD

DOUBLE END AREA				AVOL-RULE			
Station	Area	Distance	Volume	AVOL-RULE	Distance	Multiplying Factor	Volume
	(feet)	(feet)	(cubic yards)	Volume Reading	Sta. Ahead Sta. Back	Distance-100'	(cubic yards)
4+00	0			0	0	0	0
		50	25				
+50	27			50	100	1.0	50
		50	75				
5+00	54			100	60	0.6	60
		10	20				
+10	54			100	80	0.8	80
		70	175				
+80	81			150	110	1.1	165
		40	100				
6+20	54			100	90	0.9	90
		50	75				
+70	27			50	80	0.8	40
		30	15				
7+00	0		—	0	0		—
			485				485