Benha University

Shoubra Faculty of Engineering

Surveying Engineering Lecture 9: Volume Computation

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Geomatics Department

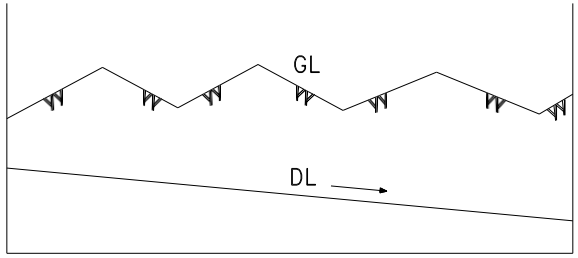
Road Longitudinal Profile

Showing the ground and design elevations in a certain long direction

Ground level: it is the actual existing ground either given by direct elevations separated by a constant distance (spacing) or by an ordinary leveling table

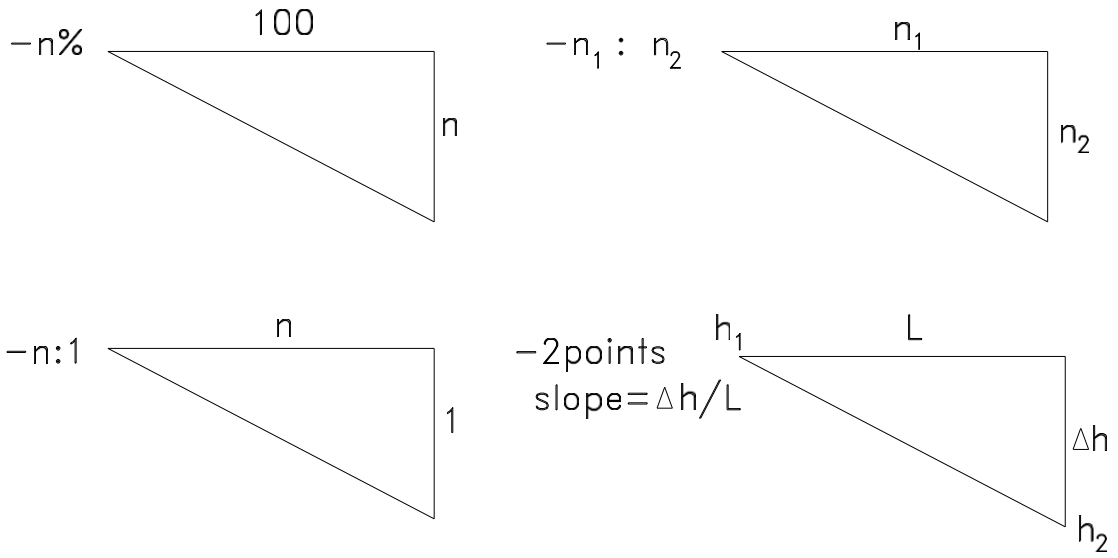
Design level: required to be constructed such as roads, canals, sewers, cables… etc.

It could be given by:
Elevation of a point on the DL and slope of DL
Elevation of 2 points on the DL
Identifying the start & end point
Satisfying certain condition



Design Level

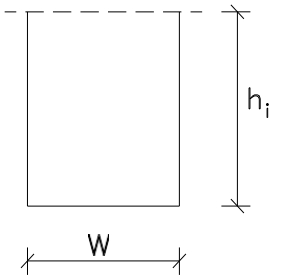
Slope could be given in different forms:

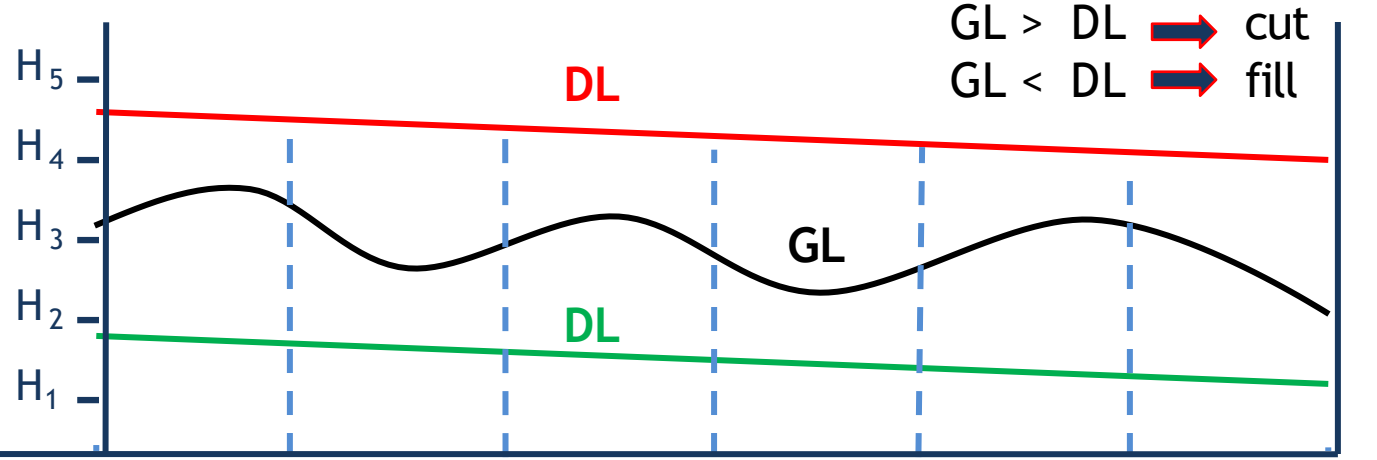


The main task is to determine the volume of cut or fill (Earthworks) required in order to reach and construct the design level

All Cut or All Fill

A- Cross section sides are vertical (constant width)





Below minimum elevation by 2m

Distance (m)	0	S	2S	3S	4S	5S	6S
Ground Level (m)	G_1	G_2	G_3	G_4	G_5	G_6	G_7
Design Level (m)	D_1	D_2	D_3	D_4	D_5	D_6	D_7
Height of cut or fill (m)	h_1	h_2	h_3	h_4	h_5	h_6	h_7
Area of cut or fill (m^2)	Area by Trapezoidal method						
Volume of cut or fill (m^3)	Total Area x Width of cross section (W)						

All Cut or All Fill

- Height of cut = GL – DL
  Height of fill = DL – GL

- Chosen Hz scale depends on available space
- (usually 1:1000 and 1:100) (unless given)

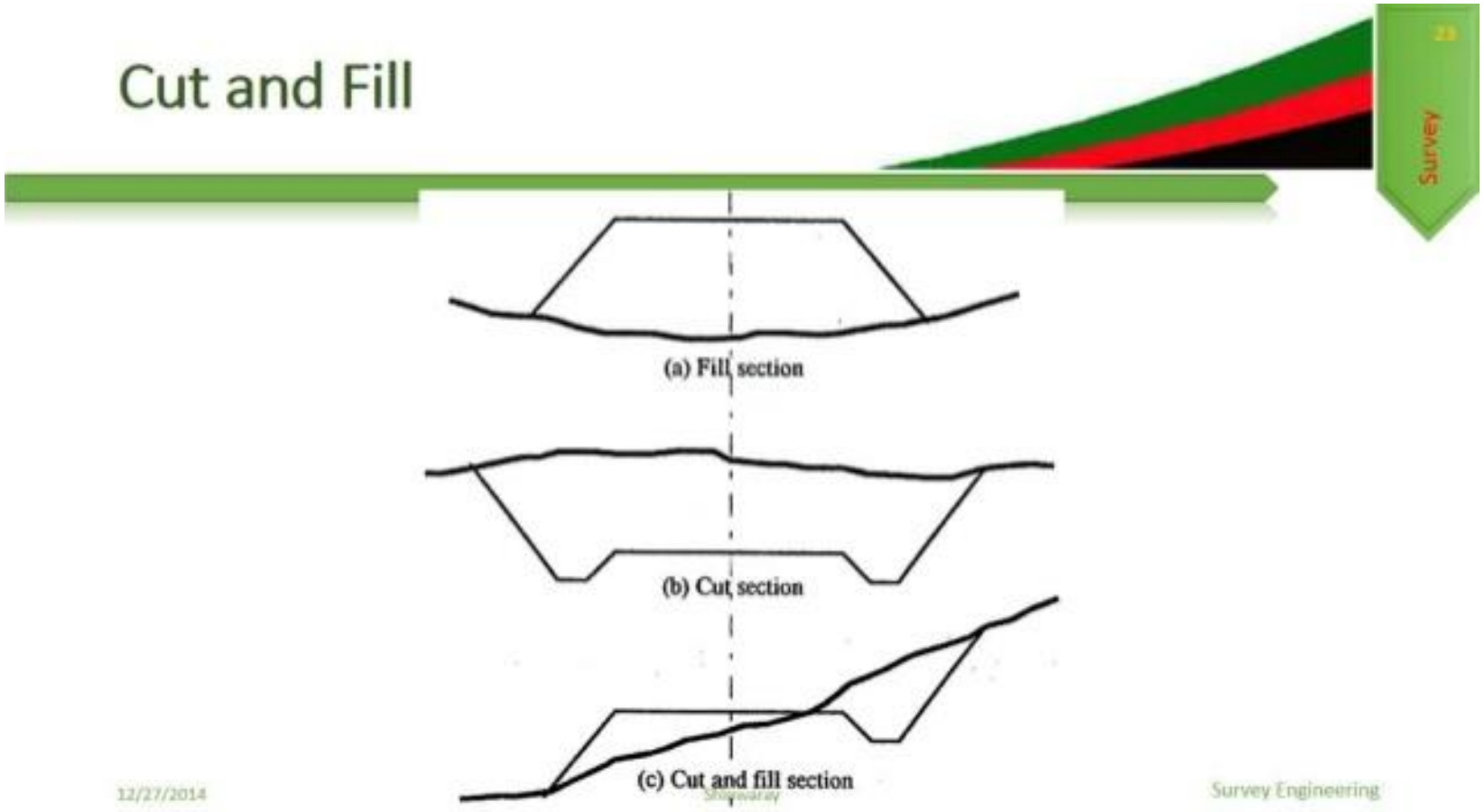
  1:1000 ➡ 1cm = 10m.

- In all longitudinal sections VL scale = 10 x HZ scale (unless given)
  e.g. Hz 1:1000 ➡ VL 1:100

- Area by trapezoidal = $\frac{S}{2}[h_1+h_n+2(h_2+h_3+\ldots\ldots h_{n-1})]$

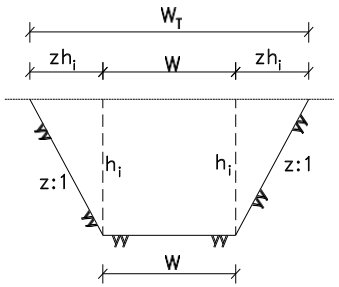
- The design level could be broken e.g. for swimming pools

Road Cross Section

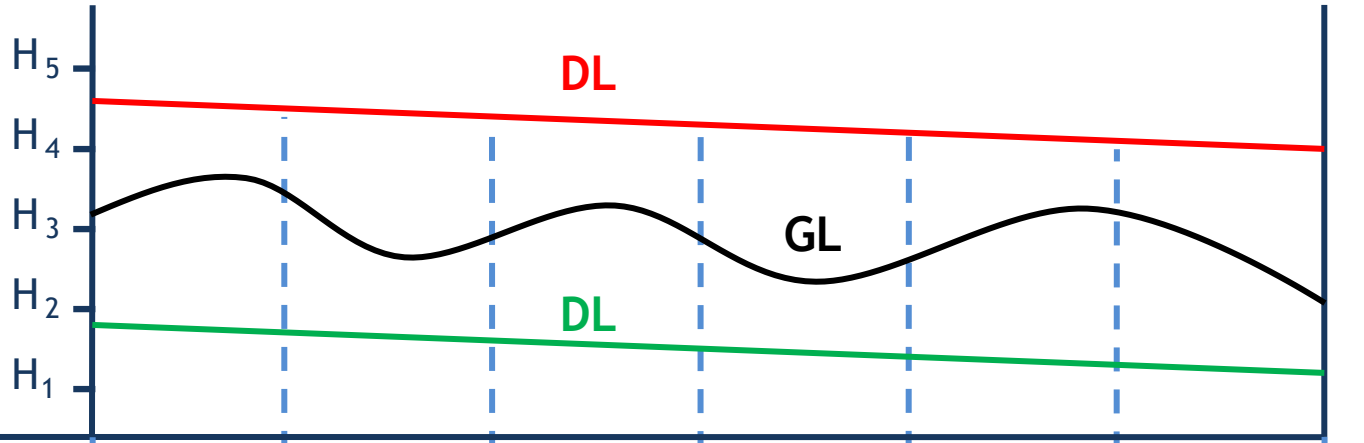


All Cut or All Fill

B- Cross section sides are sloped (variable width)



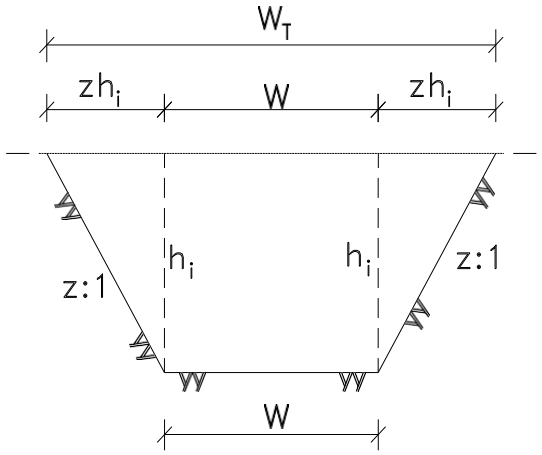
Below minimum elevation by 2m



Distance (m)	0	S	2S	3S	4S	5S	6S
Ground Level (m)	G_1	G_2	G_3	G_4	G_5	G_6	G_7
Design Level (m)	D_1	D_2	D_3	D_4	D_5	D_6	D_7
Height of cut or fill (m)	h_1	h_2	h_3	h_4	h_5	h_6	h_7
X-section Area (m^2)	A_1	A_2	A_3	A_4	A_5	A_6	A_7
Volume of cut or fill (m^3)	Volume by Simpson method						

All Cut or All Fill

- X-section Area $(A_i) = w \cdot h_i + z \cdot h_i^2$

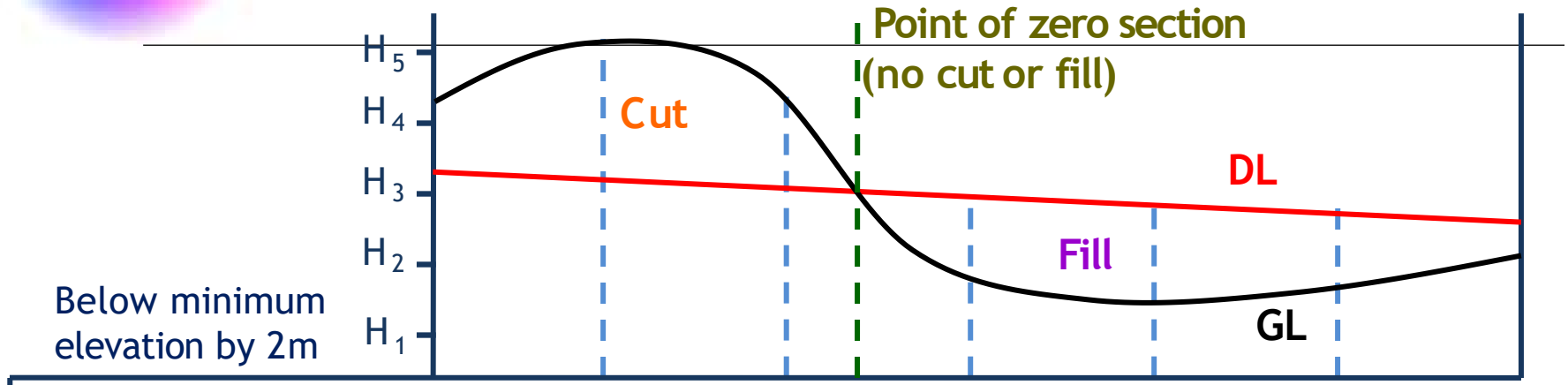


- Volume by Simpson = $\frac{S}{3}$ $[A_1+A_n+2(\Sigma odd)+4(\Sigma even)]$

- If slope 3:2 then z = 1.5

- Side slopes are made to prevent side collapse

Cut and Fill

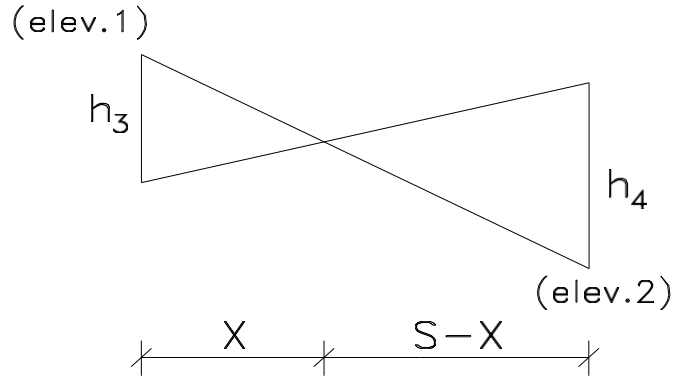


Distance (m)	0	S	2S	3S	4S	5S	6S
Ground Level (m)	G_1	G_2	G_3	G_4	G_5	G_6	G_7
Design Level (m)	D_1	D_2	D_3	D_4	D_5	D_6	D_7
Height of cut (m)	h_1	h_2	h_3				
Height of fill (m)				h_4	h_5	h_6	h_7
X-section Area cut (m^2)	A_1	A_2	A_3				
X-section Area fill (m^2)				A_4	A_5	A_6	A_7

Cut and Fill

How to calculate position of zero section?

$$\frac{h_3}{h_4} = \frac{X}{S - X}$$



Depends on slope of DL

$$\text{Elev. at zero section} = \text{elev.1} \pm X.\frac{n}{100}$$

- If X-section sides:

vertical	sloped
$A = w \,.\, h$	$A = w \,.\, h_i + z \,.\, h_i^2$

Then calculate and sum partial volumes for fill and cut area

- Sometimes required drawing of cross section at a certain distance where elevation of DL is considered constant all over X-section
  In the X-section: VL scale = HZ scale
- Sometimes side slopes of fill section differ from cut section
- If exist more than 1zero section, then repeat several times

Solved Example

A longitudinal leveling was run on a proposed centerline of a pipeline required as a protective cover for an electric cable. The elevations of the ground level are as follows:

Distance (m)	0	25	50	75	100	125	150	175	200
GL (m)	6.66	6.59	6.57	6.41	6.27	6.20	5.87	5.80	6.02

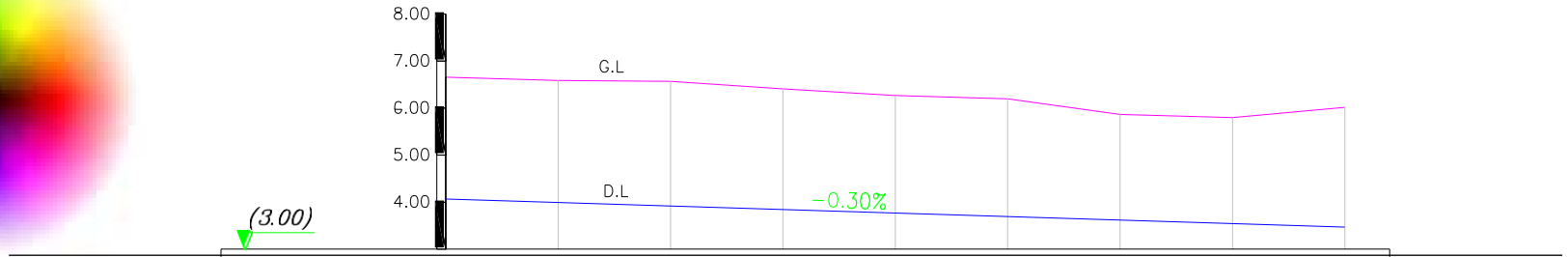
Given that the diameter of pipe is 1.5 m with side clearance 0.25 m from both sides, the design level (lower edge of the pipeline) at distance 100m is 3.77m and the slope of the pipeline is 0.3% downwards.

a) Draw the longitudinal profile of the GL and DL with Hz scale 1:2000.

b)Compute the volume of cut required to layout the pipeline if the cutting edges of the cross section is vertical (constant width).

c) Calculate the volume of fill after laying out the pipeline.

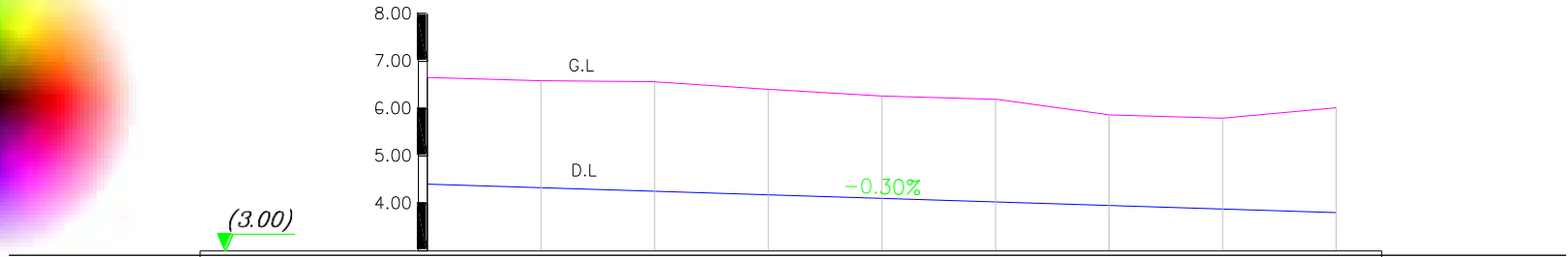
d) If the cross section is with side slopes 1:1 (variable width), Compute the net volume of earth works required to layout the pipeline.



Distance (m)	000.00	025.00	050.00	075.00	100.00	125.00	150.00	175.00	200.00
Ground Level (m)	6.66	6.59	6.57	6.41	6.27	6.20	5.87	5.80	6.02
Formation Level (m)	4.070	3.995	3.920	3.845	3.770	3.695	3.620	3.545	3.470
Height of Cut (m)	2.590	2.595	2.650	2.565	2.500	2.505	2.250	2.255	2.550
Total Area of Cut (m^2)	497.25 m^2								
Volume of Cut (m^3)	994.50 m^3								
Net Volume of Fill (m^3)	641.07 m^3								

Area of Cut = $\frac{25}{2}$[2.59+2.55+2*(2.595+2.65+2.565+2.5+2.505+2.25+2.255)]= 497.25 m^2

Volume of pipe = 200 * π * $(0.75)^2$ = 353.431 m^3



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Formation Level (m)	4.070	3.995	3.920	3.845	3.770	3.695	3.620	3.545	3.470
Height of Cut (m)	2.590	2.595	2.650	2.565	2.500	2.505	2.250	2.255	2.550
X-Sec. Area of Cut (m^2)	11.888	11.924	12.323	11.709	11.250	11.285	9.563	9.595	11.603
Volume of Cut (m^3)	2231.792rn^3								
Net Volume of Fill (m^3)	1878.361m^3								

Volume of Cut = $\frac{25}{3}$[11.888+11.603+2*(12.323+11.25+9.563)+4*(11.924+11.709+11.285+9.595)]

Supplementary files:

- http://www.ce.memphis.edu/1112/notes/project_3/ponds/cut-and-fill_1.pdf
- http://www.nzdl.org/cgi-bin/library?e=d-00000-00---off-0cdl--00-0----0-10-0---0---0direct-10---4-------0-1l--11-ps-50---20-preferences---00-0-1-00-0--4----0-0-11-10-0utfZz-8-00&cl=CL1.34&d=HASH6f6c5b7233856b445b3033.12&hl=0&gc=0&gt=1
- https://www.engineeringenotes.com/surveying/earth-work/measurement-of-volume-of-earth-work-with-diagram/14529

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Thanks

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