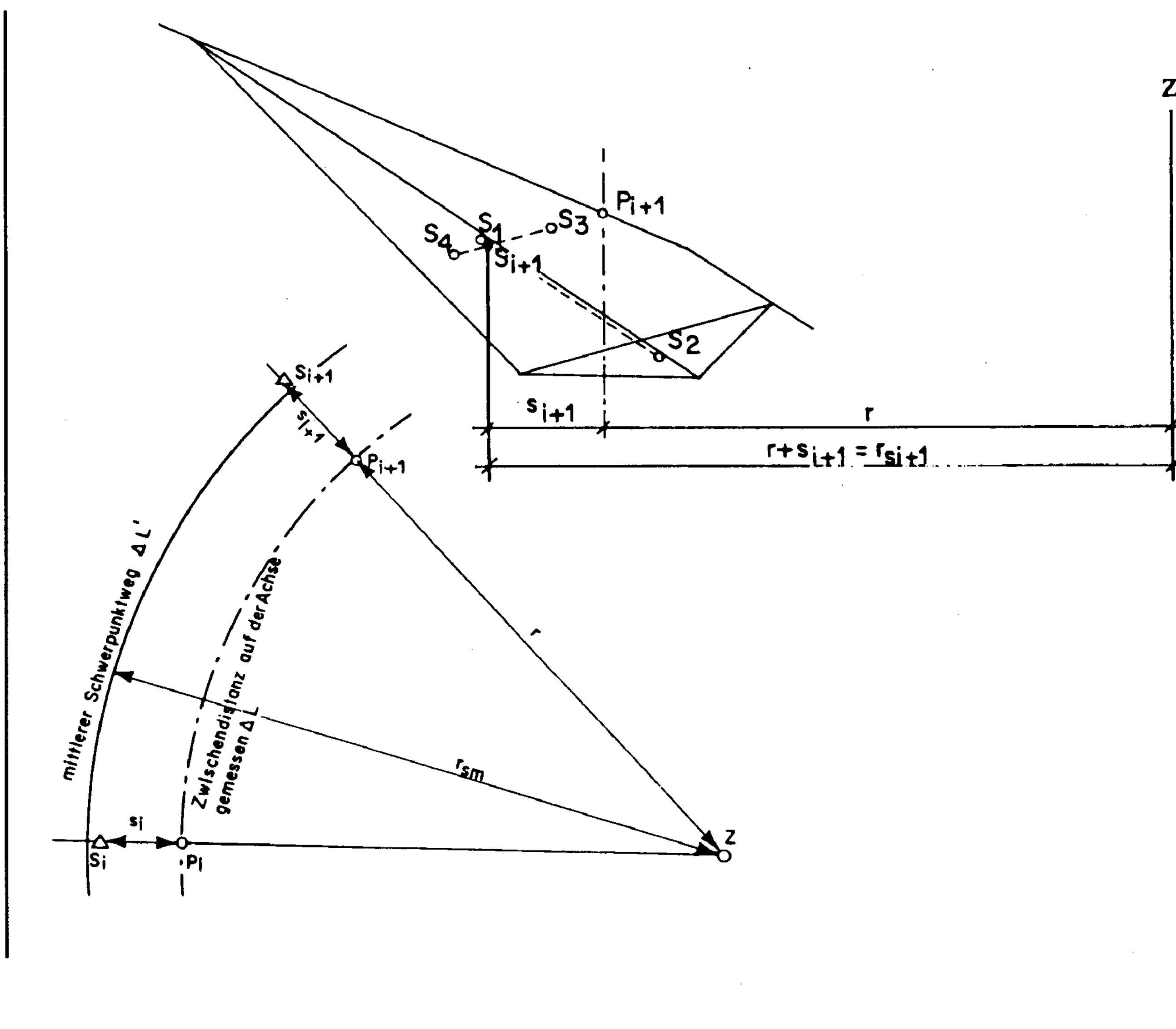
EARTH WORK AROUND SWITCHBACKS

FOREST
Road Engineering
FPE 346
Winter 1994

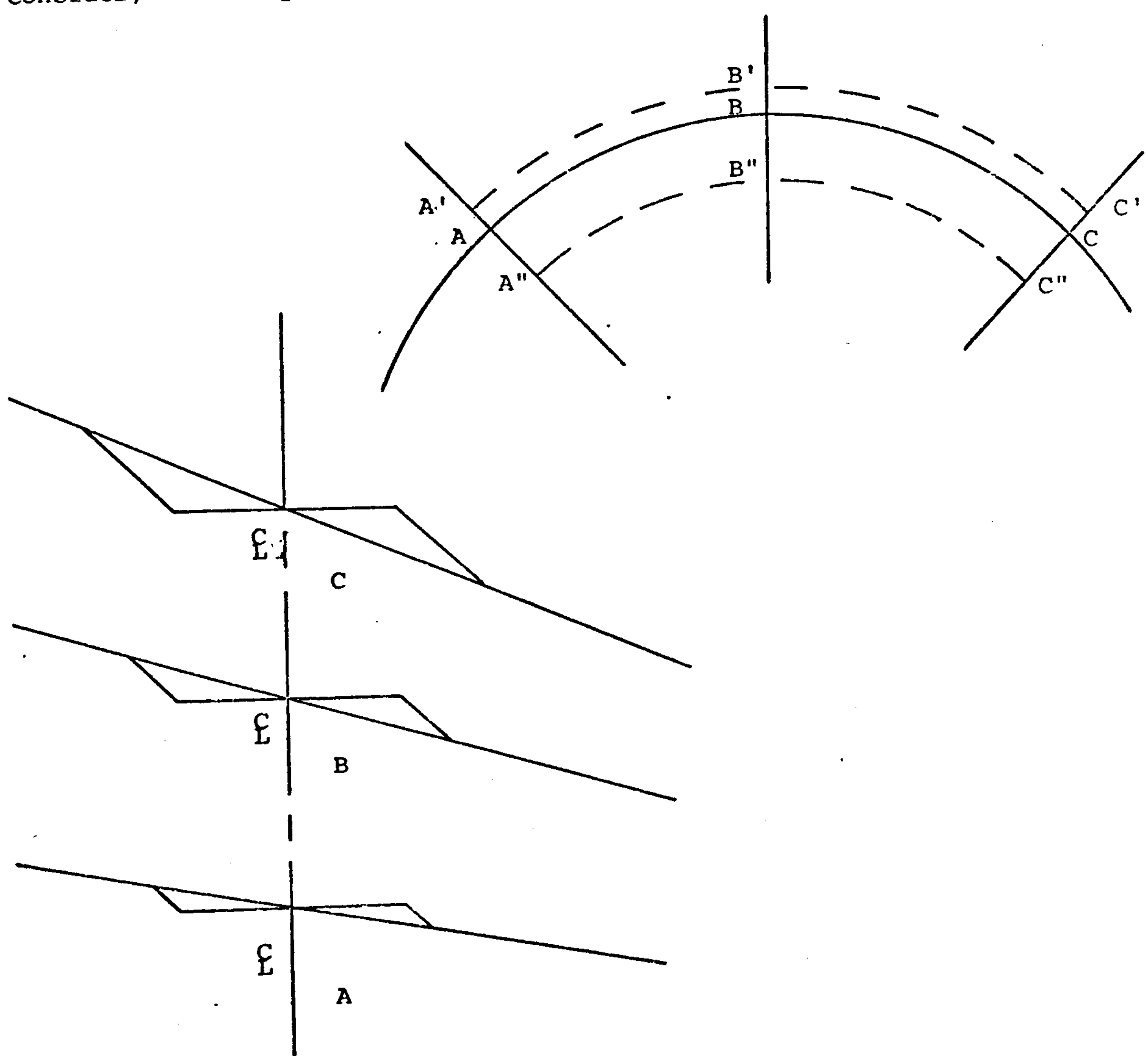


APPENDIX 2

Center of Mass Earthwork Computation

The computation of earthwork quantities for the roadway have been based on a straight line distance between cross-section. When the roadway curves the straight line distance at the centerline does not properly reflect the distance between the cross-section. The higher the degree of curvature (i.e. the smaller the radius) the greater the error in the earthwork quantities. This fact becomes very important in the low volume, low standard road because of the sharp curves utilized.

Consider, for example, the following roadway situation:



Using the normal average end area computation the distances that would be used for both cut and fill colume calculations would be _____ and _____.

However distances ________ and ________ would more correctly be the distance between the cut portions of sections A, B, and C respectively. In a similiar manner distances ________ and ________ are closer to the correct distances between the fill portions of the cross-sections.

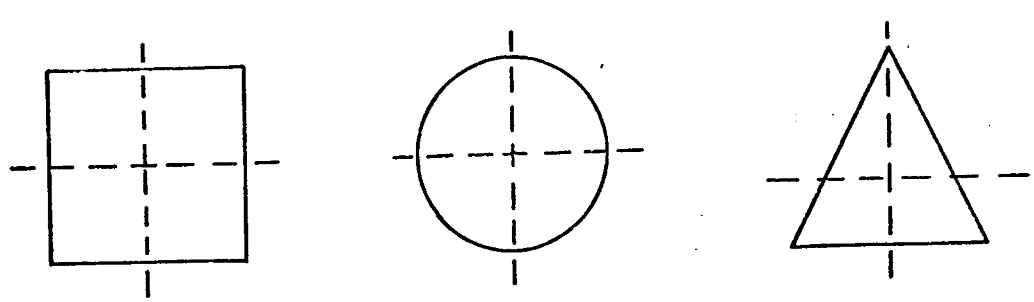
Without having to go through a computation the reader should see that _________ excavation will be generated and _________ embankment will be placed than will be computed. Using the normal double end area formula. The errors add rather than balance one another.

Given an understanding of normal forest road construction practices this situation can result in a roadway that is substantially __________ the design elevation.

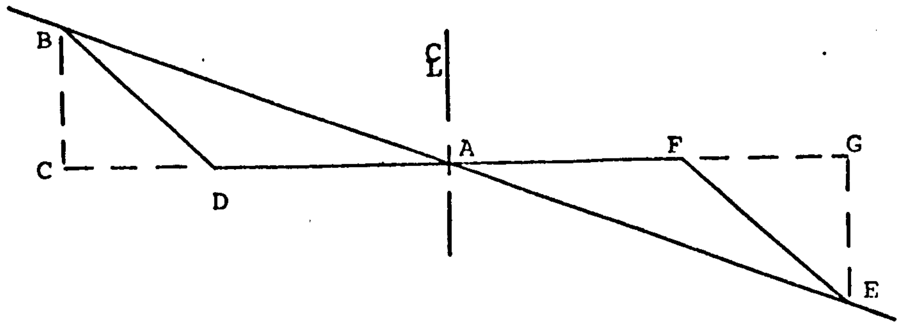
For the given cross-sections if the horizontal curve was to the left rather than the right the result would be __________ excavation and __________ embankment, therefore a gradeline that is __________ below the design elevation. The reader is encouraged to study the given figures and draw and study additional curve situations until this concept is well understood.

A more correct earthwork quantity figure can be determined by applying the concept of __________________________. The center of mass of any geometric shape is that point on the shape where it is balanced. If a set of axes were drawn through the center of mass there would be an equal amount of area east and west of the axes and an equal amount north and south.

The centers of mass for some common shapes are shown below.



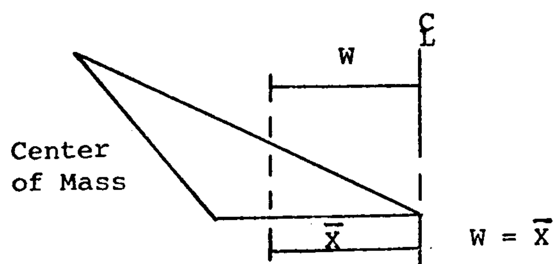
The most common cross-section shape for the forest road is the oblique triangle.



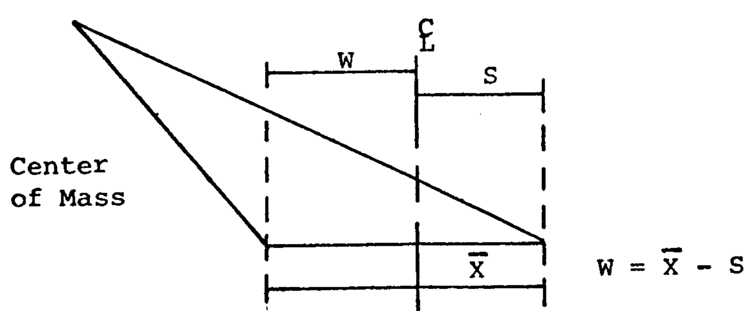
It can be shown from mathematics that the distance from point A to the center of mass is $\bar{X} = \frac{AD + AC}{3}$.

(For roadway design work the designer is not concerned with the elevation of the center of mass).

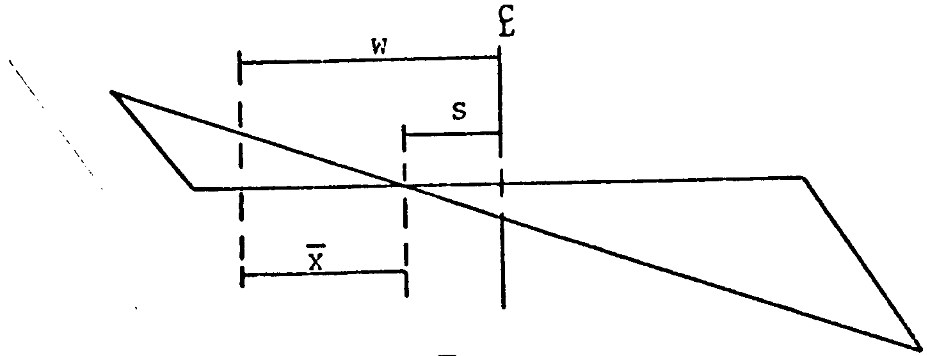
The distance that the designer is most interested in is that distance from the centerline to the center of mass. Three different cases exist.



Case I



Case II

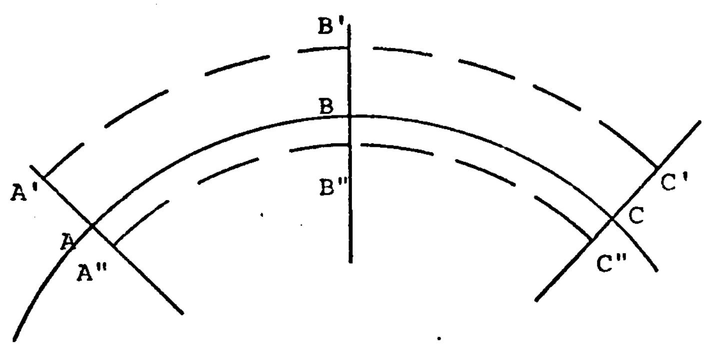


$$W = \overline{X} + S$$

Case III

At each cross-section that lays on a horizontal curve the designer needs to determine the distance W for both the cut and fill sides.

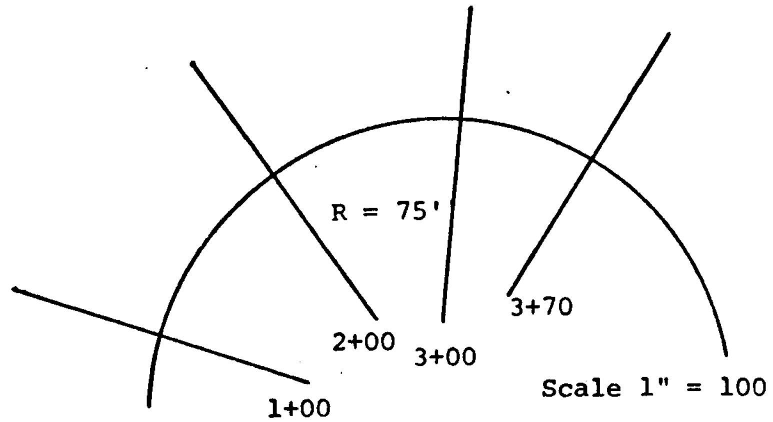
Returning to the first diagram W is the distance AA', AA", BB', BB", CC', CC", etc.

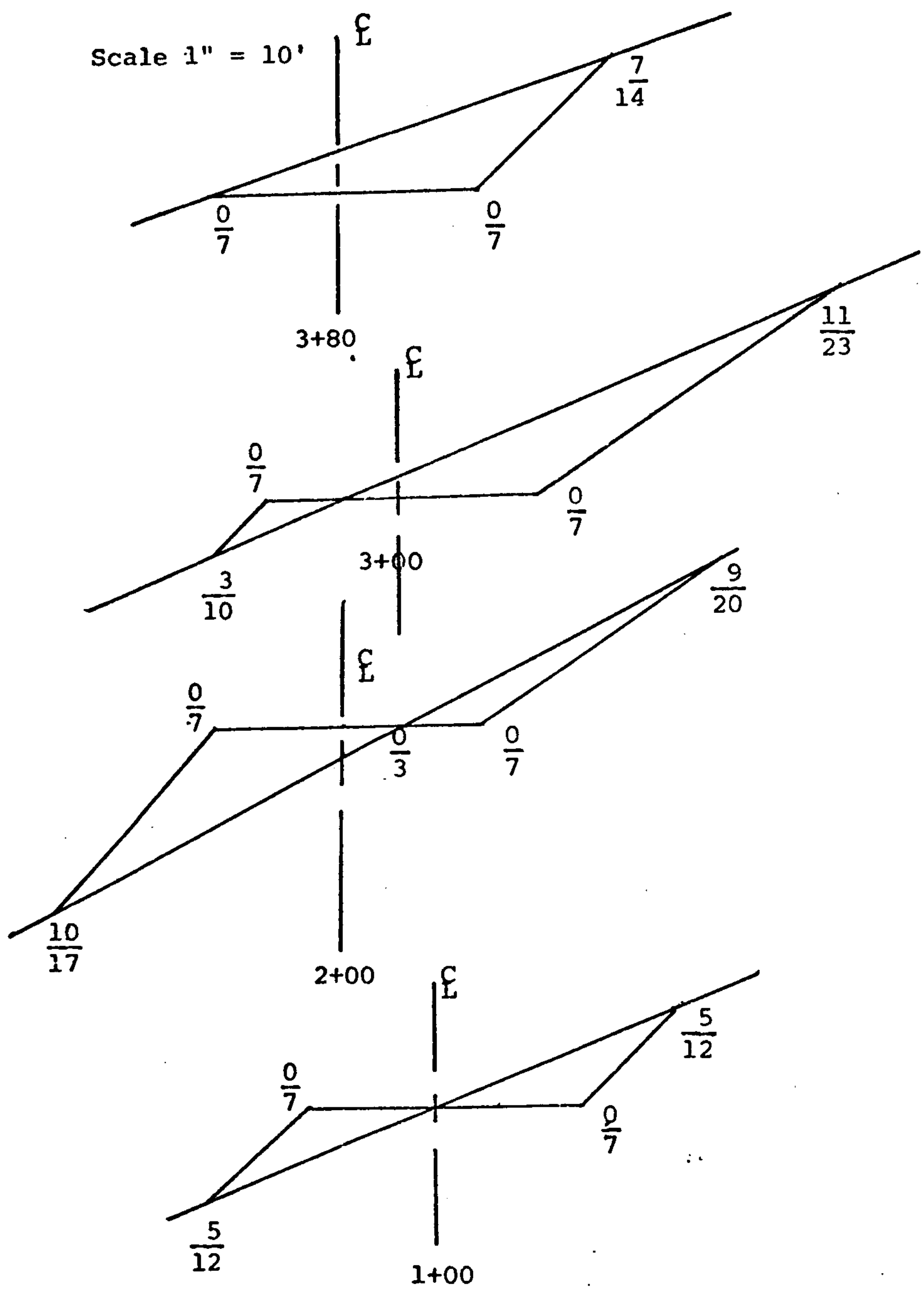


Using the distance W at each cross-section the designer should scale off W on the plan view. These are the points A', A", etc. Then the distances A'B', A"B", B'C', B"C" can be scaled off. These revised distances between the cross-section end areas are now used in the earthwork volume computation.

While the distance along the curve between the sections would be more correct than scaling the straight line distance the additional accuracy is usually not worth the computation.

Consider the following example:


R = 75'
2+00
3+00
3+70
1+00
Scale 1" = 100'


Scale 1" = 10'
℄
7/14
0/7
0/7
3+80
℄
11/23
0/7
0/7
3/10
3+00
℄
9/20
0/7
0/3
0/7
10/17
2+00
℄
5/12
0/7
0/7
5/12
1+00

The distance from the roadway centerline to the center of mass at each cross-section is as follows:

Station 1+00

Fill
Case I

$$\bar{X} = \frac{7 + 12}{3} = \frac{19}{3} = 6.3$$

Cut
Case I

$$\bar{X} = \frac{7 + 12}{3} = \frac{19}{3} = 6.3$$

Station 2+00

Fill
Case II

$$\bar{X} = \frac{10 + 20}{3} = \frac{30}{3} = 10$$

$$W = 10 - 3 = 7$$

Cut
Case III

$$\bar{X} = \frac{4 + 17}{3} = \frac{21}{3} = 7$$

$$W = 7 + 3 = 10$$

Station 3+00

Fill
Case III

$$\bar{X} = \frac{4 + 7}{3} = \frac{11}{3} = 3.7$$

$$W = 3.7 + 3 = 6.7$$

Cut
Case III

$$\bar{X} = \frac{10 + 26}{3} = \frac{36}{3} = 12$$

$$W = 12 - 3 = 9$$

Station 3 + 80

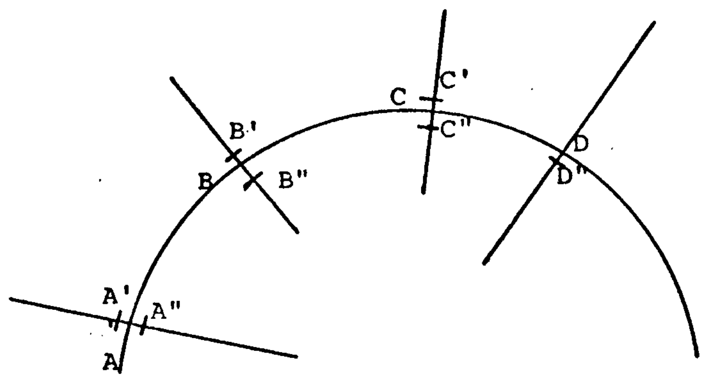
Cut

Case II

$$\bar{X} = \frac{14 + 21}{3} = \frac{35}{3} = 11.7$$

$$W = 11.7 - 7 = 4.7$$

The various values of W, the distance from the centerline to the center of mass are scaled off on the plan.



Measure, by scale, the distances between the centers of mass, A'B', A",B" etc.

A'B' = 105'
A"B" = 95'
B'C' = 107'
B"C" = 95'
C"D" = 68'

These distances can now be used to compute the correct earthwork volumes. Refer to the following earthwork quantity sheet.

On the second earthwork quantity sheet the quantities have been worked out ignoring the curve corrections. The reader should compare both the earthwork quantities and the mass ordinates to determine the significance of the curve corrections.

EARTHWORK QUANTITY SHEET

Sheet No. ______ of ______

Project ______________ No. ________ Forest ______________ Class ______________

Computation by ______________ Date ________ 19 ____ Checked by ______________ Date ______ 19 ____

STATION	DIST	AREAS IN SQUARE FEET — Cut — End Area	Cut — Dbl. end area	Fill — End area	Fill — Dbl. end area	Compaction Factor	VOLUMES IN CUBIC YARDS — % SR	EXCAVATION — Solid Rock	EXCAVATION — Common	EXCAVATION — Total	Adjusted Cut	Total Accum.	EMBANKMENT — Actual	EMBANKMENT — Total Accum.	MASS ORDIN
1+00		17.5		17.5											0
	100		35.5		67.5					66		66	125	125	
2+00		18		50											-59
	100		73		56					135		201	104	229	
3+00		55		6											-28
	70		104		6					135		336	8	237	
3+70		49		0											99