

Chapter 3

Earthwork

3.1	General Introduction.....	3-1
3.1.1	General	3-2
3.2	Classification of Soils	3-4
3.3	Cross Sections - A Design Tool	3-5
3.4	Earthwork Quantities.....	3-7
3.4.1	Method of Calculating	3-7
3.4.2	Earthwork Tabulation	3-7
3.4.3	Earthwork Accuracy	3-8
3.4.3.1	Projects With Horizontal and Vertical Controlled Cross Sections	3-8
3.4.3.2	Projects Without Horizontal and Vertical Controlled Cross Sections	3-9
3.4.4	Variation in Quantities.....	3-9
3.5	Earthwork Items of Payment.....	3-10
3.5.1	Guidelines for Selecting Earthwork Pay Items	3-10
3.5.2	Regular Excavation.....	3-11
3.5.3	Embankment.....	3-12
3.5.4	Subsoil Excavation.....	3-12
3.5.5	Lateral Ditch Excavation	3-12
3.5.6	Channel Excavation	3-13
3.5.7	Borrow Excavation (Truck Measure).....	3-13
3.5.8	Regular Excavation (RRR Projects Only)- Lump Sum.....	3-14
3.5.9	Summary of Earthwork.....	3-15

Tables

Table 3.5.1 Guidelines for Selecting Earthwork Pay Items3-10

Figures

Figure 3.1.1 Cut and Fill Limits (With and Without Subsoil
Excavation)3-3

Figure 3.4.1 Format for the Tabulation of Earthwork Quantities3-7

Figure 3.5.1 Pond Template.....3-11

Exhibits

Exhibit 3-A Fill and Truck Adjustments.....3-14

Exhibit 3-B Summary of Earthwork Box
(Projects With Cross Sections)3-15

Exhibit 3-C Summary of Earthwork Box
(Projects With Limited or No Cross Sections)3-16

Chapter 3

Earthwork

3.1 General Introduction

In 2000, the Department changed its philosophy on several issues that involved earthwork. This chapter was completely rewritten to include the changes that simplified how the Department addressed earthwork on a project. This introduction, highlighting those changes, was included in the manual to summarize the changes at a glance. Complete review of this chapter is recommended prior to plans preparation utilizing earthwork on a project.

Summary of Major Changes to Earthwork

1. Pay for all Cut Operations as Regular Excavation (CY) or Regular Excavation (Lump Sum). Do not differentiate between suitable and unsuitable.
2. Pay for all Fill Operations as Embankment or Borrow Excavation (Truck Measure).
3. Permanently Block the Pay Item for Borrow Excavation (Pit Measure).
4. Pay for all material excavated below the finished grading template as Subsoil Excavation. Do not differentiate between suitable and unsuitable.
5. Pay for subsoil excavation and backfill will be separate using the English method.
6. When quantities are large, pay for Lateral Ditch and/or Channel Excavation separately.
7. When calculating the quantity of Borrow Excavation (Truck Measure) do not subtract the quantity of Regular Excavation on the project.
8. Show soil survey borings on the Cross Section Sheets. Do not show limit lines **except** the lower limits of the removal of organic and/or plastic material to determine the quantities of subsoil excavation.
9. Revise the Earthwork Column format on the Cross Section Sheets. Show Subsoil Exc. - Regular Exc. - Embankment on the right side. Do not create columns for material classification. There will be no earthwork columns on the left side.
10. Identify Pond Excavation Limits and guidance in the PPM.
11. Material utilization will be left up to the Contractor. Adjusting quantities of material to compensate for Traffic Control or Sequence Phasing is no longer required.

3.1.1 General

Earthwork is a generic term for all items of work, materials and operations required to construct the excavated areas and the embankments of a project. **FDOT Specifications, Sections 120** and **125** define the terms, method of measure, basis of payment and pay items associated with earthwork.

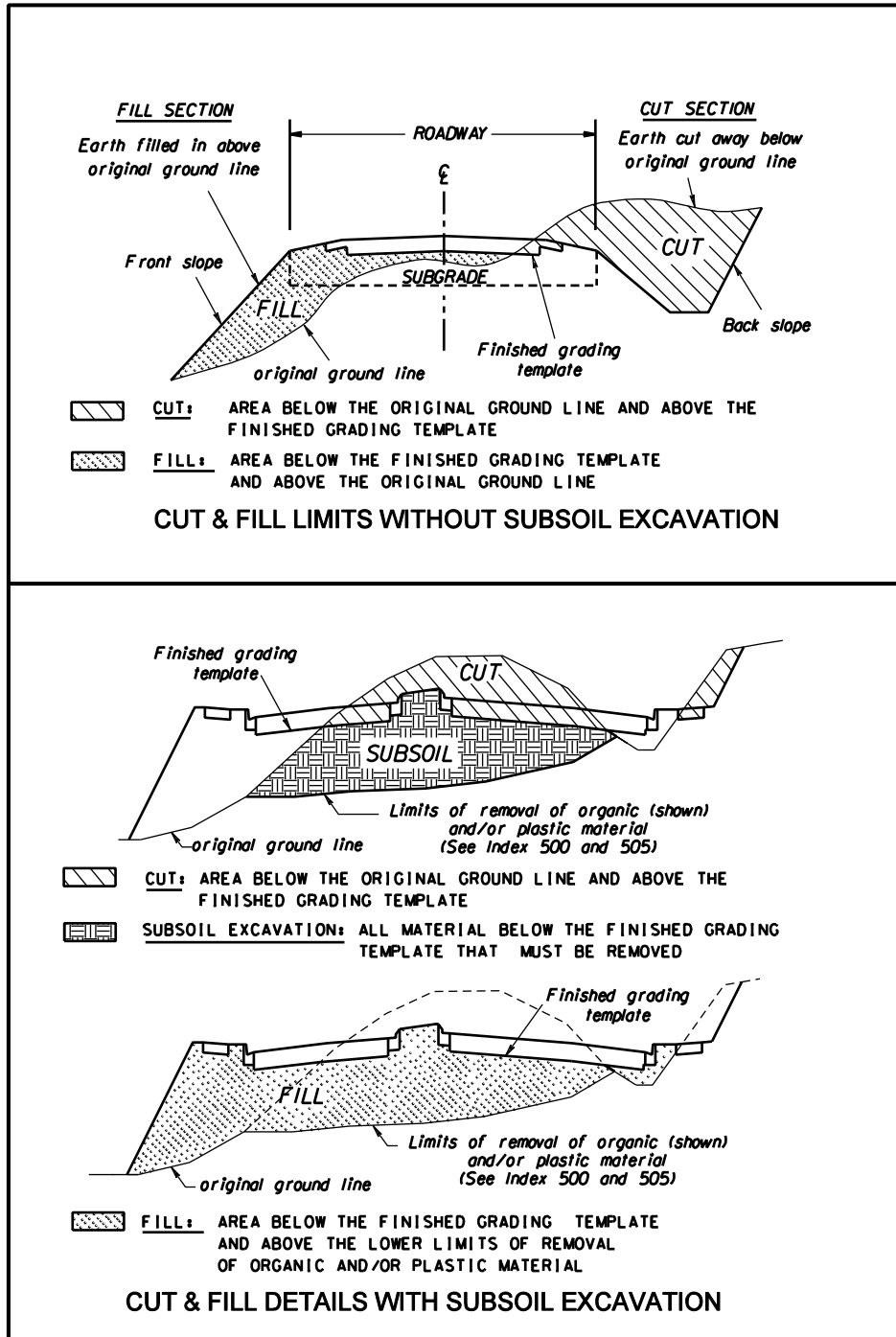
In general, earthwork on a highway project consists of:

Embankment	Compacted fill material needed to construct the roadway, excluding the base and pavement portions of the roadway and shoulders.
Regular Excavation	Excavation necessary for the construction of the roadway, ditches, ponds, channel changes, etc.
Subsoil Excavation	Excavation, removal and disposal of any material that is unsuitable in its original position and that is excavated below the finished grading template.

The most important roadway operation involving earthwork is constructing the roadbed. The roadbed is constructed by excavating soil from cut sections and placing soil as embankments in fill sections. In cut sections, the roadbed is built below the original ground - the original ground is excavated to the elevation of the proposed roadbed. In fill sections, the roadbed is built above the original ground - the earth fill is on an embankment.

The finished grading template is defined as the finished shoulder and slope lines and bottom of the completed base or rigid pavement for most pavements. The Department occasionally uses stabilized bases and sand bituminous road mixes. For these, consider the finished grading template as the top of the finished base, shoulders and slopes.

Figure 3.1.1 Cut and Fill Limits (With and Without Subsoil Excavation)



See the Design Standards, Indexes 500 and 505

3.2 Classification of Soils

The Department uses a system of soil classification that places materials into groups and subgroups based on soil fraction, liquid limit and plasticity index. This classification determines if and where the materials may be placed or left in their original position on a project. The soils survey, testing and classification of materials must be performed by a qualified geotechnical laboratory. The plans will include the information about the soil classification on the soil survey sheet and by showing the boring data soil boxes on the cross section sheets. If it is determined that an organic or plastic material must be removed below the finished grading template, the lower limits of removal of organic or plastic material will be shown to determine the area and volume of subsoil excavation. For more details, see **Volume 2** and the **Design Standards, Index 505**.

3.3 Cross Sections - A Design Tool

The details of cut and fill of earthwork are shown on the cross sections. The cross sections of the existing surface are usually obtained by location field survey or photogrammetry. The finished profile grades, typical section details, pavement design details, superelevation and horizontal alignments are used in combination to develop the finished template at each location where an existing cross section was obtained or generated. Sometimes it is advisable to develop and plot intermediate cross sections or half-sections to accurately determine quantities.

Cross sections cannot be finalized until late in the design process. However, preliminary cross section templates, developed early in the design process, can assist the designer in establishing many of the other design elements such as guardrail, shoulder gutter, inlets and special ditch grades. Preliminary cross sections are also used in performing the Soils Survey. Cross section templates should be plotted as soon as the alignment, grades and typical section details are established.

The interval selected for showing cross sections in the plans will vary according to project specific factors. For guidance see **Volume 2, Section 18.3**.

For resurfacing and minor widening and resurfacing projects, see **Section 3.5.8** of this chapter.

Additional criteria used for plotting the earthwork details are found in the **FDOT Specifications, Section 120**; the **Design Standards, Indexes 500** and **505**; and **Volume 2** of this manual.

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3.4 Earthwork Quantities

3.4.1 Method of Calculating

Earthwork quantities can be accurately determined by computer or by manual calculation, if proper care is taken. Therefore, the specifications allow it to be designated for payment as the original plan quantity unless determined to be substantially in error. Earthwork quantities are calculated by the method of average end areas:

$$\text{CUBIC YARDS} = \frac{\text{EA1} + \text{EA2} \times \text{LENGTH}}{2} / 27$$

Each set of end areas for the different types of earthwork (subsoil excavation, regular excavation and embankment) are calculated separately and shown in the appropriate column on the cross section sheets, as indicated in **Volume 2** of this manual.

3.4.2 Earthwork Tabulation

Areas and volume for subsoil excavation, regular excavation and embankment are tabulated on the right hand side of the cross section sheet. The designer must be familiar with the control lines for earthwork operations in order to properly delineate and calculate earthwork quantities.

Figure 3.4.1 Format for the Tabulation of Earthwork Quantities
 (Show the appropriate tabulation on the right side of the sheet)

Projects With Limited or No Cross Sections		Projects With Cross Sections					
See Example in <i>Section 3.5.7</i> of this chapter.		SUBSOIL EXC.		REGULAR EXC.		EMBK.	
A	V	A	V	A	V		

3.4.3 Earthwork Accuracy

There are two methods of documenting the earthwork quantities for projects. The most accurate and preferred method involves the preparation of cross sections to define the quantities of earthwork involved. This method is mandatory on all new construction and major reconstruction projects. The other method, using working typical sections, is only to be used on RRR type projects where it has been determined that the project is a candidate for payment by Regular Excavation, Lump Sum. It is critical that the designer choose which method is best suited for their project with input from construction.

The calculation of earthwork volumes is not simple but, when performed with care and properly checked, many of the inaccuracies common in earthwork quantity calculations can be avoided. The primary causes for inaccurate earthwork quantities are found to be errors in calculating end areas and choosing inappropriate intervals between the cross sections. Correct methods and techniques for computing earthwork quantities will eliminate the gross errors.

3.4.3.1 Projects With Horizontal and Vertical Controlled Cross Sections

1. Calculate end areas and volumes by computer, when possible, and print the calculations for verification and future use by others.
2. Plot cross section details at the largest scale the sheets will permit. Care should also be taken when plotting slopes that extend over long distances.
3. If end areas are calculated from cross sections manually, show the breakdown of areas, etc. on work sheets and include these as backup in the computation book.
4. When computing volumes, determine lengths between sets of end areas to compensate for volumes that do not run the entire lengths between the normal station lengths.
5. Properly use match lines and turning lines to divide end areas when separate lengths should be used to calculate volumes.
6. Reduce the interval between cross sections to 25 feet or less on ramps or sharp turning roadways, or determine and use the centroid of the section as the length for computing volumes.
7. Exclude bridge spans, large culverts or other exceptions where earthwork is not required.

8. Include quantities for fill slopes under bridges, at guardrail installations and at culvert extensions. Show extended shoulder slope on cross sections at guardrail locations (not steeper than 1:10 per the *Design Standards, Index 400*).
9. Make sure that the fill for all subsoil excavation is included in either the embankment or borrow excavation (truck measure) quantities.

3.4.3.2 Projects Without Horizontal and Vertical Controlled Cross Sections

1. Include working typical cross sections in the computation book at all locations where there is a change in either the existing or proposed templates.
2. Working typicals should include the station limits of the typical, and the end areas of all cut and fill sections. Working typicals may be placed in the plans, but are not required.
3. The thickness of the base box is calculated on the most probable base option. A plan note should also be shown in the plans stating which option was used for calculating the earthwork quantities.
4. Extra fill material needed for the extended shoulder for guardrail placement should be documented in the computation book with the final quantity being tabulated on the summary of earthwork. The quantity should be based on working typical sections showing the extended shoulder slope on cross sections at guardrail locations (not steeper than 1:10 per the *Design Standards, Index 400*).

3.4.4 Variation in Quantities

When detailing and determining earthwork quantities, the designer shall use the most probable base option within the optional base group. A plan note should also be shown in the plans stating which option was used for plotting the cross sections and calculating the earthwork quantities. The Specifications do not allow adjustment of the earthwork quantities that were designated to be paid as plan quantity because a base of different depth was chosen during construction.

3.5 Earthwork Items of Payment

3.5.1 Guidelines for Selecting Earthwork Pay Items

Table 3.5.1 Guidelines for Selecting Earthwork Pay Items

Description		Control Lines	Recommended Pay Item	
			Projects with Cross Sections	Projects with Limited or No Cross Sections
Earthwork operations above the original ground line and below the finished grading template	Fill	from original ground to the finished grading template	Embankment (CY)	Borrow Excavation (Truck Measure) (CY)
Earthwork operations below the original ground line and above the finished grading template	Cut	from original ground to the finished grading template	Regular Excavation (CY)	Regular Excavation (3-R Projects) (LS)
Earthwork operations below the original ground line and below the finished grading template	Cut	from the finished grading template or original ground, whichever is lower, to the lower limits of removal of organic or plastic material	Subsoil Excavation (CY)	Subsoil Excavation (CY)
	Fill	from the lower limits of removal of organic or plastic material removed to the finished grading template	Embankment (CY)	Borrow Excavation (Truck Measure) (CY)
With significant quantities of lateral ditch or channel excavation the designer may select to pay for separately		from finished ground to the finished grading template	Lateral Ditch Exc. Channel Exc. (CY)	N/A

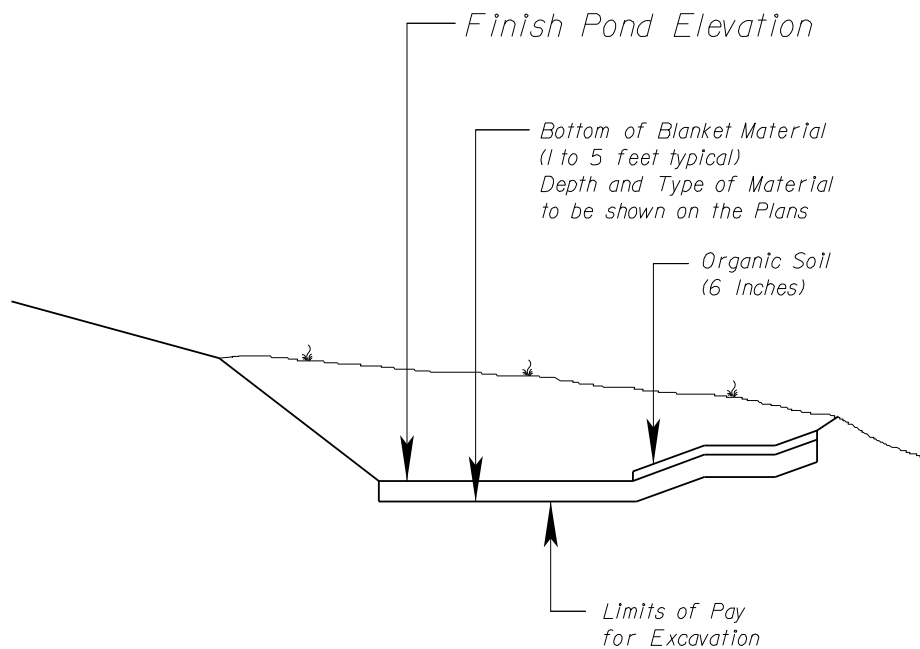
3.5.2 Regular Excavation

This is the most general classification of earthwork excavation. When Lateral Ditch or Channel excavation pay items are not called for in the plans, the total quantity of all excavation shall be paid for as Regular Excavation. Regular Excavation may include roadway, pond and ditch excavation. Roadway Excavation consists of the net volume of material excavated between the original ground line and the finished grading template of the roadway.

Retention or detention areas that require considerable excavation should be summarized separately and added to the Regular Excavation. This is especially important if there is a large quantity and the area is removed from the project by some distance.

Some environmental permits now require that the plans call for excavating additional depth below the finish elevation of the bottom of a pond or ditch. They also require that the area of extra depth be replaced with "blanket material" that will either allow for percolation or not allow for percolation as required by the permit. The drawing below shows the limits of pay for excavation in this situation. The depth and type of fill material must be identified in the plans.

Figure 3.5.1 Pond Template



3.5.3 Embankment

This item includes placing material above the original ground line, or above the lower limits of removal of organic and/or plastic material to the finished grading template.

3.5.4 Subsoil Excavation

Subsoil Excavation consists of the excavation and disposal of any material that in its original position is excavated below the finished grading template or original ground, whichever is lower.

The soils investigation survey documents the organic and/or plastic material found on the project. Likewise, the cross sections and the earthwork calculations must use the lower limits of removal of organic or plastic material in determining the quantities for Subsoil Excavation.

Subsoil excavation areas and volumes shall be tabulated on the right side of the cross section sheets. The fill quantities (areas and volumes) shall include areas and volumes required to fill the excavated areas created by subsoil removal. See example given in **Section 3.1** of this chapter.

The payment for subsoil excavation shall not be included in the pay quantities for other items no matter how small the subsoil quantities.

Embankment (fill) or Regular Excavation (cut) should be used in conjunction with the pay item Subsoil Excavation. Both Embankment and Regular Excavation are plan quantity items. The quantities are based on line and grades shown in the plans and would allow construction personnel to field verify the quantities of material used on a project. Subsoil Excavation is a field measure item, and the final pay quantity will be determined by cross section taken when the removal of the material is completed.

3.5.5 Lateral Ditch Excavation

Excavation required to construct inlet and outlet ditches at structures, changes in channels of streams and ditches parallel to the right of way, but separated from the roadway template, may be designated by the designer as Lateral Ditch Excavation.

On projects with very little of this type of excavation, this earthwork is usually included in the Regular or Roadway Excavation. If there is a significant amount of Lateral Ditch Excavation, it should be detailed, calculated and summarized on separate cross section sheets and shown separately in the Earthwork Summary. For more details on lateral ditch cross sections, see **Volume II** of this manual.

Excavation included for payment or that will be bid as work under **FDOT Specifications Section 125, Excavation for Structures and Pipe**, must not be included again in Lateral Ditch or other excavation pay items.

3.5.6 Channel Excavation

The pay item for Channel Excavation consists of the excavation and satisfactory disposal of all material from the limits of the channel as shown in the plans. This work is generally called for by the plans and has lines, grades, typical sections and other details shown for excavating a channel change or a major modification to an existing channel or stream. This work may be significantly different from regular excavation or lateral ditch excavation, requiring draglines, barges or other special equipment. It should be detailed, calculated and summarized separately, in most cases.

3.5.7 Borrow Excavation (Truck Measure)

Borrow Excavation is the pay item used to indicate that the contractor is to furnish earthwork material from areas provided by him and generally outside the project limits, including material with a specific minimum bearing value for building up existing shoulders, when appropriate for the project.

Borrow material, if available, may be obtained from within the right of way of the project. Obtaining material from the project right of way shall not create an unsafe condition or unprotected hazard. Proper design criteria shall be applied to proposed excavation areas that will fill with water. The proposed borrow areas shall be reviewed and coordinated with the District Environmental Coordinator to minimize environmental disturbance and promote a future original appearance.

When the designer chooses the method of payment as Borrow Excavation (Truck Measure), a fill adjustment must be made to the net total fill material calculated from the plans to allow for handling. An additional adjustment (truck) is added to obtain a representative volume of material required. This is not a plan quantity item, but it is very

important that the most realistic determination of quantities possible be calculated by the designer. Recommendations on fill and truck adjustment percentages should always be obtained from either the District Materials or Construction Office during the design process.

Exhibit 3-A Fill and Truck Adjustments

EXAMPLE: Fill (From Working Typical)	253 CY
Fill Adjustment (+20%) (253 x 0.20)	<u>51 CY</u>
Fill	304 CY
Truck Adjustment (+25%) (304 x 0.25)	<u>76 CY</u>
Borrow Excavation (Pay Item)	380 CY

Adjustment percentages shown are for example only. Contact District Materials or Construction Office for actual percentages to be used for each project.

3.5.8 Regular Excavation (RRR Projects Only)-Lump Sum

The Pay Item for Regular Excavation (RRR Projects Only) - Lump Sum is to be used on resurfacing or minor widening and resurfacing (RRR) projects that conform to the following guidelines:

1. There are limited or no cross sections on the project.
2. Existing typicals are reasonably consistent throughout the project.
3. If utility adjustments are a consideration on the project, the designer will need to be sure that sufficient data is available to allow the utility to be relocated or adjusted.
4. There are no right of way requirements on the project.
5. There is no change in the existing horizontal or vertical alignment.
6. There are no major special ditches on the project.
7. There are no major intersection modifications.
8. Show quantity of Excavation in Summary Box, but pay for as 1 Lump Sum.

Regular Excavation (RRR Projects Only) - Lump Sum can be used on projects other than RRR, but only if they are minor projects complying with the same listed guidelines.

Earthwork will be paid for as Borrow Excavation (Truck Measure) and Regular Excavation

(RRR Projects Only) – Lump Sum. The designer will calculate these quantities based on information obtained from the field and the proposed typical section. The designer must conduct a thorough field review to ensure existing field conditions are accurately reflected in earthwork estimates.

3.5.9 Summary of Earthwork

The last sheet in each group or cross section group (mainline, sidestreet, pond 1, etc.) should tabulate the totals for each earthwork operation (subsoil excavation, regular excavation and embankment).

Below is an example of a summary of earthwork box for projects with cross sections. The summary should document all the groups totals in one location. This summary should be shown on the Summary of Quantities Sheet.

**Exhibit 3-B Summary of Earthwork Box
 (Projects With Cross Sections)**

SUMMARY OF EARTHWORK (CUBIC YARDS)	
ROADWAY EXCAVATION, Mainline	10,000
ROADWAY EXCAVATION, Sidestreet Name	800
REGULAR EXCAVATION, Pond No. 1	1,005
REGULAR EXCAVATION, Lateral Ditches	5,000
TOTAL REGULAR EXCAVATION	16,805
EMBANKMENT, Mainline	20,000
EMBANKMENT, Sidestreet	7,000
TOTAL EMBANKMENT	27,000
SUBSOIL EXCAVATION, Mainline	2,080
SUBSOIL EXCAVATION, Sidestreet Name	1,100
TOTAL SUBSOIL EXCAVATION	3,180

Below is an example of a summary of earthwork box that should be used for projects with limited or no cross sections. This summary should be shown on the Summary of Quantities Sheet. The summary should show all quantities and adjustments.

**Exhibit 3-C Summary of Earthwork Box
 (Projects With Limited or No Cross Sections)**

SUMMARY OF EARTHWORK (CUBIC YARDS)	
FILL	253
GUARDRAIL LOCATIONS	70
CROSS DRAINS	<u>100</u>
	423
FILL ADJUSTMENT (20%) (423 x 0.20)	<u>+ 85</u>
FILL	508
TRUCK ADJUSTMENT (25%) (508 x 0.25)	<u>+ 127</u>
TOTAL BORROW EXCAVATION	635
REGULAR EXCAVATION	200

The pay items used will be:

Regular Excavation (RRR Projects Only)	1 (LS)
Borrow Excavation (Truck Measure)	635 CY

Adjustment percentages shown are for example only. Contact District Materials or Construction Office for actual percentages to be used for each project.