Brown Bag –part 2 of 3

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EARTHWORK WITH GEOPAK

Earthwork Overview

- Basic Requirements:

In order to compute earthwork, GEOPAK requires?: (Hint – 2 requirements & a 3rd for CFLHD methods)

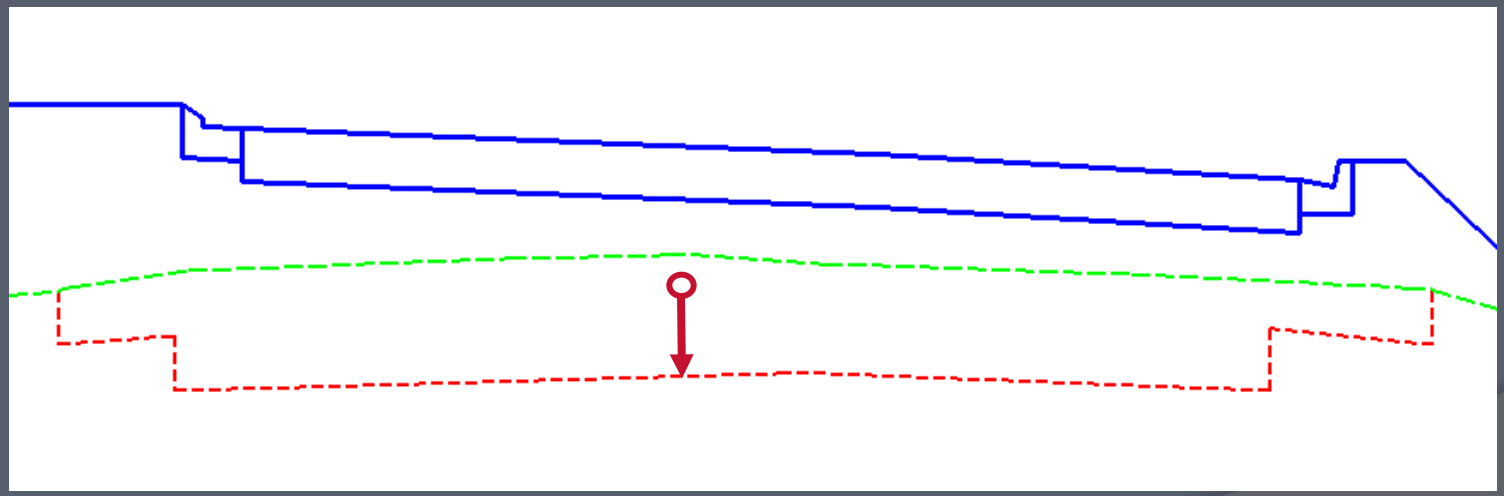
- MicroStation cross section design file
- GEOPAK coordinate geometry database file (.gpk) if the baseline used to generate the cross sections has station equations
- *Earthwork Input file (required for CFLHD method)*

Geopak Process...Simplified

- The GEOPAK earthwork computation process can be simplified into three basic steps. The basic steps are:
  - Find an enclosed area
  - Determine the centroid of the area
  - Determine the material type of the area

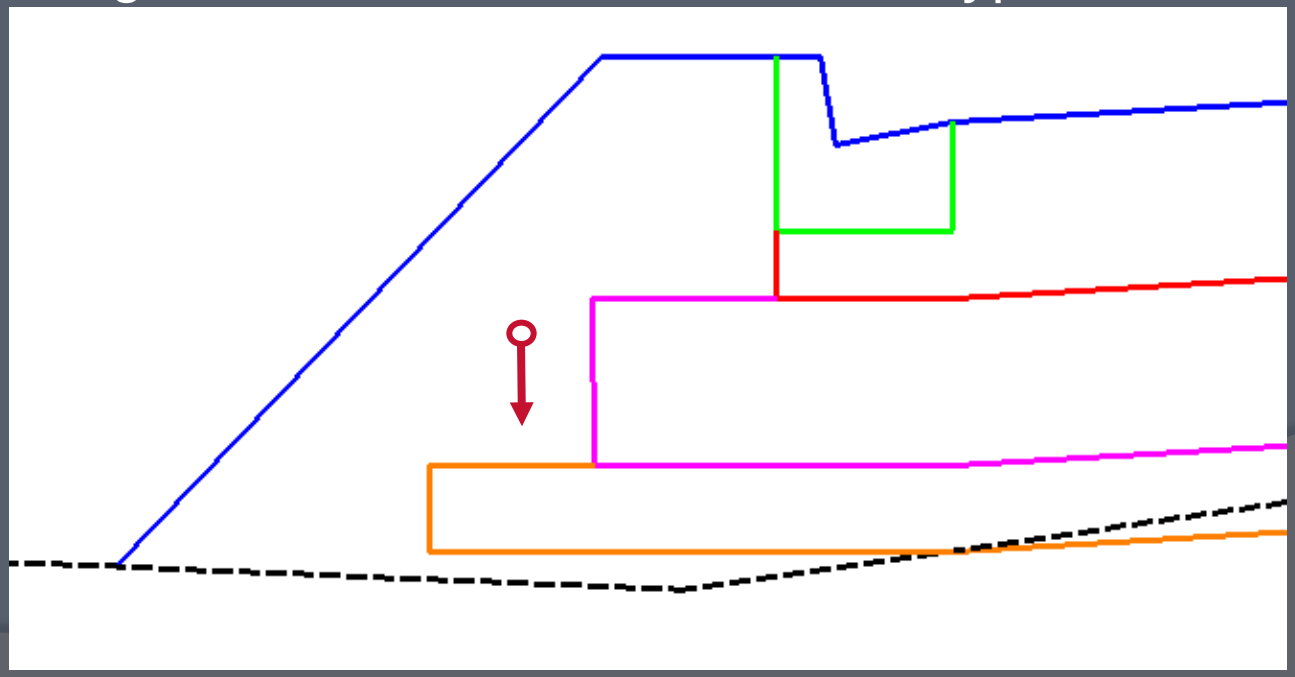
Geopak Process...Simplified

- How does it determine the material type?
  - First, it intersects the graphical element directly below the centroid.
  - It then matches the intersected symbology to the defined material types.



Geopak Process...Simplified

- The user must be aware of possible errors!
  - In this example, the centroid is directly over the roadway base. Thus, choosing the wrong material.
  - The FLH X30 criteria works well, and we don't have to worry about this.
  - No guarantees on hand-edited/non-typical sections.

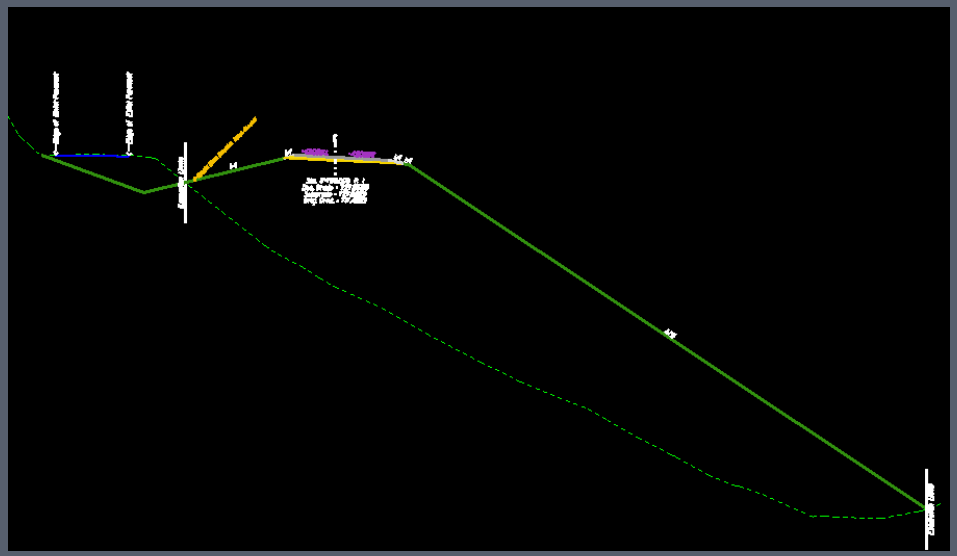


Geopak Process...Simplified

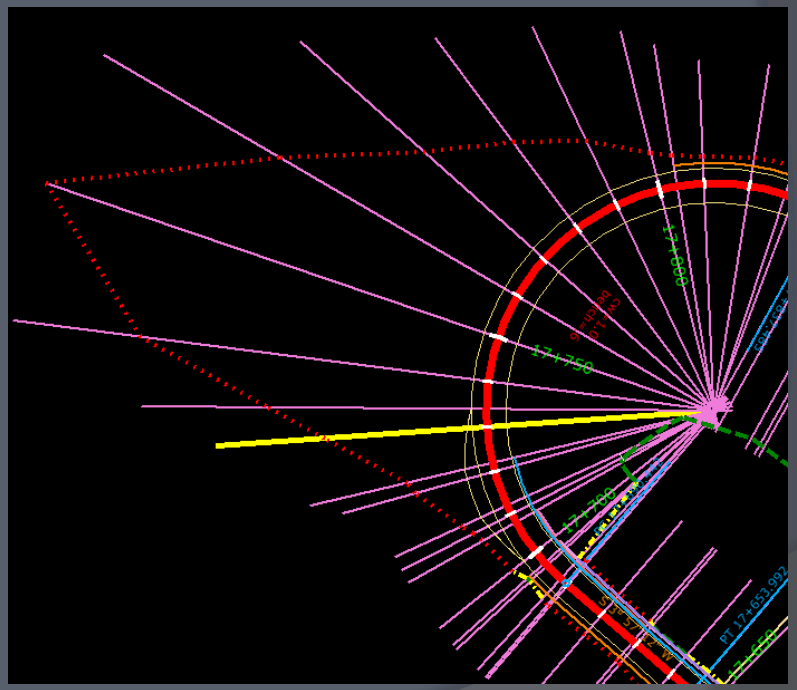
- Geopak Number Crunching
  - **GEOPAK computes earthwork *(using the Average End Area Method)*** by reading and interpreting the MicroStation design files containing proposed and existing ground cross sections. This approach affords the user maximum flexibility in that it is irrelevant whether the cross section elements were created entirely by GEOPAK or were created or modified using generic MicroStation commands.
  - $V = L(A_1 + A_2)/2$

Geopak Process...Simplified

- What if your xs looked like this?



- At a location like this?



Geopak Process...Simplified

- How do we adjust for Horizontal Curvatures?
  - Earthwork volumes are calculated by averaging end areas and then multiplying these averaged areas by the distance between two successive cross sections as measured along the baseline. **If the bulk of the cross section areas are located predominantly to either the left or the right of the baseline**, as in a detour, **an error occurs in the volume calculations for all non-tangential portions of the baseline**. This error can be negligible or substantial depending on the degree of baseline curvature as well as the degree to which cross section areas are offset about the baseline.
  - These types of errors can be optionally accounted for via specification of the **"centroid" adjustment** keywords. These keywords can be placed immediately before the process earthwork for baseline = ... statement. The option invokes a procedure that adjusts volumes based upon the lateral offset between the centroid of cross section end areas and the baseline.

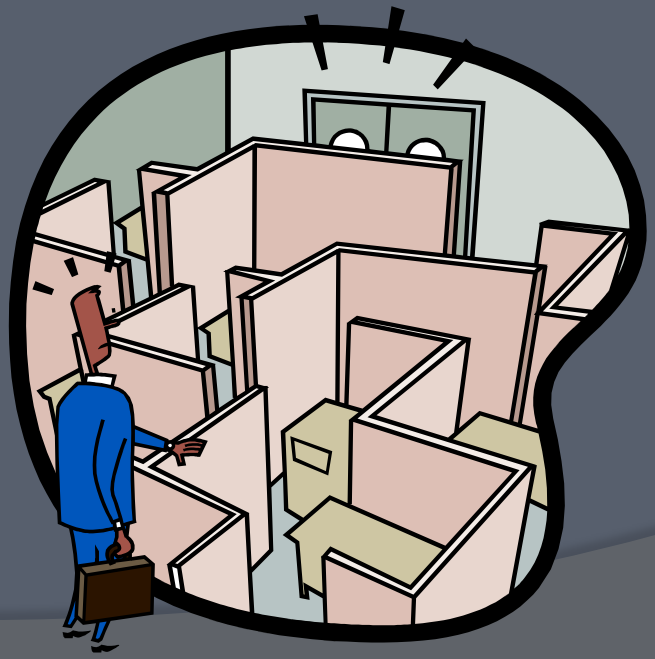
```
Centroid Adjustment    /* CFL specific  */

  Process Earthwork for Baseline = sample
      job number = 000

      beg sta = 100+00 R 1
      end sta = 115+46.07 R 1
```

Understanding Geopak Earthwork

- Excavation Types, Embankment Types, Functional Class, Soil Types……?
- Subgrade, Subsoil, Proposed Finished Grade, Existing Ground….?
- Undercuts, Suitables, Unsuitables, Shrink/Swell…..?
- **Aaarrghhh! This doesn't make sense!**



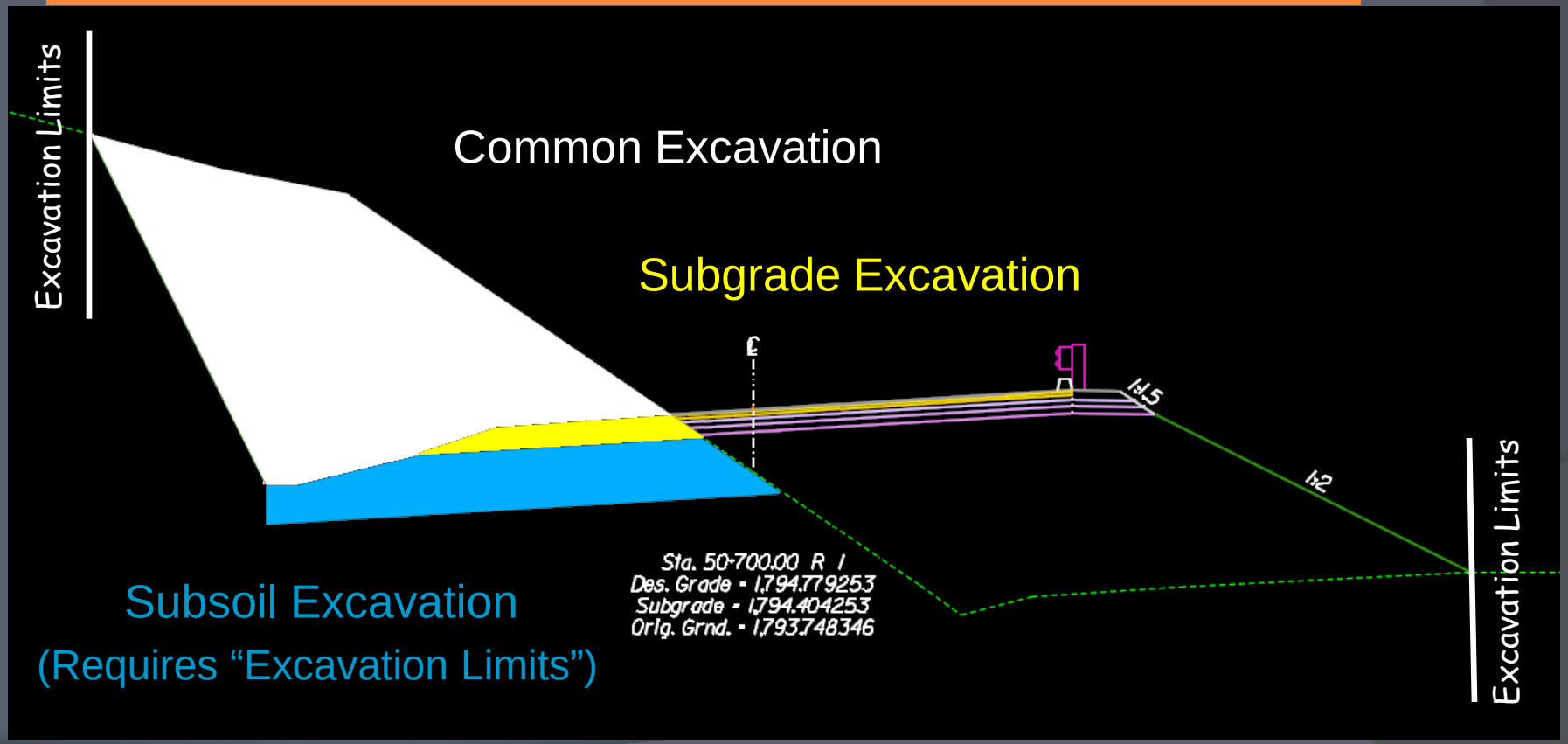
Understanding Geopak Earthwork – Let's keep it simple

- **Excavation Types:** Can you name the three?
  - **Common excavation** - excavation volumes that are not backfilled with an earthwork material. This includes the excavation required for cut sections as well as for pavement thickness, shoulder thickness, etc.
  - **Subgrade excavation** - excavation volumes that are backfilled with an earthwork material.
  - **Subsoil excavation** - excavation required to remove unsuitable material either 1) down to the bottom of the proposed template or 2) down to the bottom of the unsuitable material layer in cases where excavation limits are defined.

Understanding Geopak Earthwork – Let's keep it simple

Excavation Types:

- There are 3 main Excavation types. Individual volumes can be combined or separated.
- **Can you name the earthwork shape excavation types?**



Understanding Geopak Earthwork – Let's keep it simple

- **Embankment Types**
  - In addition to the excavation types, GEOPAK determines where fill material is required. The user does not specify where embankment is required as GEOPAK determines it from the graphic elements in the MicroStation cross section design file. **GEOPAK does not have various types of fill** similar to the various types of excavation, however, **the user does have control of the various types of material used for embankment**. Let's look at the basic requirements for earthwork.

Understanding Geopak Earthwork – Let's keep it simple

- **Functional Class**
  - **Functional classes -** are set by the designer and **identify the function or purpose of the cross section element**. GEOPAK supports **six** different classes. Within each class there can be multiple soil types.

Understanding Geopak Earthwork – Let's keep it simple

- **Functional Classes**
  - There are 6 Functional Classes, two of which are required.
    - **Proposed Finished Grade –** Must connect to another proposed finished grade element or to existing ground. Must also connect to existing ground an even number of times and a minimum of two places in each cross section.
    - **Existing Ground –** is a line string or connection of elements that are the bases for all earthwork volumes.
  - The Federal Lands Highway standards for Existing Ground and Proposed Finished Grade are:

Existing Ground Line	Proposed Finish Grade
soil type = RdwyExc roadway exc mult factor = 1.00 subsoil exc mult factor = 1.00 fill mult factor = 1.00 type = line, line_string lvname = x_e_ground_xs co = 8	soil type = Embankment /* RdwyExc - WFL*/ roadway exc mult factor = 1.00 subsoil exc mult factor = 1.00 fill mult factor = 1.00 type = line lvname = x_p_cutslope, etc, etc…. co = 0,1,15,29,40,42,…

Understanding Geopak Earthwork – Let's keep it simple

- **Functional Classes**
  - There are 6 Functional Classes, two of which are required.
    - **Proposed Finished Grade**
    - **Existing Ground**
  - Can you identify the remaining 4?
    - **Proposed Undercut** - are used to define any proposed component which is not part of the finished grade. It is important to remember that the soil type is not the material being removed, but what the area will be backfilled with. **All proposed undercuts must tie to another proposed undercut or proposed finish grade, not to existing ground.**
    - **Existing Suitable –** is material removed **only** if its excavation is needed to build the proposed design. (Example: if existing pavement is an "Existing Suitable" and a proposed cross section is entirely in fill, the pavement will not be removed.)
    - **Existing Unsuitable –** is material that is removed, if within the excavation limits regardless if its excavation is needed to build the proposed design. (Example: if existing pavement is an "Existing Unsuitable" and a proposed cross section is entirely in fill, the pavement will be removed.)
    - **Excavation Limit –** *(no soil type needed)*

Understanding Geopak Earthwork – Let's keep it simple

- **Functional Class Common misconceptions:**
  - *"Unsuitable" means unused, wasted or disposed*
  - *"Existing suitable" means material that is used.*
  - *Removed = disposed*
- *In the example below, "Existing Suitable" is the functional class.*

```
/* For use with sidewalks */
      Existing Suitable Material
        soil type = SidewalkExc
        roadway exc mult factor =  1.00
        subsoil exc mult factor =  1.00
        fill mult factor =  1.00
            type = line
            lvname = x_p_sidewalk_exc
            co = 31
```

Understanding Geopak Earthwork – Let's keep it simple

- Soil Types
  - With each functional class, additional project-specific information must be supplied in order for GEOPAK to compute the quantities. This information required to compute quantities includes: Soil Type, Search Criteria and Shrink/Swell Factors.
  - **Soil Type – is extremely important as it dictates what materials are re-used and which materials are not.** The soil type variable is nothing more than a "name" for the material and is used for reporting purposes. The name of the soil type is created by the designer and the number of types is unlimited.
  - In the same example, the soil type is "SidewalkExc".

```
/* For use with sidewalks */
      Existing Suitable Material
        soil type = SidewalkExc
        roadway exc mult factor =  1.00
        subsoil exc mult factor =  1.00
        fill mult factor =  1.00
            type = line
            lvname = x_p_sidewalk_exc
            co = 31
```

Understanding Geopak Earthwork – Let's keep it simple

- **Search Criteria –** are the element attributes or parameters (level, color, linestyle, weight) that define and provide uniqueness to a specified material.
- **Shrink/Swell –** or "multiplication factor" is the specified value of how much a volume will increase or decrease once removed or placed and can be specified for each material type. The value is expresses as a decimal percentage with the default value (1.0) equaling no shrink or swell. (Example: a material that swells 5% would have a Shrink/Swell value of 1.05. If not specified, GEOPAK defaults the missing factor to 1. If the material type is used in several classifications, (such as topsoil in both existing unsuitable and proposed undercut), the factors must be identical in each classification.
  - In some cases, it is desirable to omit some materials from the mass ordinate. Multiplication factor = 0 is supported in GEOPAK, and will keep the material out of the mass ordinate for existing suitables and unsuitables, which accrue their own mass ordinates. However, the easiest method for Proposed Undercuts is the activation of the **Do Not Include in Mass Ordinate** toggle or command.

Geopak Earthwork – Procedures and Outputs

- **Procedure Methods** – There are two methods in which earthwork can be processed.
  - **Through the Project Manager**
  - Through the use of an **Earthwork Input file** (CFLHD's preferred method)

Geopak Earthwork – Procedures and Outputs

- **Earthwork Shapes:**
  - When the Draw Earthwork Shapes toggle\command is active, the earthwork shapes are drawn with color fill attributes. When the Fill toggle is active on the View Attributes dialog, color filled complex shapes are displayed.
  - The shapes either can be drawn in a single color or various colors can be assigned to various types of cut and fill. When the Stratify Shape Color **is not** active, the actual color corresponds to the color defined for the plot parameters.
  - Variations in color between various cut and fill options are achieved with the **Stratify Shape Color** toggle **active.**
    - Color assignments initialize at zero, regardless of the color listed in the plot parameters of the write earthwork shapes. However, the specified level is utilized for drawing the complex shapes. In the first material type, color 0 is assigned to excavation areas, while color 1 is assigned to fill. Color stratification for the various types of excavation is not supported. For the next material, color 2 is assigned for excavation, while color 3 is utilized for fill. Note the pattern that all excavation colors are even, while all fill colors are odd.

Geopak Earthwork – Procedures and Outputs

- **Earthwork Report:** The earthwork report consists of four major parts:
  - Individual cross section quantities
  - Grand Total Summary
  - Balance Point Summary (Included only if there are balance points)
  - Centroid Adjustment Summary (Included only if the centroid adjustment option is active.)
- Example of Station Quantities:

Station	Material Name	End Areas (sq. ft.)	Unadjusted Volumes (cu. yd.)	Adjusted Volumes (cu. yd.)	Mult Factor	Mass Ordinate
639+00.00	A2&A3					
	Common Exc	1075.93	0	0	1.00	
	Subgrade Exc	0.00	0	0	1.00	
	Subsoil Exc	0.00	0	0	1.00	
	Fill	3973.53	0	0	1.00	0
640+00.00	A2&A3					
	Common Exc	793.93	3463	3463	1.00	
	Subgrade Exc	0.00	0	0	1.00	
	Subsoil Exc	0.00	0	0	1.00	
	Fill	3796.16	14388	14388	1.00	-10925