

Title: ArcMap: Calculating Soil Areas for Storm Water Pollution Prevention Plans

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Abstract: The use of ArcMap to calculate soil areas for storm water pollution prevention plans has allowed for more accurate and comprehensive calculations. Present and proposed layouts of projects were initially used in AutoCAD to calculate the area of soil under the right of way; this value was then used to estimate the soil areas under the existing road and the proposed road. However, through the use of ArcMap the actual areas of individual soils under each of the roads can be calculated and eliminate any error caused by estimation. Calculated areas are used to determine USDA TR-55 Curve numbers, these numbers are based on hydrologic soil groups to determine the amount of site rainfall runoff. Area data is entered into a spreadsheet where curve numbers are determined. Soils maps, location vicinity maps, and site topographic maps are also created with the use of ArcMap.

Introduction

The Tennessee Department of Transportation (TDOT) monitors all road projects in the State of Tennessee. Before construction begins, TDOT is required to acquire permits for construction sites. One such permit is for storm water runoff pollution control. This permit is issued by the Tennessee Department of Environment and Conservation (TDEC) under the authority of the Clean Water Act and the National Pollutant Discharge Elimination System (NPDES). When heavy machinery and grading operations remove the top layer of grass, trees and brush, leaving only the bare earth, there is high potential for transport of erosion sediment to streams in the area. Therefore, every construction project that disturbs more than one acre of land must apply for a NPDES permit by completing a Notice of Intent (NOI) and preparing a Storm Water Pollution Prevention Plan (SWPPP). Amec is subcontracted to prepare the SWPPP reports for TDOT. These reports provide specific instruction for minimizing erosion and controlling the amount of sediment loss that occurs on the construction site. They are composed of the erosion prevention and sediment control plans for the construction site, outfall locations, stream information, wetland information, soil information, and maps. In order to prevent erosion and to control sediment from leaving the construction Right-Of-Way (ROW), TDOT has developed Best Management Practice (BMP) standards. These standards are used by the project designer and are shown on the erosion prevention and sediment control plans.

The Curve Number (CN) is an index used to determine the general tendency of soils within a specific area to either shed excess precipitation as runoff or be absorbed into the soil during a rainfall event. It was developed by the Soil Conservation Service (SCS), now called the Natural Resource Conservation Service (NRCS), in Technical Release 55 (TR-55). The CN is a function of land cover and the physical characteristics of the soil. Previously, project area maps and CN approximations developed by AMEC were created using AutoCAD. Hard copy soil maps from NRCS county soil surveys were used in a best guess approach to estimate the percentage of different soil types within a project ROW area. However, this method lacked the ability to determine the exact area of individual soils. Permit regulators desired a more accurate weighted CN and the creation of a better method was needed to calculate these values.

In recent years the NRCS has created spatial soil data digitized from the original soil surveys. These maps are available for public use at the NRCS website (soildatamart.nrcs.usda.gov). One limitation of the data is that it is only compatible with ArcGIS and not with AutoCAD. As a part of this work, options were explored for performing these calculations in ESRI's ArcMap using the spatial soil data. Using ArcMap to analyze the soil data was found to benefit the SWPPP production process because it allowed for a more accurate calculation of weighted CN values and a higher quality of map creation.

This paper describes the methods, demonstrates the uses, shows the results and discusses the benefits of using ArcMap in the calculation of soil areas for SWPPP's. TDOT construction plans for Netherland Inn Road Bridge over North Fork Holsten River in Hawkins County, TN are used to illustrate the process of calculations and map creation in ArcMap. This process consists of four main components: resources, methods, calculations, and map creation.

Resources

Several resources are needed to begin a SWPPP report. USGS topographic maps, also known as Digital Raster Graphics (DRG) are acquired from the Geo Community website (download.geocomm.com). Soil data for the study area is obtained from the NRCS website, however, some counties are still in the process of creating spatial soil data. If only tabular data is available, soil data must be created from existing paper soil maps. This will add a few steps to the GIS process as the user is required to manually scan the soil maps, georeference them to the topographic maps, and create the soils for the construction ROW. Once all of these resources are available, the SWPPP production process is ready to begin.

Methods

Construction plans are the basis for calculating the CN and soil areas. Each set of plans includes present layout sheets and proposed layout sheets. They are received in hard copy format, scanned in as a .pdf and converted to .tiff format. The “tiffs” are then brought into ArcMap.

Construction plans show spatial coordinates, usually as Northings and Eastings for various points along the proposed layout. These are the main points used to georeference the plans. Georeferencing means that the plans are placed geographically in the world, to scale. Once one page is georeferenced, the others can be done by using the Northings and Eastings along with match lines. Match lines represent page breaks in the plan design and are used to connect separate plan sheets together. When there are not adequate Northings and Eastings available to connect the plans, other control points are used for georeferencing.

Plans show boundary lines for the existing roads, proposed roads, and the construction ROW. Each of these features is digitized to create polygon shapefiles. These polygons comprise the model of the construction site and are used in performing calculations for the SWPPP.

This data contains attributes about the soil, such as the soil type (represented in the ‘musym’ field). Spatial soil data is added to the ArcMap in order to “clip” the soils to the polygons. In some cases, projections may need to be adjusted to achieve a more accurate alignment of the soils with the topographic map. The resulting polygons only contain the soils under that particular area. These polygons must be created within a personal geo-database in order to be able to calculate the soil areas. This technique is performed for the existing roads, the proposed roads, and the construction ROW, resulting in three new polygons: soils under existing, soils under proposed, and soils under ROW. Once the soils are clipped the symbology must be set to categories so that individual soil types can be represented by a unique color. Figures 1a-1c display three such polygons.

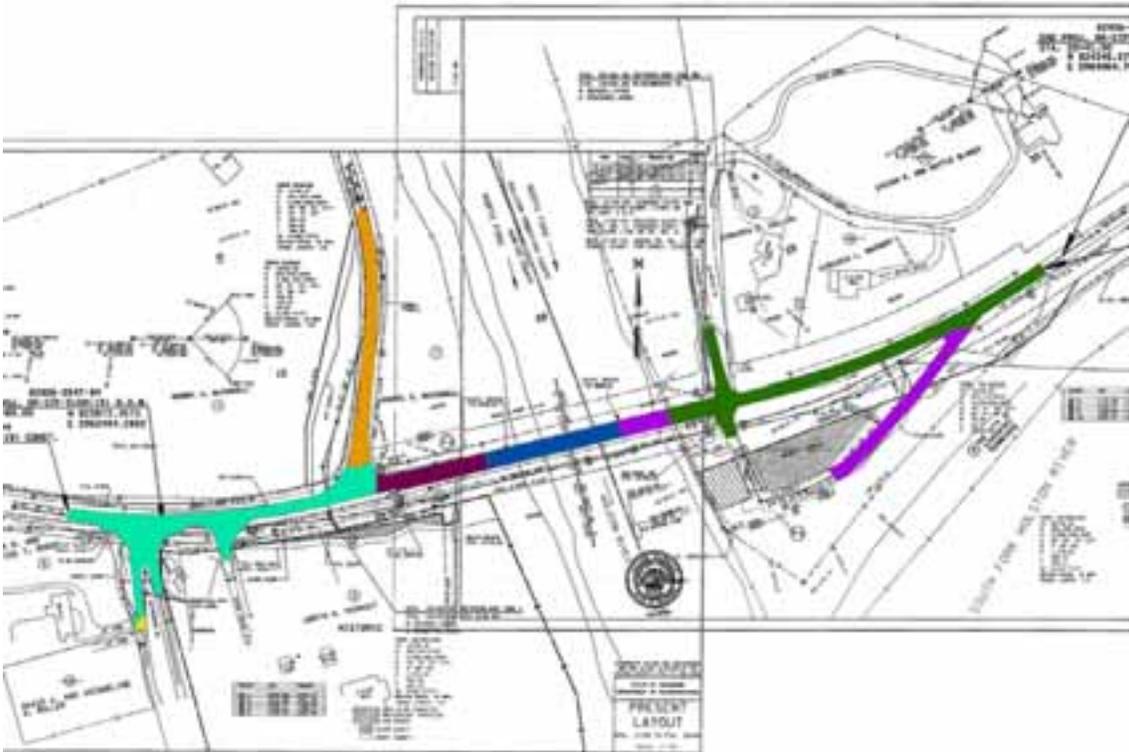


Figure 1a. Polygon showing soils under the existing road.

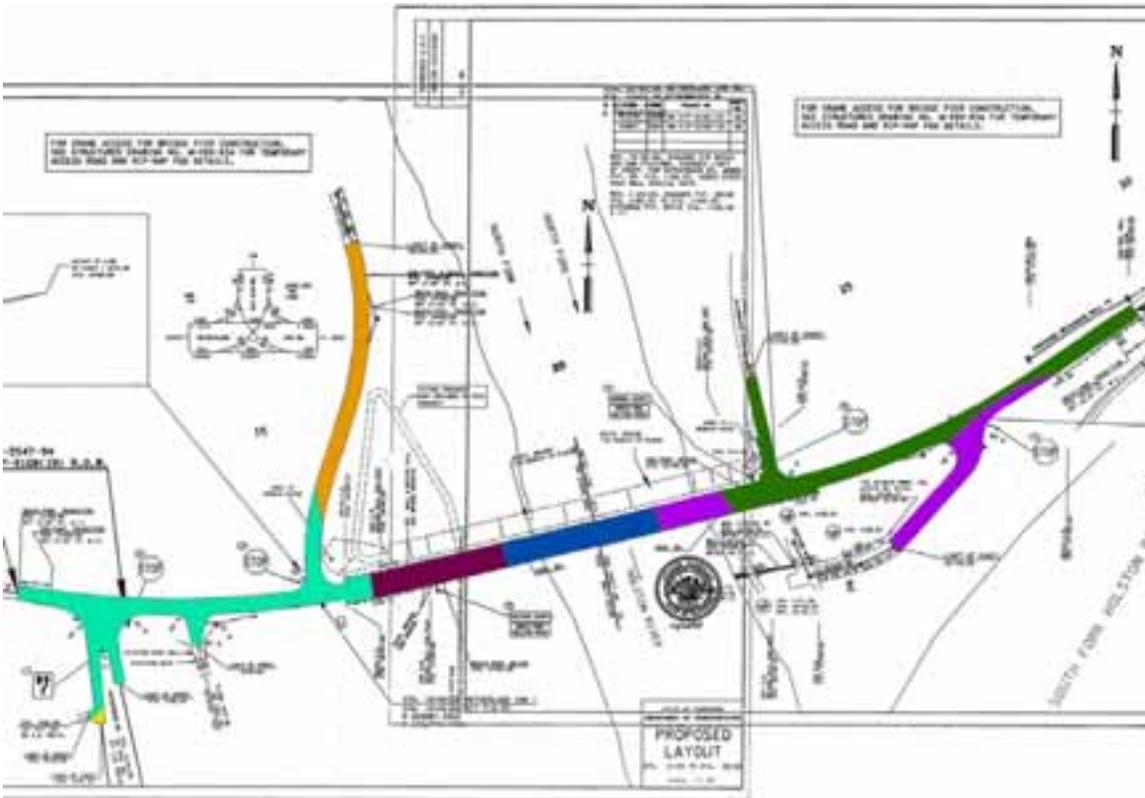


Figure 1b. Polygon showing soils under the proposed road.

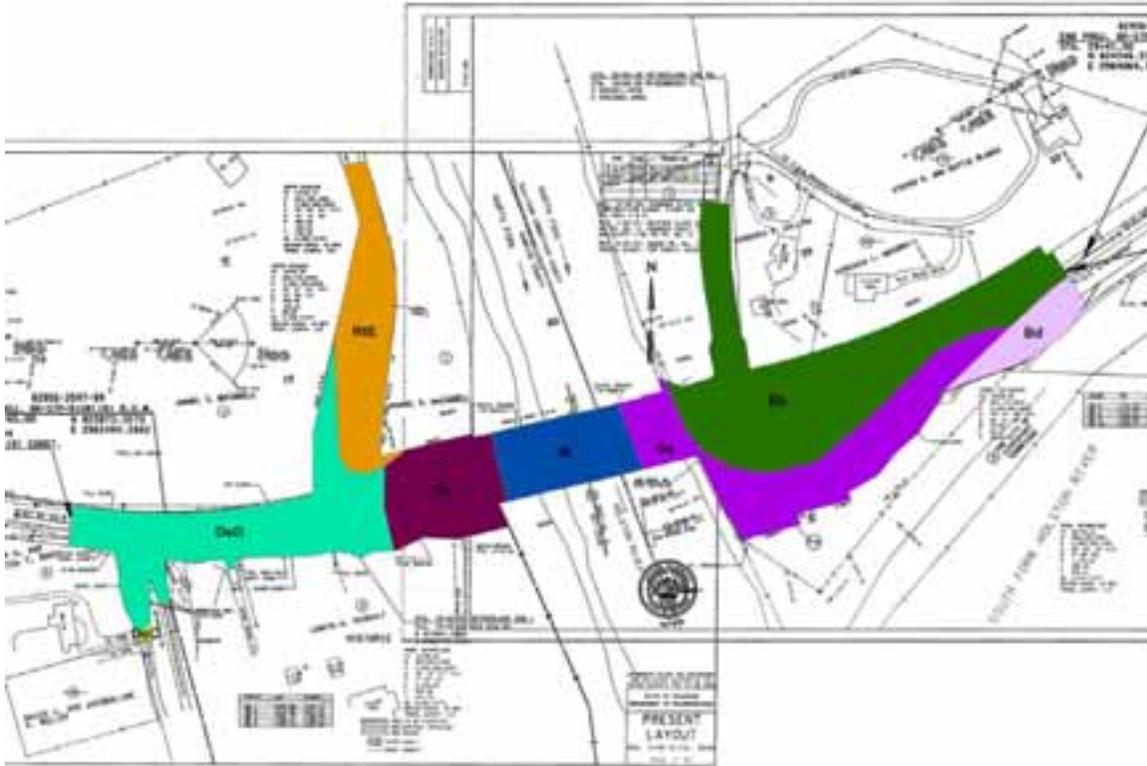


Figure 1c. Polygon showing soils under the construction ROW.

Calculations

The soil polygons show all of the different soil types under each project feature. For instance, the soils under the ROW polygon now displays all soils that lie within the construction ROW boundary. These polygons are used to calculate the areas of each soil type. In order to calculate soil areas, the user must open the attribute table and summarize the ‘musym’ field. This task creates a Microsoft Excel table that will show the area for each soil type. This is repeated until all the polygons have been summarized.

The soil areas are used in the calculation of CN values. Depending on the projection of the model, the user may be required to convert the units of the soil areas. Present and proposed CN table spreadsheets are set up to convert the data given in ArcMap from square feet into acres and percentage of total soil area. According to TR-55 each soil is assigned a hydrologic soil group: A, B, C, or D. The user must enter the proper hydrologic soil group for each soil and its associated CN value, based upon land cover above the soil. These spreadsheets are used to calculate a final weighted CN for the present conditions and proposed conditions of the construction site. The higher the CN value, the higher potential there is for runoff. As an example: an impervious asphalt road would have a CN of 95 whereas a pervious grass field may have a CN of 65. Table 1 and Table 2 display Present Condition CN and Proposed Condition CN spreadsheets. Note that in Table 2 the addition of impervious area, in the form of asphalt in the construction project, has increased the CN from present to proposed conditions. This means that there will be more storm water runoff in the proposed condition than in the present condition. Once the present and proposed CN tables have been completed they are ready to be included in the SWPPP.

Present Conditions					
Soils Under Existing Roads					
Soil Symbol	Square Footage	Acres	%	Hydrologic Soil Group	Curve #
Bd	0	0.0	0.00%	A	98
DeC	388	0.0	0.49%	B	98
DeD	24,506	0.6	30.41%	B	98
RtE	11,044	0.3	13.71%	D	98
Se	10,440	0.2	12.96%	C	98
Sh	20,961	0.5	26.01%	C	98
Ss	5,904	0.1	7.33%	B	98
W	7,341	0.2	9.11%	Null	98
	80,582	1.8	100		

ROW Minus Existing Roads					
Soil Symbol	Square Footage	Acres	%	Hydrologic Soil Group	Curve #
Bd	14,392	0.3	5.53%	A	32
DeC	97	0.0	0.04%	B	58
DeD	43,839	1.0	16.84%	B	58
RtE	28,312	0.6	10.87%	D	79
Se	46,750	1.1	17.96%	C	72
Sh	79,487	1.8	30.53%	C	72
Ss	26,689	0.6	10.25%	B	58
W	20,793	0.5	6.10%	Null	98
	239,565	6.0	100		
		7.8			

CN 76

Table 1. Microsoft Excel table showing calculation of the CN for present conditions.

Proposed Conditions					
Soils Under Proposed Roads					
Soil Symbol	Square Footage	Acres	%	Hydrologic Soil Group	Curve #
Bd	0	0.0	0.00%	A	98
DeC	399	0.0	0.30%	B	98
DeD	34,498	0.8	25.82%	B	98
RtE	15,962	0.4	11.96%	D	98
Se	19,634	0.5	14.69%	C	98
Sh	32,672	0.8	24.45%	C	98
Ss	13,925	0.3	10.42%	B	98
W	15,525	0.4	12.37%	Null	98
	133,515	3.1	100		

ROW Minus Proposed Roads					
Soil Symbol	Square Footage	Acres	%	Hydrologic Soil Group	Curve #
Bd	14,392	0.3	6.94%	A	32
DeC	84	0.0	0.04%	B	58
DeD	33,847	0.8	16.33%	B	58
RtE	23,393	0.5	11.26%	D	79
Se	37,556	0.9	18.11%	C	72
Sh	67,775	1.6	32.69%	C	72
Ss	18,667	0.4	9.00%	B	58
W	11,610	0.3	3.41%	Null	98
	195,715	4.8	100		
		7.8			

CN 80

Table 2. Microsoft Excel table showing calculation of the CN for proposed conditions.

Maps

SWPPP requirements include three maps of the construction site: a site topographic map, a soil map, and a vicinity map. These maps were traditionally created within AutoCAD. Through the modeling of the construction site in ArcMap, these maps are now able to be created with greater detail and a higher resolution.

The site topographic map is created in ArcMap by using the DRG for the construction site. The proposed road, existing road, and the construction ROW polygons are then added to the map. The proposed layout also displays outfalls, streams and wetlands. Figure 2a is an example of a site topographic map.



Figure 2a. Topographic map of construction site with outfalls.

The soil map for the SWPPP consists of the DRG for the construction site and the types of soils under the construction ROW. Figure 2b is an example of a soil map.

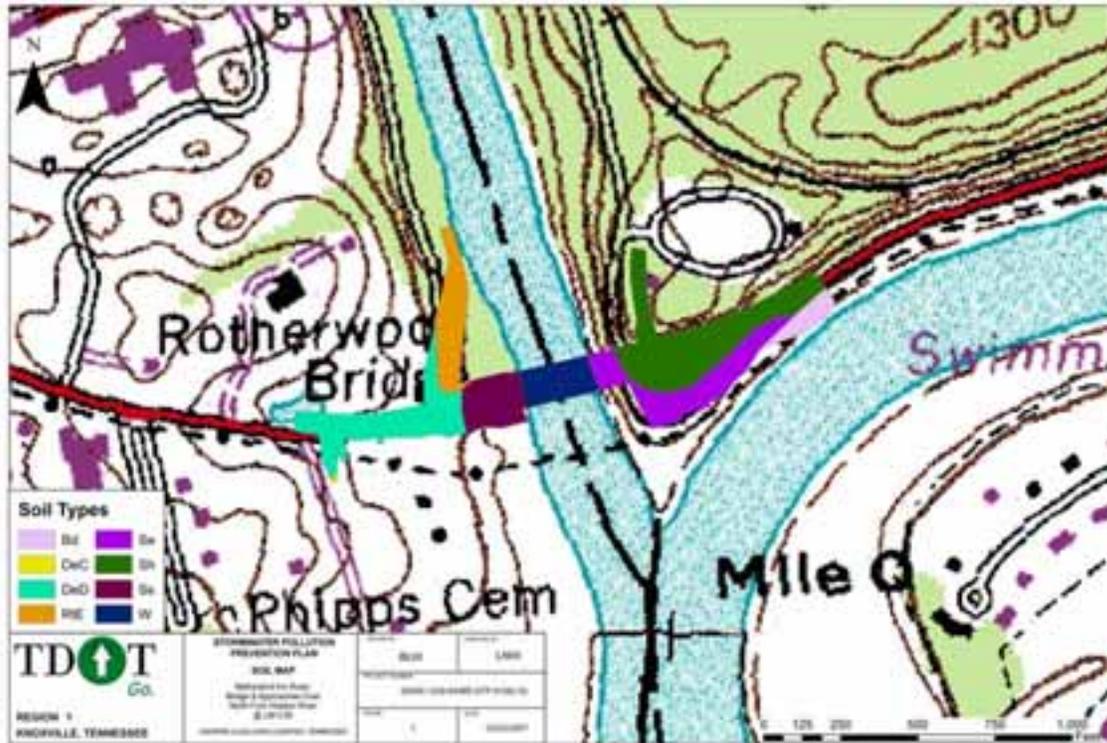


Figure 2b. Soil map of construction site.

The vicinity map is the last required map; it shows the location of the construction site in relation to major cities or landmarks. Figure 2c is an example of a vicinity map.

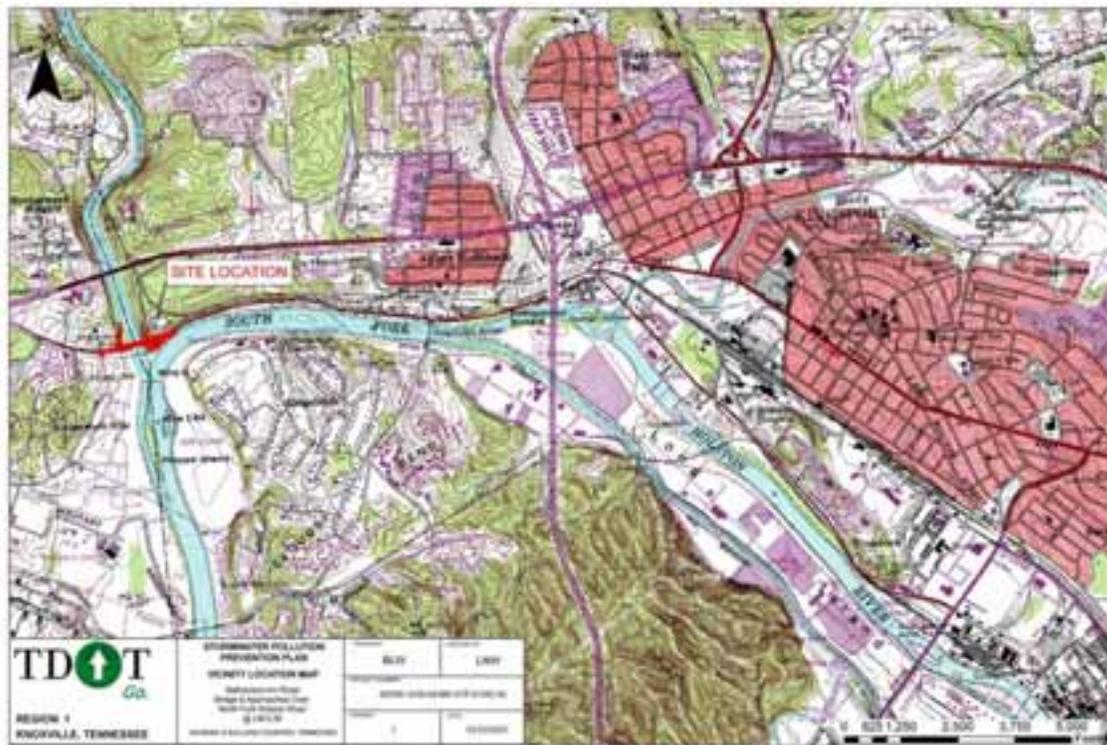


Figure 2c. Vicinity map of construction site.

Conclusion

Once all maps and calculations have been completed they are added to the SWPPP. Complete SWPPP's are then sent to the client for their use in applying for construction permits. With the availability of spatial data, this application of GIS is a much more efficient way to develop these models and calculations. This technique has greatly improved the SWPPP process and has given more accurate areas for construction plans and permits. However, further studies and implementation of new tools are still being explored to improve the accuracy of calculations, quality of maps, and to shorten the process time.

Acknowledgements

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