



Using AutoCAD® Civil 3D® for Construction Quantification on Transportation Projects

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CI2824

Class Description: are you using AutoCAD Civil 3D software on a transportation project and still struggling to solve construction earthwork problems? If you fall under either one of these categories, consider attending this class: (1) you have struggled with bridging the gap between the old cross-section methods in CAiCE™ Visual® Transportation software or AutoCAD® Land Desktop software and the new methods in Civil 3D, or (2) you are convinced that Civil 3D cannot handle the cross section solutions and therefore cannot replace the old software already mentioned. In this class, we will use review using Civil 3D as a complete construction quantification tool. We will cover strategizing for success, editing surfaces; editing sections; creating Autodesk® Quantity Takeoff criteria that will work for your situation, creating material quantities; adding earthwork exceptions; and reporting earthwork to Microsoft® Excel®.

Learning Objectives

At the end of this class, you will be able to:

- Set Civil 3D Construction projects up for success
- Get the data in
 - Replicate important data from 2D plans in Civil 3D
 - Translate data from other sources such as CAiCE
- Editing Section Surfaces in Civil 3D
- Replicate Section based edits using Surfaces
- Create Earthwork and what goes into this

About the Speaker

Rick has been an Applications Engineer with Autodesk since June of 2011. He is a Subject Matter Expert on Transportation and works throughout North America. Prior to joining Autodesk, Rick was a Methods Development Engineer at Wisconsin DOT. It was at WisDOT that he led teams that selected their last two Design software (CAiCE and Civil 3D). His last priority at WisDOT was to lead Methods Development's implementation of Civil 3D. Rick's WisDOT career spanned 24 years in many different areas, including: Design/Construction Project Engineer/Manager; Automation Development Supervisor; Engineering Operations; Construction Administration Coordination and Methods Development Engineer.

Rick is a registered Professional Engineer and a Licensed Residential Contractor in the State of Wisconsin. In his spare time, Rick loves to spend time with his wife MaryLou and three grown children (Charlee, Frankie and Erik).

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Introduction

As the joke goes...Bob walks into a DOT and asks a Planning Engineer 'what 2+2 equals?' The Planning Engineer responds 'somewhere around 10'. Bob continues his quest and asks a Design Engineer 'what 2+2 equals?' The Design Engineer responds '4.0000000'. Not satisfied, Bob continues on and asks the Construction Engineer 'what 2+2 equals?' The Construction Engineer responds 'what do you want it to be?' After spending a lot of time working in, or with Construction either at Wisconsin DOT or in my own personal Construction business, I can tell you this joke is not far from the truth. Construction just isn't as neat and clean as Design is. This presentation is an attempt to summarize some of the approaches we have been working on with various organizations throughout North America. I am sure that we could spend the rest of the week talking about Construction solutions if we wanted to get into the depths and details. Seeing as we are limited to 90 minutes I have picked out a few items that I think are very important for a successful experience using Civil 3D for Construction Quantification.

Set Civil 3D Construction projects up for success

I know we have all heard this before, but I have been reminder dozens of times how important it is to establish our project data standards for success. Civil 3D users that have successfully used Civil 3D to complete a project will attest to the importance of managing their data successfully. If they are not doing this, I will almost guarantee someone took the tile to set this up for them and train it into the workflow up front. Construction projects are no different than Design projects and should be treated as such. In fact Construction projects may be more demanding on data management because most Construction users are not using Civil 3D every day and need that ability to get back to what they were working on without by using their data management rules of thumb. The paragraphs below outline things to consider when setting up your Construction users.

Project folder structure:

Use a standard folder structure for your organization. It is probably good to allow flexibility under the main folders. Having the base structure set up is very important as projects get passed from one user to another or even passed to you for support purposes.

- Establish a project folder structure that makes sense to your organization.
- The top level folder or Project name is important. Some organizations use the unique Design or Construction project ID as the project name.
- Use this as a Project Template so users automatically grab the correct structure when setting up their Data shortcut projects

File naming and placement

Use rough file naming templates when implementing in the organization. For example:

- A surface drawing containing Original Ground surface - Original Ground – Surface.DWG
- Placed in the \Project ID\01-BaseData\05-Products folder (I like to have my folder structure appear in a logical order, so I add the numeric prefix

Object naming and management

Most Construction projects will probably use a combination of multiple folders, files, mixed in with data shortcuts and Xreferences to successfully manage the data. Names of the objects are very important to be able to identify what they are later. Some suggestions when naming the Civil 3D objects you create:

- Name the objects what they are. I was limited by my former paradigm, or CAiCE's naming conventions when putting together some Wisconsin DOT naming standards. It didn't take me very long to realize that a name like **STH25 Reference Line** is a lot better than **PRL1**. I suggest you consider as much as you move forward.
- You may want to add the type of object to the name. I know Civil 3D does a terrific job of putting the selected objects into their proper collection, but still

Drawing templates

Make sure your drawing template is somewhat complete before implementing for any users. If you are just starting out go out to sites for current users and download their standards. This will help immensely as you review and adjust standards rather than trying to start from scratch.

That is the bottom line? A little up front work goes a long way towards the success of any implementation. Set yourself up for this by implementing standards right away. Train your users on workflow that incorporates the standards and they normally will not know another way. Don't worry about getting everything right before implementation. Implementing any software is iterative and as long as you have a mechanism in place to handle change, you will be fine.

Get the data in

A unique thing about Construction projects is that we can receive data from pretty much any anywhere, including plans. This section highlights different methods of getting the data into Civil 3D.

Replicate important data from 2D plans in Civil 3D

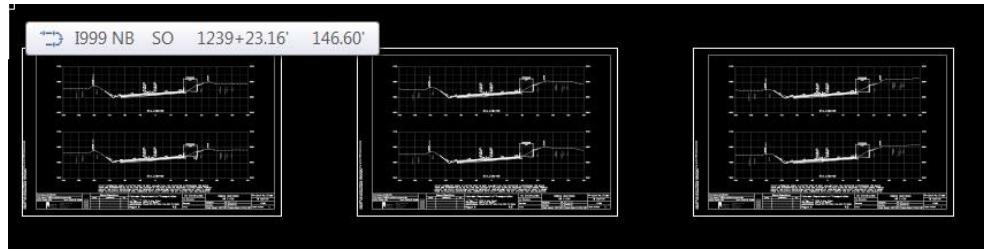
Many Civil 3D users are not starting out from a completed Civil 3D Design. In fact, many of the people I have talked with over the past 18 months do not even have electronic data. Thankfully Wes Newman and Jerry Bartels who have listened to these users and developed solutions to bring this data into Civil 3D. Wes and Jerry have created a couple of tools for your use:

- A workspace created specifically for Construction needs
- The Xsect2Surf tool for us to digitize sections that are scanned in or attached as a reference
- Both of these (and more) are downloadable from the [Talking Transportation blog](#) – here is the link <http://autodesk.typepad.com/transportation/>

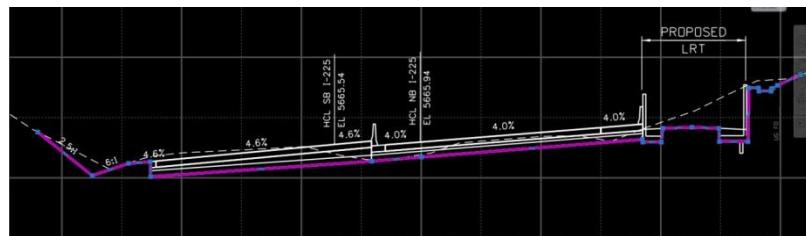
Example 1: Creating Surfaces from Cross Sections summary

- Please find the Example summary in the **CI2824 - AU 2012 - Example Summary.docx** document
- Example Data is found in the **CI2824 - AU 2012 - Examples.zip** file

The Xsect2Surf tool uses the scanned image or .pdf of the plan Cross Sections to create Section Surfaces. Our example uses cross sections from .pdf. The sections are Xreferenced into the working drawing and placed using the proper horizontal scale (the Xsect2Surf tool applies the vertical scale is applied). Polylines are digitized that trace the sections (Raster Design can be used if a scanned image is inserted that represents the sections). Notes: 1) vertical links should be offset slightly as surfaces cannot have vertical faces; 2) when using a .pdf underlay we can turn on Enable Snap

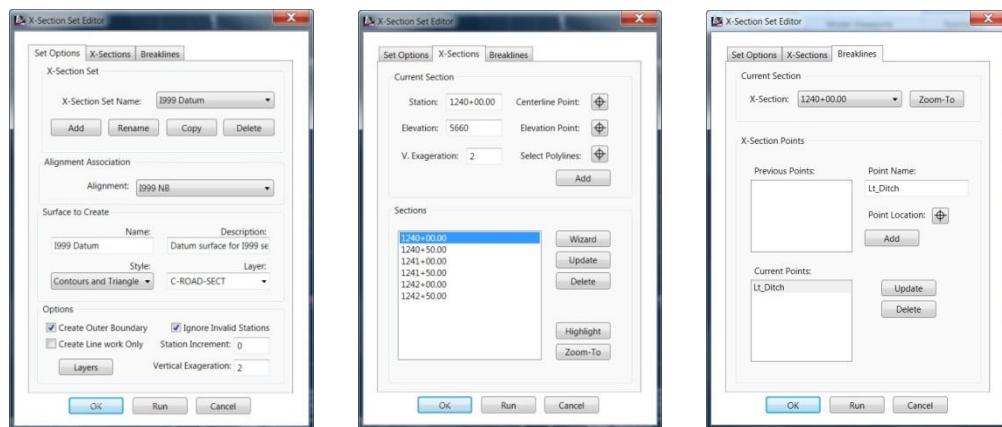


Xreferenced Cross Sections

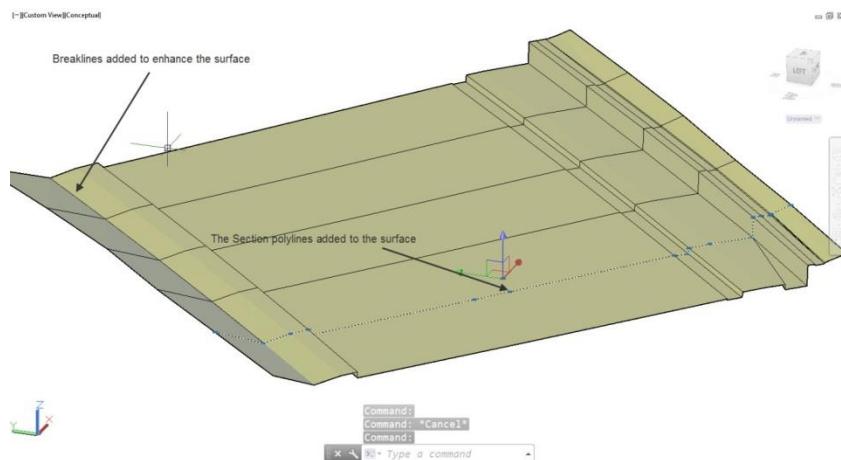


Digitized Polylines

The Xsect2Surf tool is used to create the X-Section Set with respect to a selected alignment. Options (**Set Options** tab) are established for the X-Section set. Critical options include: X-Section Set Name; Alignment; Surface name (optional); Surface style and layer; and vertical exaggeration. Notes: vertical exaggeration can be overridden in the individual sections; the Station increment is a handy feature that allows us to step down the alignment. The computed station value can be overridden by typing in the station on the command line. X-Sections (**X-Section** Tab) are established using Station value, Centerline point, Elevation point, Vertical exaggeration and selecting this surface polyline. Repeat the process for all stations for a given surface. Breaklines (**Breaklines** tab) can also be stored to enhance the Section Surface. Go to the selected station, insert a breakline name and digitize the point that represents that breakline. Repeat the process for other stations that should include this breakline. Notes: Breakline names are stored in the X-Section set, we do not have to retype all of this information every time we want to store a breakline point with the same name; breakline points with the same name are connected longitudinally along the alignment, add the side to the name when you store common breaklines such as ETW, Ditch points, etc.



The Xsect2Surf tool creates the Section and the Breakline Polyline and inserts them into the drawing. The Section and Breakline polylines are added to the surface (if one is to be created) as surface breaklines. The new surface Breakline collection includes a list of the Polylines used to create the surface.



Good things to know when creating the Section Surfaces using the Xsect2Surf tool:

- Use Osnaps for everything from storing surface polylines to digitizing the X-Section centerline and elevation point!
- Store multiple Xsection sets and access whenever you open the Xsect2Surf
 - Go to Set Options tab
 - Select the desired X-Section set from the Xsection Set name
- You can edit the data for a X-Section set
- Be careful to scale the Xref correctly. This is pertinent to the horizontal scale, vertical scale is handled by the Xsect2Surf tool
- No vertical links on the digitized sections, offset the links slightly
- Be careful when entering the vertical exaggeration for the section
- Play around with the tool some, you'll probably find some things we haven't touched on

Translating data from other sources such as CAiCE

A large part of our efforts to ready ourselves for Construction quantification will involve getting data in from multiple sources. Civil 3D readily reads Design data from CAiCE or LDT. LandXML is probably your best when translating data from other Design sources.

Example 2: Importing CAiCE data summary

Note: the CAiCE extensions are not available for Civil 3D 2013 at this time. This example uses the CAiCE translators for Civil 3D 2012.

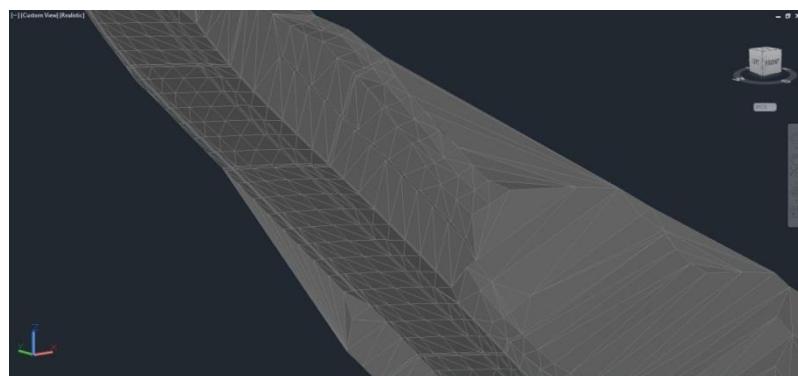
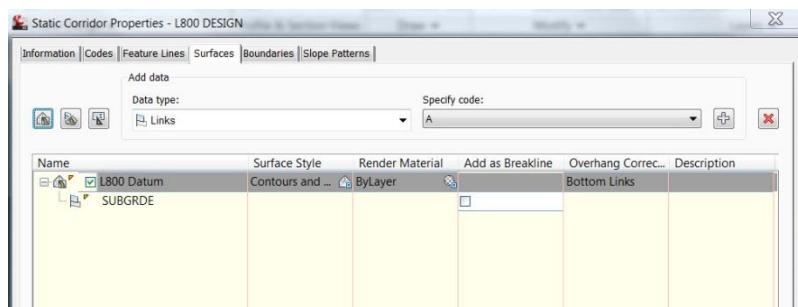
- Please find the Example summary in the **CI2824 - AU 2012 - Example Summary.docx** document
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The CAiCE translators are available for a variety of CAiCE formats. Example 2 specifically steps through the process of importing the **L800** alignment and the **L800 Design.EAR** cross section file.

Once the reference alignment has been imported, import the cross sections. Please note: CAiCE's cross sections have no peer object in Civil 3D. Therefore, when the CAiCE Cross Sections are imported the following are created:

- Sample Lines (optional – although helpful)
- Section Views (optional – not as helpful)
- Static Corridor
 - Does not have Assemblies/Regions
 - Has one Baseline
 - Has Points and Links
 - Used to create Corridor Surfaces for our use

Once the cross sections have been imported the Static Corridor (**L800 Design** – same as the CAiCE EAR file) is used to create the Corridor surface.



Good things to know

- Alignments (i.e., **L800**) can be added to our project data shortcuts and shared throughout the project. This is very handy when we have to create sections.

- Surfaces (i.e., **L800 Datum**) can be added to our project data shortcuts and shared throughout the project. This is very handy when we are working directly from surfaces or want to create sample lines and sections
- The Drawing file that contains the Surface (**L800 Datum**) can be Xreferenced into another drawing and the Surfaces used on sample lines and sections (for computational purposes). We cannot use the surface for surface operations. For example: pasting the **L800 Datum** surface to another surface.
- These surfaces are not as robust as we want for a total surface solution. That given, we are creating volumes using average endarea on sample lines. As long as the sample lines used for edits and volume calculations land on the actual sections from the original, our computations are no different than what was done using cross section based systems. Remember, we would have to cut new sections if we deviated from the original alignment or stationing. Using this method our stationing is set by Design and we work from that.

Edit Section Surfaces in Civil 3D

Anyone who has done Construction Quantification on a real project understands that the surfaces we use for actual computations are a compilation of Design data, Construction data and lots of edits to make things work. Many factors come into play, such as:

- Design surfaces not matching Construction conditions
- Design soundings/borings are not precise representations of the substrata
- Construction surfaces can be incomplete and need to be combined with Design surfaces
- Construction finals are often left “hanging” so project personnel can complete closure or trim/exclude the excess material
 - Civil 3D automatically closes Materials on these hanging surfaces. This is TERRIFIC for Design, but can cause headaches in Construction

What is the bottom line? Computing materials for Construction is just not as neat and tidy as computing materials for Design. Civil 3D is a terrific surface based tool, we certainly can do most, if not all of the edits we need using surface solutions. The problem is when get the data from Cross Section Design tools. This covers most of the Design data we work with in Construction these days and probably into the near future.

Note – this section removed until approval is granted to demonstrate.

Replicate Section based edits using Surfaces

Example 3 focused on Editing Section Surfaces using the Section Surface Editor. We will now explore doing edits directly to surfaces, then preparing for Earthwork.

Example 4: using the Section Surface Editor

- Please find the Example summary in the **CI2824 - AU 2012 - Example Summary.docx** document
- Example Data is found in the **CI2824 - AU 2012 - Examples.zip** file

Follow along with the Example 4 in the **CI2824 - AU 2012 - Example Summary.docx** file.

Our Section Edits include several types of edits. Although it may seem a bit unnatural to some, we can do these edits using Surfaces and Gradings. Please note: the biggest reason this would seem unnatural to some of us is because we are so used to doing edits in a Cross Section type environment. Examples of Edits and how they can be accomplished are listed below

- Extend
 - Section Surfaces
 - AutoCAD commands can be used on the individual station polyline
 - Grip Edits to extend
 - Normal Surfaces
 - Create a Feature Line along the end points of the surface to be projected in the area to be extended.
 - Grading to extend to the target surface
 - Paste the Grading surface into the surface to be projected
- Trim
 - Section Surfaces
 - AutoCAD commands can be used on the individual station polyline
 - Grip Edits to extend
 - Normal Surfaces
 - Use Minimum Distance between Surfaces – Surface to Trim/Trimming Surface
 - This draws Polylines that represent the Zero distance between Surfaces
 - Create a Polygon from the Original Surface Boundary and the Zero Difference lines where Surface is to be trimmed
 - Add the Boundary to the Surface to be Trimmed
- Combine
 - Create a new Surface
 - Paste Passive Surface
 - Paste Dominant Surface
- Copy

Good things to know

- We use Sample Line Group/Sample Lines to create our Quantities, we need to make sure the Surfaces have strict outer Boundaries. Extraneous Triangles can cause confusion when looking at a Surface in Section Views and trying to identify areas where Extends are necessary
- Be careful when editing the Section Surface breaklines. Make sure extends or trims are on the same plane as the section

- Section Surfaces are fine to use as long as we maintain the correct stationing when doing our computations. In other words, do not create Sample Lines that do not match the Section Surface stations. This is no different than working with Cross Sections

Create Earthwork and what goes into this

Once we have completed our Section or Surface editing, we are ready to create the Earthwork. The following remarks assume we have the DWG file ready for Earthwork. Basically, it assumes the file contains:

- Alignment with Sample Line Group
- Surfaces we will use to compute Earthwork
- Section Views

In the first section we talked about the need to make sure that our Project Files and Data are managed in an organized fashion. Obviously with the Examples used here, I did not heed to my own advice. In a real project situation it will not be as easy as a one Drawing file project. So, in a normal situation we may run into issues trying to share and Alignment Sample Line Groups across multiple DWG files. I have used the following to help with this:

- Create a Drawing
- Data Reference the Alignment
- Create the Sample Lines
- Explode the Sample Lines

Example 5 takes us through automatically creating the QTO criteria and matching the generic materials to the actual materials.

Example 5: Creating the Quantity Takeoff Criteria

Example 4 took us through some example Surface Edits and cleaned up the DWG file for further work. We will now use some interactive capabilities to create QTO Criteria for our Materials Computations. The **Create Material Criteria start - Civil 3D 2012.dwg** file found in the **Example 5** folder is a perfect start for our work as it contains the **L100A1** Alignment, Sample Line Group, and Section Views. This drawing file contains the following surfaces:

There are two schools of thought when it comes to creating Quantity Takeoff criteria:

QTO Criteria are provided as a part of the organizational DWT

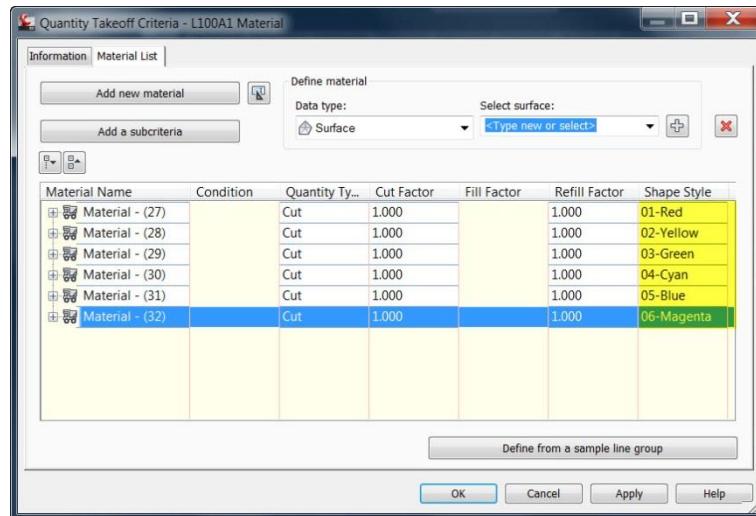
- Standards are very important - users follow standard naming for the surfaces they create
- If users have followed naming closely enough they can match surface names when applying the QTO Criteria to a Sample Line Group
- QTO Criteria can be large and complex
- This usually ensures that the QTO Criteria will work within a given organization
- A small number of 'special' QTO Criteria are created on demand by local support

Users are trained to generate QTO Criteria themselves

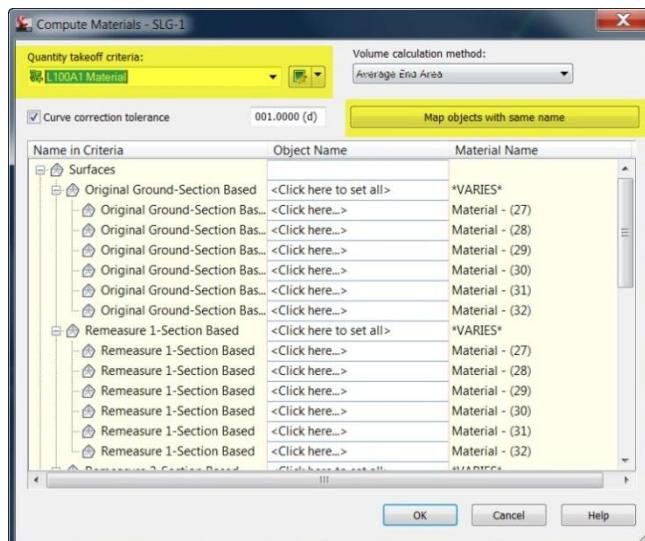
- Users can name surfaces whatever they want
- Create the QTO Criteria on the fly

- Greater chance for error
- Users need to be well versed on the in's and out's to creating the QTO Criteria
- These QTO Criteria vary between simple and complex

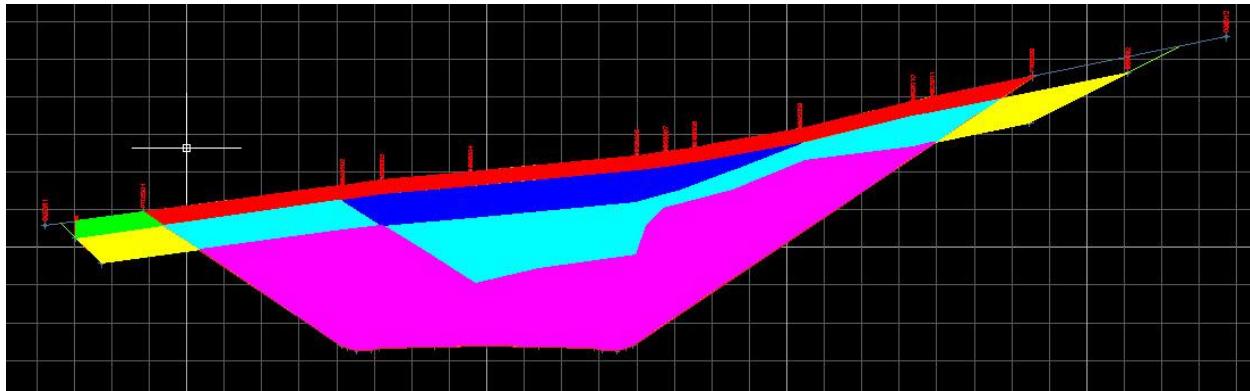
This example assumes the Alignment, Sample Line Group, Surfaces and Section Views are already created. We use the **Define from a Sample Line Group** when we establish the **QTO Criteria**. To do this we apply colors to the material shapes as shown below.



We then import this QTO Criteria to the **Sample Line Group**, and **Map Objects with same name**. This maps the surfaces to the correct QTO Criteria.



The Section Views will be updated with the colors as we have defined. We can identify the Materials from these colors, update the QTO Criteria and reload to the Sample Line Group.



- Red: Stripping
- Yellow: NA Omit
- Green: NA Omit
- Cyan: Type B
- Blue: Type C
- Magenta: Type A

Example 6: Computing Material Volume Report

Example 5 took us through creating the QTO Criteria and applying to the **L100A1** Sample Line Group. Example 6 creates a Material Report for this Sample Line Group, save to a text file and open the text file in Excel using the **Create Material Report start - Civil 3D 2012.dwg** file found in the **Example 6** folder.

Most of our heavy lifting has been completed by the time we create the Material Volume Report. **Analyze Tab→Volumes and Materials Panel→Volume Report** allows us to Report Quantities. The Material Quantification process works on a Sample Line Group and is doing a couple of things:

- Creates the **C:\Users\larsonri\AppData\Local\Temp\QuantityReportTempXML.xml** file
 - This is a detailed XML view of all of the materials that go with the selected Sample Line Group
- Uses an XSL (style sheet) to report the XML file
 - This is called an XML transformation...basically making it something that is readable
- Opens up the resulting report in a web browser
 - These reports can be saved to a text file and brought into Excel for further work

The XSL files that come with Civil 3D are very generic and a new one is provided in Example 6 to report material areas by station, separated by a comma. This Example makes easy work of getting the data into Excel for further detailed work.

Notice that I do mention using Excel for material quantification. Excel provides excellent tools for creating the computations, reports and even Plan documents that you want. An example of this comes from Wisconsin DOT, their workflow for Earthwork involves

- Creating the **C:\Users\larsonri\AppData\Local\Temp\QuantityReportTempXML.xml** file
- Saving that file for later use

- Using a macro that reports Selected Material Areas to Excel for detailed and summary Earthwork Computations
- WisDOT applies their Earthwork exceptions in Excel as well, these include
 - Run in/out for a Material
 - Start and End a Material
 - Gaps

Good things to know

- Style Sheets can be edited to fit your needs
- Check out State downloads to see what they are doing for Material Quantification.
 - Florida DOT does extensive QTO and has a downloadable State kit for Civil 3D 2012
 - Massachusetts DOT has sample downloads
 - WisDOT has all of their content downloadable
- Example - WisDOT uses a Macro to write Earthwork to Excel and use this for their balances, reports and Plan Documents
 - Macro uses Areas only (as we have shown above)
 - Volumes calculated within Spreadsheet
 - Summary sheet is per WisDOT standards
 - Works with WisDOT QTO Criteria

Wrap up

The learning objectives for this class included:

- Set Civil 3D Construction projects up for success
- Get the data in
 - Replicate important data from 2D plans in Civil 3D
 - Translate data from other sources such as CAiCE
- Editing Section Surfaces in Civil 3D
- Replicate Section based edits using Surfaces
- Create Earthwork and what goes into this

All of these items were discussed in some detail and are covered in greater detail in the associated **CI2824 - AU 2012 - Example Summary.docx** and data. Note there was certain detail stripped out of the document due to late approvals for demonstration. We will seek approval to demonstrate these items at Autodesk University.