Managing 1,000,000 Tons of Soil for the Green Line Extension Project

(Using 3D time-enabled GIS)

Boston, Mass.

Cris Perez

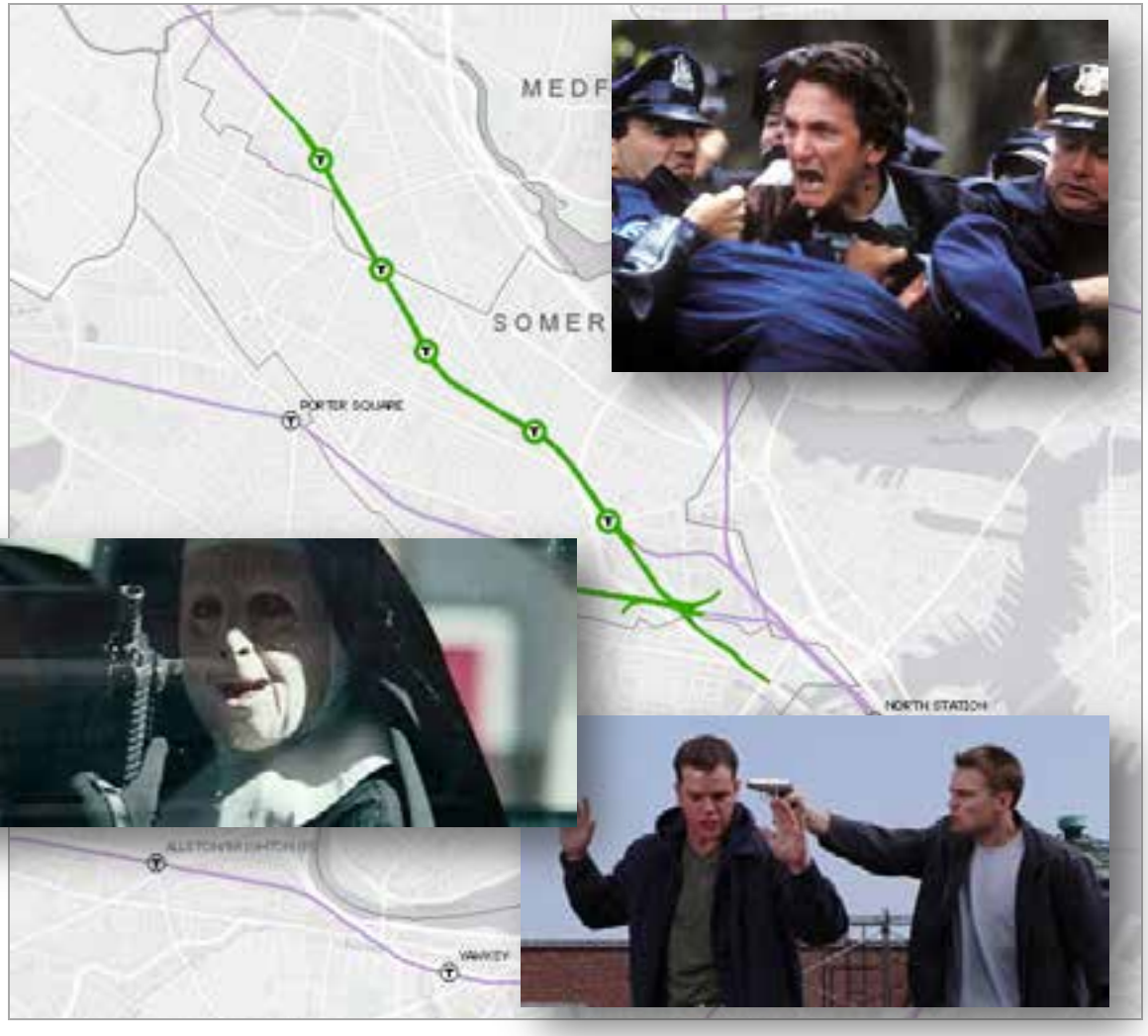
Berkley Myers

July 2014

KLEINFELDER
Bright People. Right Solutions.

The Green Line Extension

- MassDOT + MBTA
- Green Line Extension (Cambridge to Medford)
  - 5 miles of new track
  - 7 New Stations
  - Vehicle Maintenance Facility



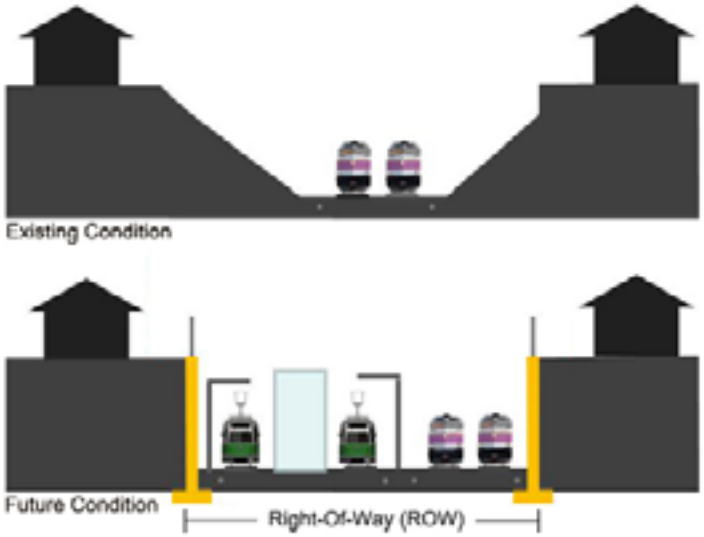
Kleinfelder's Role

- Part of the HDR/Gilbane JV for Program Management & Construction Management
- Environmental Design and Construction Lead
- Site Characterization
- Management of all excavated soil

Environmental Soil Mgt. Requirements

Requirements:

- Quantify soil excavation
- Classify soil contamination
- Update estimates with new data
- 2-feet intervals by depth
- Conservative “interpolation” methodology
- Soil Tracking - “Cradle to Grave”
- Easy QAQC
- Share data with team
- Use iPads and mobile devices!

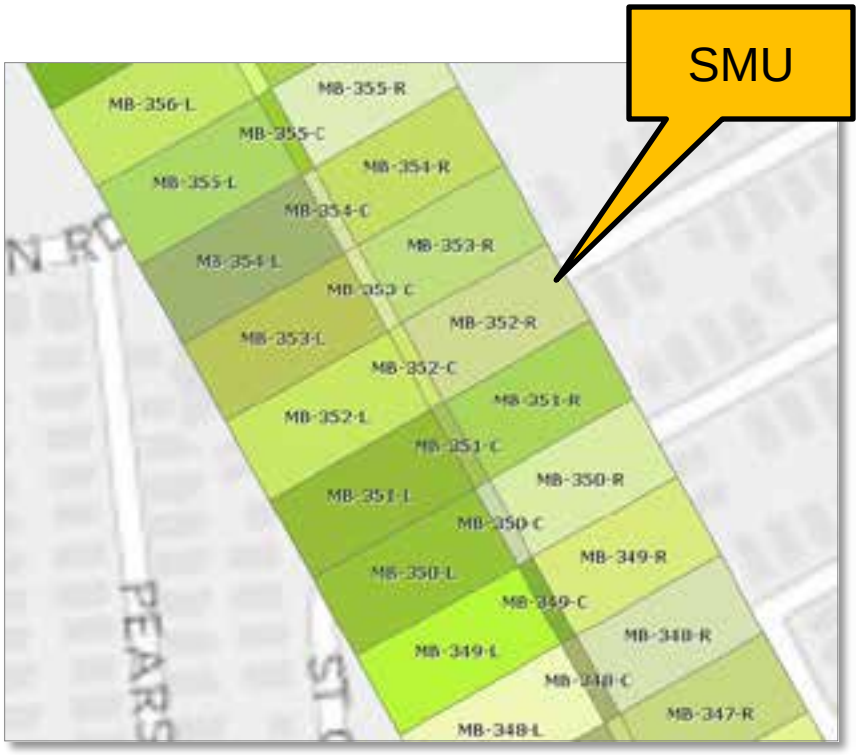


Environmental Soil Mgt. Requirements

Considerations:

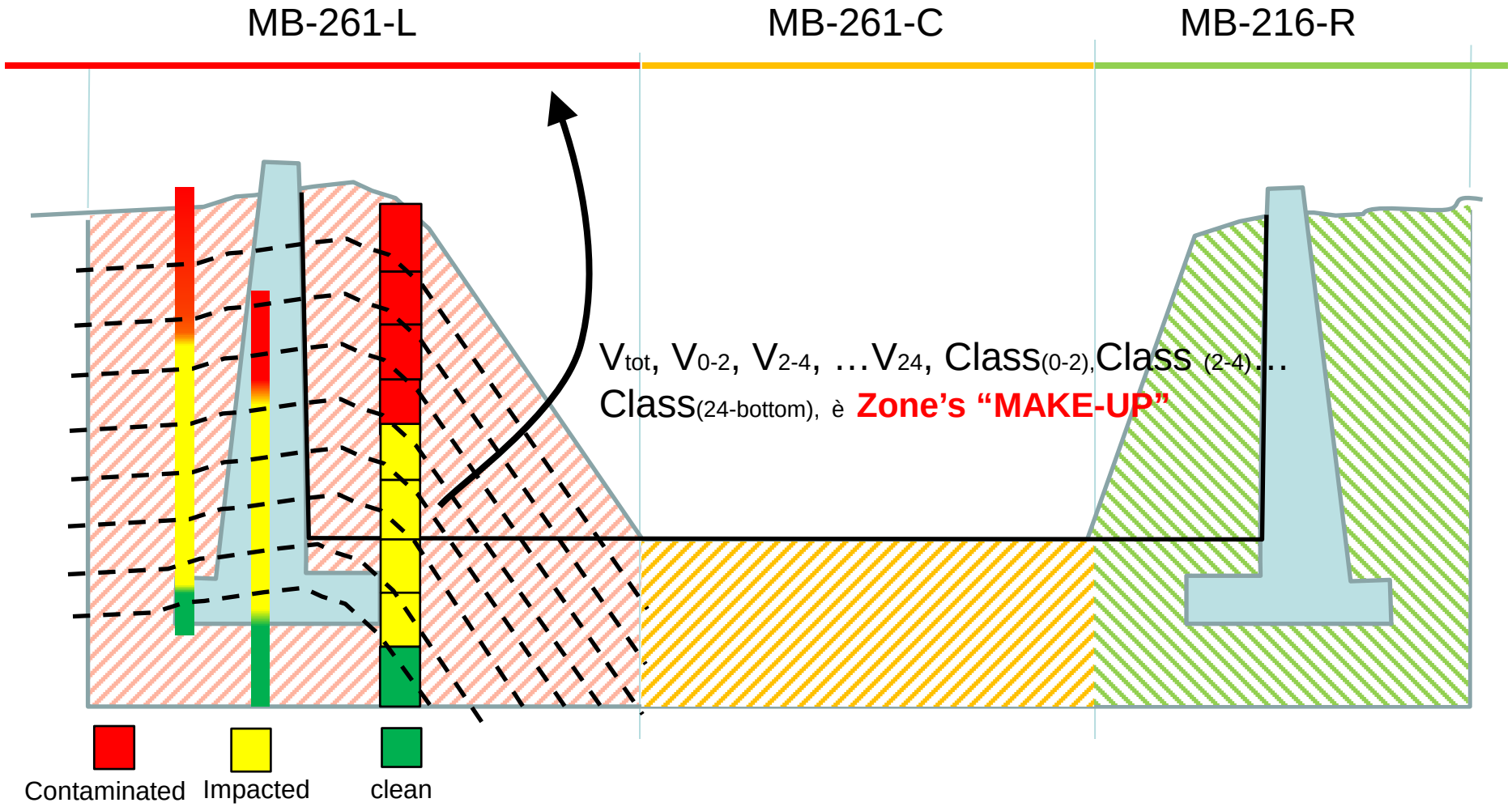
- Design still in progress
- Continuous soil data collection program
- State and Federal regulations subject to change
  - Soil reuse and disposal options

GIS Plan

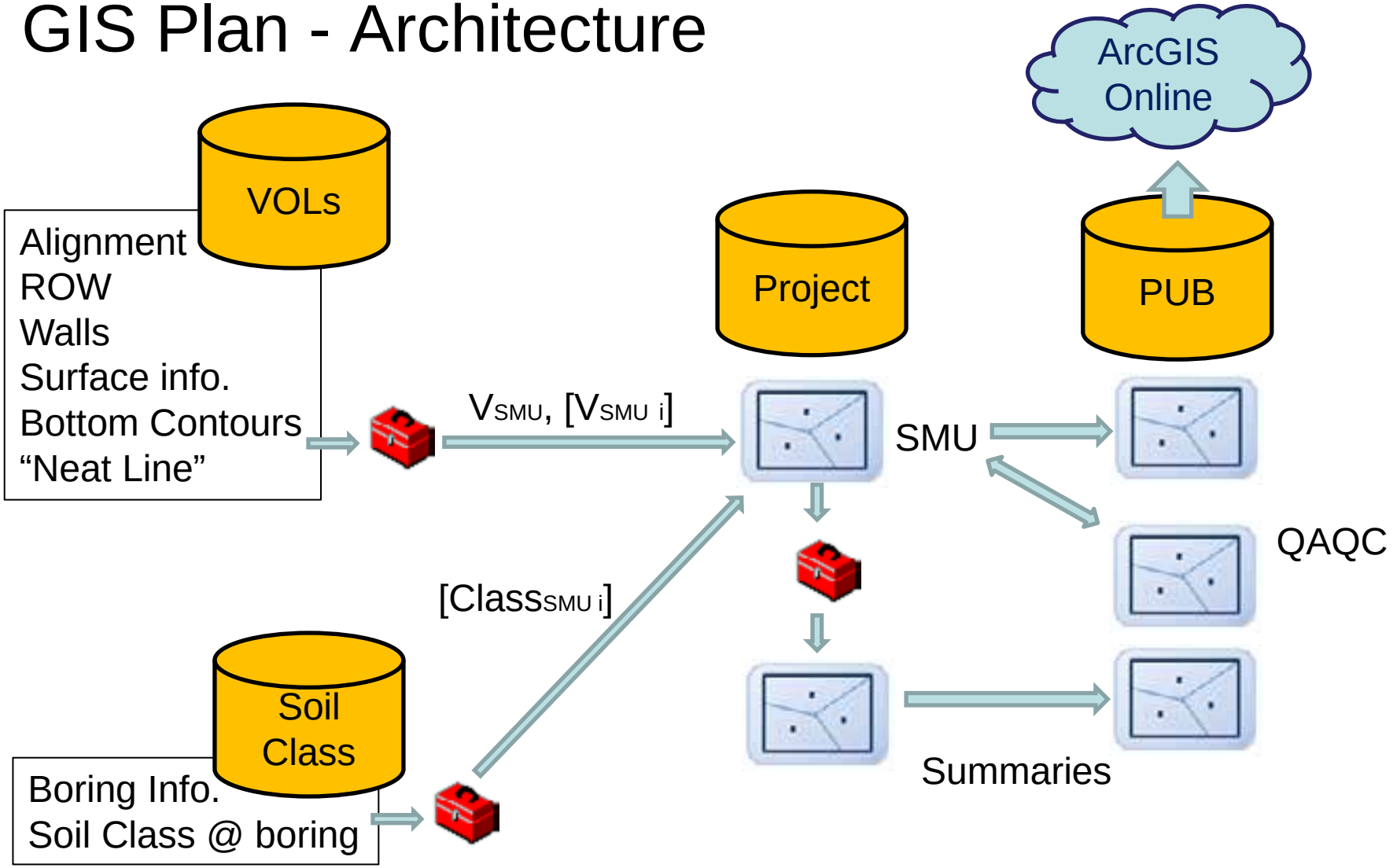


BRANCH	STATION	POSITION	GROUP	ZONEID
MB	251	L	MB-L	MB-L-251

GIS Plan - Conceptual



GIS Plan - Architecture



Total Volume Calculations

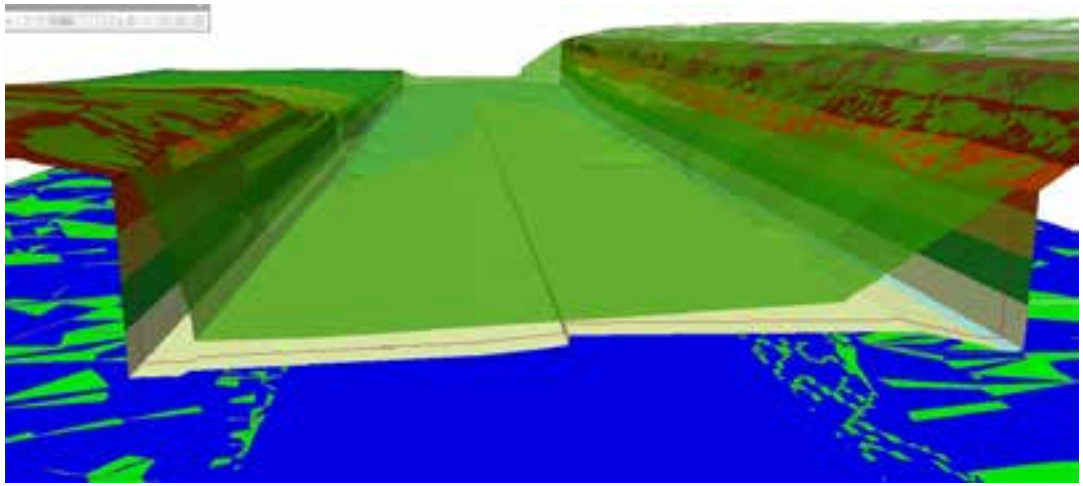
Input Data

- LiDAR for existing conditions

- CAD data for track alignment (alignment stations)

- Civil 3D custom-built sub-assemblies (walls)

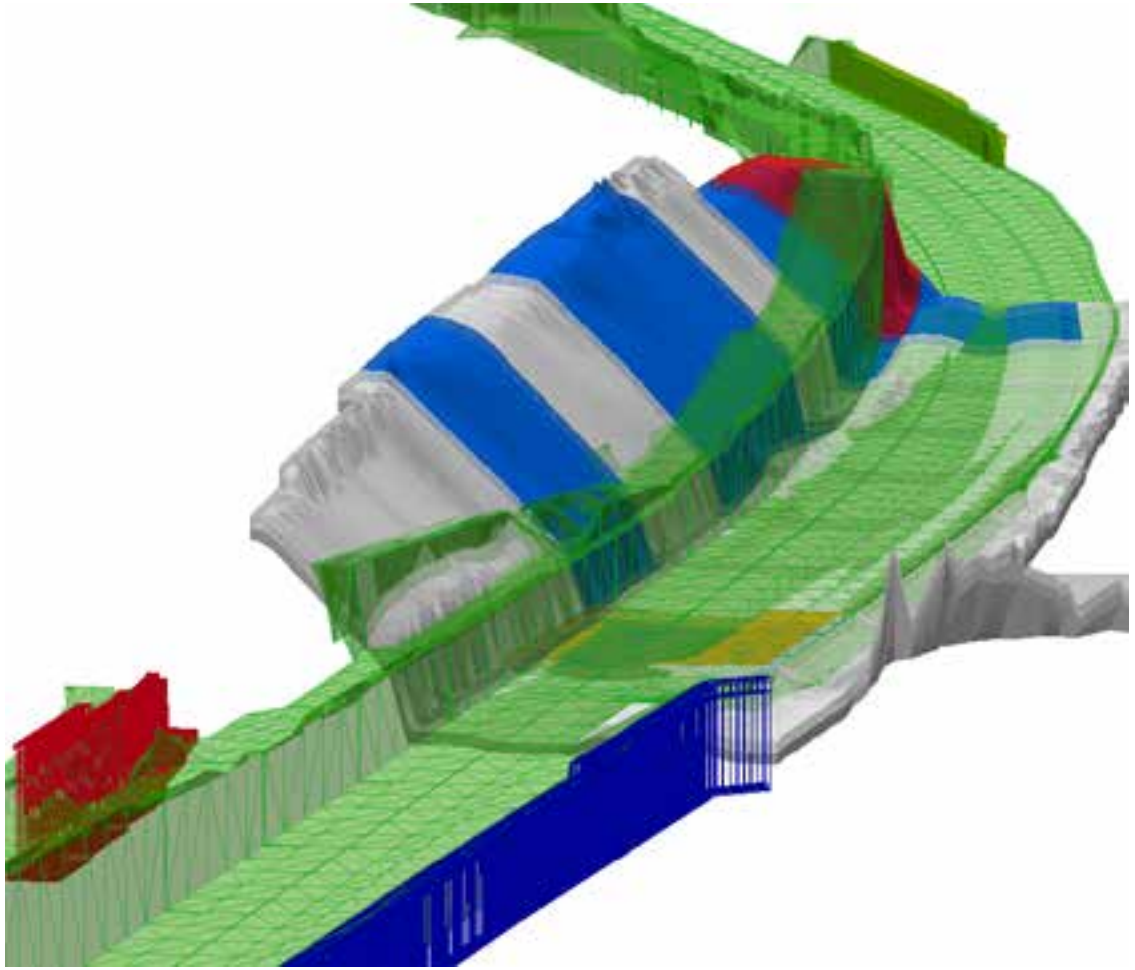
- Bentley “in Roads” bottom contours



Total Volume Calculations

Pilot

- Tin:
  - Extrude between
  - Surface Difference
- Vector:
  - Multipatch-features
  - Polygon Volume
- Raster
  - Raster Math
  - Cut-fill
- CAD (comparison)



Total Volume Calculations – Pilot results

- Tin Method:
  - Difficult to work with and replicate workflow effectively
  - Rough edges induced gaps
  - Inefficient processing

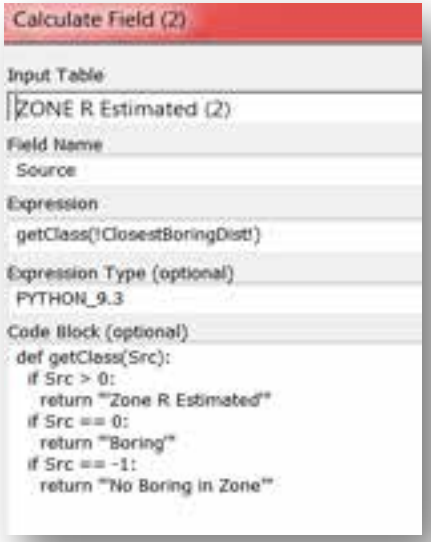
Method	Vol (cu yd)
CAD - Tin math	10,000
Raster Analysis (3 ft res)	17,000
Raster Analysis (1 ft res)	10,849
GIS - Tin math	10,800

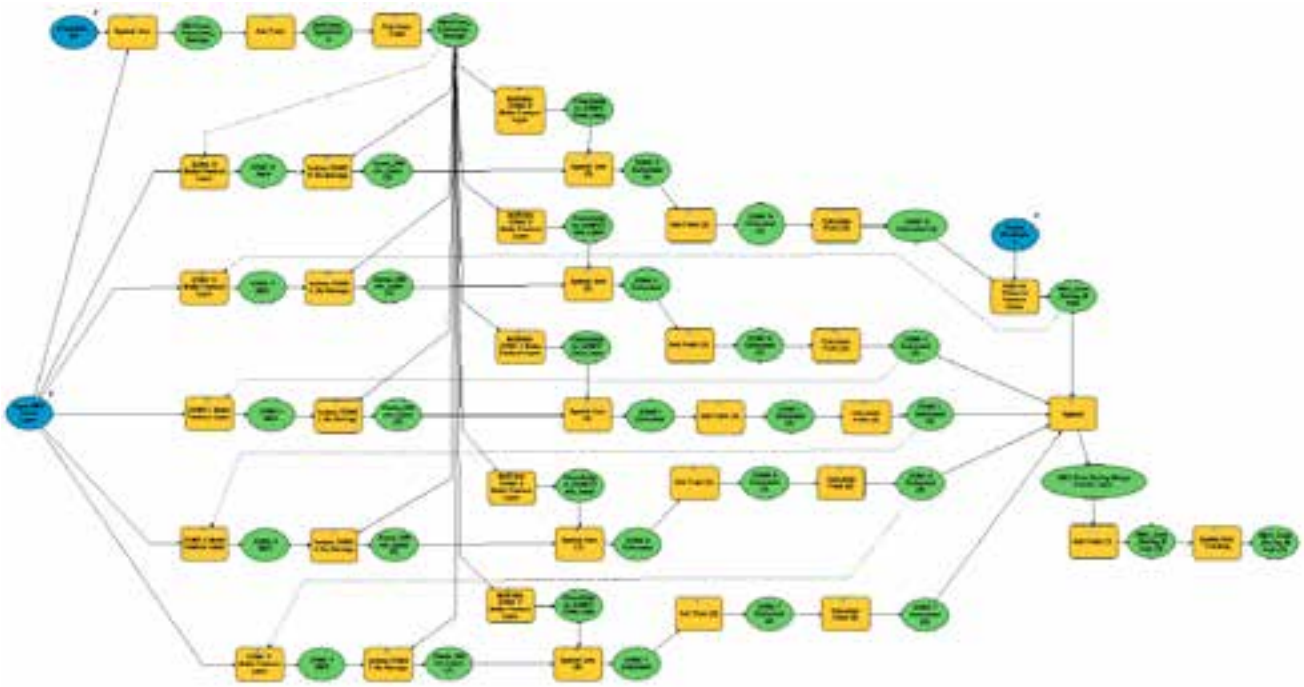
- Vector Method:
  - Too many additional processing steps
  - Conversion left open Multipatch features

- Raster
  - Workflow integrates multiple concurrent calculations with same Cut Fill tool calculation
  - Inherent error
  - Efficient and routine processing

Soil Classification Process

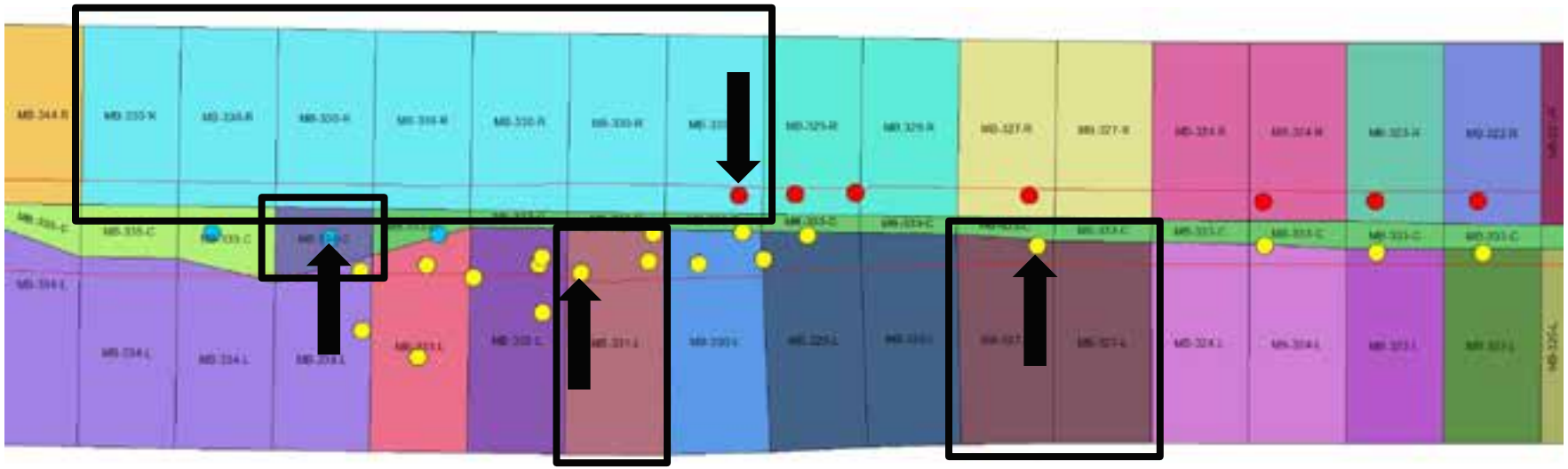
- 60 analytes è Data stored in EQuIS
- GIS/Env. Professional è creates “classified” FC
- Uploads soil class FC to eGIS
- Calculate “SMU make up” for the zones that have borings (.mdb)
- Import back to eGIS
- Geoprocessing (Model Builder) to assign make-up of closest SMU to SMUs that don’t have data of the same GROUP.





Filling-in the Gaps

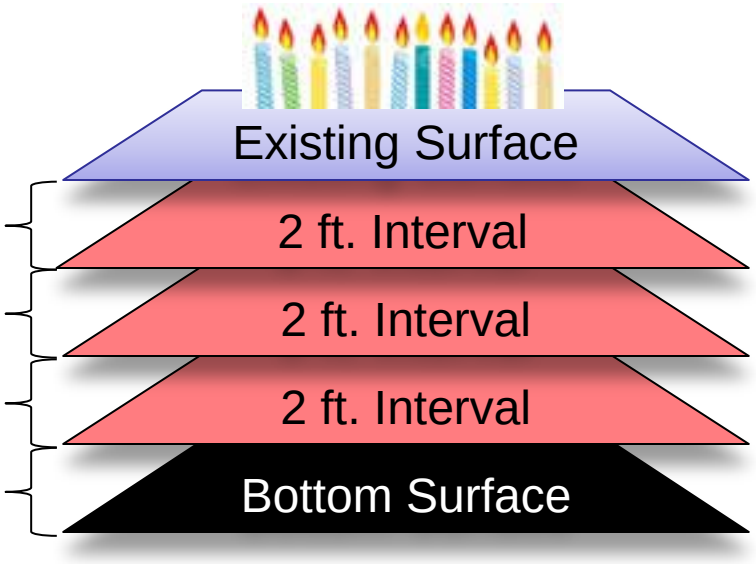
- Now, all the zones that have a boring have a make-up
- Zones with no boring get the make-up from the closest zone that has one
- Need to do this automatically over time, and overwrite as data is QAQC'd.



- With this step: Total volume per zone, and soil class by depth, every 2 ft.

Making “The Cake”

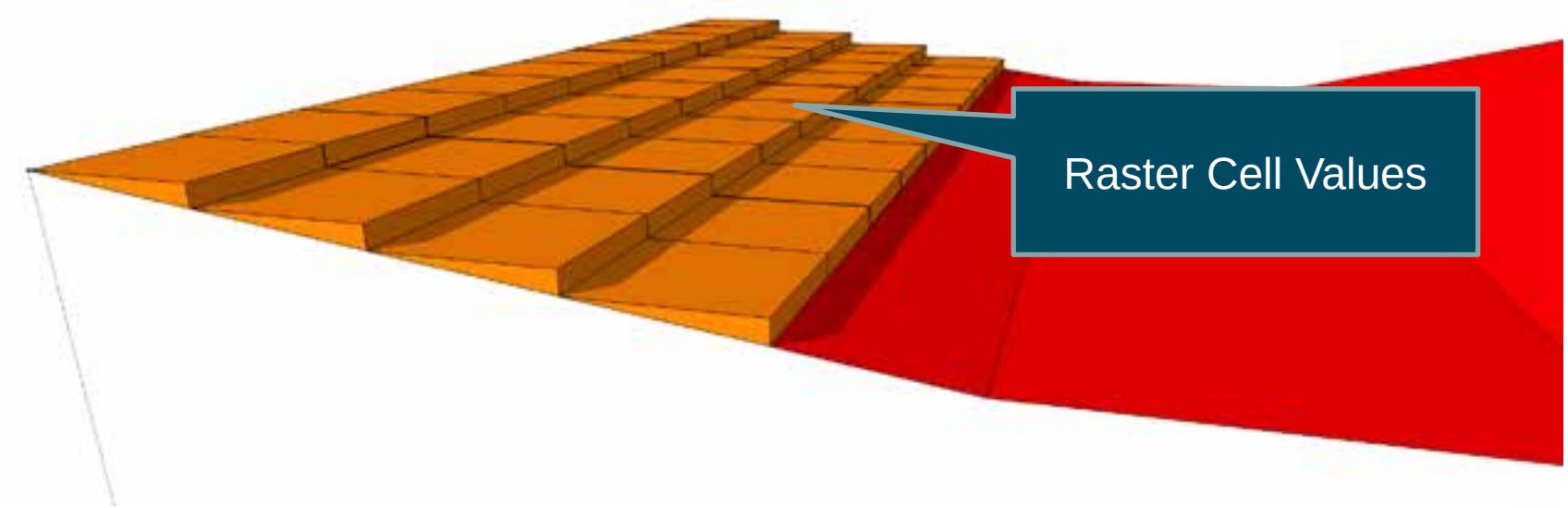
- Need to calculate Volumes per at 2 feet intervals per zone, and summarize by soil classification through the corridor (and by project area – future request)
- Slicing the 3D model in 2-ft intervals and assigning the soil classifications



$$\text{Interval Vol.} = (\text{Elev.}^{(\text{Upper})} - \text{Elev.}^{(\text{Lower})}) \times \text{Cell Size}$$

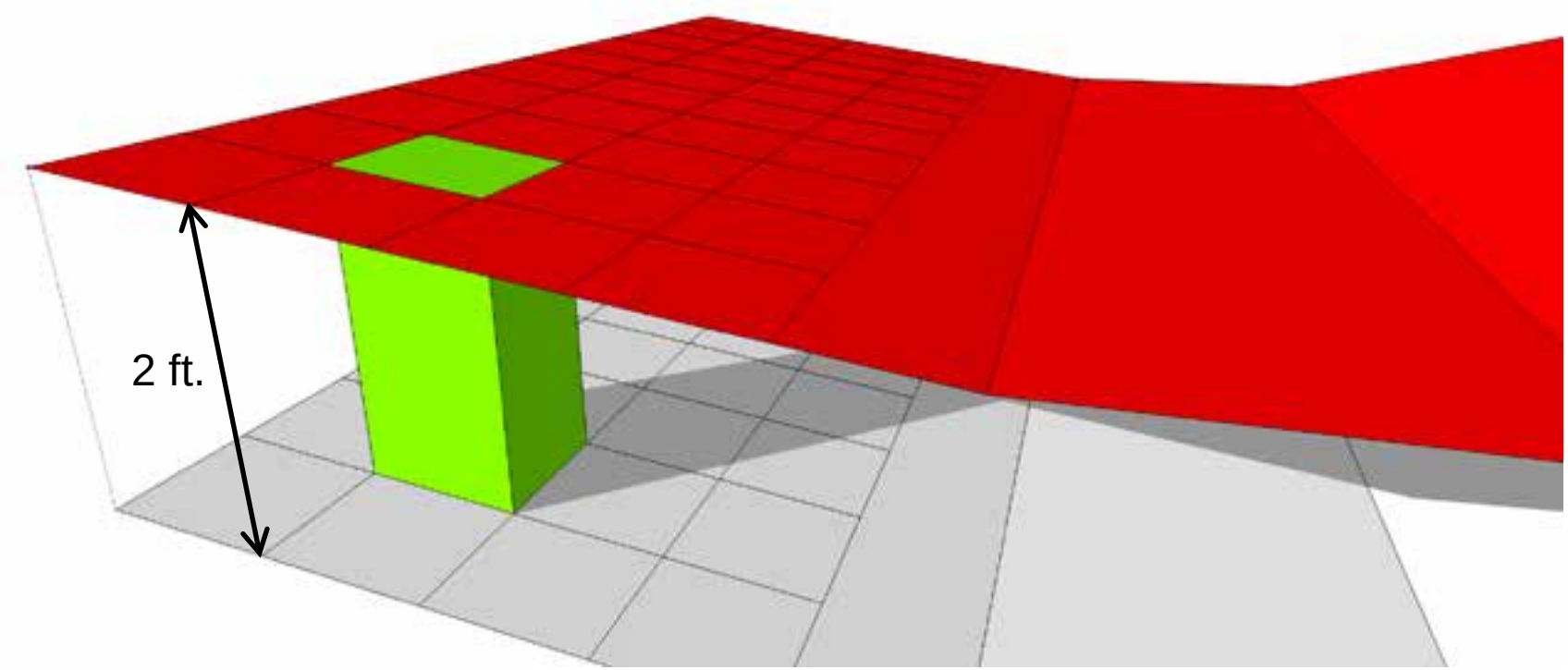
$$\text{SMU Vol.} = \sum \text{“Cut” Cell Vol.}$$

What raster values really represent in 3D.



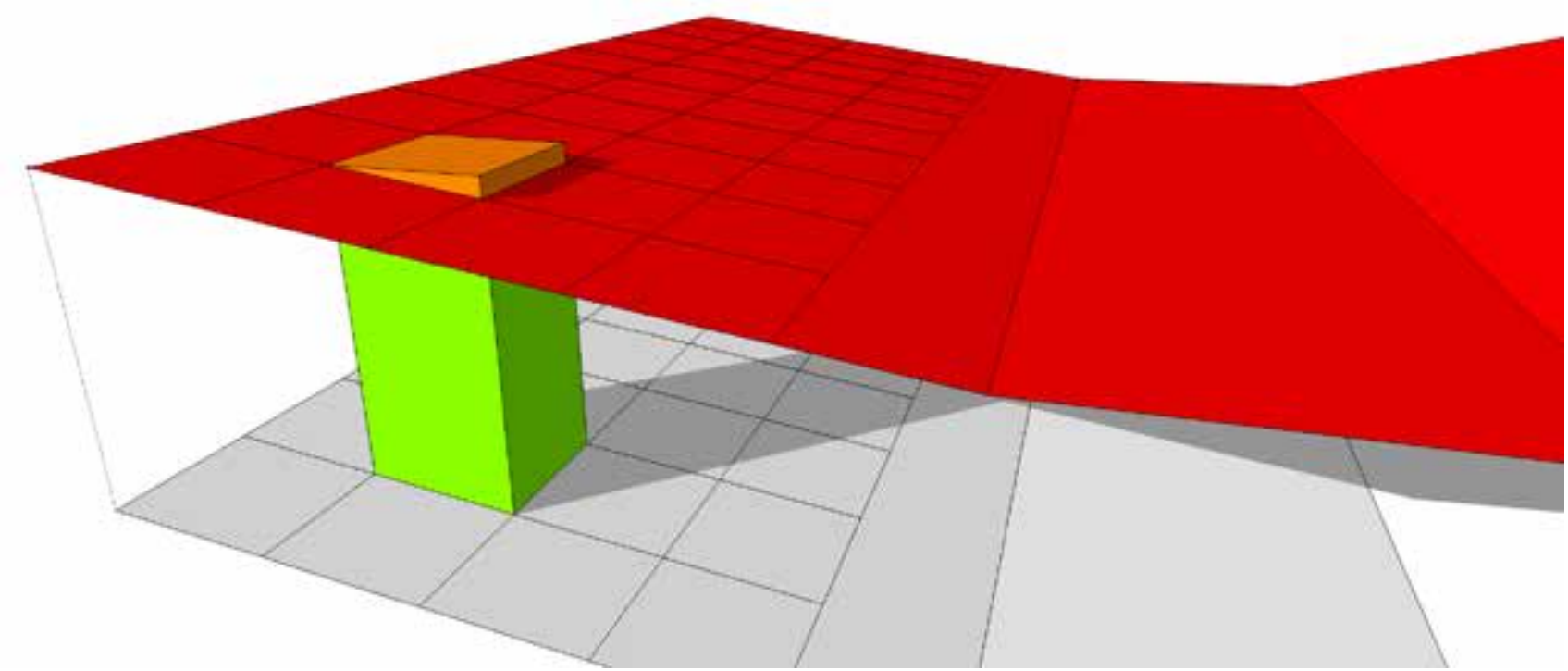
- Each raster cell contains one value
  - Values can be anything
  - Commonly: Elevation, Concentration, Color

Calculate Interval Surfaces



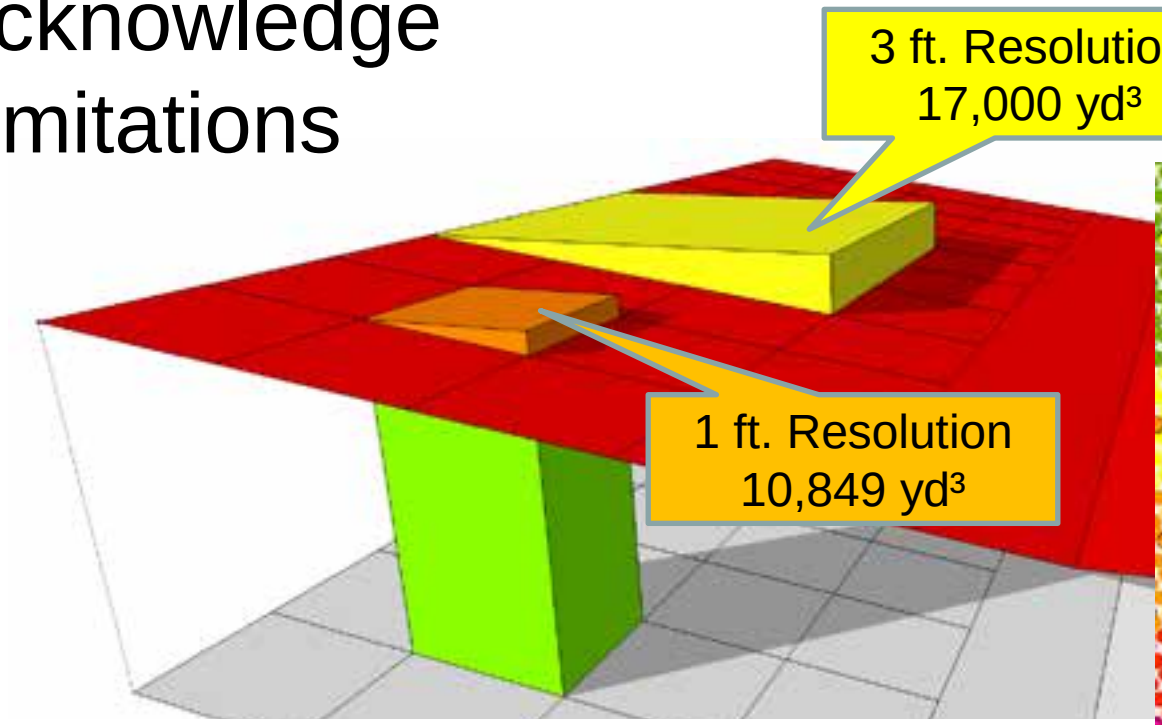
- Calculate surface intervals between existing and proposed bottom

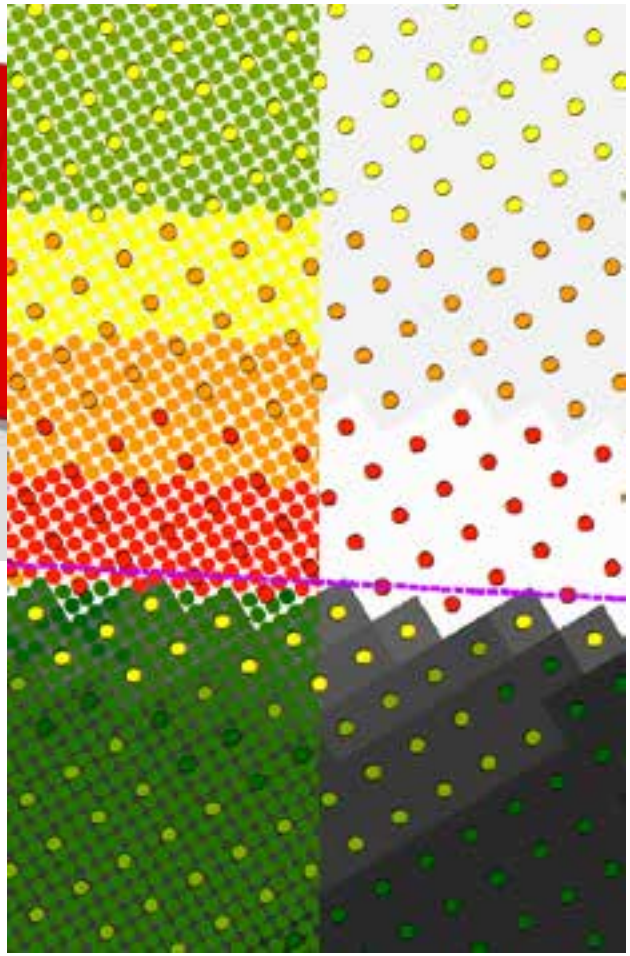
Calculation Setup



- Calculations:
- Elevations for each interval raster
- Surface Delta (Elev.$^{(Upper)}$ – Elev.$^{(Lower)}$)

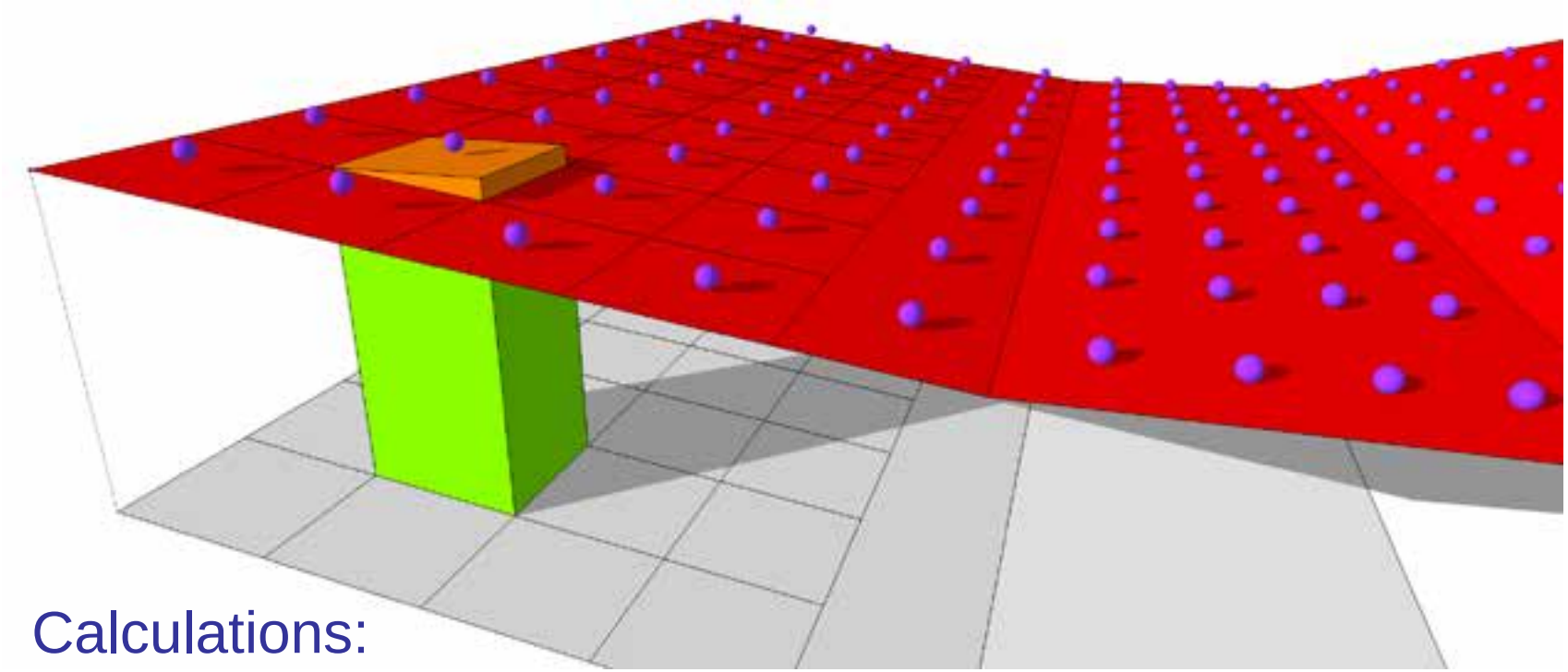
Acknowledge Limitations





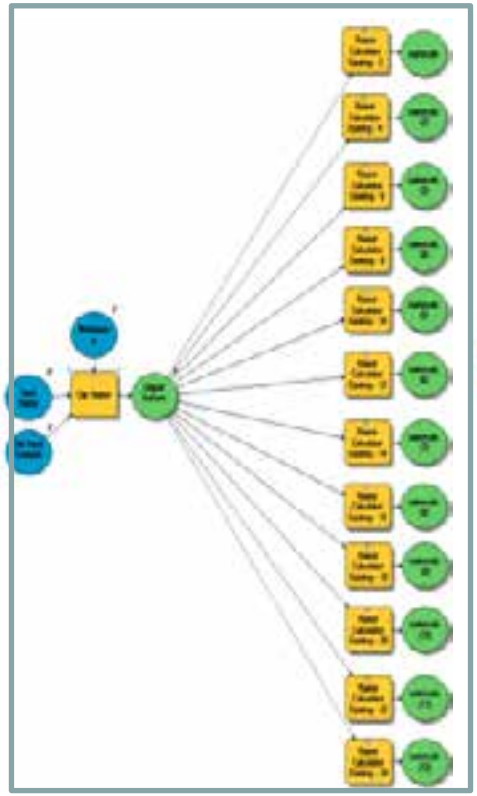
- Select resolution
- Cell values represent the avg. value
- Consider resolution of source data
- Acceptable error vs. Efficiency

Calculations Beyond the Raster

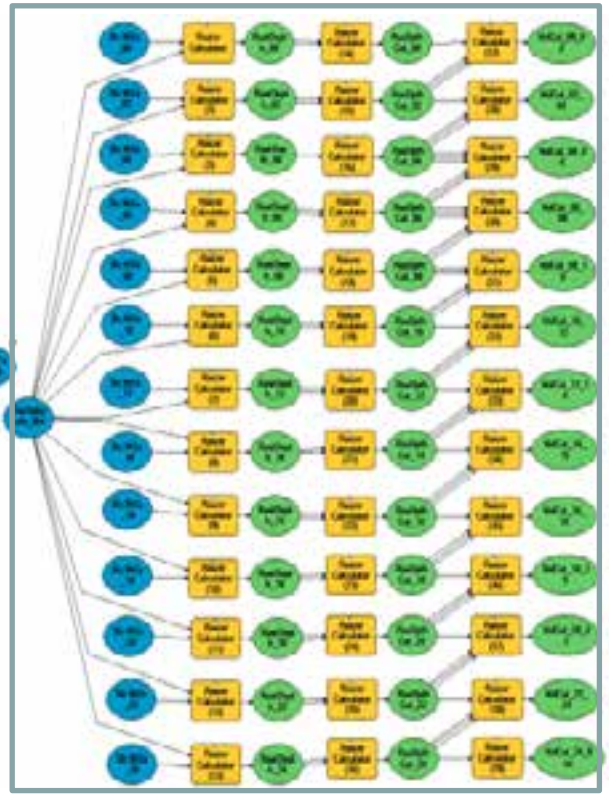


- Calculations:
- Convert raster values to another format
- Interval Vol. = (Surface Delta) x (Cell Size) + Unit Convert
- Integrate SMU attributes for statistics and filtering

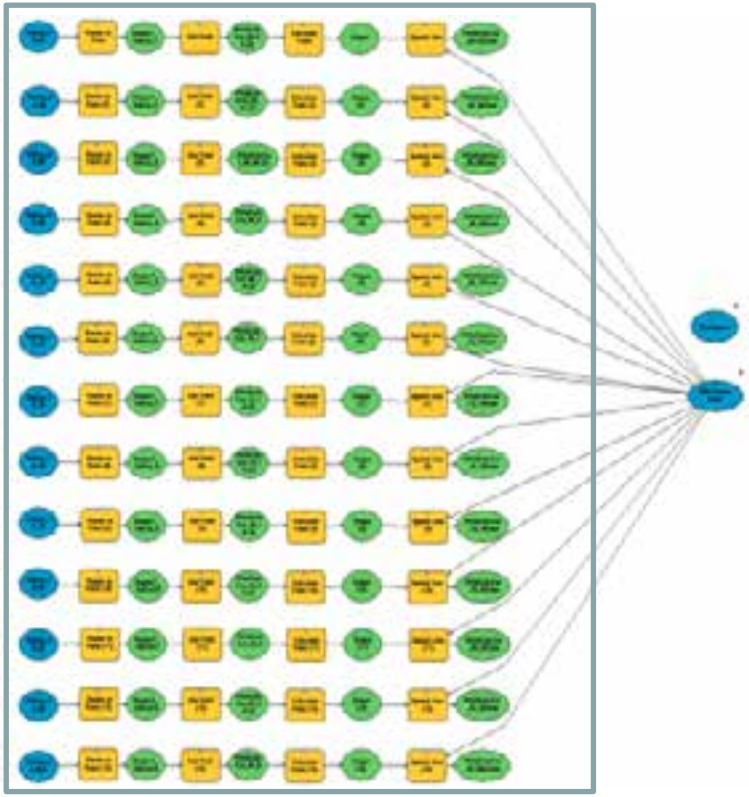
Modeling “The Cake”



1. Create Interval Surface Rasters

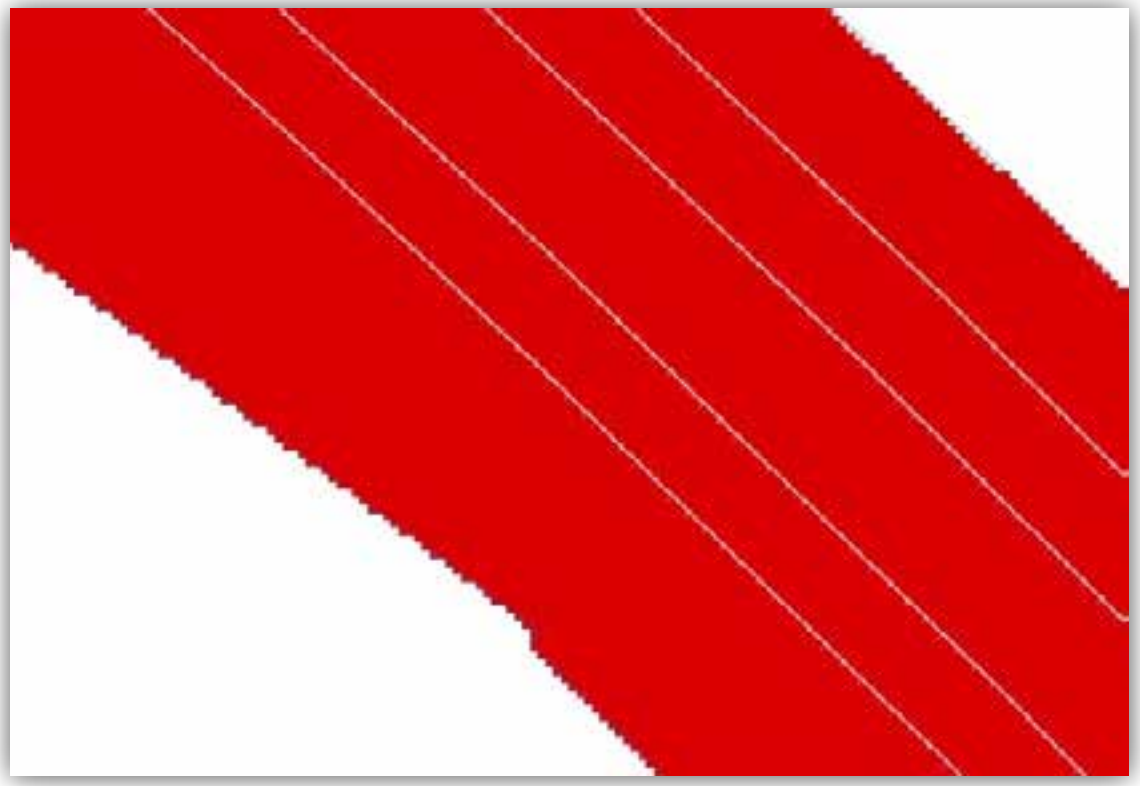


2. Calculate Interval thickness and manage “fill” areas



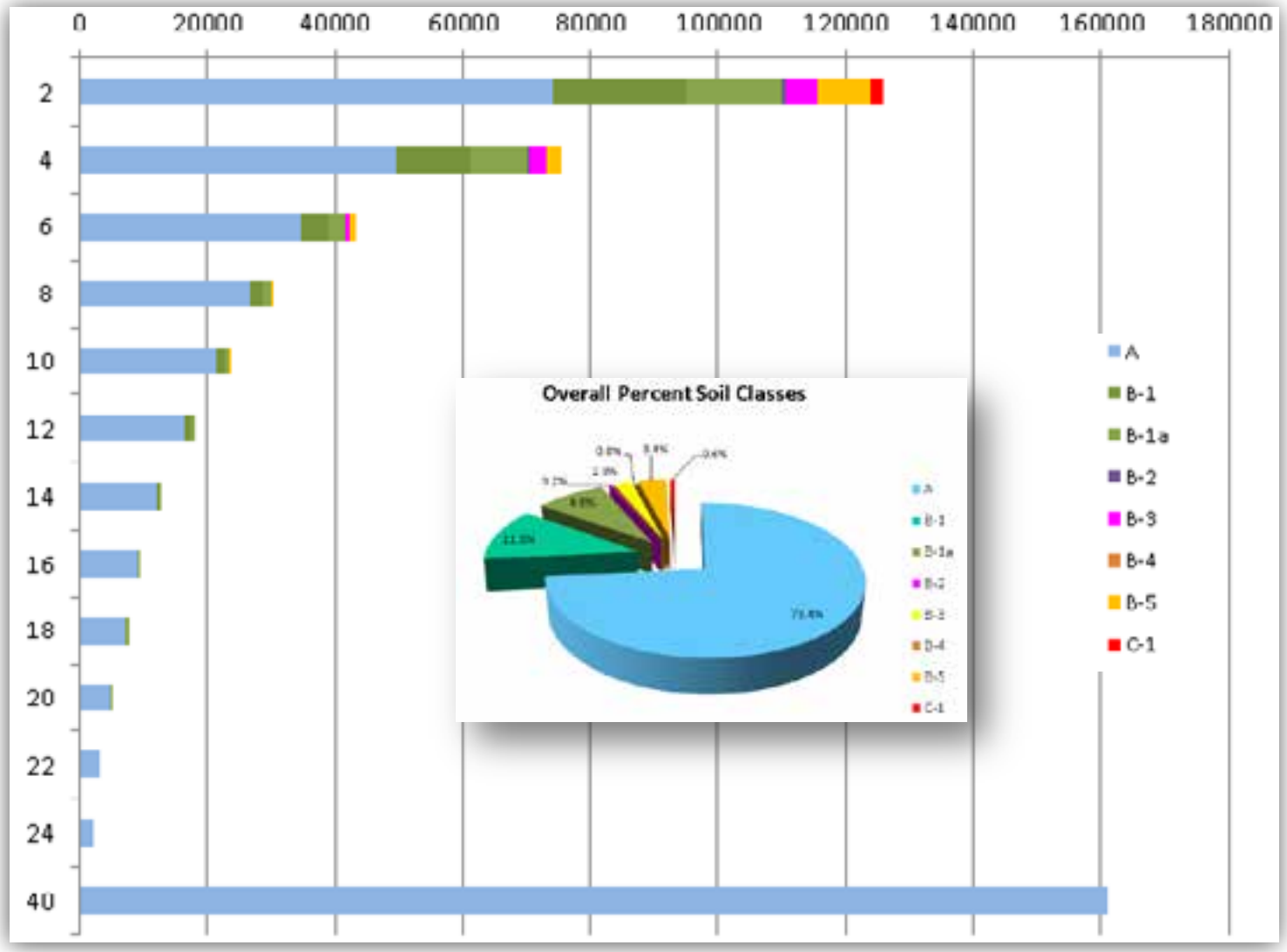
3. Convert to points, calculate volumes, convert units

Making “The Cake” – Slicing the layers



Results

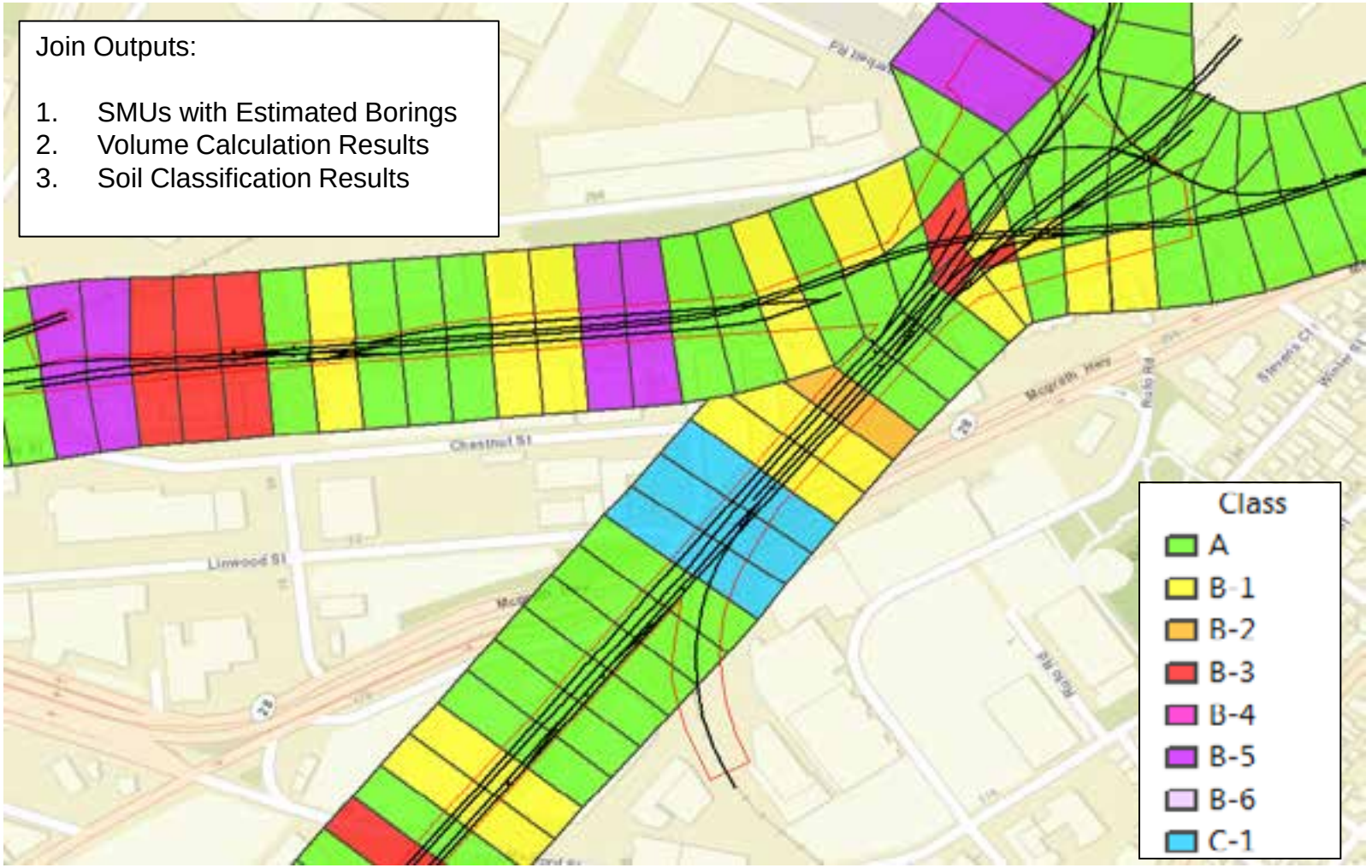
~500,000 yd3
~ 700,000 tons



Results

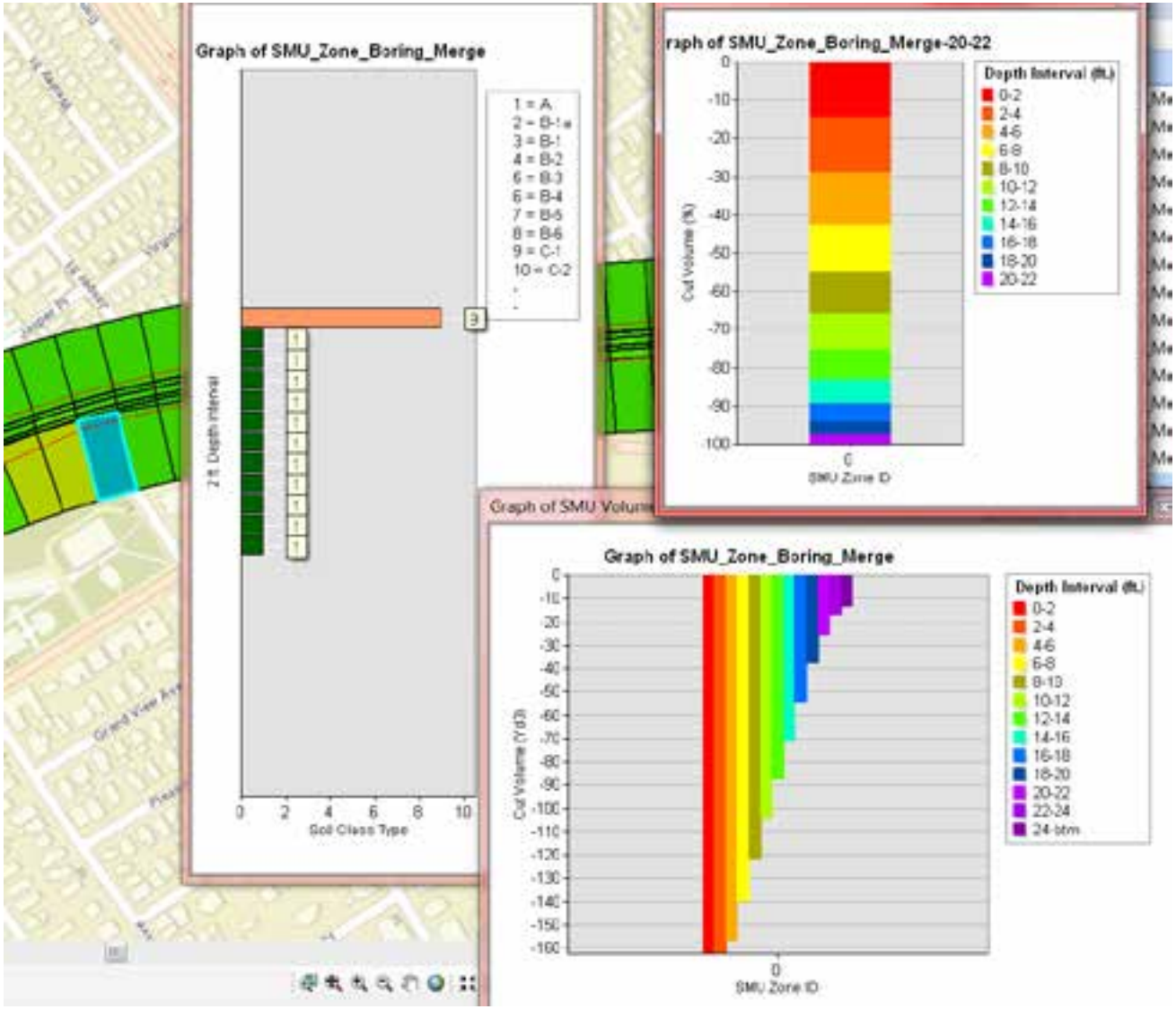
Join Outputs:

1. SMUs with Estimated Borings
2. Volume Calculation Results
3. Soil Classification Results

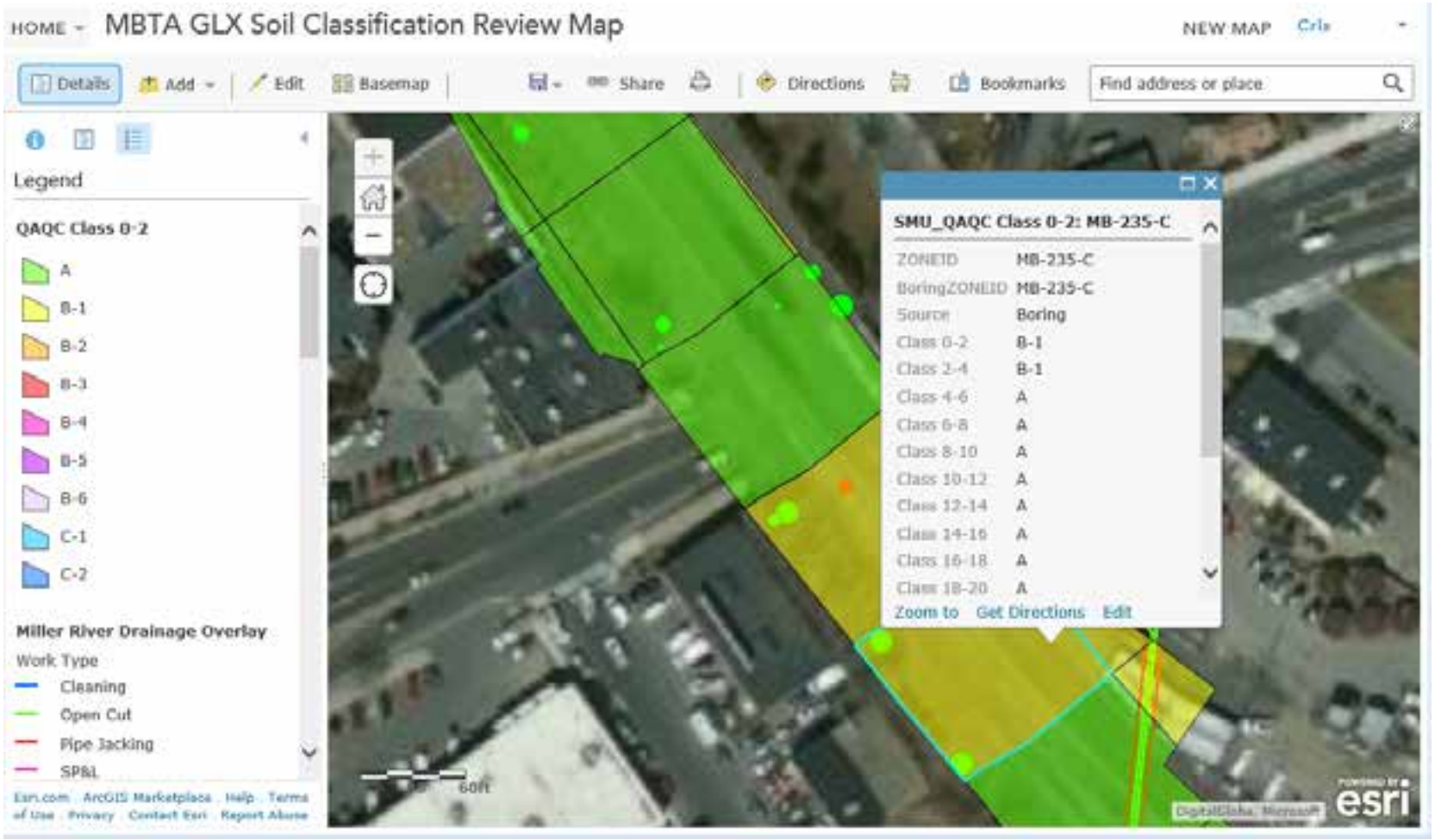


Results

- Symbology
- Statistics and Filters
- Trend Analysis
- Report Output
- Dynamic Graphs



QAQC tool


HOME
MBTA GLX Soil Classification Review Map
NEW MAP
Details
Add
Edit
Basemap
Share
Directions
Bookmarks
Find address or place
Legend
QAQC Class 0-2
A
B-1
B-2
B-3
B-4
B-5
B-6
C-1
C-2
Miller River Drainage Overlay
Work Type
Cleaning
Open Cut
Pipe Jacking
SP&L
SMU_QAQC Class 0-2: MB-235-C
ZONEID MB-235-C
BoringZONEID MB-235-C
Source Boring
Class 0-2 B-1
Class 2-4 B-1
Class 4-6 A
Class 6-8 A
Class 8-10 A
Class 10-12 A
Class 12-14 A
Class 14-16 A
Class 16-18 A
Class 18-20 A
Zoom to
Get Directions
Edit
60ft
esri

Next Steps

- Data Dashboard
- Planning viewer
- Soil tracker app
- Stock-pile mgt.(?)

- Update model with improved/new source data
- Include excavation from utilities
- Integrate EQuIS into eGIS and automatize boring classification
- Enable time
- Produce dynamic summaries for project areas

Questions?