Well Pad Design
And
Heavy Truck Freight Transport

Nick Tonias, P.E.

The CEDRA Corporation

1985 The CEDRA Corporation is established.
1987 CEDRA begins a long standing relationship with ESRI.
1993 CEDRA becomes an authorized ESRI Business Partner and Developer.

CEDRA offers engineering/GIS solutions in the form of software and services to governmental agencies, engineering consultants, tax assessors, oil companies and various utility enterprises.

The CEDRA Approach

- Develop ArcGIS and ArcGIS Server based problem-solving applications
- Utilize ArcGIS as the interface for graphical display, database interaction and data storage
- Desktop: VB6, .Net, Python
- Server: JavaScript, JQuery, HTML, CSS

Stuart asks how to perform

Setting Well Pad Elevations

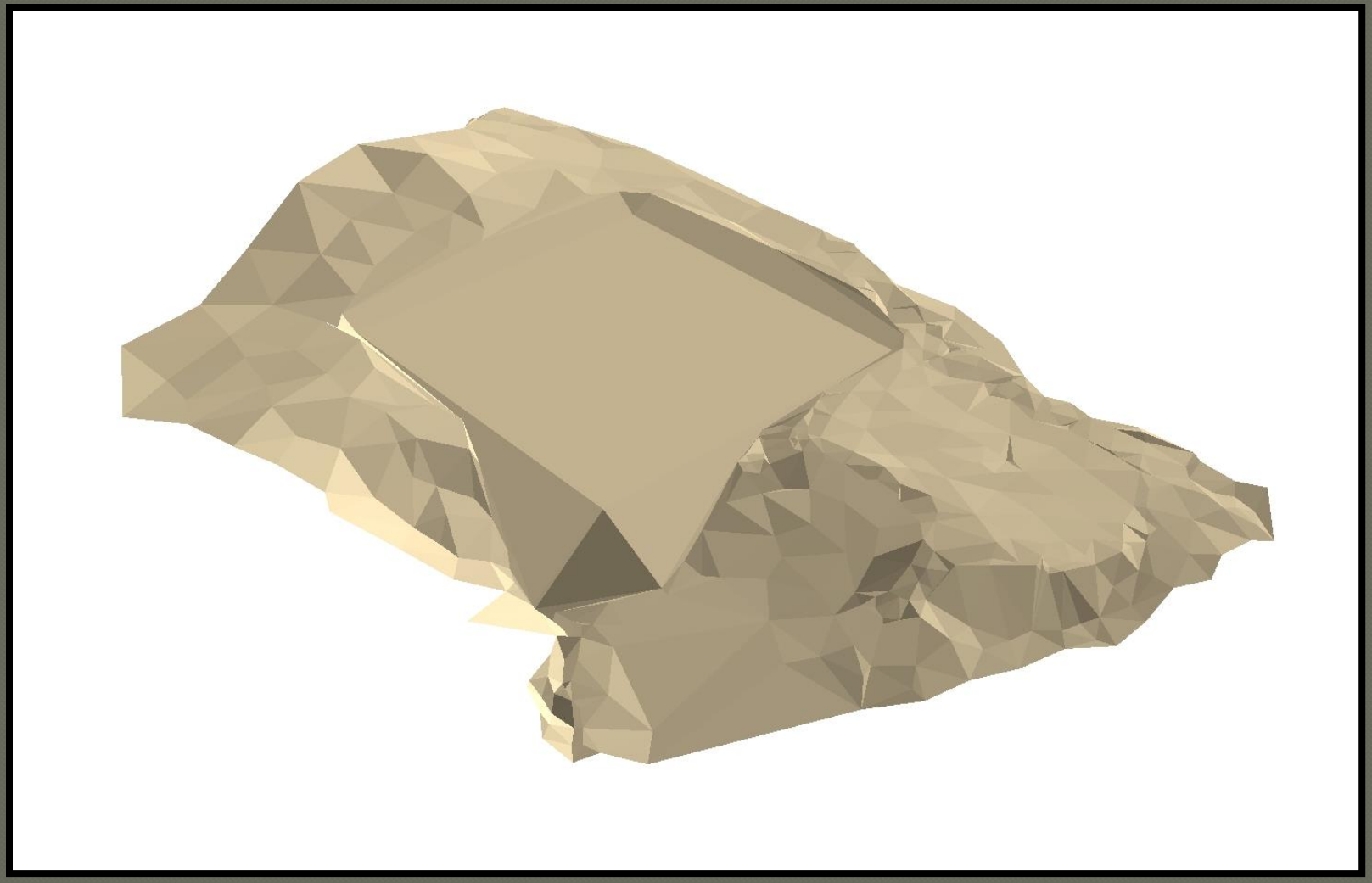
“I seldom talk to humans but when I do I talk to this guy”

The Desired Goal

Given a Well Pad Surface with an Initial Control Elevation, change the Control Elevation by raising or lowering the elevation until the Cut and Fill volumes are within a user-specified tolerance within ArcGIS

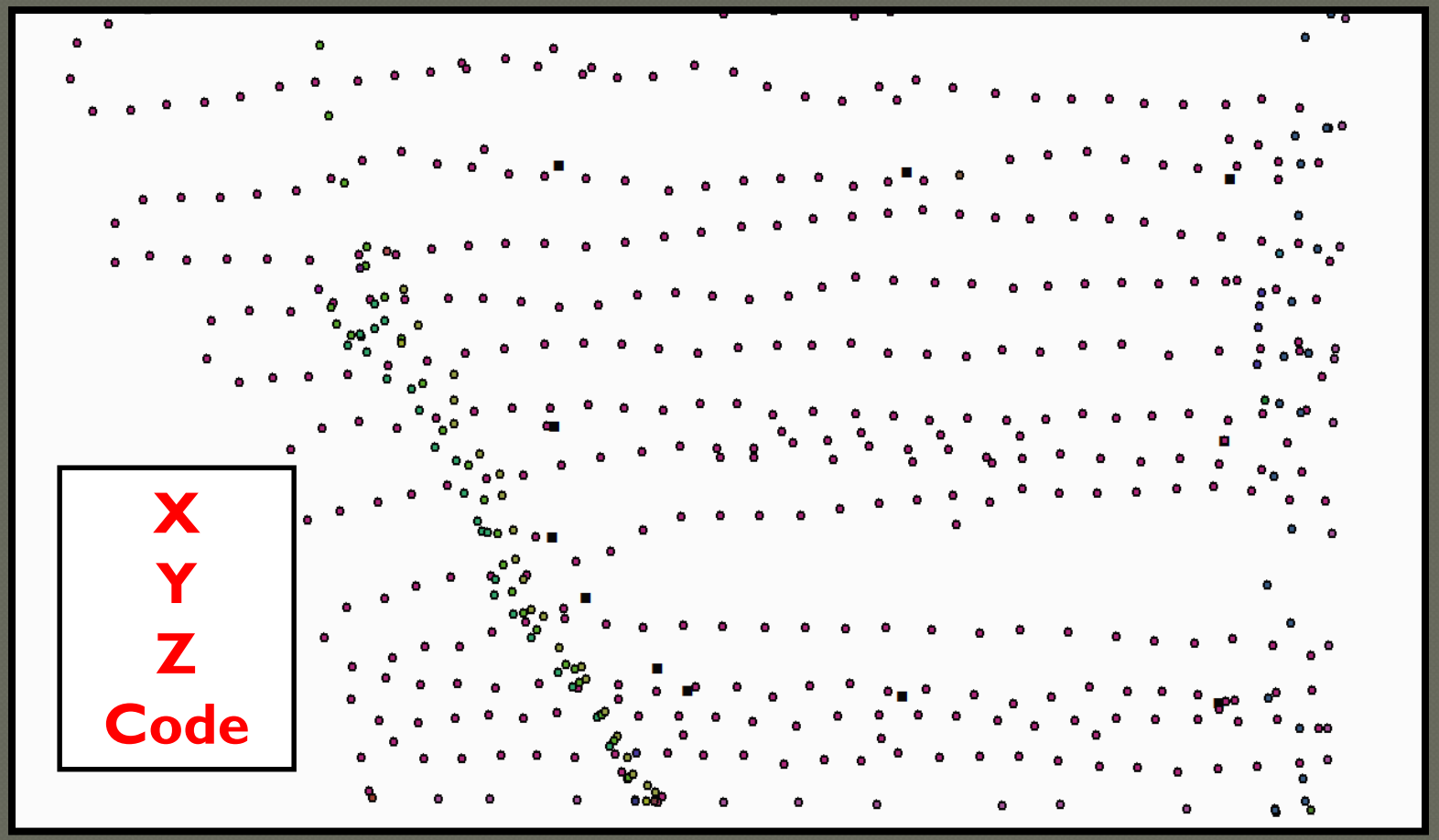
“Balanced Earthwork”

The Desired Goal in Picture Form



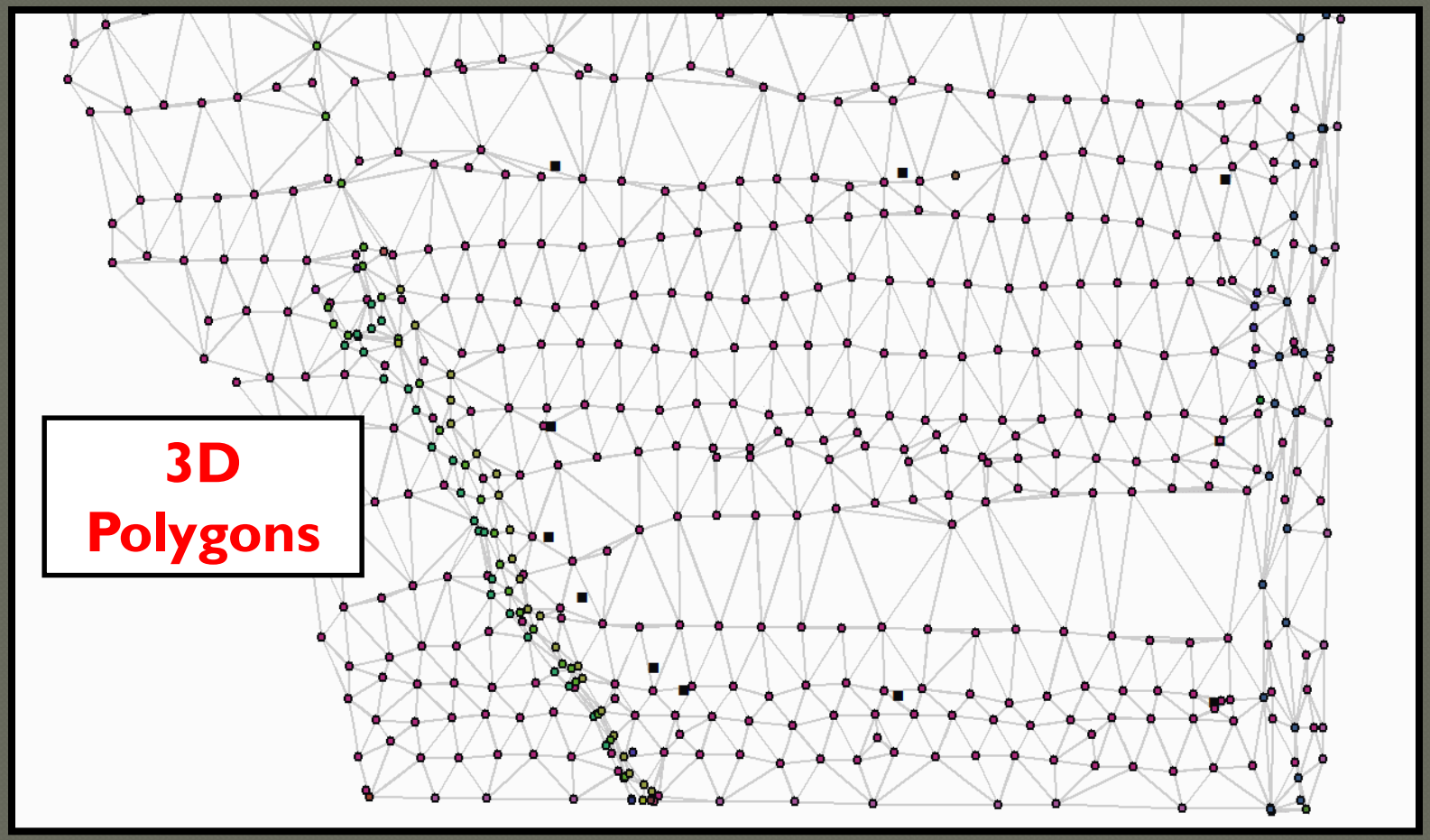
Developing the Original Ground Surface

GPS Field Collected Ground Survey



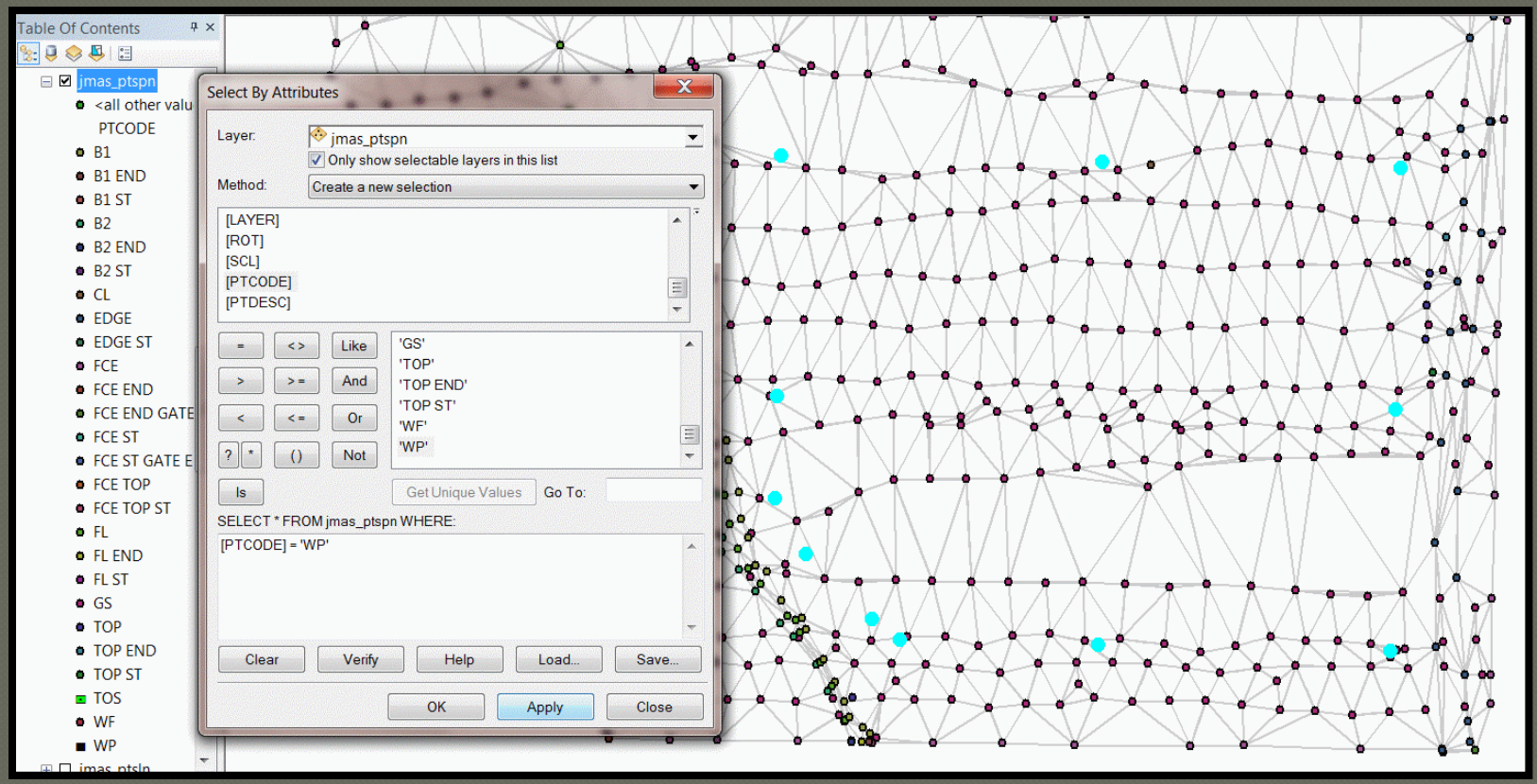
Developing the Original Ground Surface

Create the Original Ground TIN



Developing the Well Pad Surface

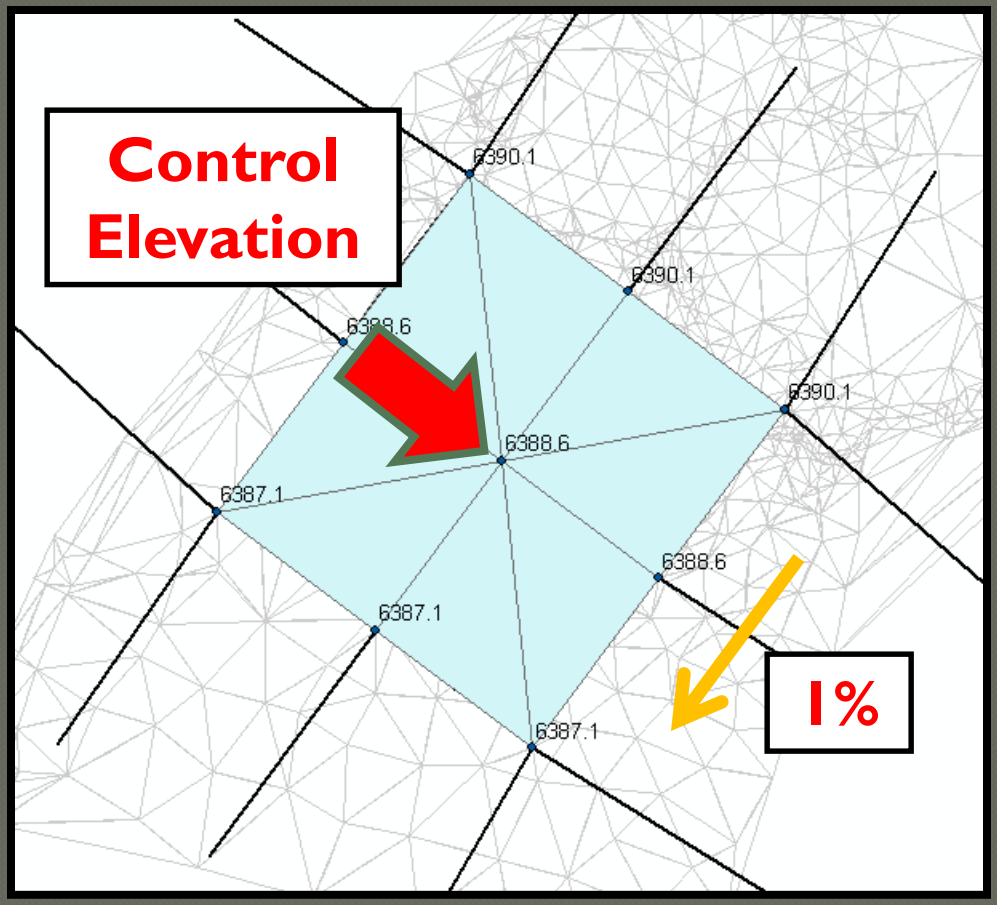
Set the Well Pad Perimeter Points From Survey Data or Interactively Entered



Developing the Well Pad Surface

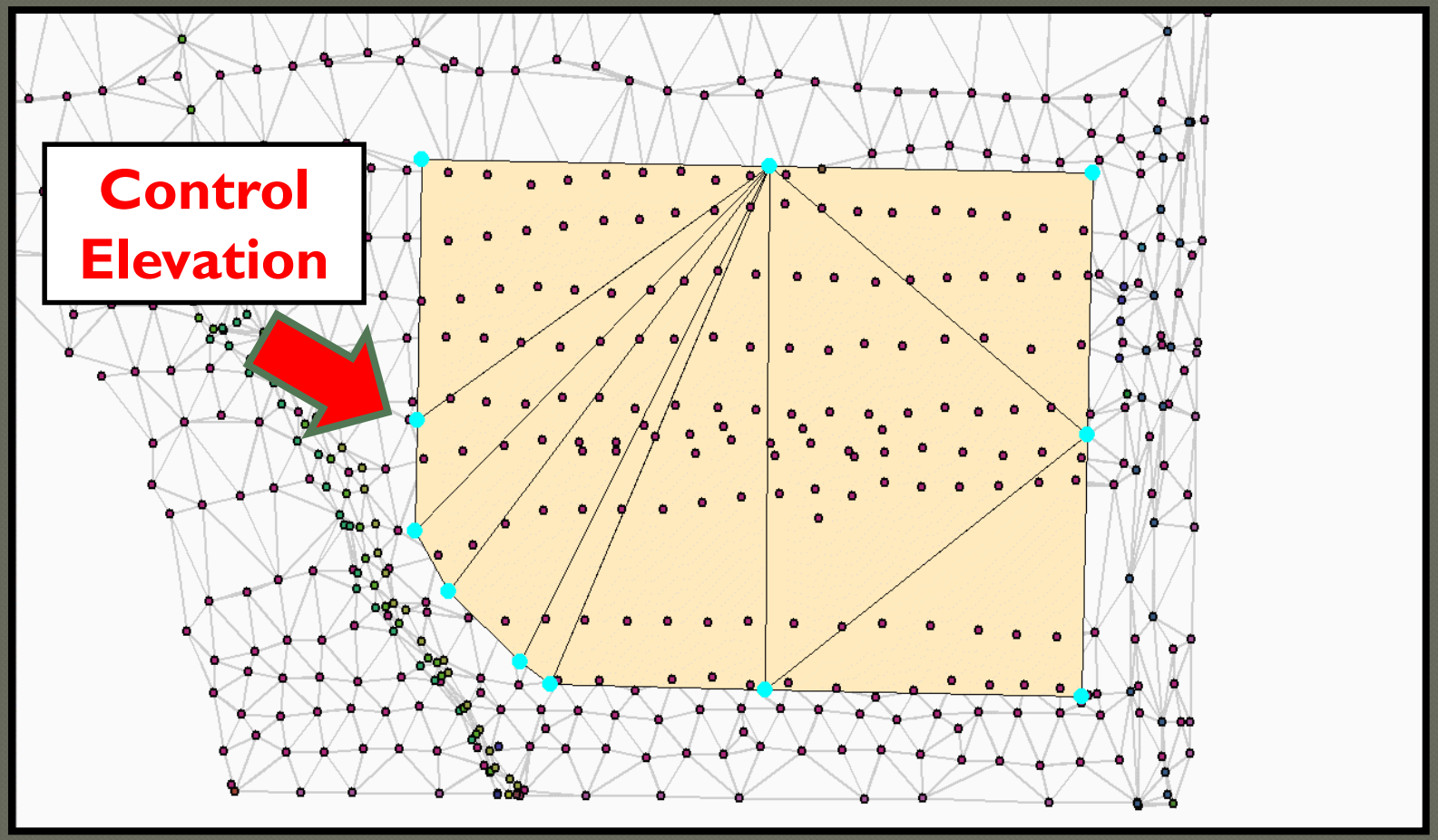
Well Pad TIN – Option 1 Sloped Surface

A Specific Elevation on the Well Pad Surface acts as the control point when balancing earthwork which enables the Well Pad to be sloped for drainage



Developing the Well Pad Surface

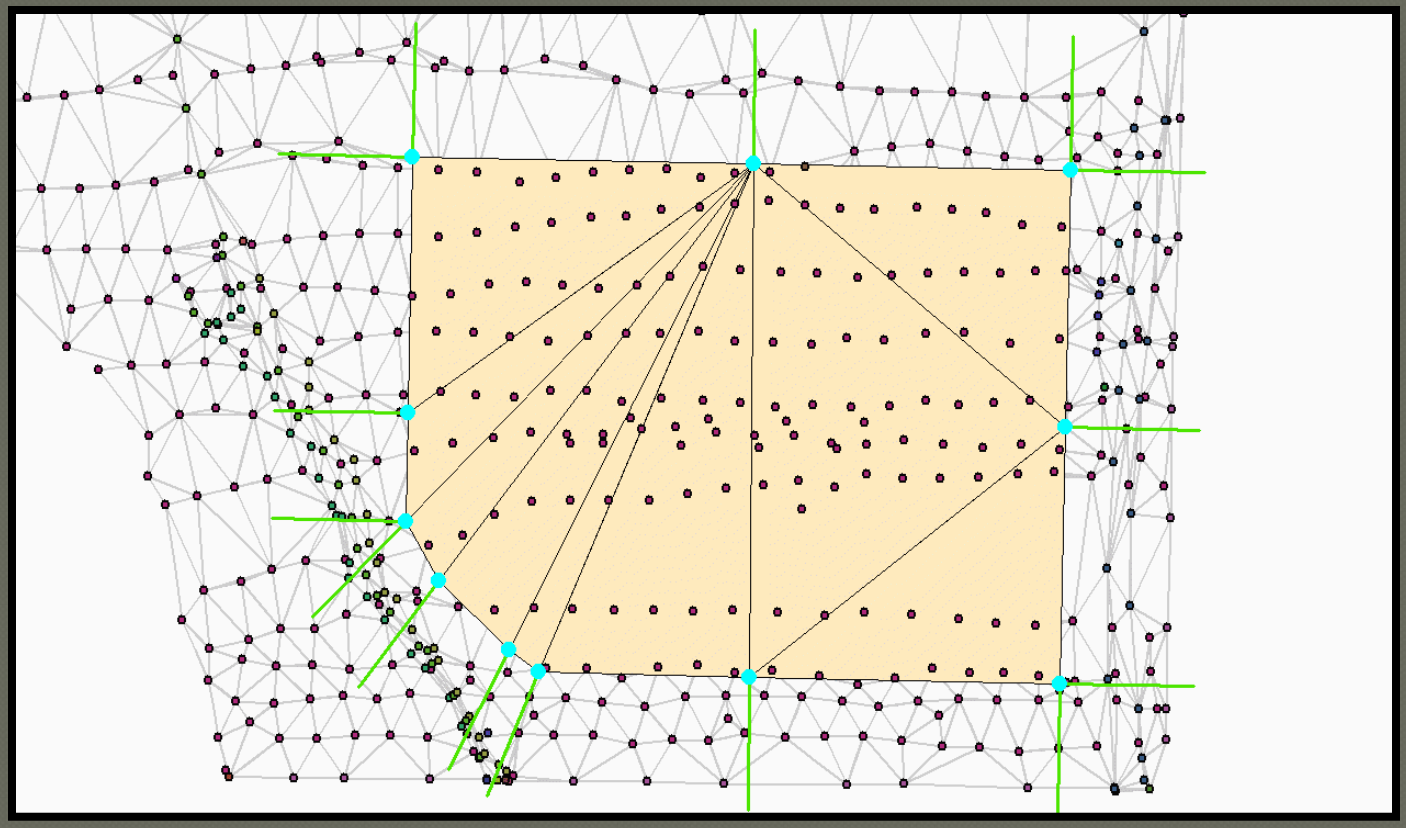
Well Pad TIN – Option 2 Constant Pad Elevation



Developing the Slope Lines

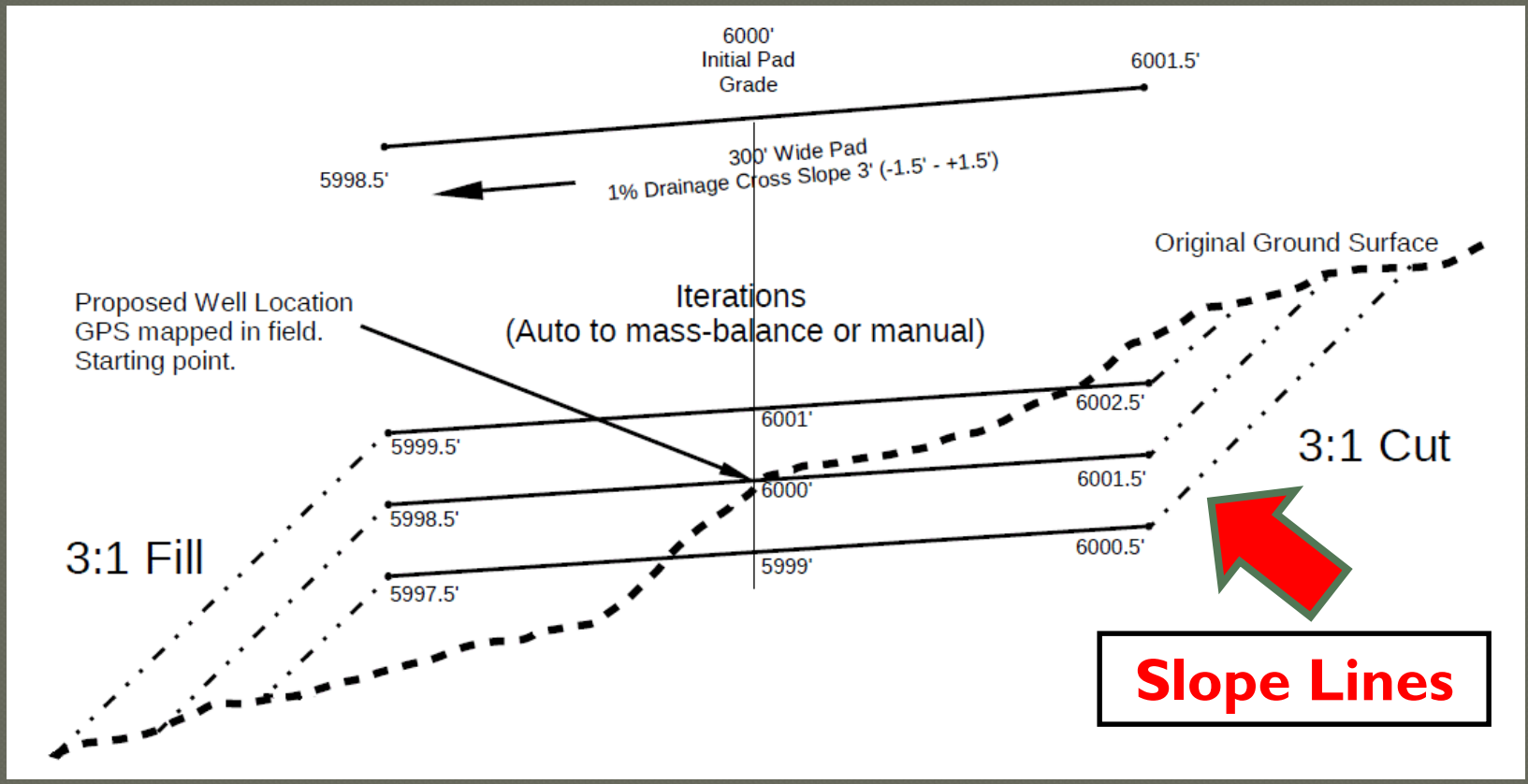
Slope Lines defined at Well Pad Perimeter Points
1 on 2, 1 on 3, 1 on 4, etc.

Slope Lines tie the Well Pad Surface to the Original Ground Surface



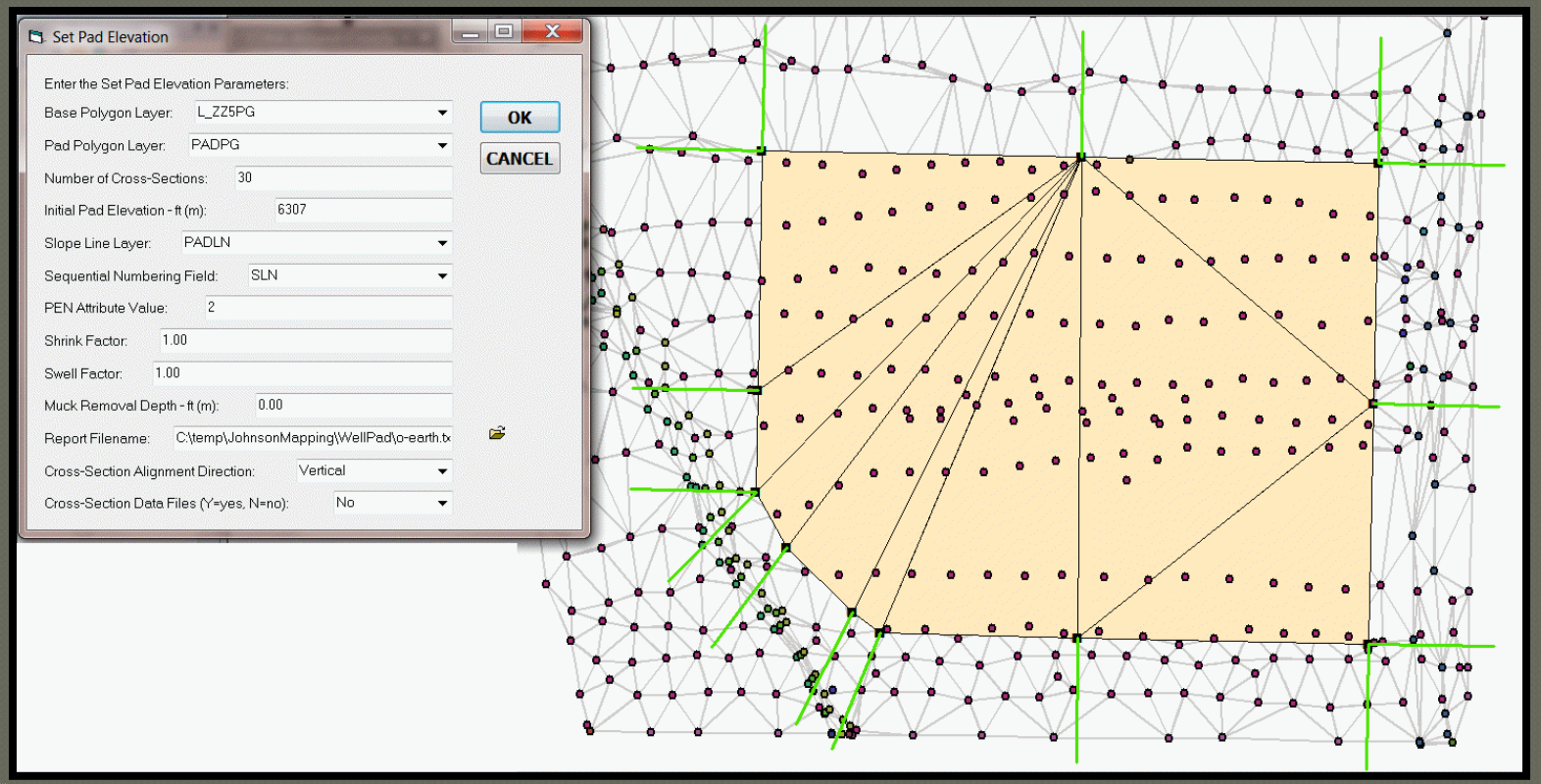
Developing the Well Pad Surface

Using cross-sections, the control elevation is raised or lowered until the cut and fill values are "equal"



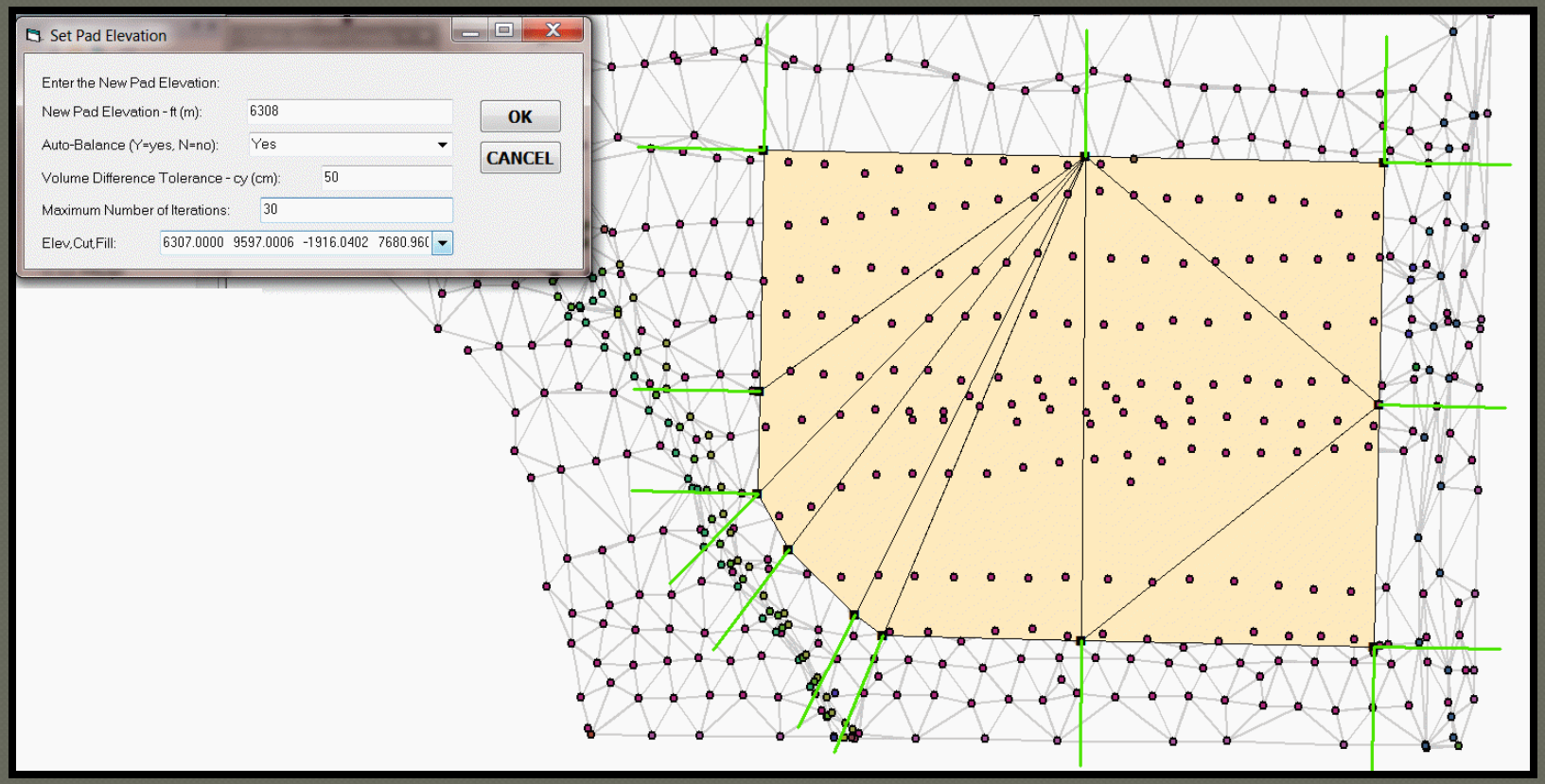
Developing the Well Pad Surface

[Set Well Pad Elevation] command
Base Layer, Pad Layer, Initial Pad Elevation,
Slope Line Layer, Shrink, Swell, Muck, Report File, etc.



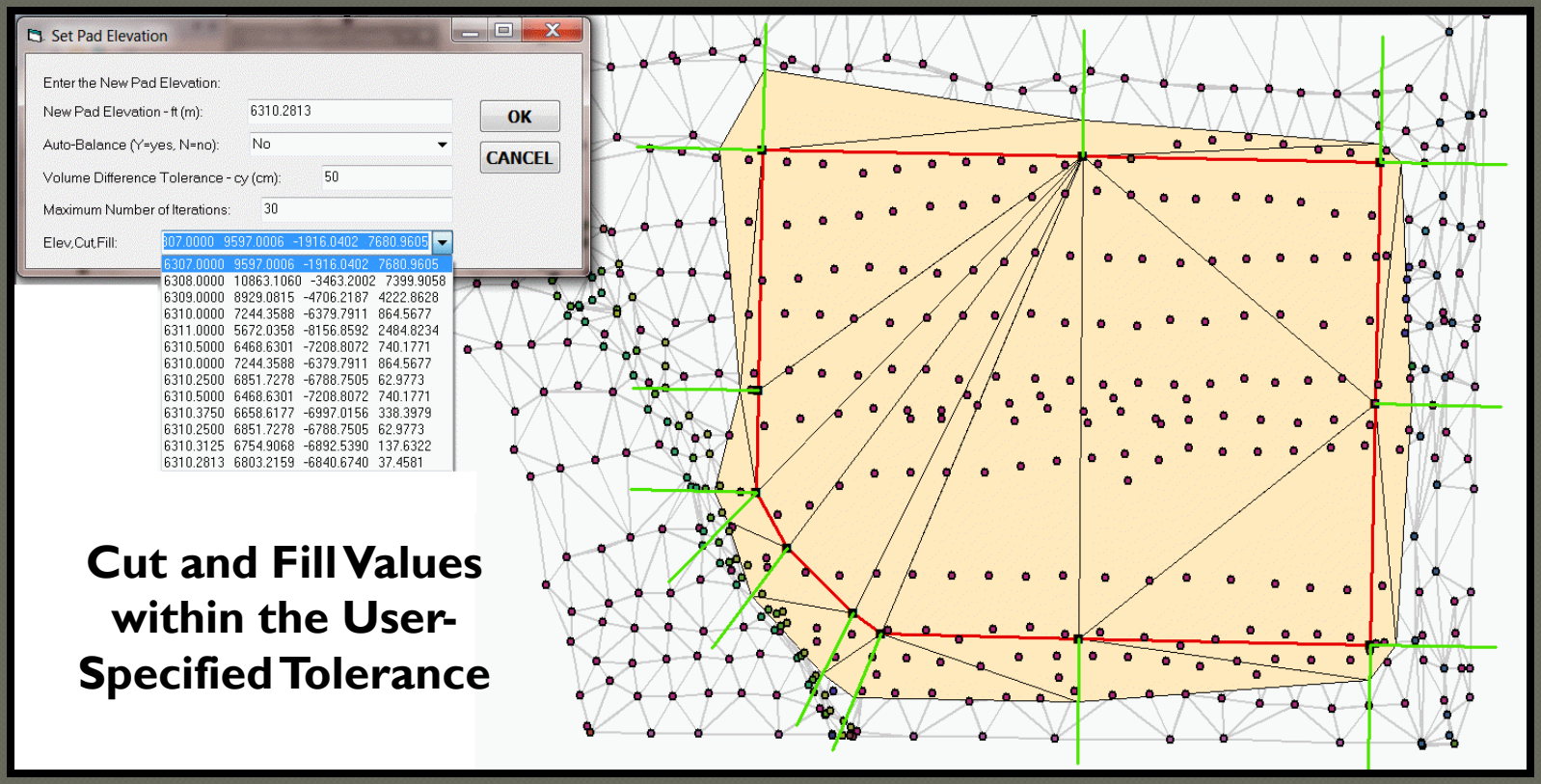
Developing the Well Pad Surface

Iterative Process to balance Earthwork Within a User-Specified Tolerance



Developing the Well Pad Surface

Final Computed Elevation with Polygons which tie the Pad Surface to the Original Ground Surface Added to the Pad Layer



Cut and Fill Values within the User-Specified Tolerance

Developing the Well Pad Surface

Earthwork Summary Table

Table contains each iteration with the Pad Elevation, Cut Volume, Fill Volume and Difference values

o-earthTBL.txt

PAD_ELEV	CUT_VOL	FILL_VOL	DIFF	OBJECTID *
6307	9597.0006	-1916.0402	7680.9605	1
6308	10863.106	-3463.2002	7399.9058	2
6309	8929.0815	-4706.2187	4222.8628	3
6310	7244.3588	-6379.7911	864.5677	4
6311	5672.0358	-8156.8592	2484.8234	5
6310.5	6468.6301	-7208.8072	740.1771	6
6310	7244.3588	-6379.7911	864.5677	7
6310.25	6851.7278	-6788.7505	62.9773	8
6310.5	6468.6301	-7208.8072	740.1771	9
6310.375	6658.6177	-6997.0156	338.3979	10
6310.25	6851.7278	-6788.7505	62.9773	11
6310.3125	6754.9068	-6892.539	137.6322	12
6310.2813	6803.2159	-6840.674	37.4581	13

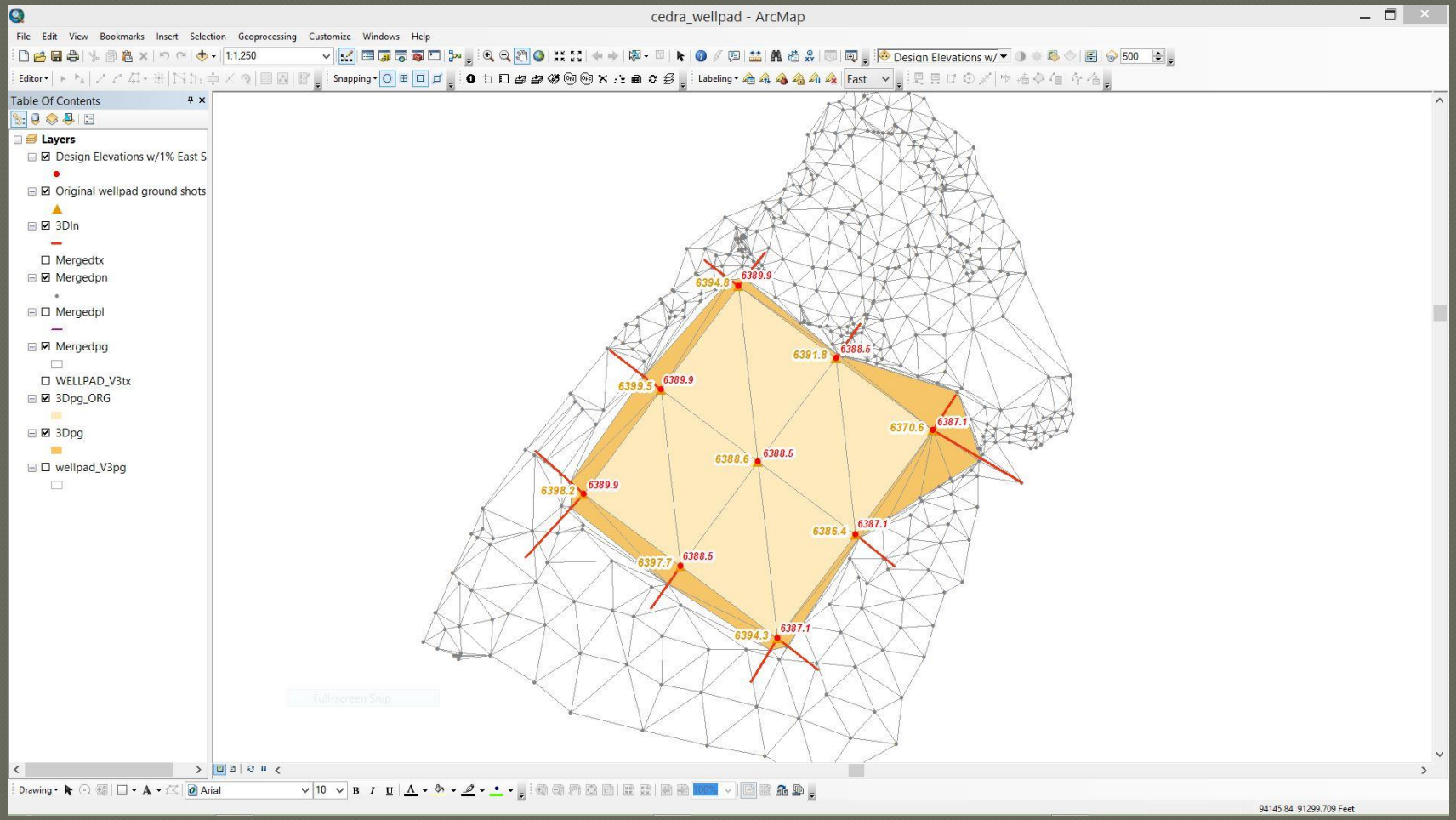
1 (0 out of 13 Selected)

o-earthTBL.txt

Well Pad 3D Visualization

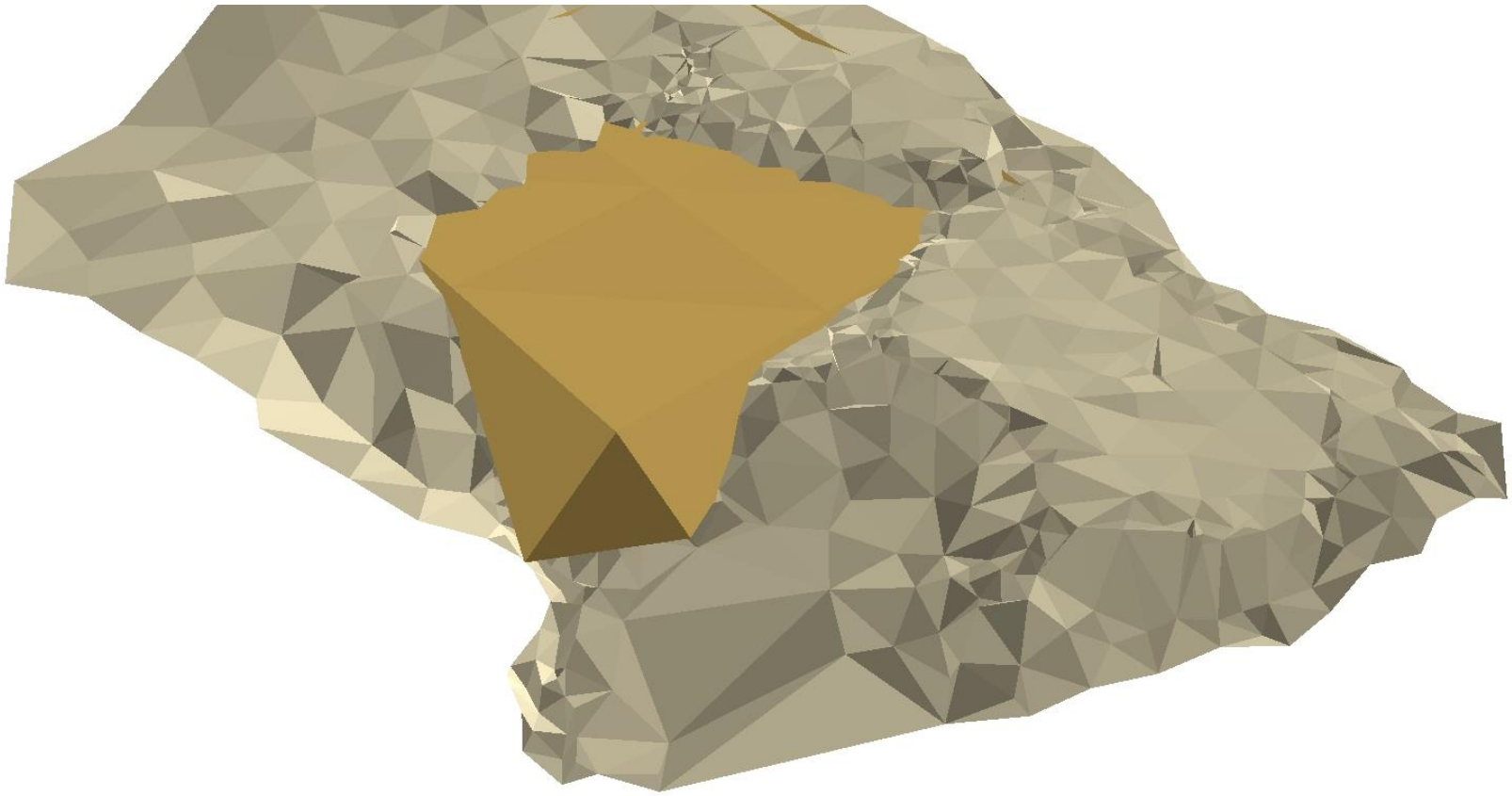
Given an Original Ground Surface and a Well Pad Surface that has been tied to the Original Ground Surface merge the surfaces and use ArcMap 10.3 to visualize the results

Existing Ground & Well Pad Surfaces – 2D

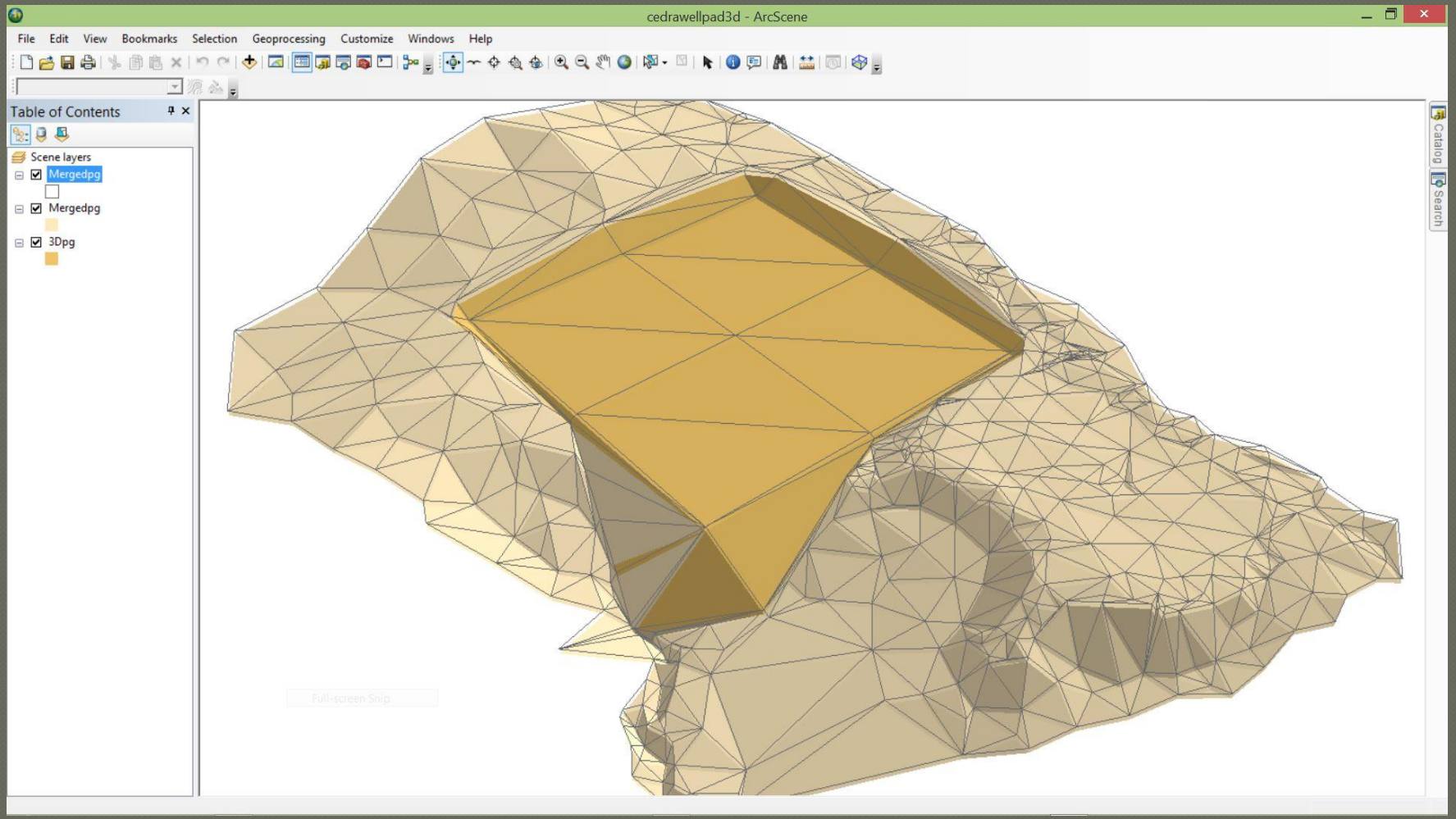


Existing Ground & Well Pad Surfaces – 3D

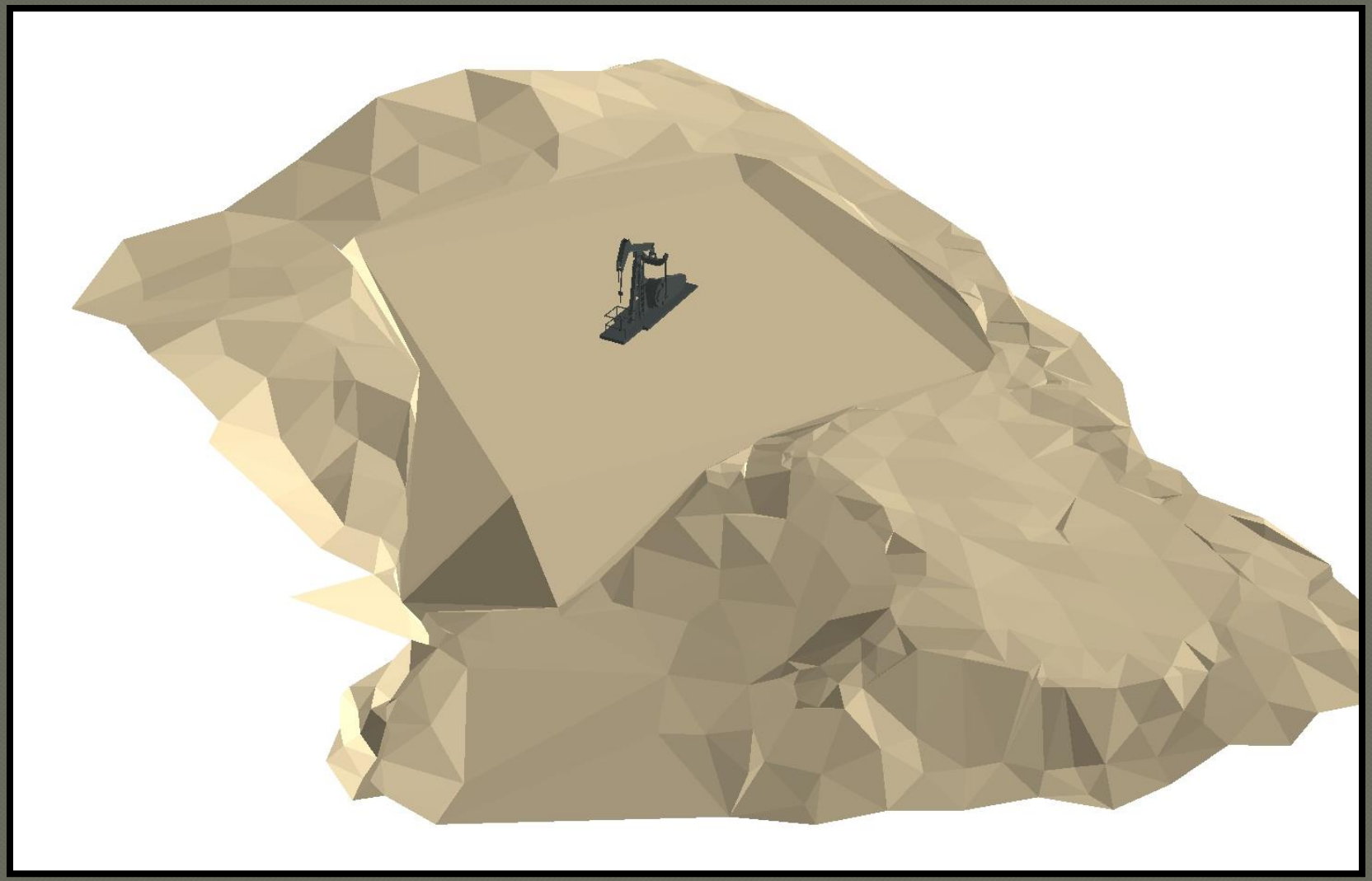
3D Model showing Pad Design with 3:1 slopes indicating cuts/fill



Merged Surfaces



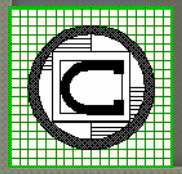
Merged Surfaces



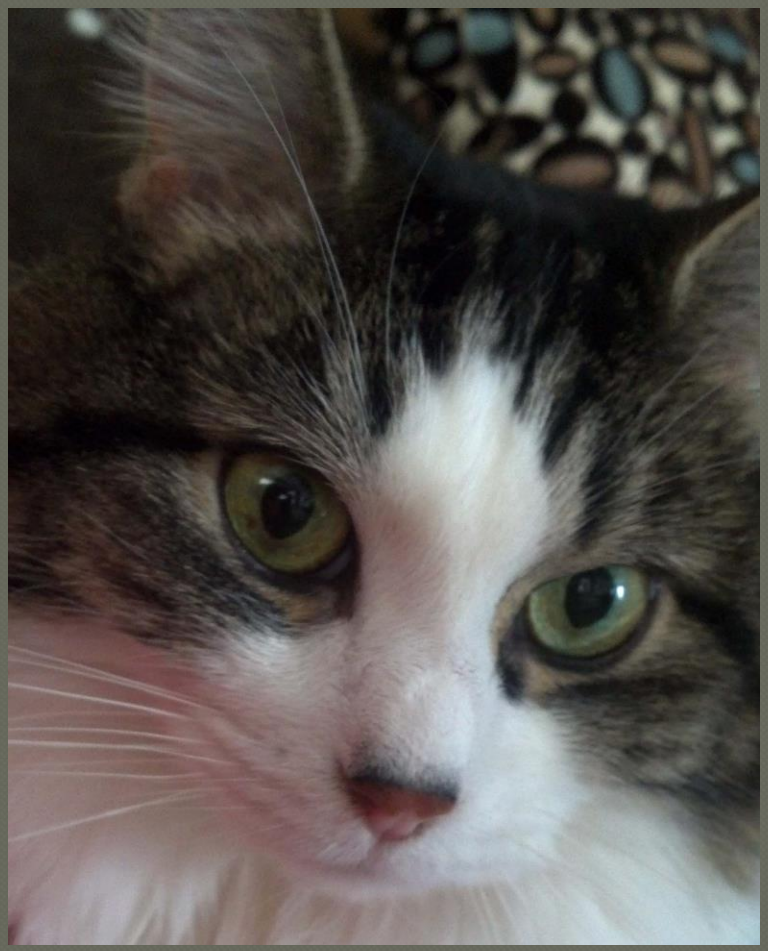
References

Dave Fosdeck

Johnson Mapping and Surveying, LLC
Farmington, New Mexico



Emma asks how to perform



Routing Heavy/Wide Vehicles for Safety

“Emma says this is a purr-fect application for Network Analyst”

Bachman-Turner Overdrive

"Roll on Down the Highway"

Unofficial Theme Song of Truckers

No GPS in 1974

The Routing Problem

Routing Heavy and Wide Load Vehicles differs from routing passenger vehicles

Truck characteristics need to be included in the routing process which conventional navigation systems do not take into account

Vertical Clearance Issue

Typical Trailer Height 13’ to 13’-6”

New York State experiences ~200 bridge strikes annually

Vertical Clearance Issue

NYSDOT estimates 81% of bridge strikes due to trucks using non-commercial navigation systems

From 2005 – 2008 ~5,000 Bridge Strikes in the U.S.

Horizontal Turning Restrictions

Single Trailer Lengths typically 45', 48', 53'

Truck Drivers using some kind of GPS System

2007 – 11%, 2008 – 19%, 2008 – 27%, 2012 – 54%

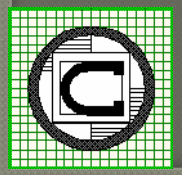
Trailer Length Issue

Wind Turbine Blade Radius varies from 130’ to 300’

59% of truckers determine their own route/directions
28% have their carrier provide route/directions
12% use combination of own and carrier
1% from special permit

Routing Solution using ArcGIS

- Network Analyst
  - Street Centerline Dataset
  - Network Dataset
    - User Created
    - StreetMap Premium (TomTom,HERE)
  - Route Analysis Layer
  - Network Analysis Service (ArcGIS Server)
    - User Created
    - World Route
    - StreetMap Premium (TomTom,HERE)

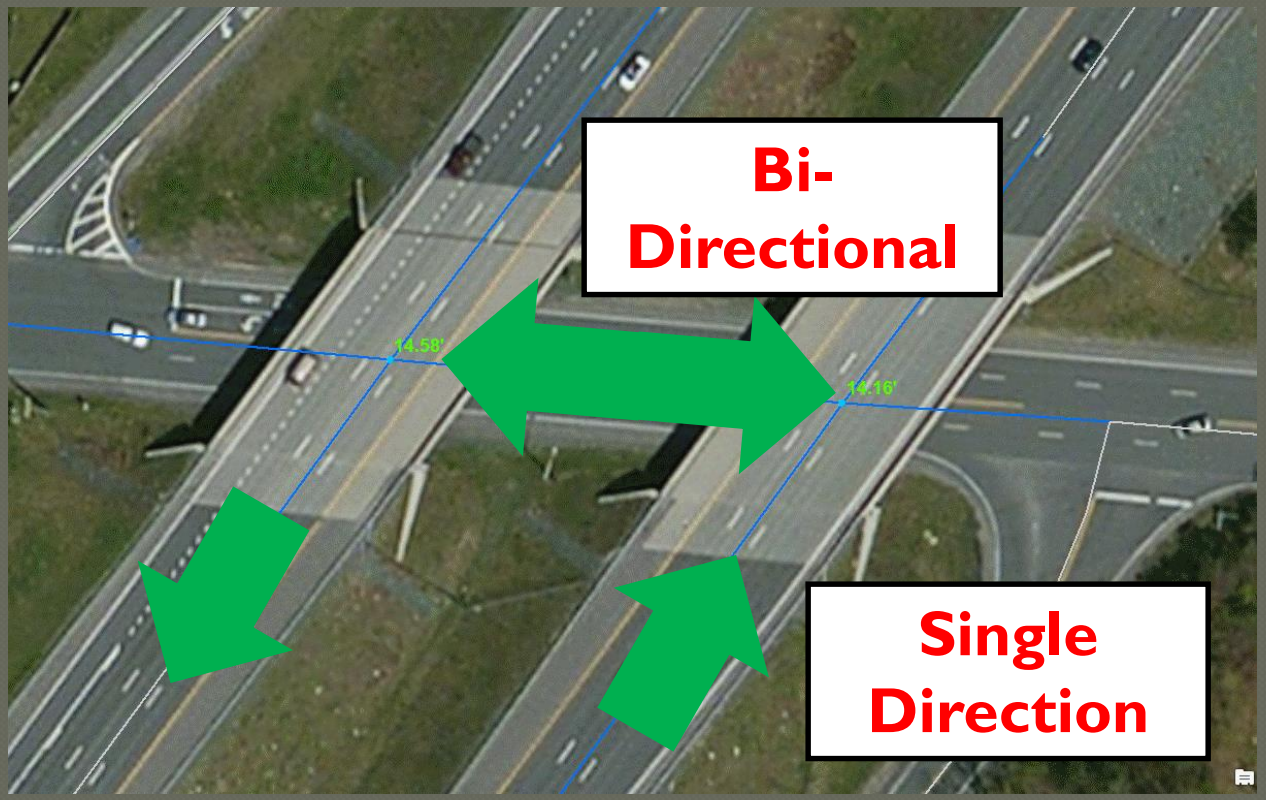


Network Datasets Elements

Junctions, Edges and Turns

How elements are connected determines the route

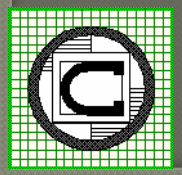
2D/3D



Network Dataset Attributes

Network attributes are properties of the network elements that control traversability over the network

Attribute	ParameterName	Value
Height	Height Restriction	0
Weight	Weight Restriction	0
Speed	Desired Speed	0
Oneway	Oneway	Prohibited
Truck	Driving a Truck	Avoid_High
Toll_Road	Avoid Toll Roads	Prohibited



Available Network Datasets

User-Created, using any available street centerline dataset the user builds from scratch a Network Dataset.

ESRI World Route routing service, which replaces the ESRI basic routing service, and offers world-wide coverage, without the ability to account for height, weight and hazardous material restrictions.

StreetMap Premium – TomTom based, which provides world-wide coverage with the ability to account for height, weight and hazardous material restrictions.

StreetMap Premium – HERE based, which provides world-wide coverage with the ability to account for height, weight and hazardous material restrictions.

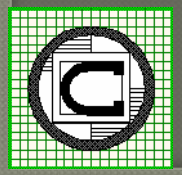
User Created Network Datasets

Advantages

- Total Control of the street database
- Any desired attributes can be added

Disadvantages

- Very time consuming when dealing with large areas
- User is responsible for obtaining:
  - street centerline dataset
  - roadway speed limits
  - roadway direction
  - roadway attributes used for directions, etc.



World Route/StreetMap Premium Network Datasets

Advantages

- Mature datasets that have existed for years
- Large area coverage
- Ready-to-go Network Analysis Layer

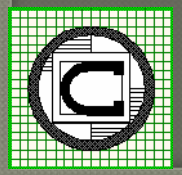
Disadvantages

- Inability to modify the street centerline database
- Annual license fee (desktop $, server $$$)

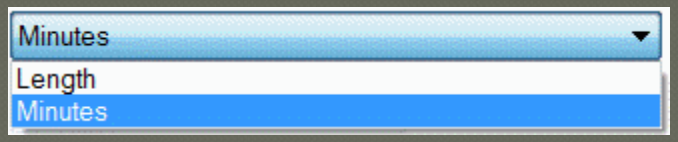
Network Datasets Comparison

Routing Service	Impedances	Restrictions	Parameterized Restrictions
Sample User-Defined	2	5	3
ESRI World Route	2	19	0
StreetMap – TomTom	8	32	6
StreetMap – HERE	5	32	8

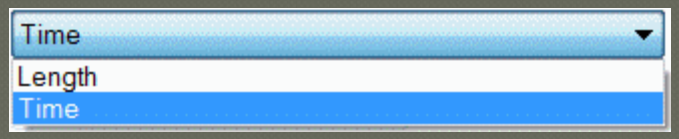
The route that is generated is based upon the settings of the Network's Impedance and Restrictions



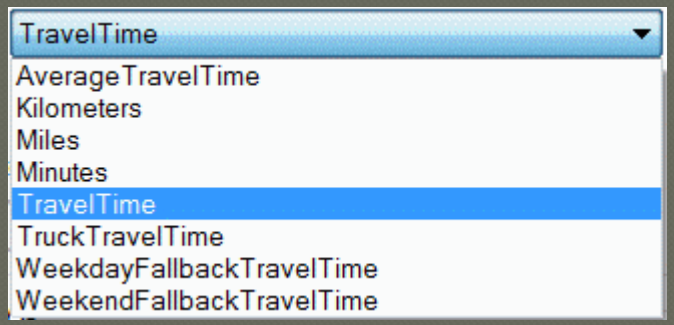
Network Datasets Impendances



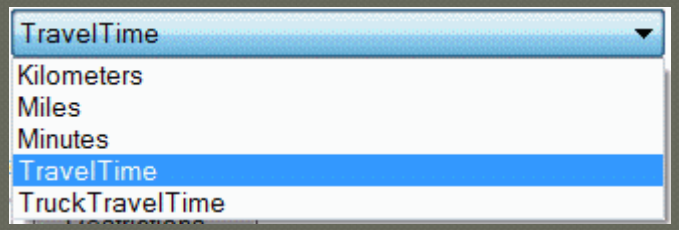
User-Defined



ESRI World Route



StreetMap Premium TomTom



StreetMap Premium HERE

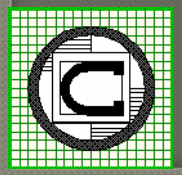
Network Datasets Restrictions

Restriction	Preference	Value
☑ Height	Prohibited	0.000000
☑ NoTrucks	Prohibited	
☑ Oneway	Prohibited	
☑ Speed	Prefer: Medium	0.000000
☑ Weight	Prohibited	0.000000

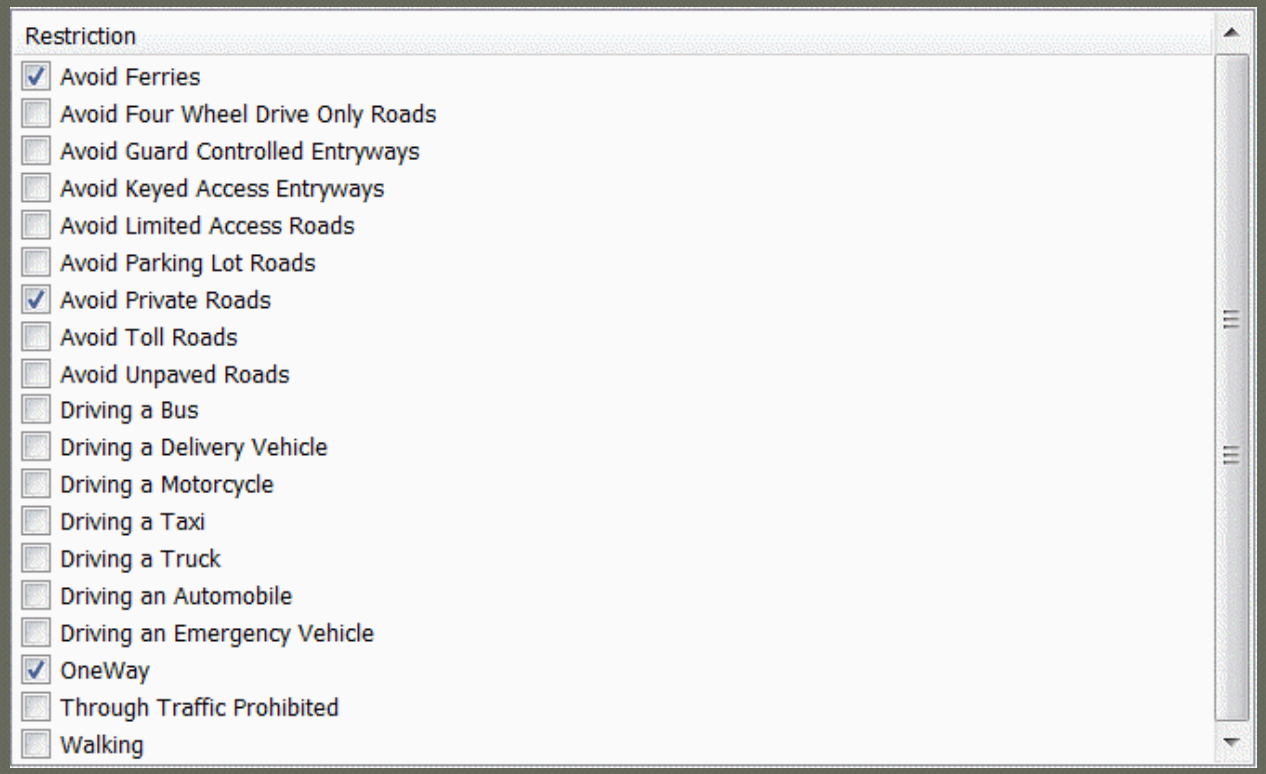
User-Defined

Creating a robust Network Dataset is a very labor intensive operation

Months to Decades depending upon Coverage



Network Datasets Restrictions



ESRI
World Route
19 Restrictions

Network Datasets Restrictions

Restriction	Preference	Value
☐ Any Hazmat Prohibited	Prohibited	
☐ Avoid Back Roads	Avoid: Medium	
☑ Avoid Carpool Roads	Prohibited	
☑ Avoid Express Lanes	Prohibited	
☐ Avoid Ferries	Avoid: Medium	
☑ Avoid Gates	Avoid: Medium	
☐ Avoid Limited Access Roads	Avoid: Medium	
☑ Avoid Pedestrian Zones	Prohibited	
☑ Avoid Private Roads	Avoid: Medium	
☑ Avoid Roads for Authorities	Prohibited	
☐ Avoid Roads in Poor Condition	Avoid: Medium	
☑ Avoid Service Roads	Prohibited	
☐ Avoid Toll Roads	Prohibited	
☑ Avoid Unpaved Roads	Avoid: High	
☑ Avoid Walkways	Prohibited	
☐ Driving a Commercial Vehicle	Avoid: Medium	
☑ Driving a Passenger Car	Prohibited	
☐ Driving a Public Bus	Prohibited	
☐ Driving a Residential Vehicle	Prohibited	
☐ Driving a Taxi	Prohibited	
☑ Driving a Truck	Prohibited	
☑ Height Restriction	Prohibited	0.000000
☑ Length Restriction	Prohibited	0.000000
☐ Riding a Bicycle	Prohibited	
☑ Roads Under Construction Prohibited	Prohibited	
☑ Through Traffic Prohibited	Avoid: High	
☑ Trailer Length Restriction	Prohibited	0.000000
☐ Use Preferred Hazmat Routes	Prefer: Medium	
☐ Use Preferred Truck Routes	Prefer: Medium	
☑ Weight per Axle Restriction	Prohibited	0.000000
☑ Weight Restriction	Prohibited	0.000000
☑ Width Restriction	Prohibited	0.000000

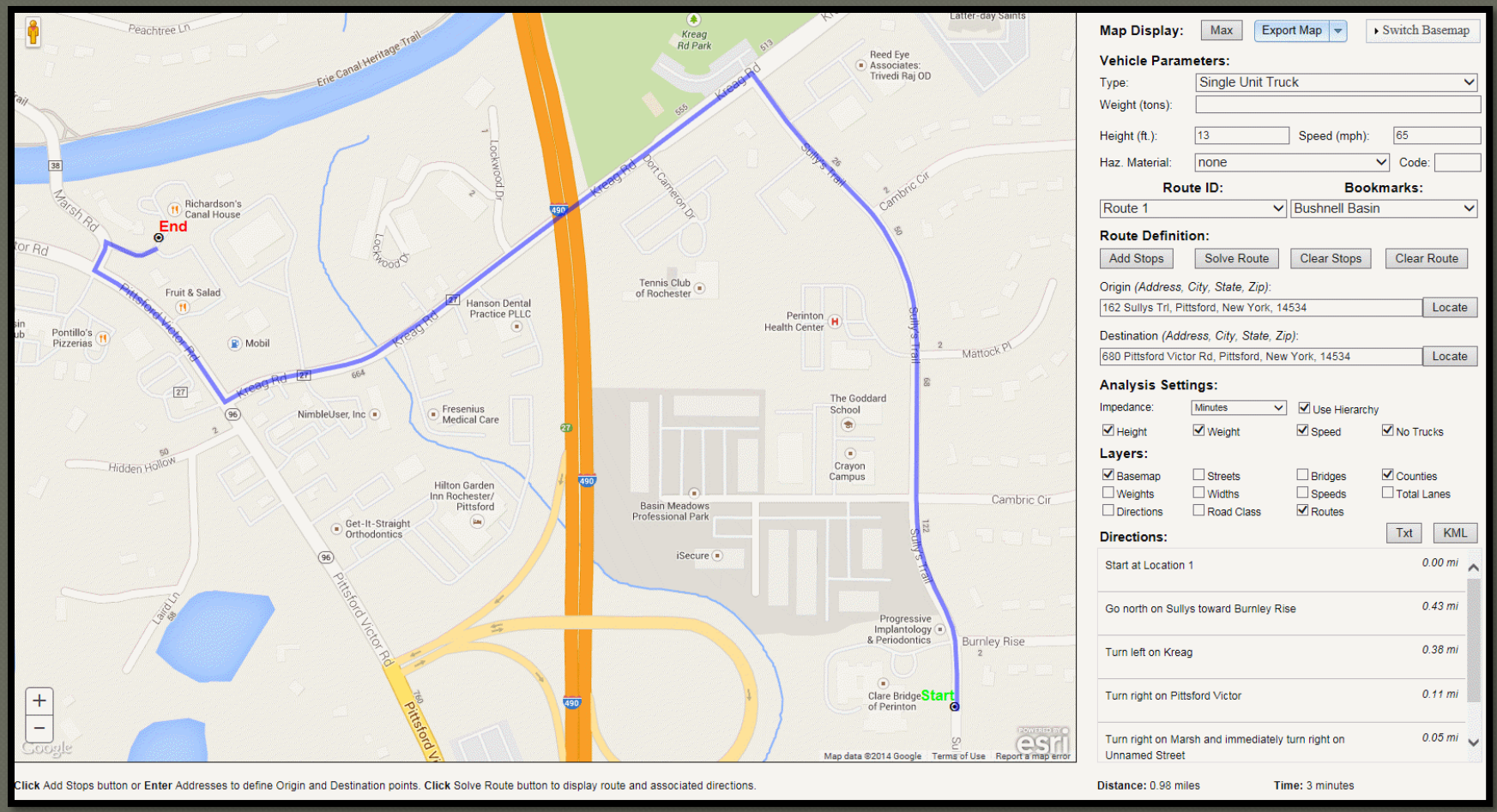
StreetMap Premium TomTom
32 Restrictions
6 Parameterized

Network Datasets Restrictions

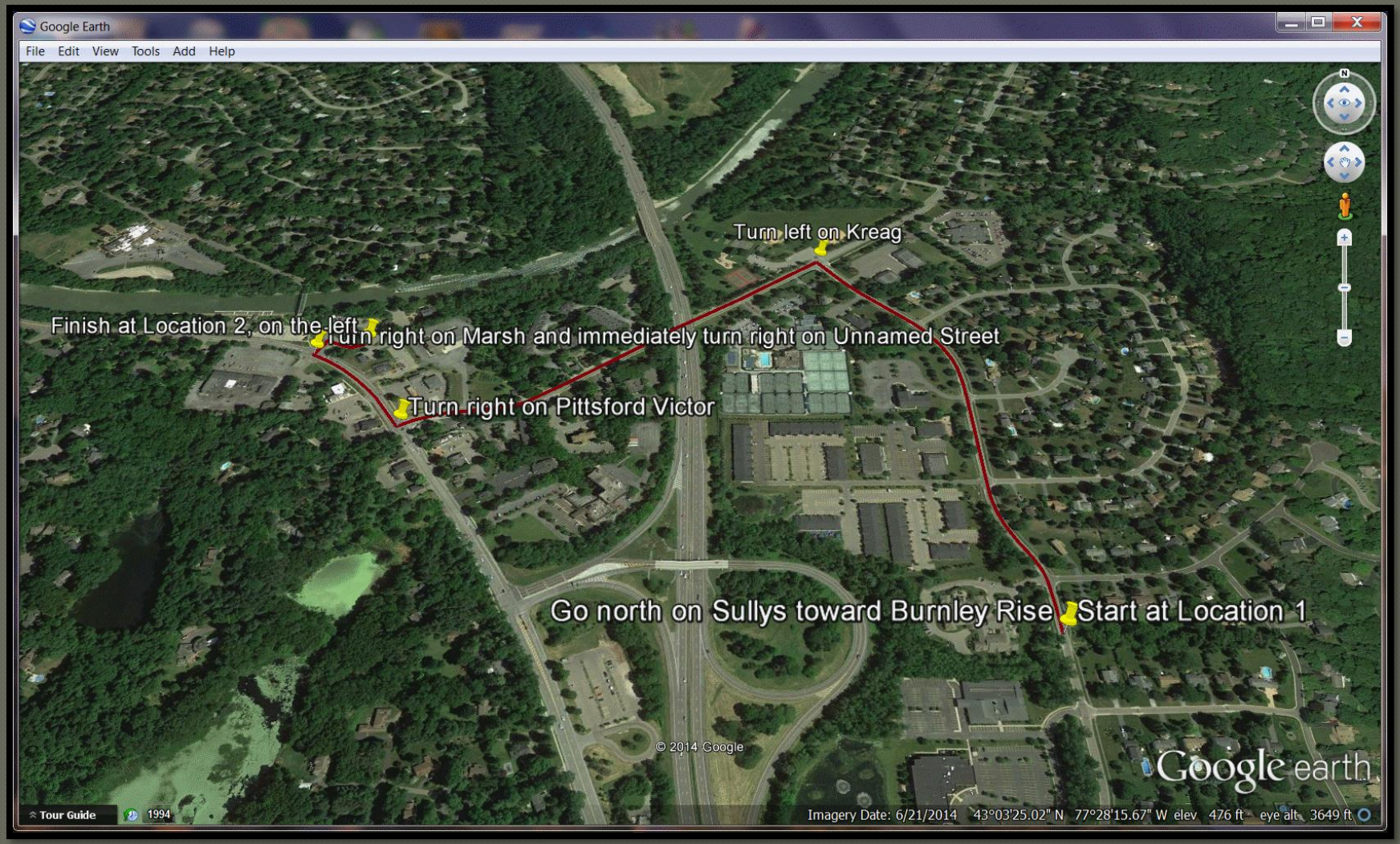
Restriction	Preference	Value
☐ Any Hazmat Prohibited	Prohibited	
☑ Avoid Carpool Roads	Prohibited	
☑ Avoid Express Lanes	Prohibited	
☐ Avoid Ferries	Avoid: Medium	
☑ Avoid Gates	Avoid: Medium	
☐ Avoid Limited Access Roads	Avoid: Medium	
☑ Avoid Private Roads	Avoid: Medium	
☐ Avoid Toll Roads	Avoid: Medium	
☑ Avoid Unpaved Roads	Avoid: High	
☐ Axle Count Restriction	Prohibited	0.000000
☐ Driving a Bus	Prohibited	
☐ Driving a Delivery Vehicle	Prohibited	
☐ Driving a Taxi	Prohibited	
☐ Driving a Truck	Prohibited	
☑ Driving an Automobile	Prohibited	
☐ Driving an Emergency Vehicle	Prohibited	
☐ Height Restriction	Prohibited	0.000000
☐ Kingpin to Rear Axle Length Restriction	Prohibited	0.000000
☐ Length Restriction	Prohibited	0.000000
☐ Riding a Motorcycle	Prohibited	
☑ Roads Under Construction Prohibited	Prohibited	
☐ Semi or Tractor with One or More Trailers Prohib...	Prohibited	
☐ Single Axle Vehicles Prohibited	Prohibited	
☐ Tandem Axle Vehicles Prohibited	Prohibited	
☑ Through Traffic Prohibited	Avoid: High	
☐ Truck with Trailers Restriction	Prohibited	0.000000
☐ Use Preferred Hazmat Routes	Prefer: Medium	
☐ Use Preferred Truck Routes	Prefer: Medium	
☐ Walking	Prohibited	
☐ Weight per Axle Restriction	Prohibited	0.000000
☐ Weight Restriction	Prohibited	0.000000
☐ Width Restriction	Prohibited	0.000000

StreetMap Premium HERE
32 Restrictions
8 Parameterized

Custom Routing Application using Network Analyst and StreetMap



Route Exported to Google Earth - KML



Summary

It is possible to customize ArcGIS in a variety of manners to add specific functionality not available in native ArcGIS.

This can be a specific tool or command or a complete application.

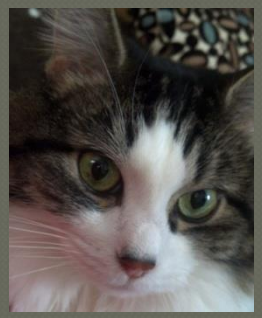
ArcGIS provides the user-interface and database functionality for customization.

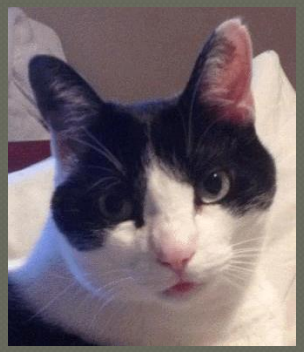
References

"Assessing the Use of Navigation Systems in the Trucking Industry", American Transportation Research Institute 2013

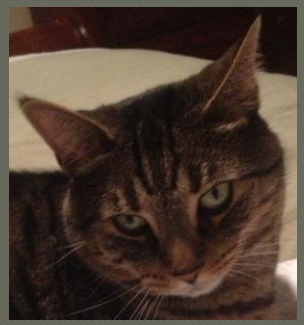
"Strikes on Low Clearance Bridges by Over-Height Trucks in New York State", City College of New York 2013
http://www.rita.dot.gov/utc/publications/spotlight/2013_01/html/spotlight_0113.html

Contact Info





Stuart, Emma, Sally, David,
Oliver and StanLee ask
How do we get to know CEDRA



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