



2023 Fall Conference at Ashore Resort & Beach Club
Ocean City, Maryland

Utilizing Unmanned Aerial Vehicles & Data in Geotechnical Analysis & Construction

Mike Close, P.E. M.S.

September 29, 2023

BIOGRAPHY

- 40 years of engineering experience
- Bachelors & Masters degree in Civil Engineering
- Licensed Unmanned Aerial Vehicle Pilot
- Licensed Professional Engineer in Maryland, Michigan, North Carolina, South Carolina, & Virginia

ABSTRACT

Utilizing Unmanned Aerial Vehicles & Data in Geotechnical Analysis & Construction

Brief overview of presentation

- How can professionals use Unmanned Aerial Vehicles (UAVs) or drones to do more in less time?
- What online data and tools are available to make the most of the data collected using drones (UAVs)?
- 1.0 PDH

Agenda

**Introduction
&
Definition of
Terms**

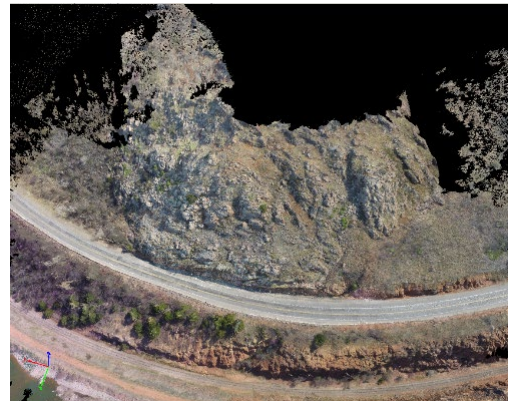


**UAV Recon
vs.
Traditional**



**Post
Processing**

Applications



Conclusions

How Many of Your Firms/Agencies utilize UAV Technology



Introduction & Definition of Terms



Introduction & Definition of Terms

Basic Terminology of Unmanned Aerial Systems (UAS)

Unmanned Aerial System (UAS) consists of:

- **UNMANNED AERIAL VEHICLE (UAV)** commonly referred to as “drones”.
- A **PILOT** the operator responsible for safe operation of the flight
- **SOFTWARE** – a variety of software is available to aid in the pilot in safely operating the drone to obtain data required to complete mission objectives.
- **SENSORS & ACCESSORIES** – Any combination of customizable data collection devices that store data and provide information to the pilot.

Mission Planning and Safety

Regulations for Commercial Flights

- **Part 107**
 - Pass FAA Knowledge Test
 - 16 Years Old
- **Section 333 Exemption**
 - Part 61 Pilot's Licensed & current
 - Requires Visual Observer
 - Airman Medical Certificate



UAV Recon vs. Traditional



TRADITIONAL SITE CHARACTERIZATION

- Access limitations
- Time intensive
- Physical demands
- Expensive (to get what we want)
- Subject to human error
- Spatial gaps (hundreds of points)

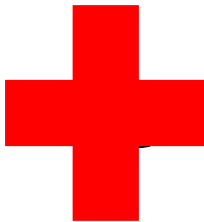


UAV SITE CHARACTERIZATION

- Safe
- Quick & easy
- Affordable
- Thorough (millions and millions of points)



UAV RECON VS. TRADITIONAL



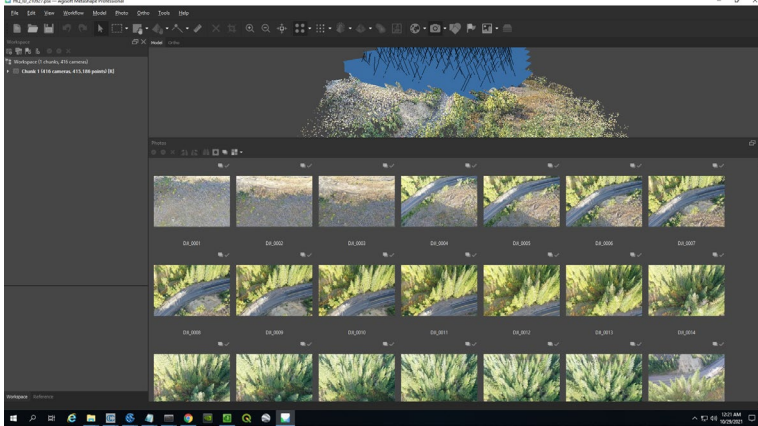
Post Processing



Processing—Drone Images



Raw images



**Photogrammetry
(SfM) software**

Agisoft
Metashape
/Pix4D,
etc.



Ground control panels

Point Cloud

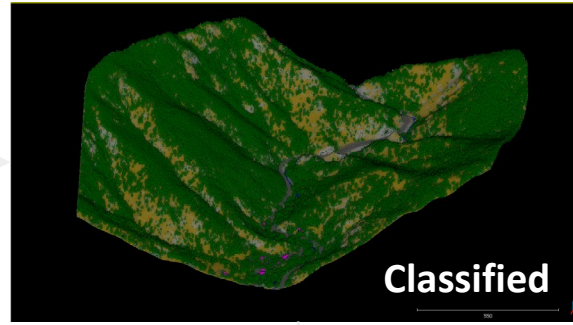


Orthomosaic

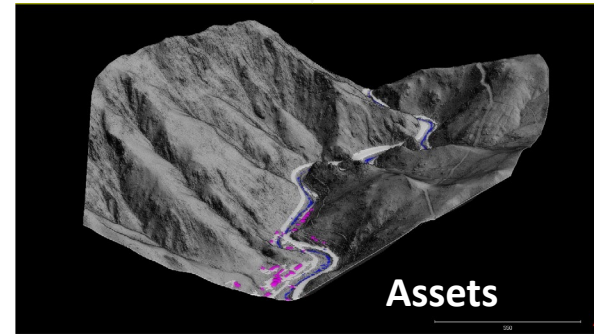
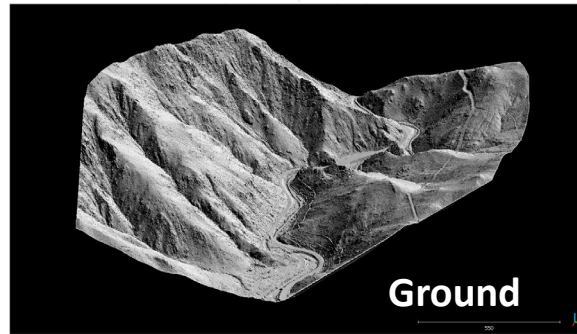


Geohazard Workflow

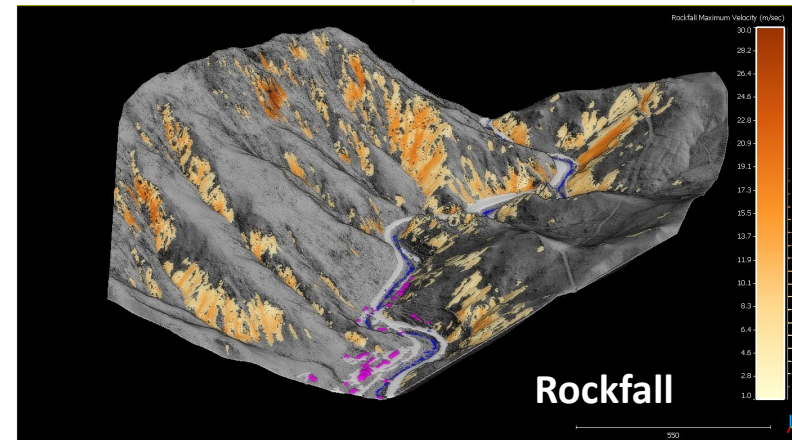
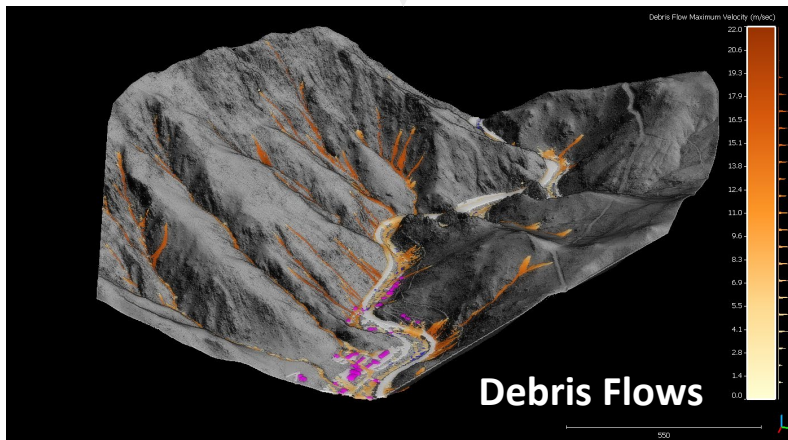
Classification



Feature extraction



Modeling



ML/AI/Runout models, etc.

Applications



Applications

What can you do with Point Clouds?

- Engineering & Design
- Planning & Logistics
- Post-construction Monitoring
- Change Detection & Monitoring
- Susceptibility & Risk Modeling
- Asset Management

Applications

What can you do with Point Clouds?

- Engineering & Design
- Planning & Logistics
- Post-construction Monitoring

REACTIVE

- Change Detection & Monitoring
- Susceptibility & Risk Modeling
- Asset Management

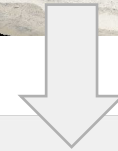
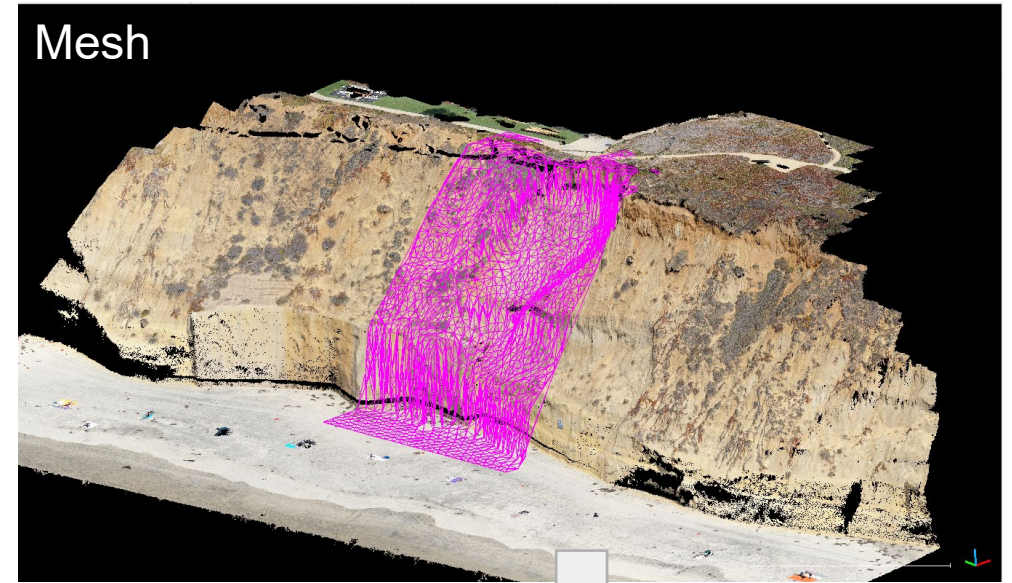
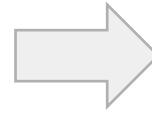
Applications

What can you do with Point Clouds?

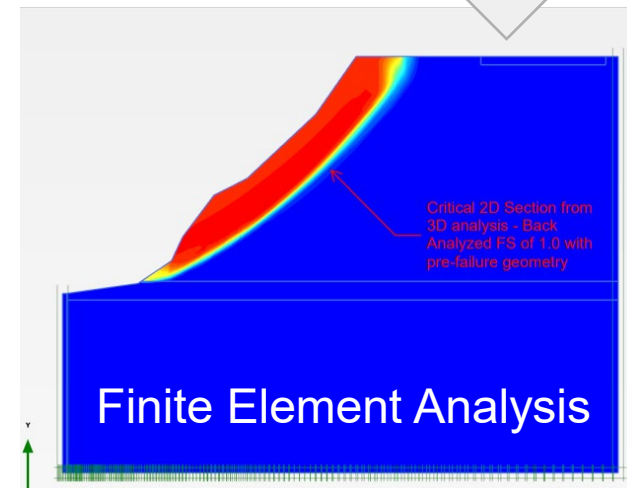
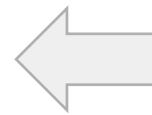
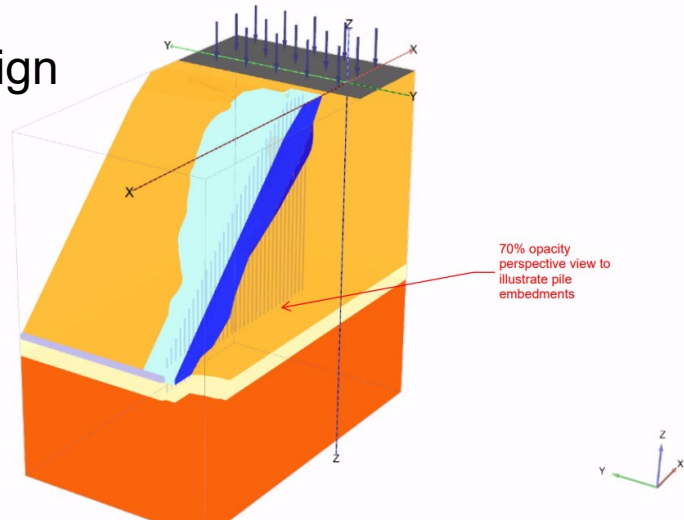
- Engineering & Design
- Planning & Logistics
- Post-construction Monitoring
- Change Detection & Monitoring
- Susceptibility & Risk Modeling
- Asset Management

PROACTIVE

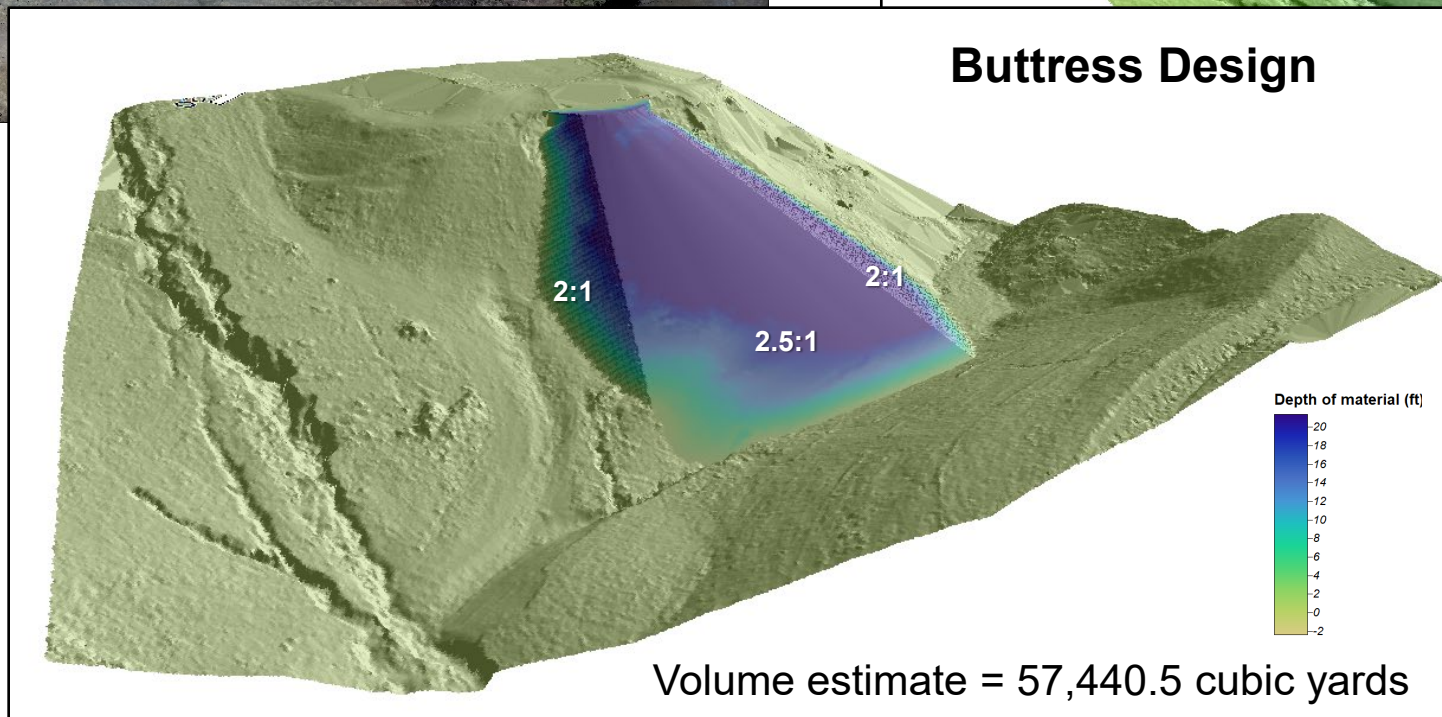
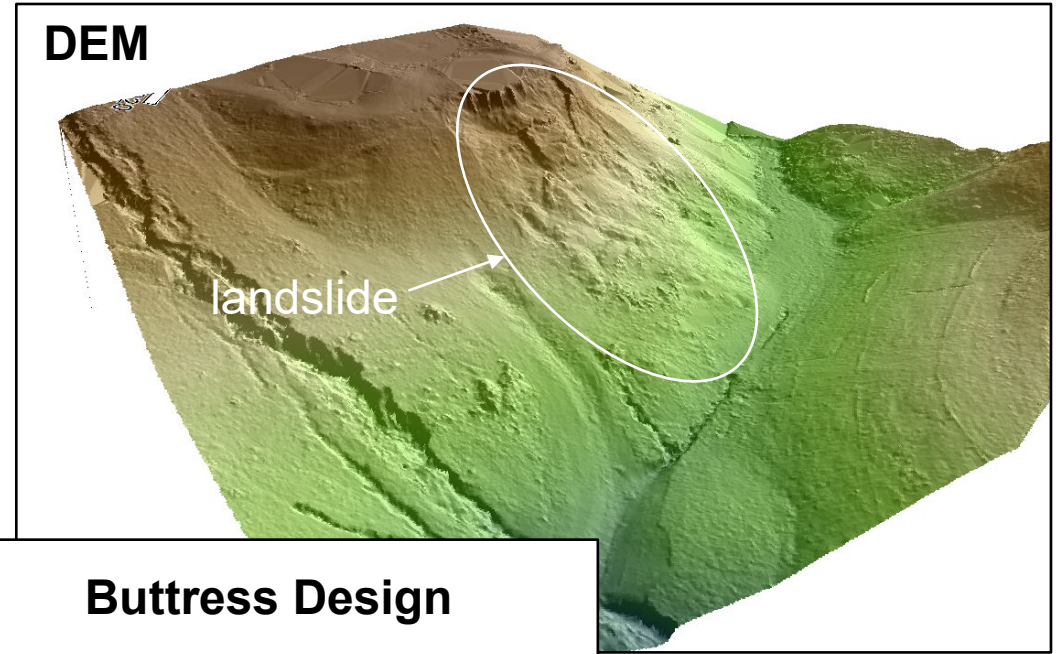
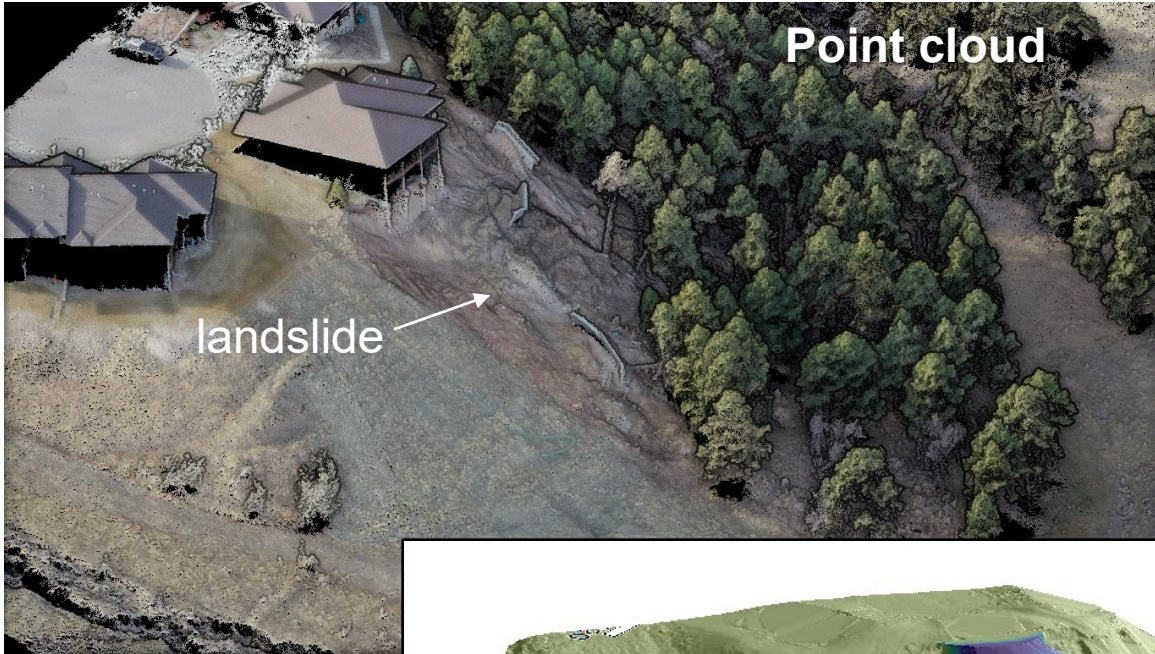
Applications—Design & Engineering



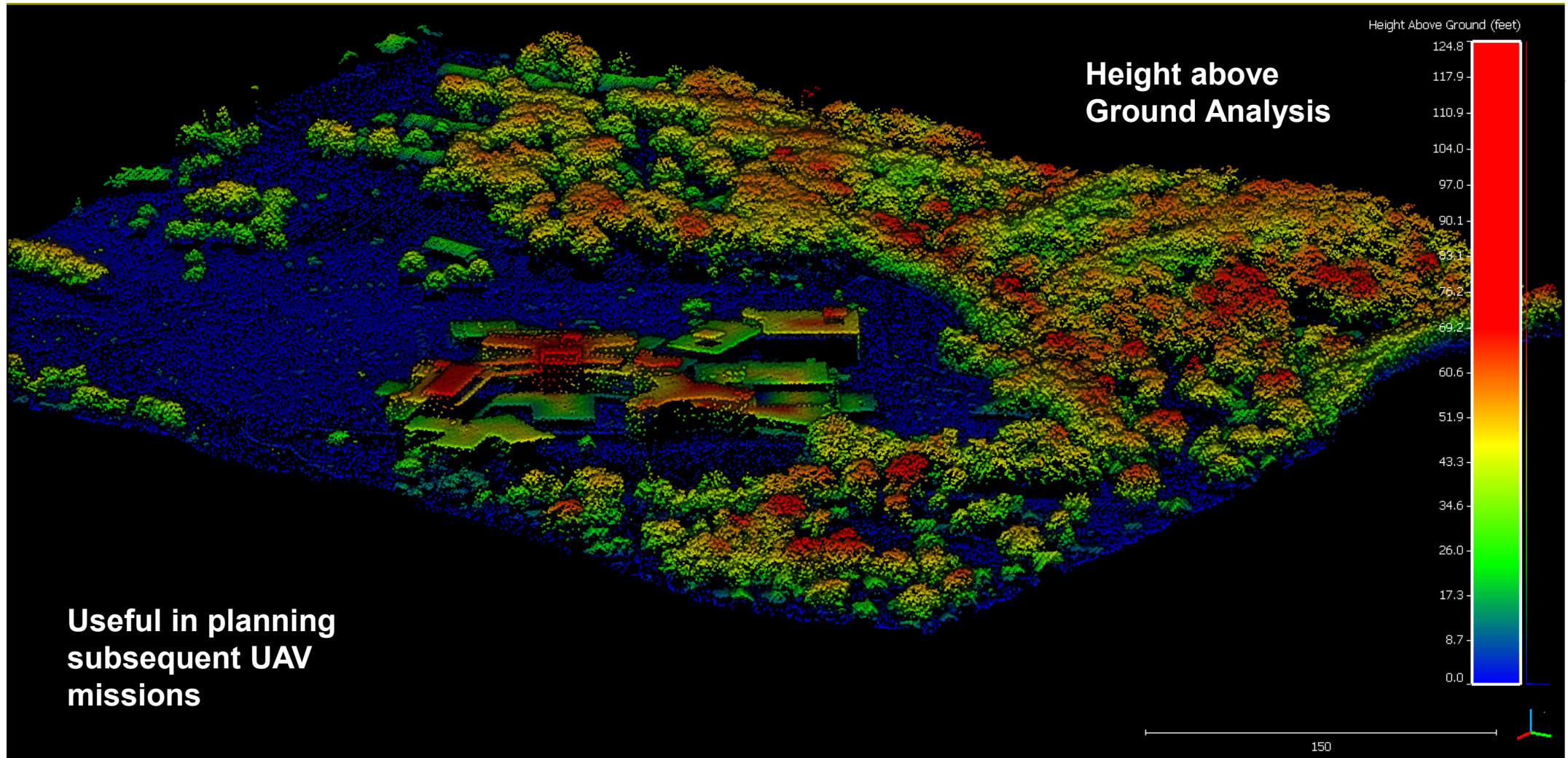
Robust Design



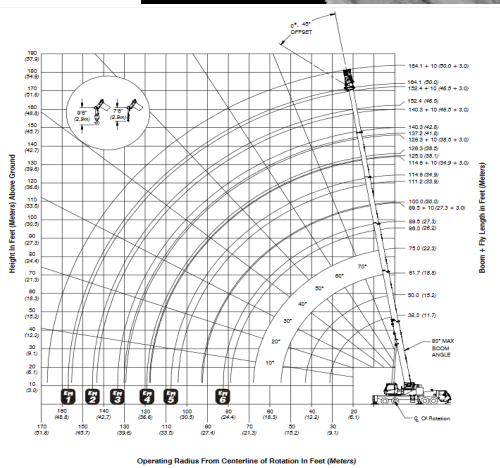
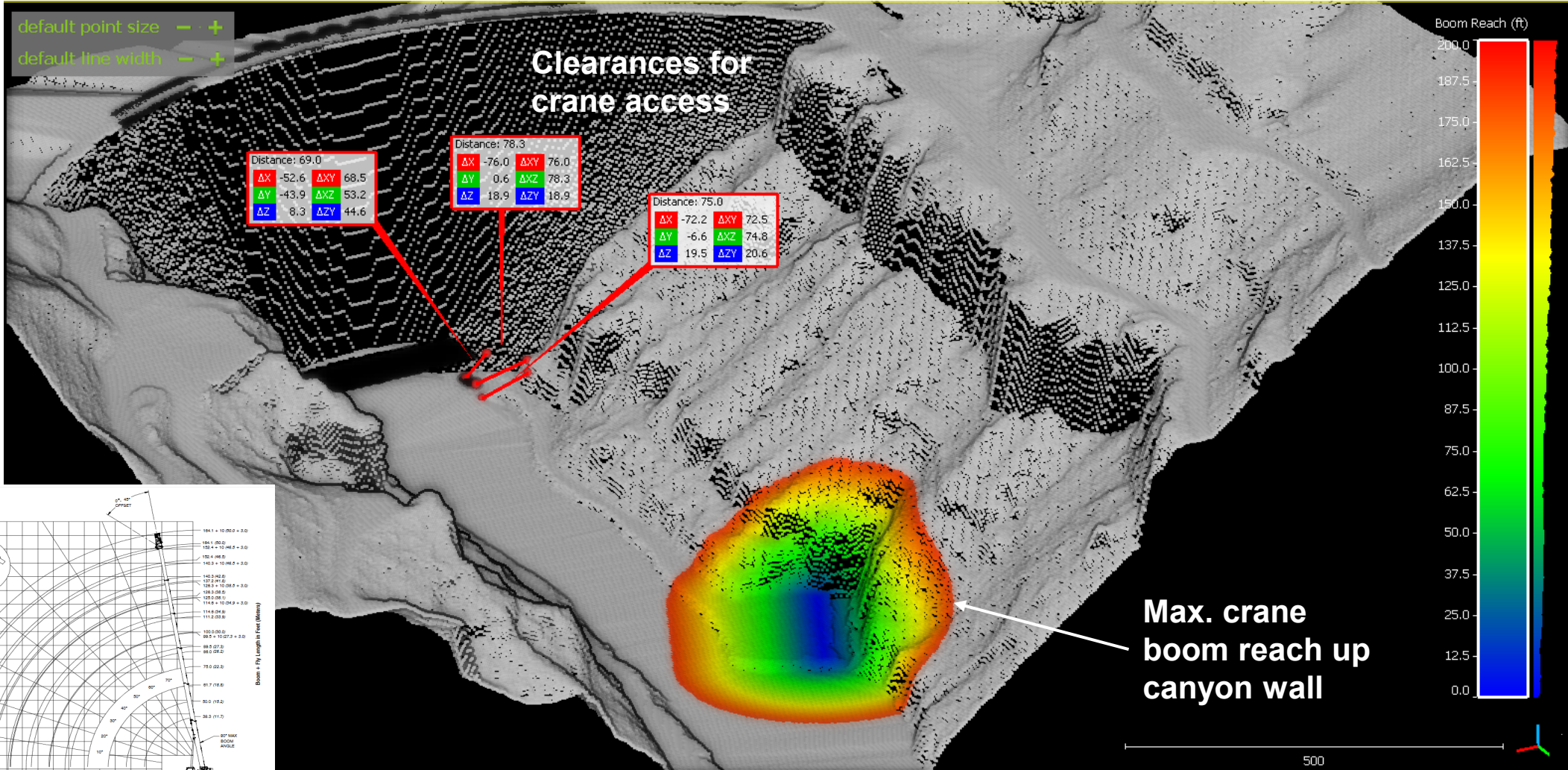
Applications—Design & Engineering



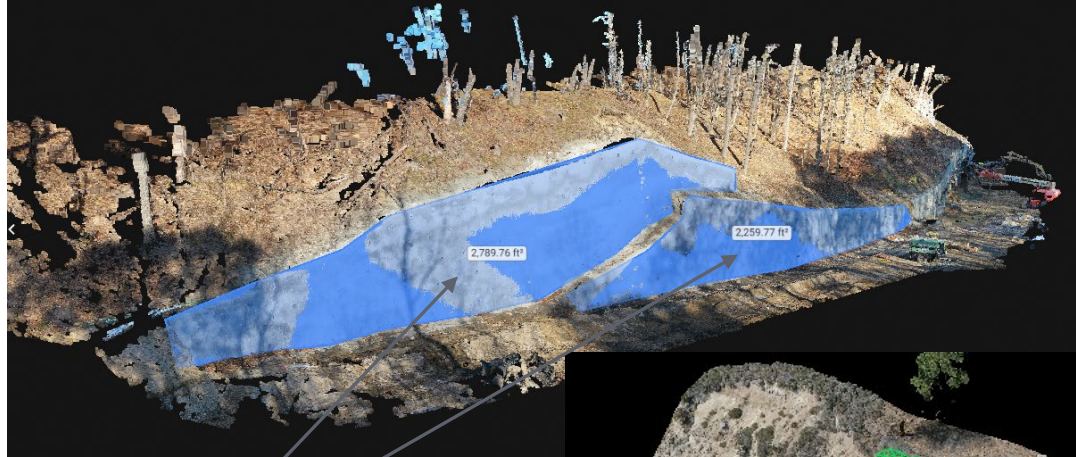
Applications—Planning & Logistics



Applications—Planning & Logistics



Applications—Post Construction Monitoring



3D As-Builts

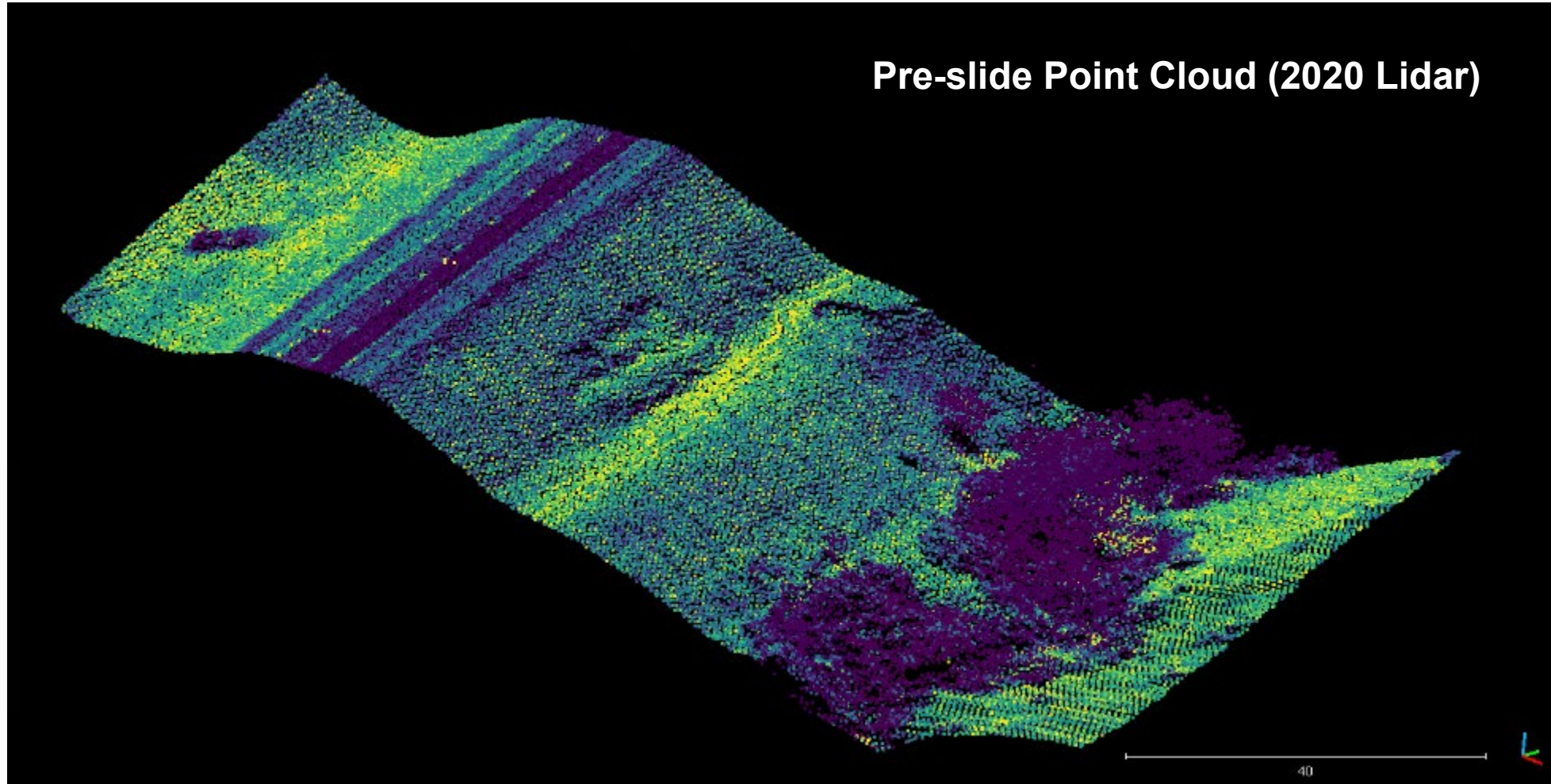
- Quality assurance
- Materials back-checking
- Warranty assurance
- Performance Monitoring

Shotcrete wall area:
5,118 sq. ft.

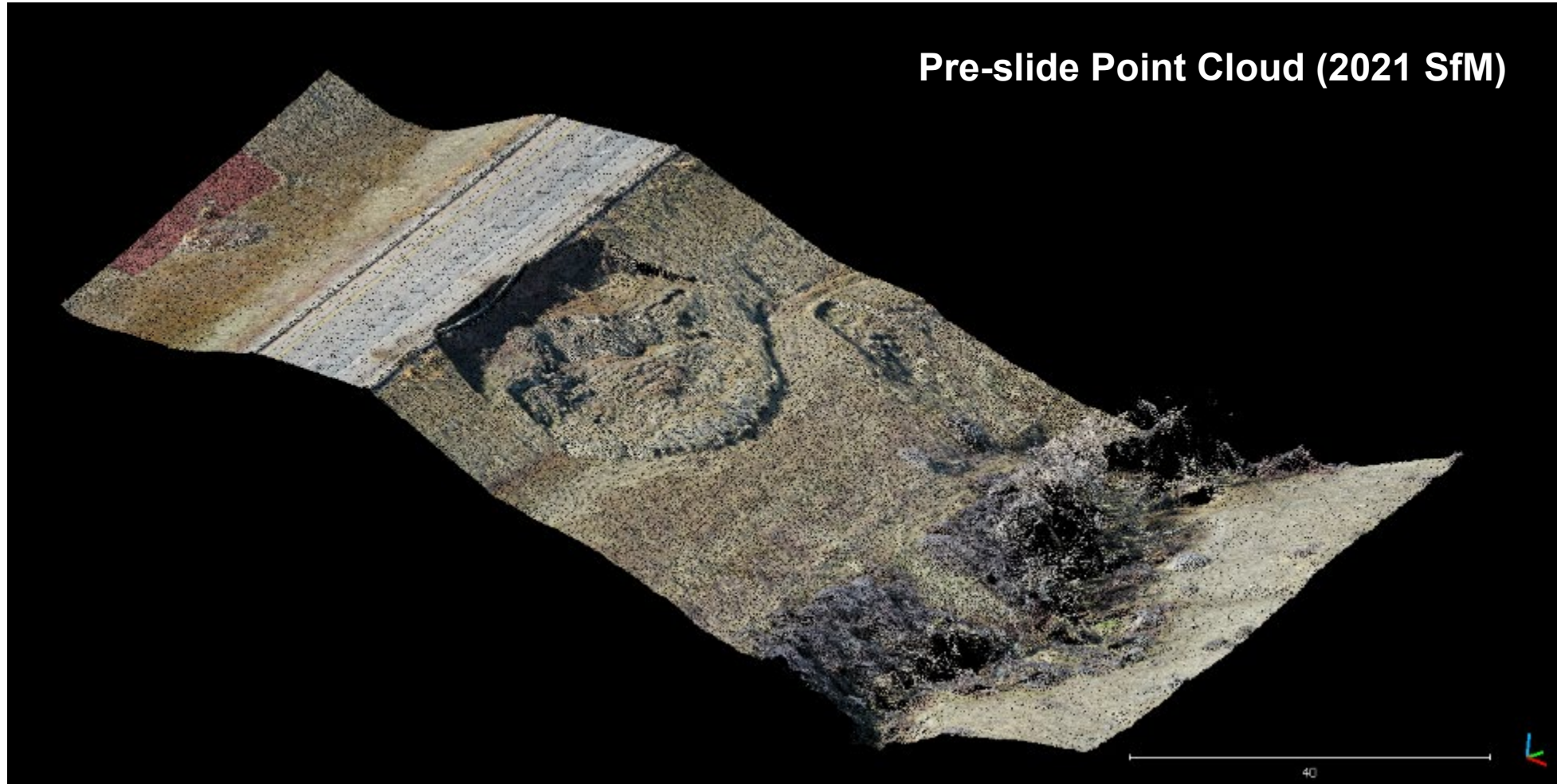


Draped mesh area: 193,762 sq. ft.

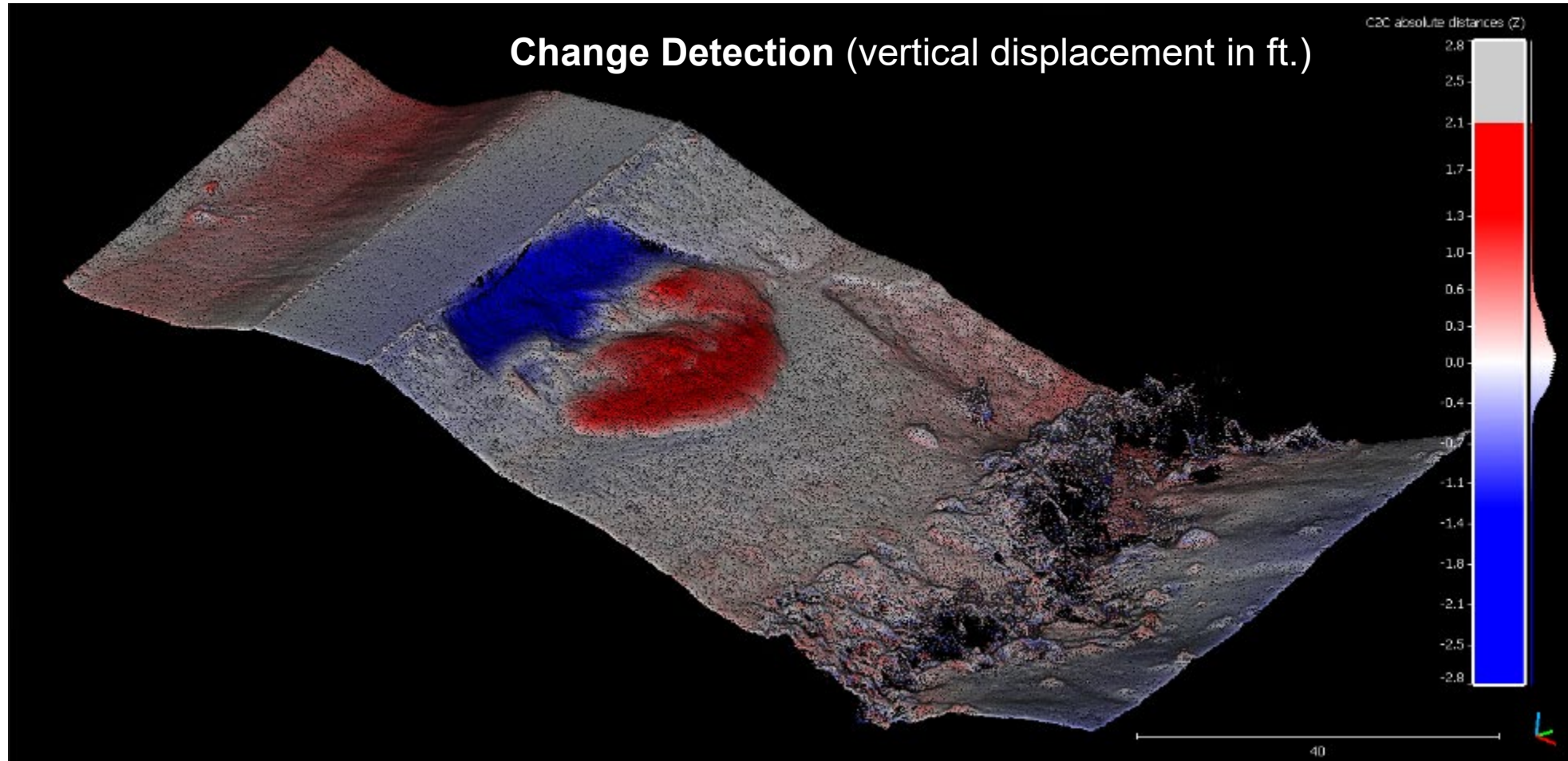
Applications—Change Detection & Monitoring



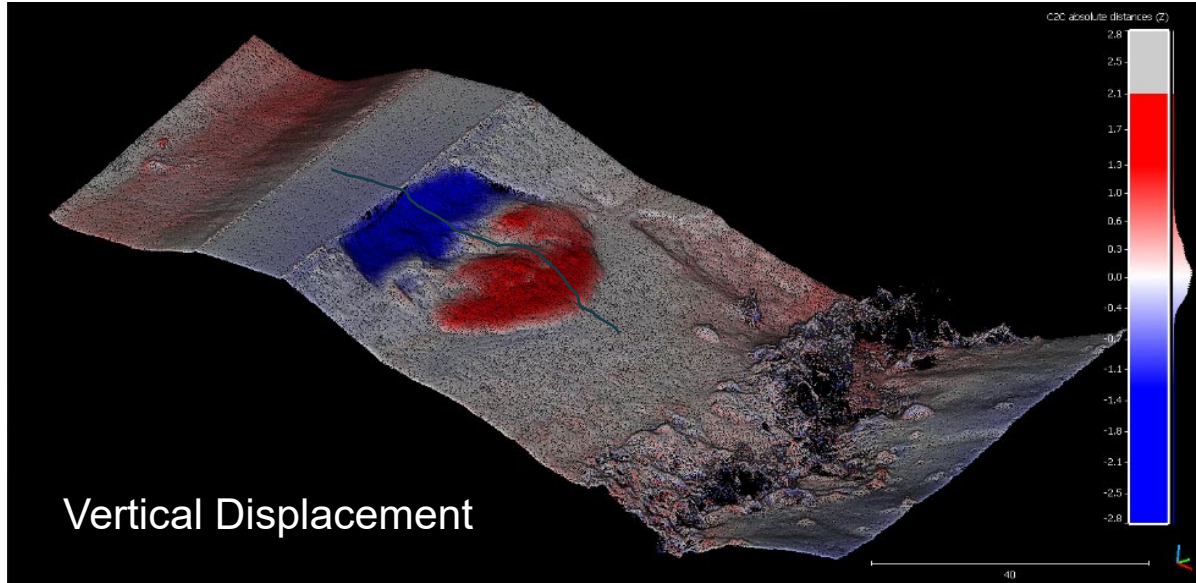
Applications—Change Detection & Monitoring



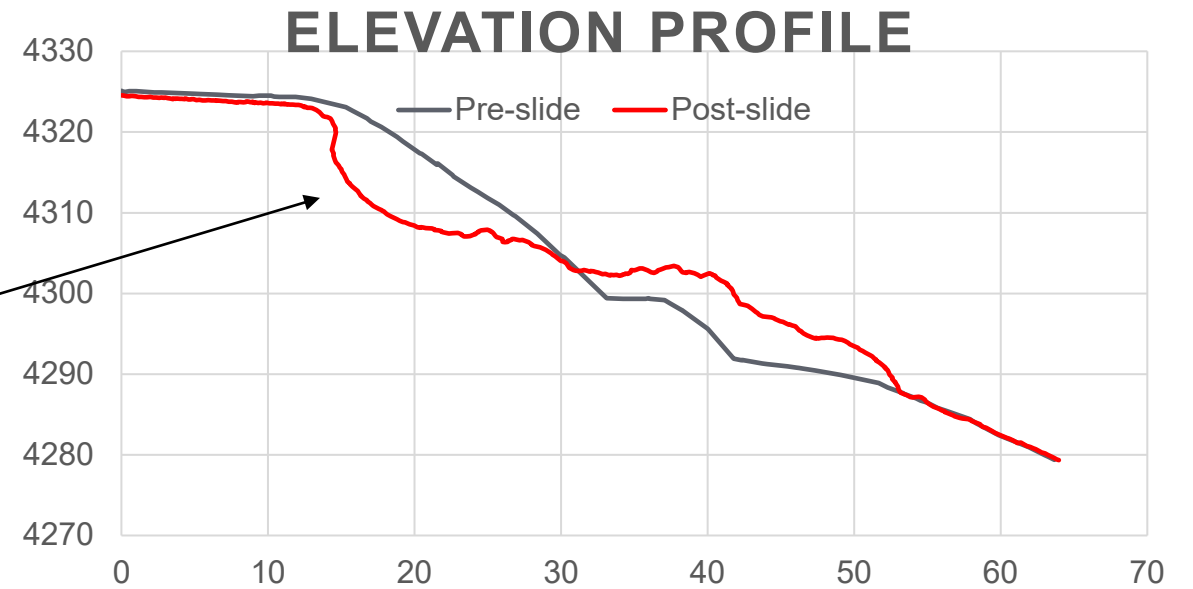
Applications—Change Detection & Monitoring



Applications—Change Detection & Monitoring



Failure surface



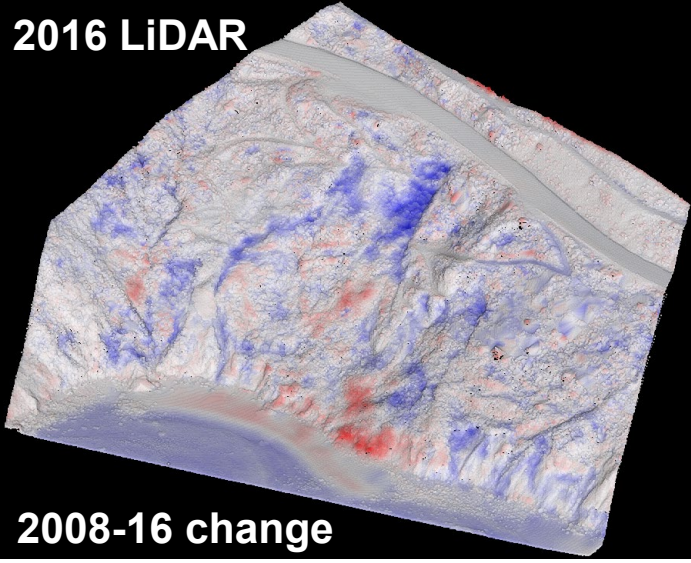
Applications—Change Detection & Monitoring

Cumulative
Vertical
displacement
(ft)

5.4
4.7
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
-4.0
-4.5

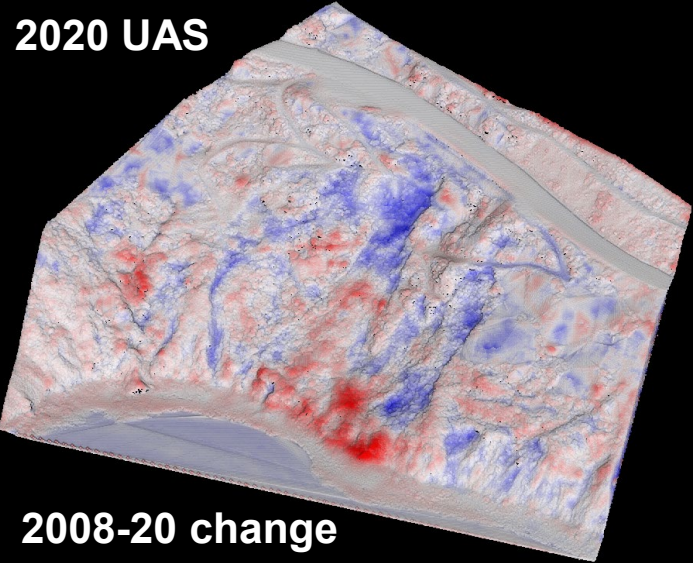


2016 LiDAR



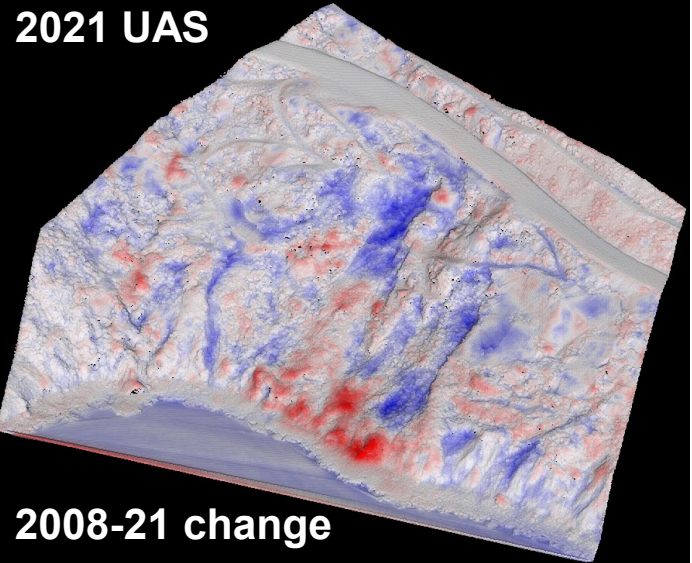
2008-16 change

2020 UAS

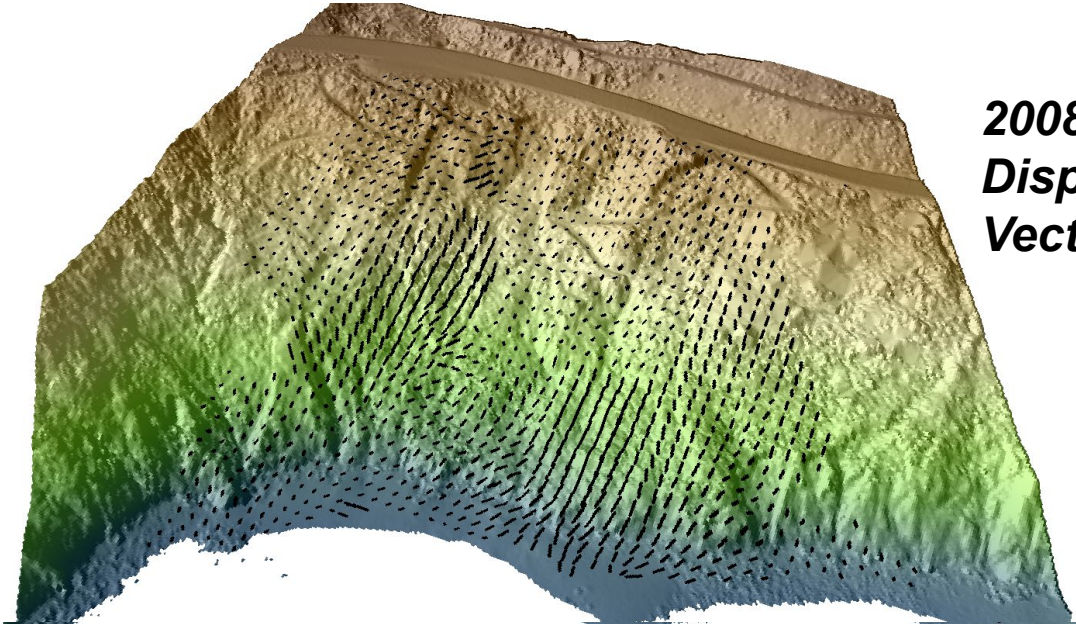


2008-20 change

2021 UAS

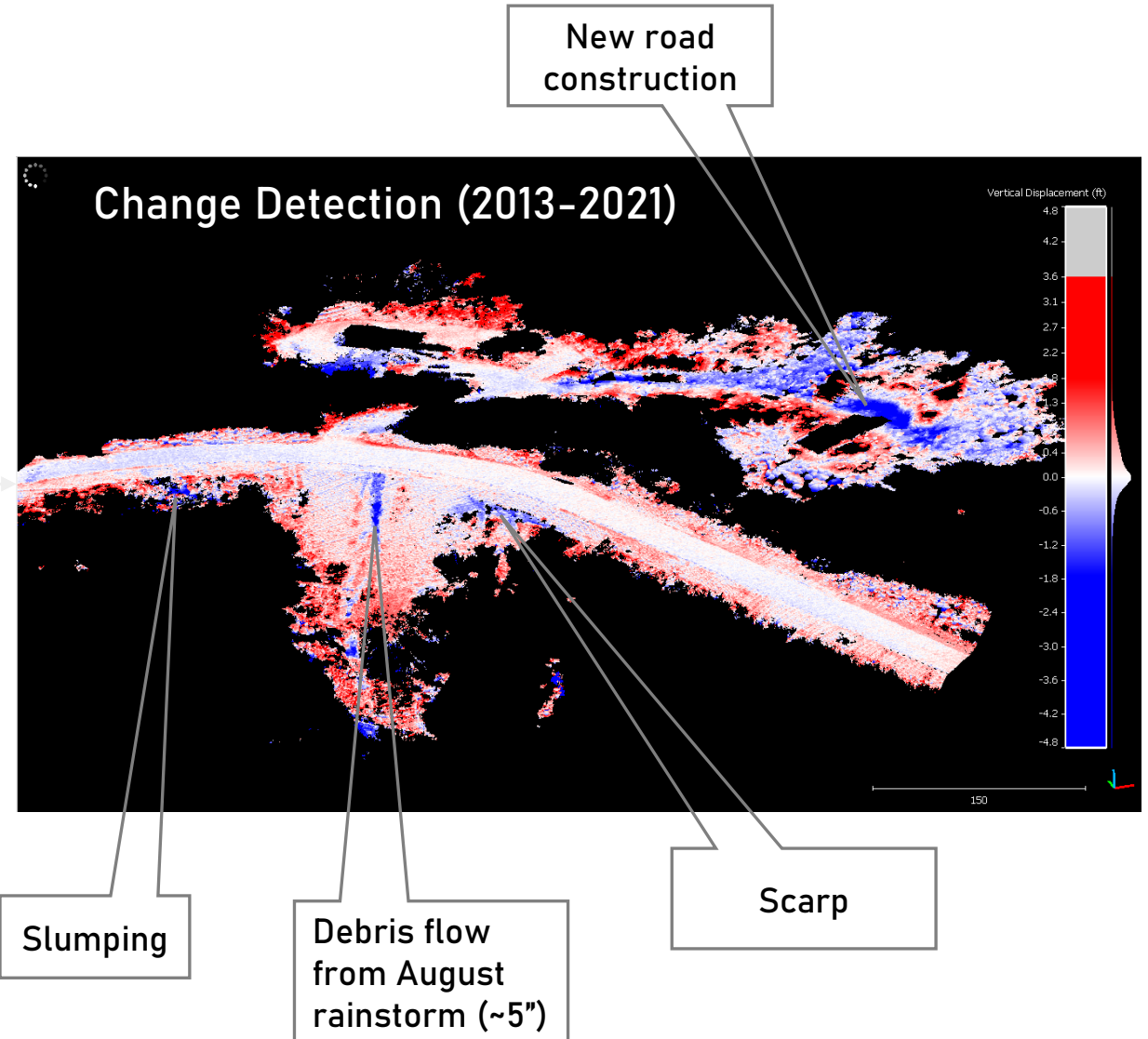
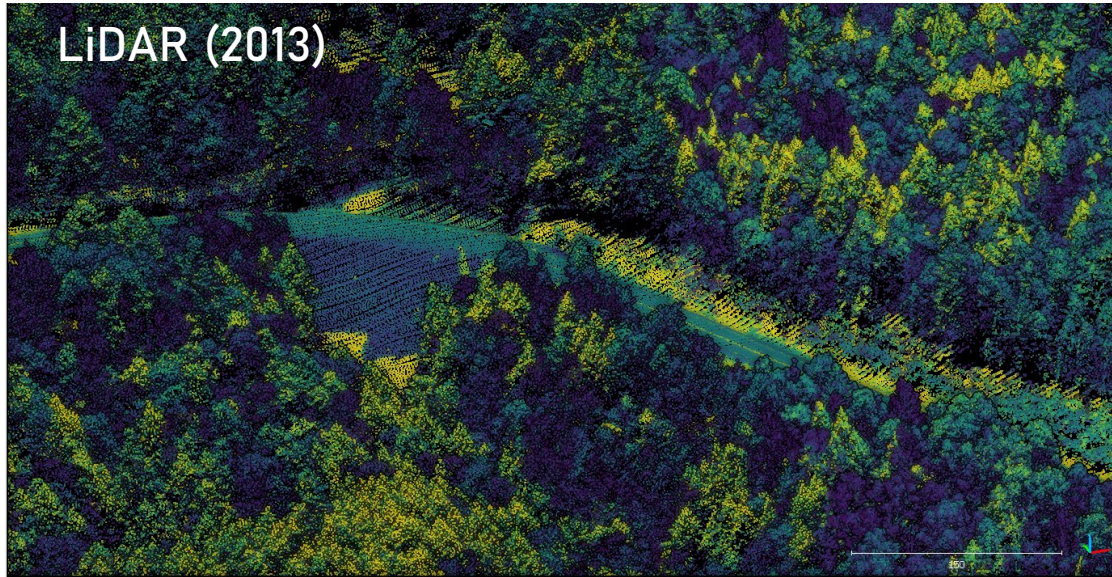


2008-21 change

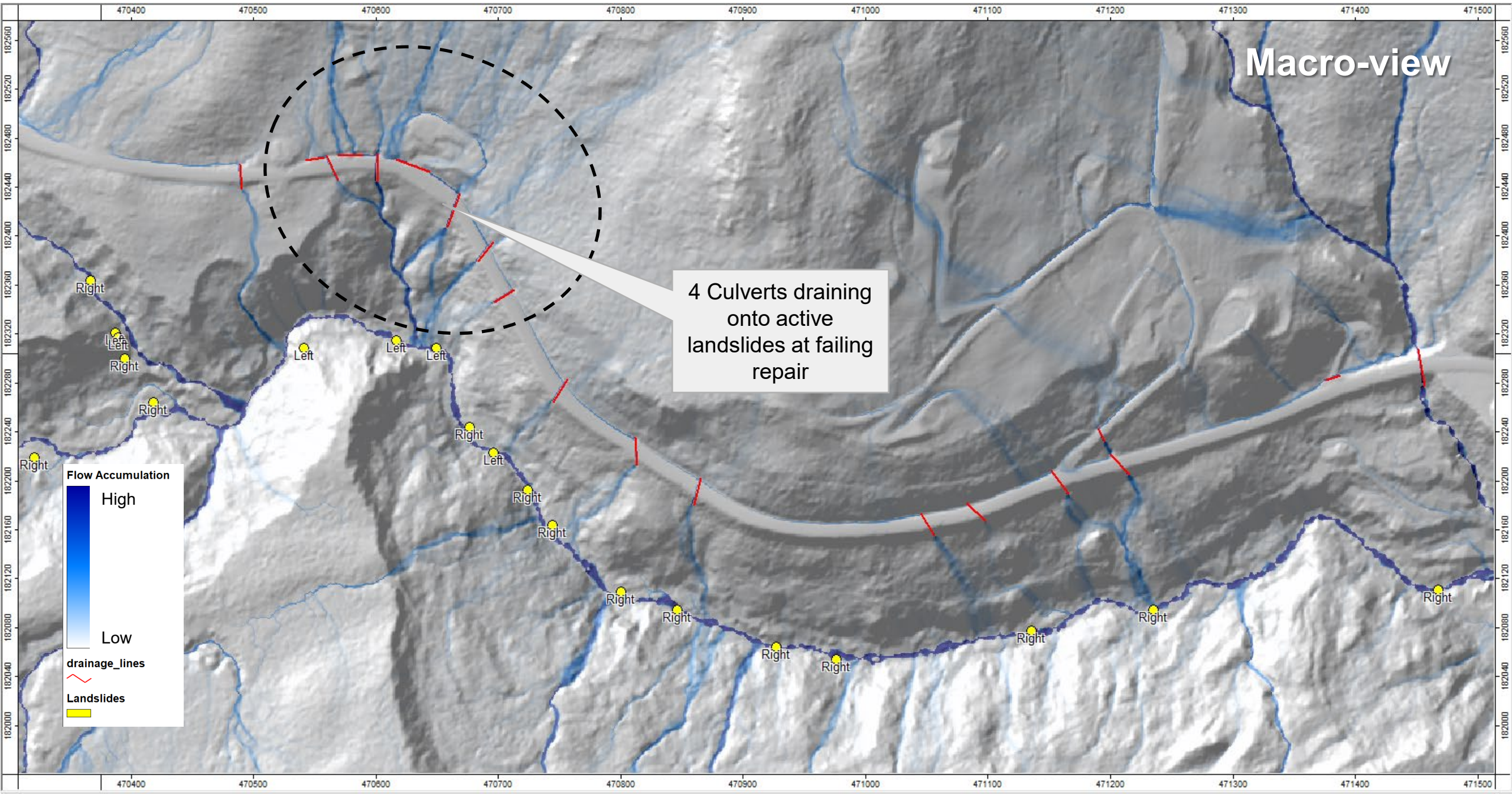


**2008-2021
Displacement
Vectors**

Applications—Change Detection & Monitoring



Applications—Change Detection & Monitoring



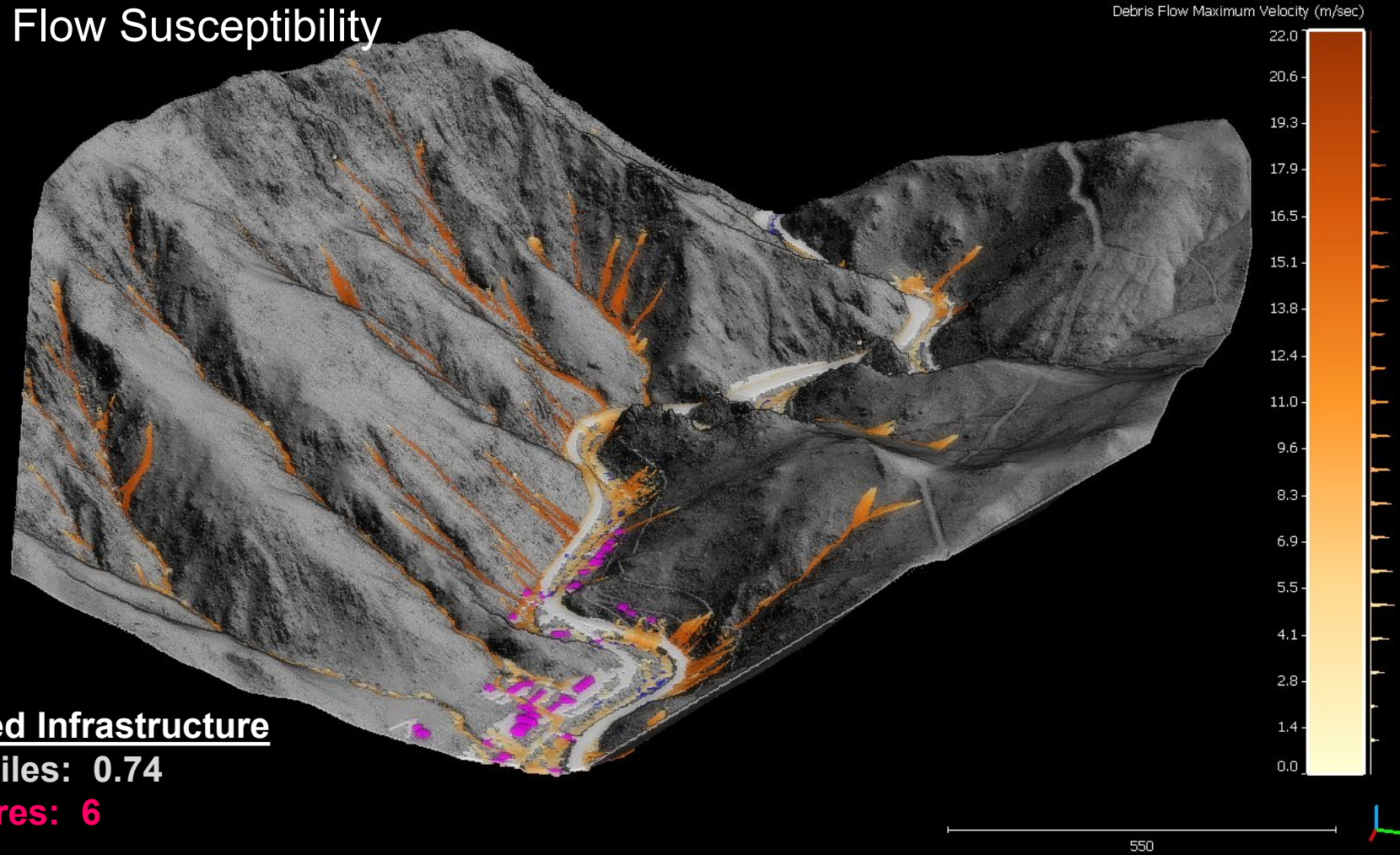
Applications—Susceptibility & Risk Modeling

Debris Flow Susceptibility Model

Impacted Infrastructure

Road miles: 0.74

Structures: 6



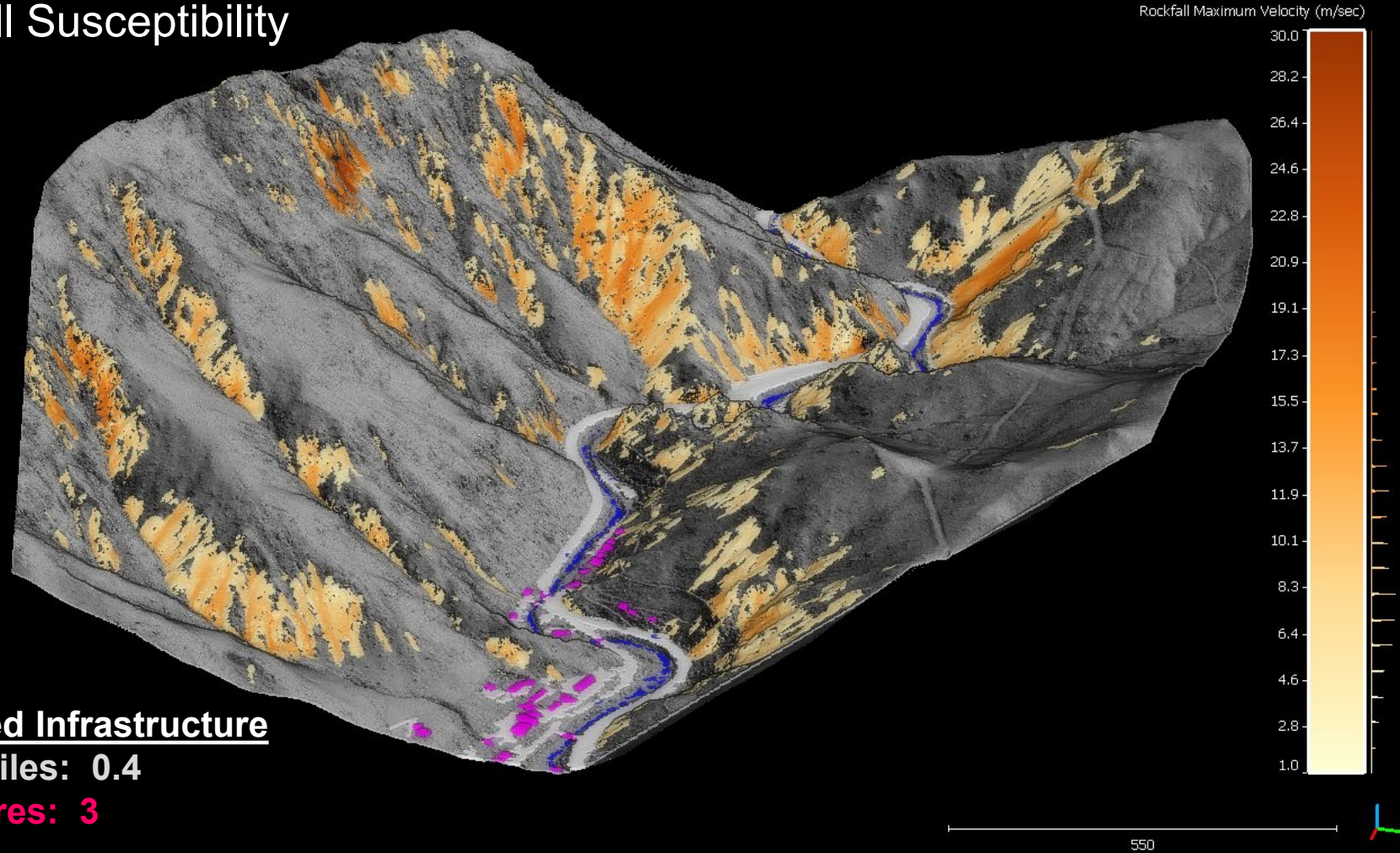
Applications—Susceptibility & Risk Modeling

Rockfall Susceptibility Model

Impacted Infrastructure

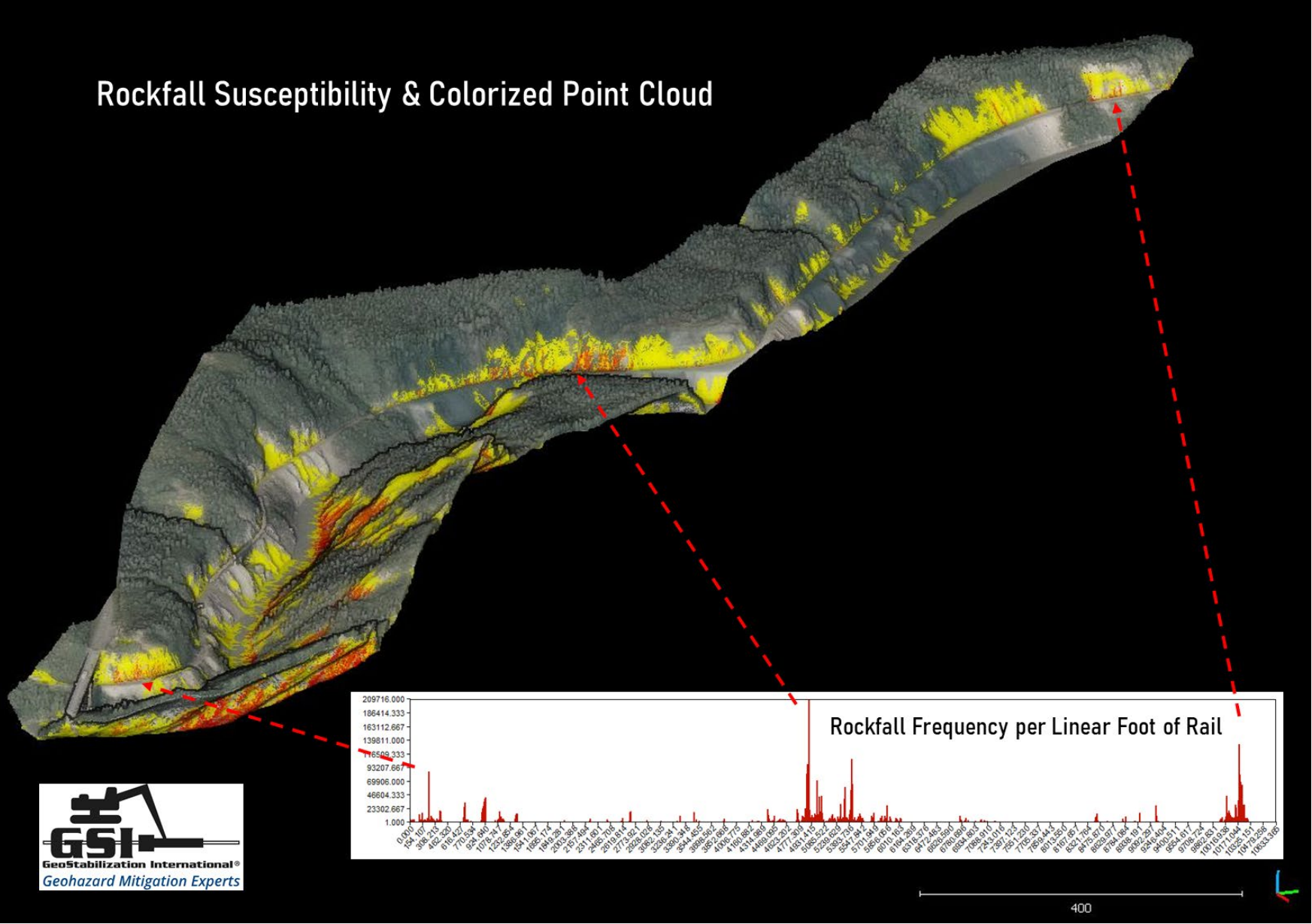
Road miles: 0.4

Structures: 3



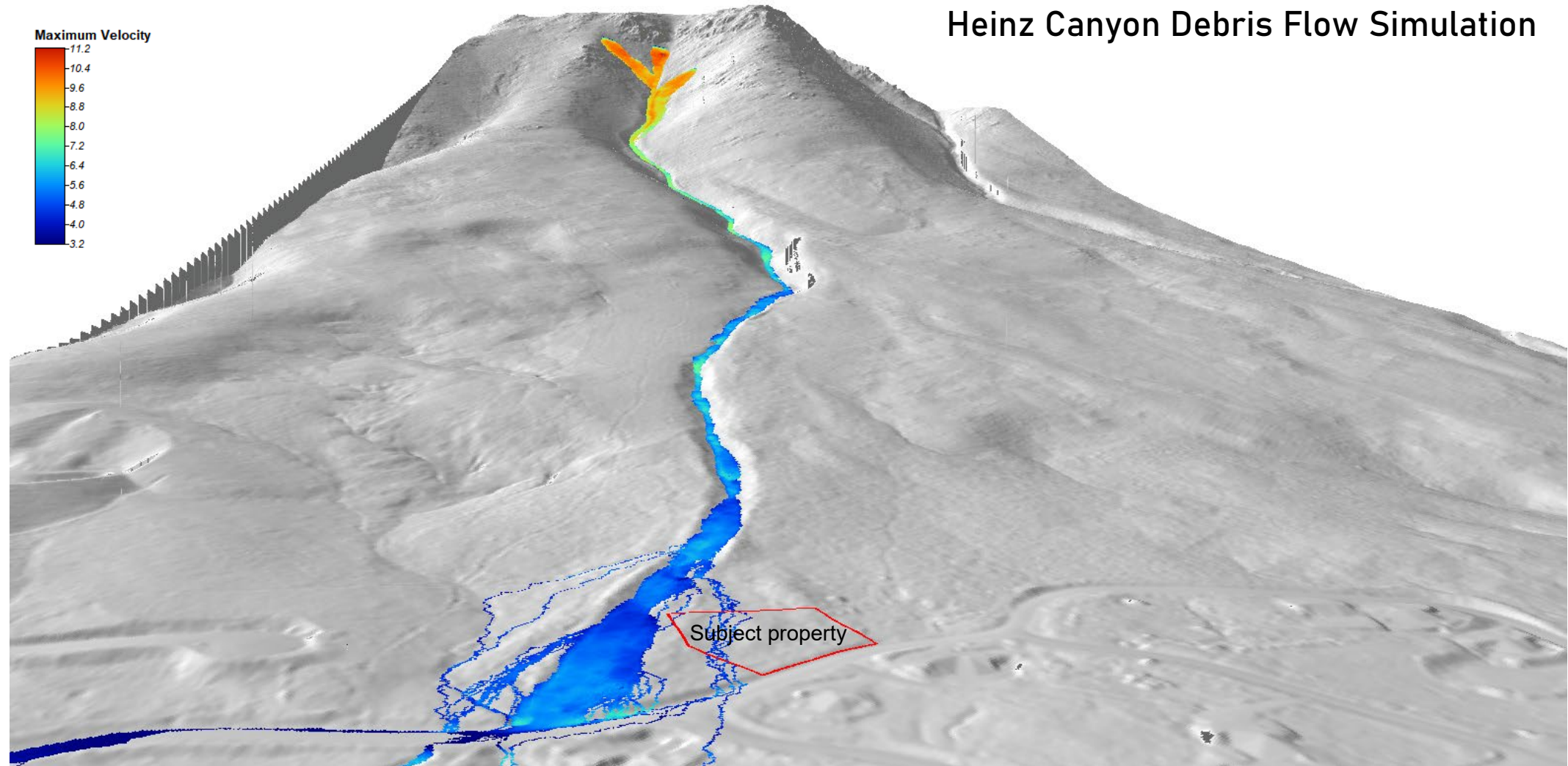
Applications—Susceptibility & Risk Modeling

Rockfall Susceptibility & Colorized Point Cloud



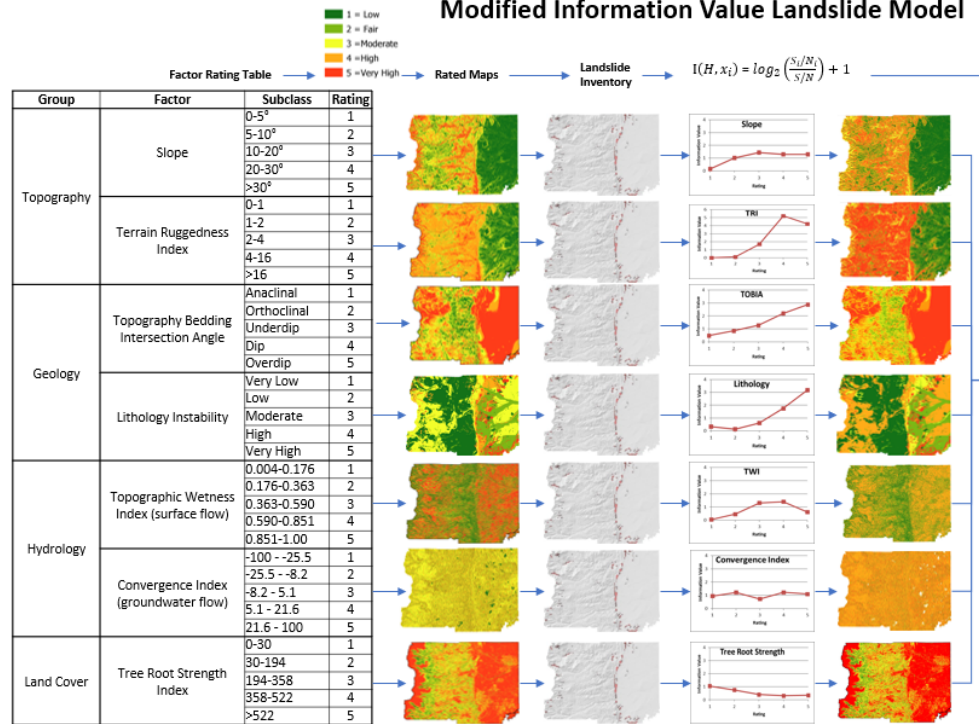
Applications— Susceptibility & Risk Modeling

Heinz Canyon Debris Flow Simulation

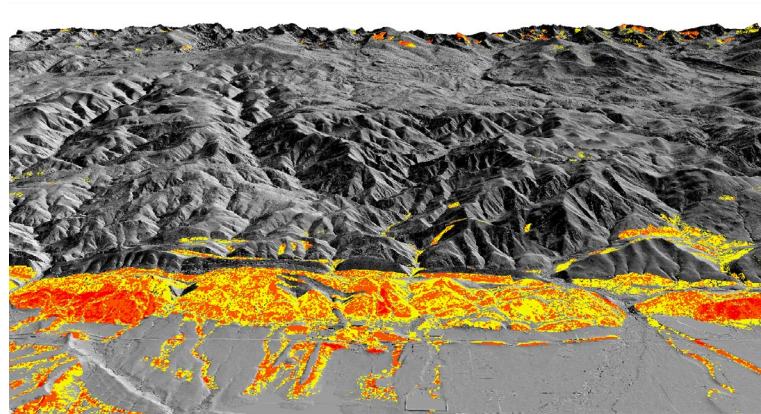
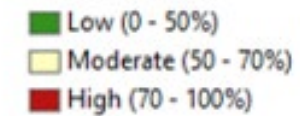
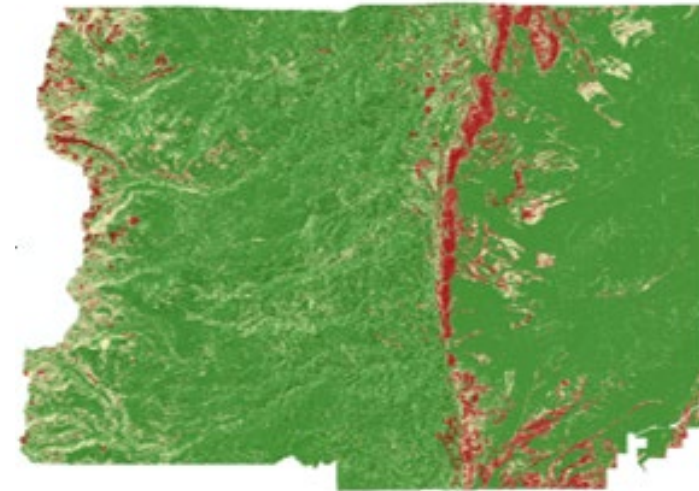


Applications— Susceptibility & Risk Modeling

Modified Information Value Landslide Model



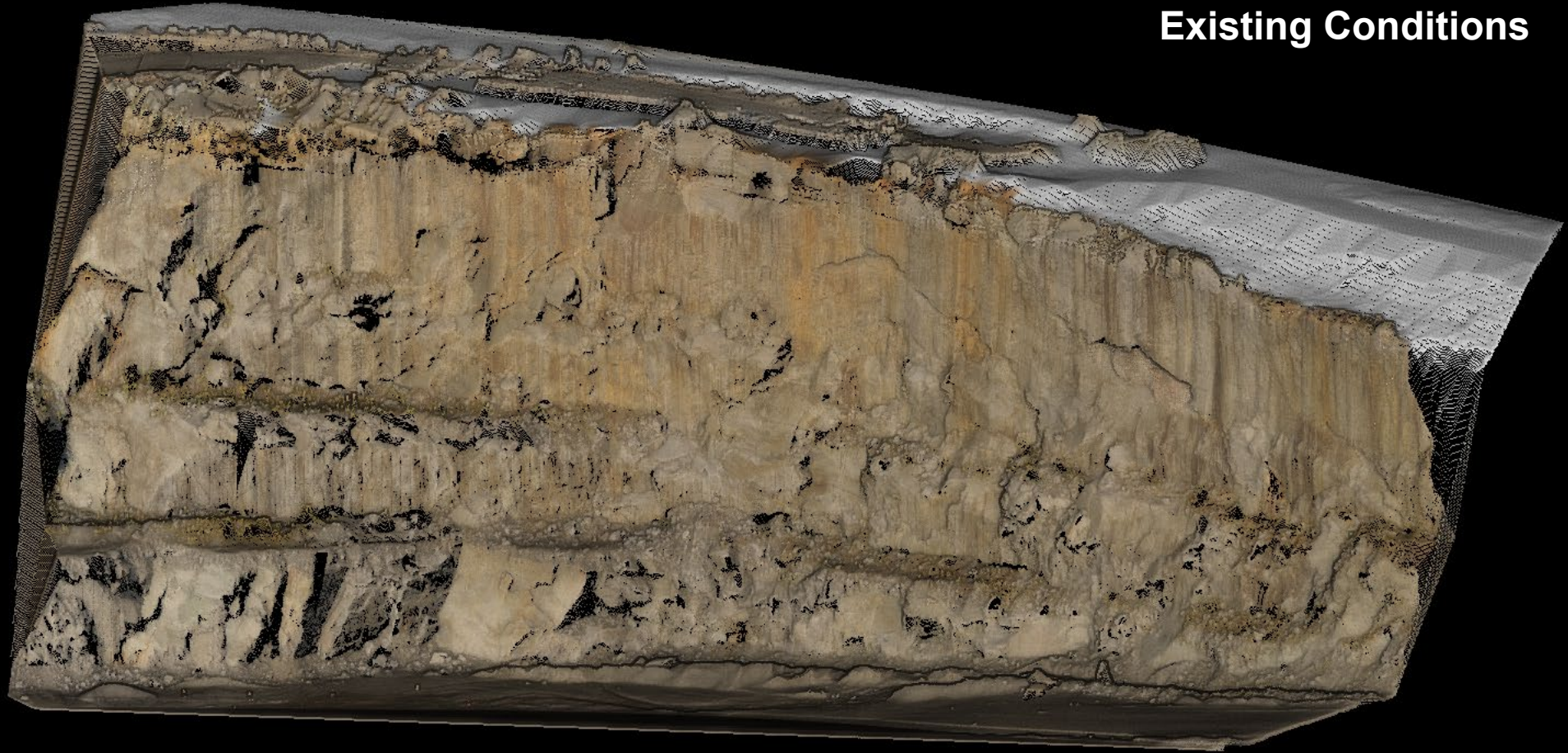
Normalized Landslide Susceptibility Map



Applications—Mine Highwall

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

Existing Conditions

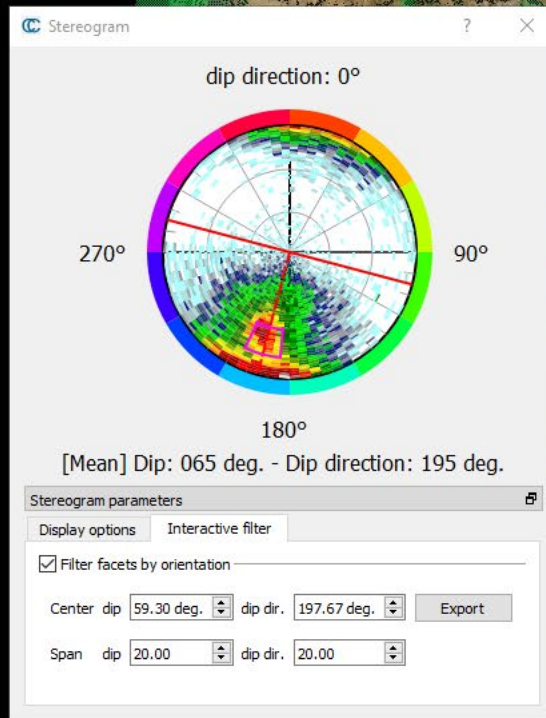


150

Applications—Mine Highwall

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

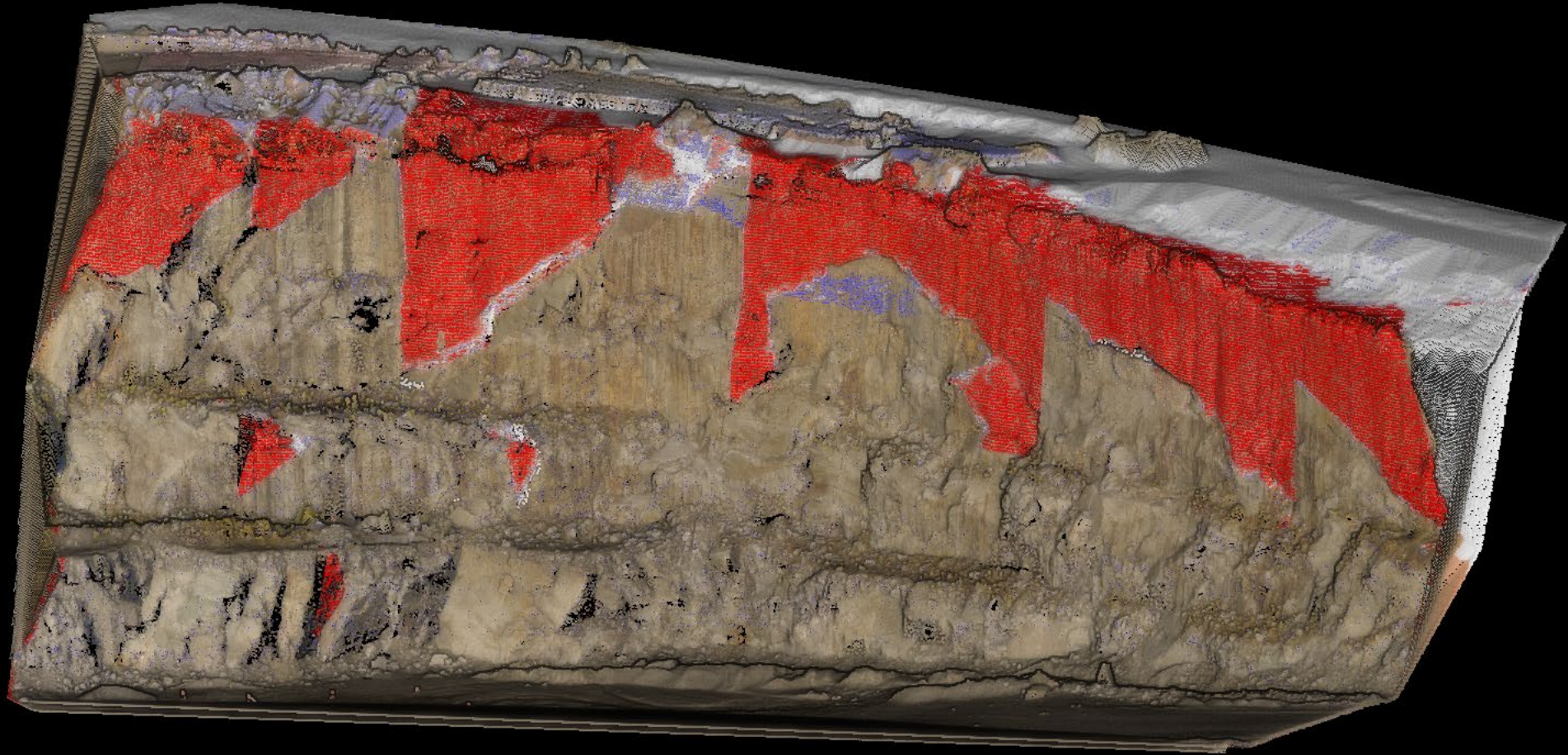
Facet Analysis & Fracture Planes



Applications—Mine Highwall

Planar Failure Hazards

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

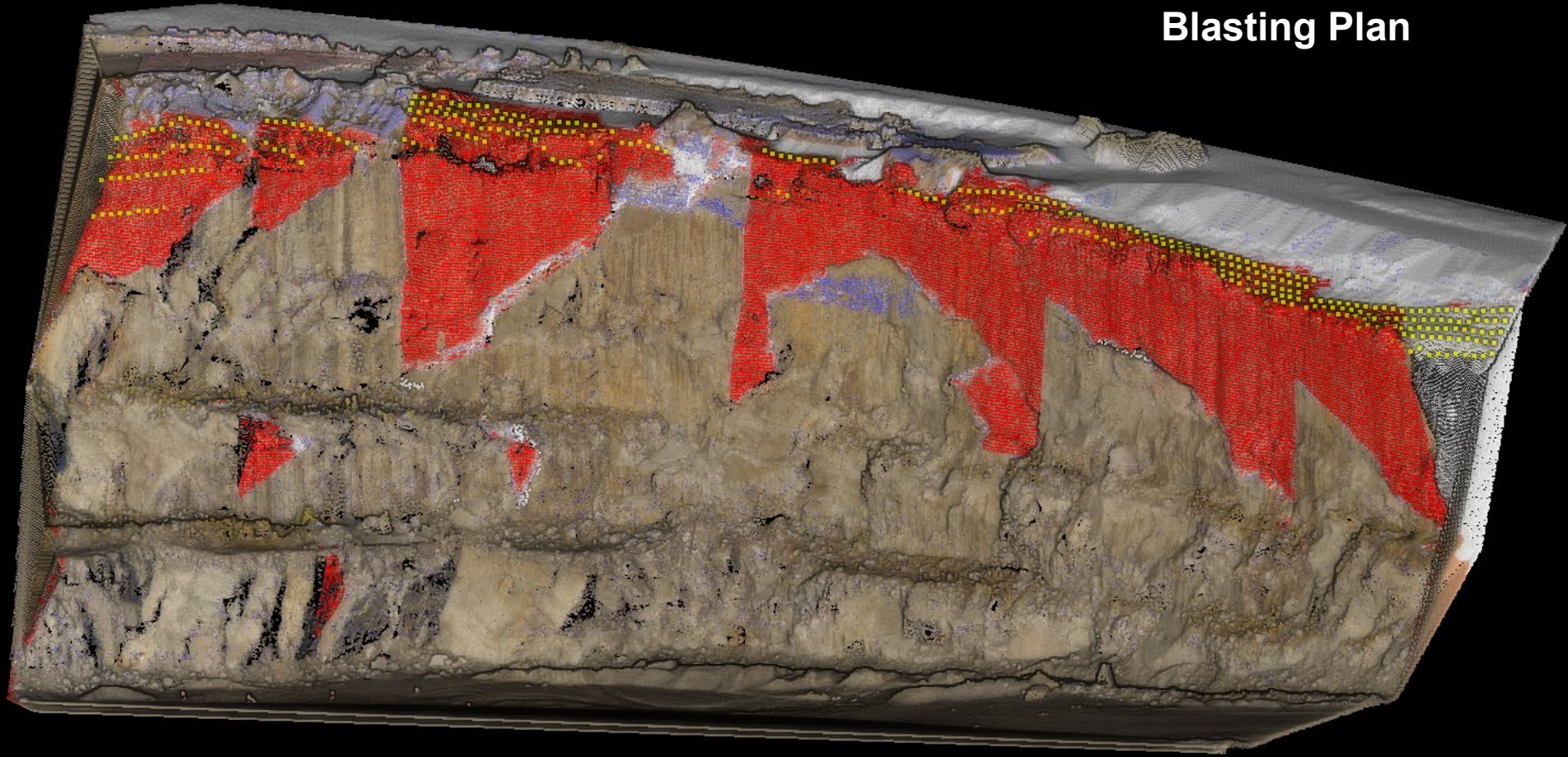


150

Applications—Mine Highwall

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

Blasting Plan

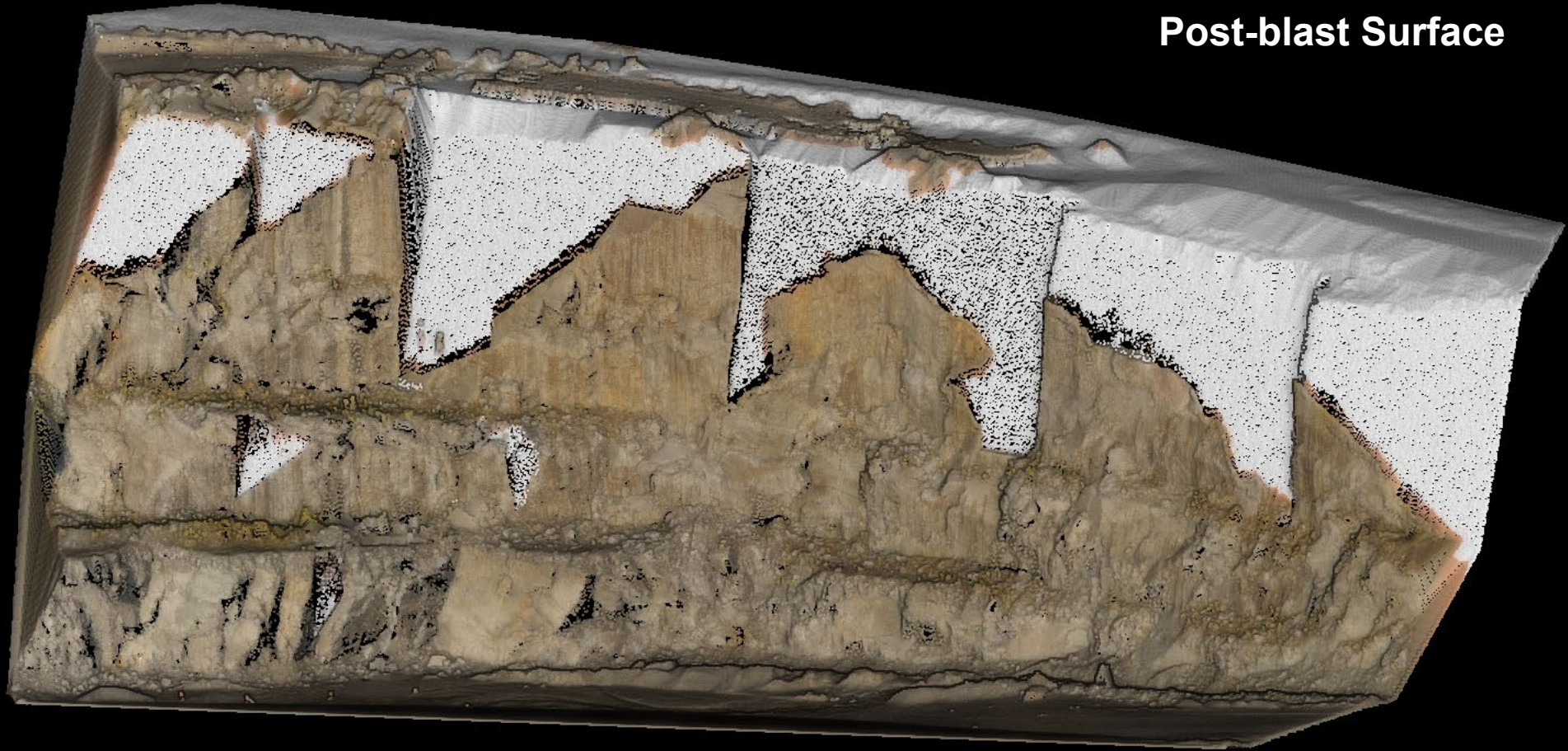


150

Applications—Mine Highwall

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

Post-blast Surface



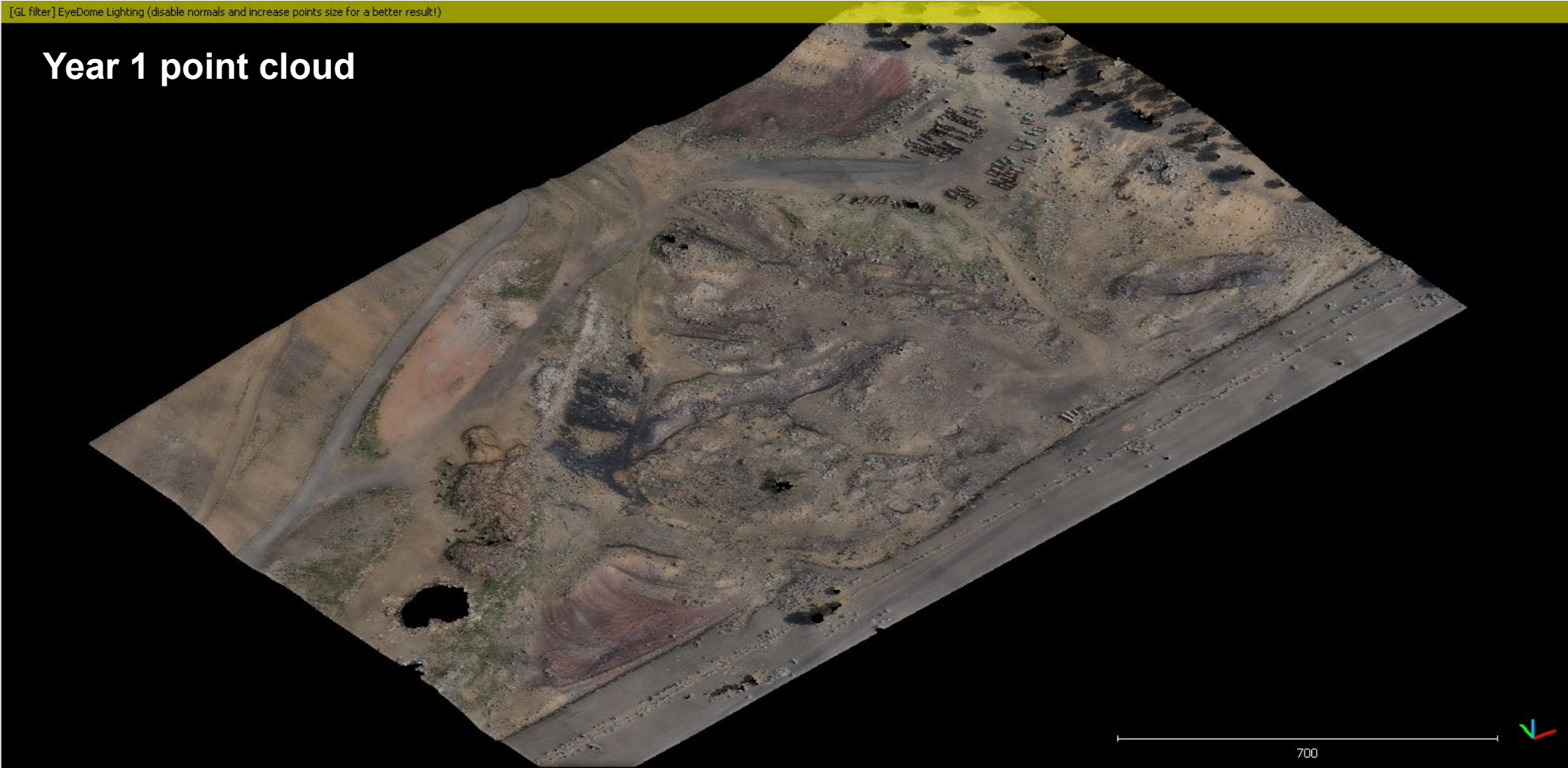
150



Applications—Asset Management

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

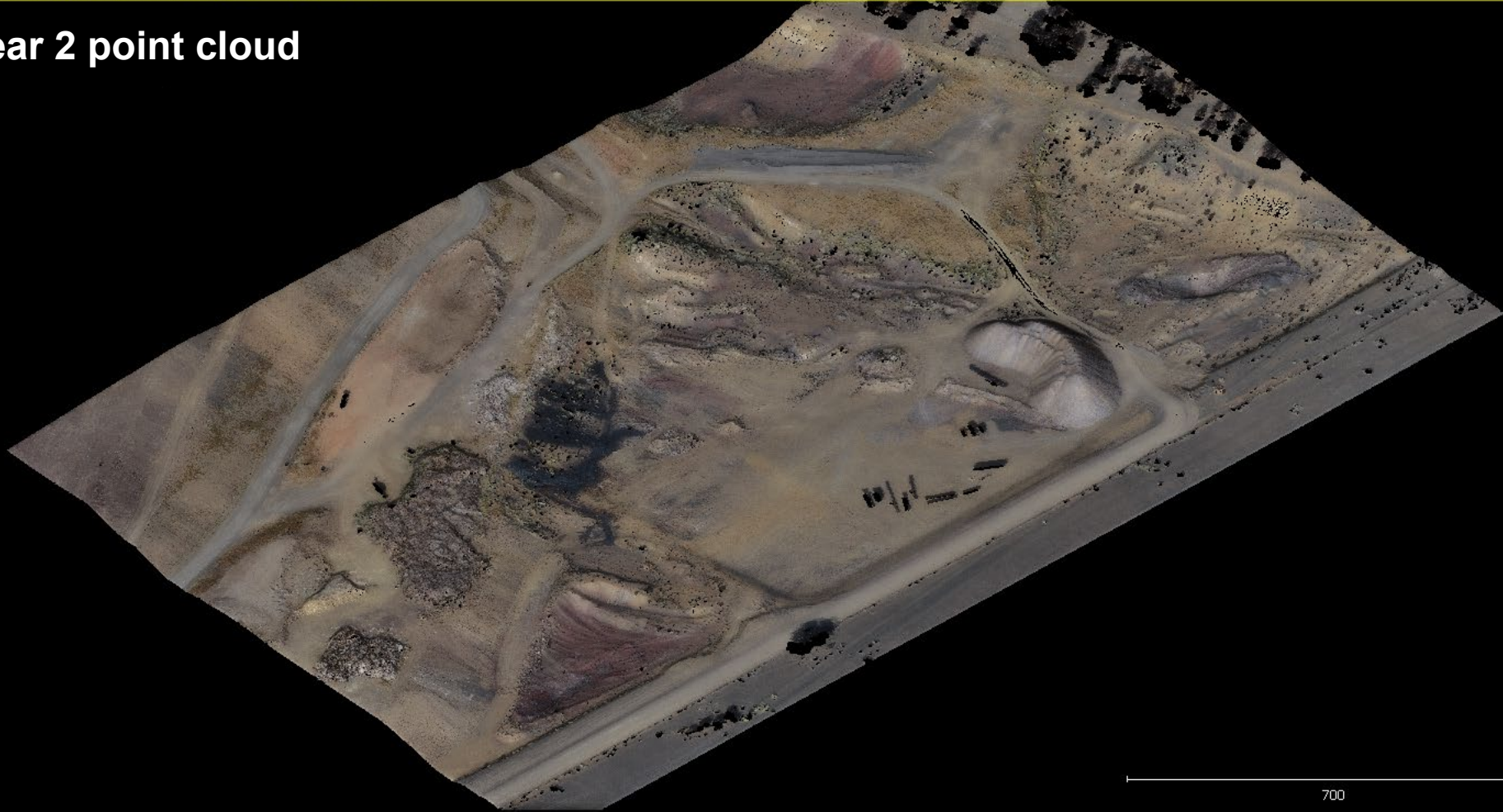
Year 1 point cloud



Applications—Asset Management

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

Year 2 point cloud



Applications—Asset Management

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

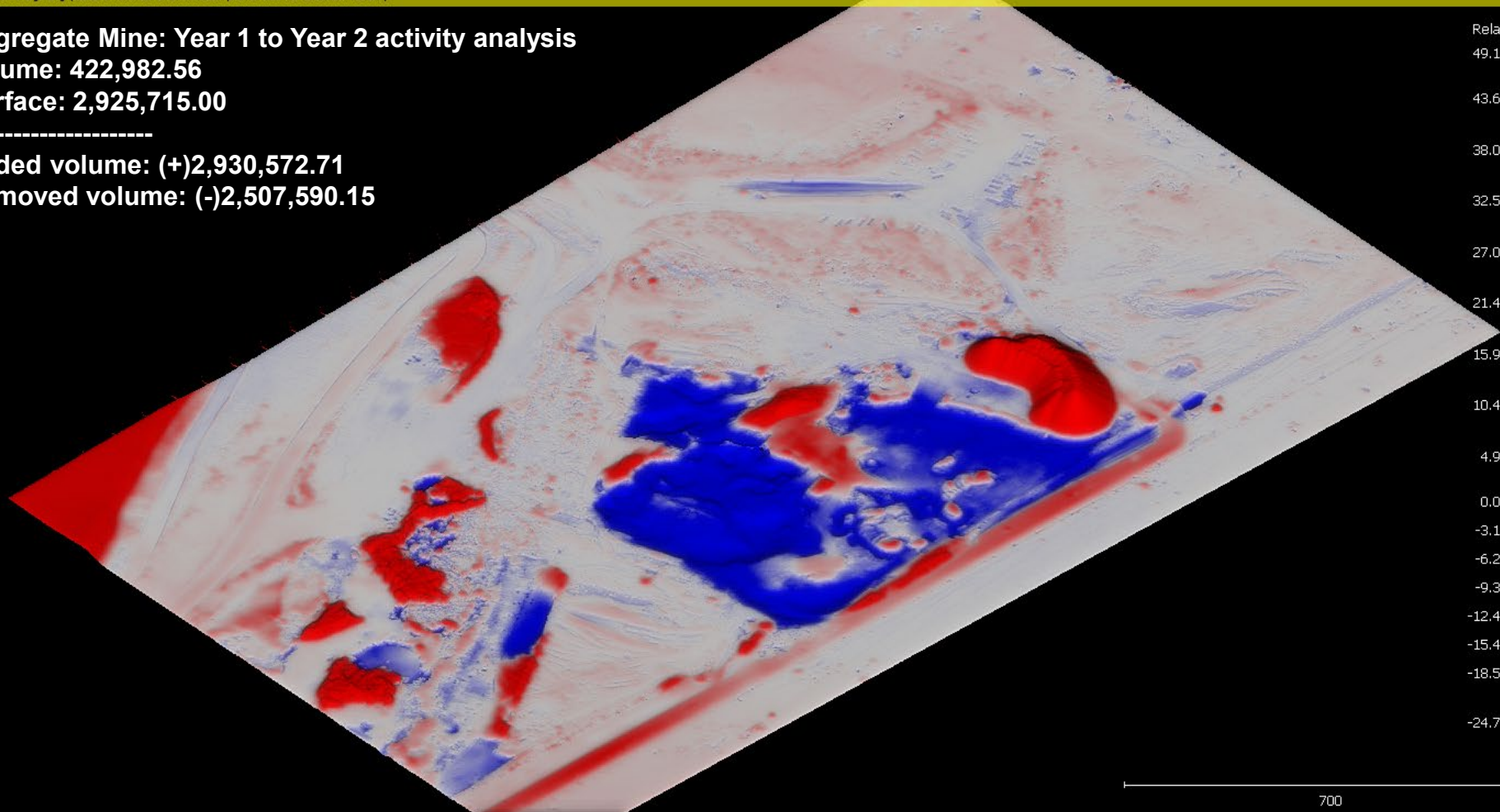
Aggregate Mine: Year 1 to Year 2 activity analysis

Volume: 422,982.56

Surface: 2,925,715.00

Added volume: (+)2,930,572.71

Removed volume: (-)2,507,590.15



Relative height

49.1

43.6

38.0

32.5

27.0

21.4

15.9

10.4

4.9

0.0

-3.1

-6.2

-9.3

-12.4

-15.4

-18.5

-24.7

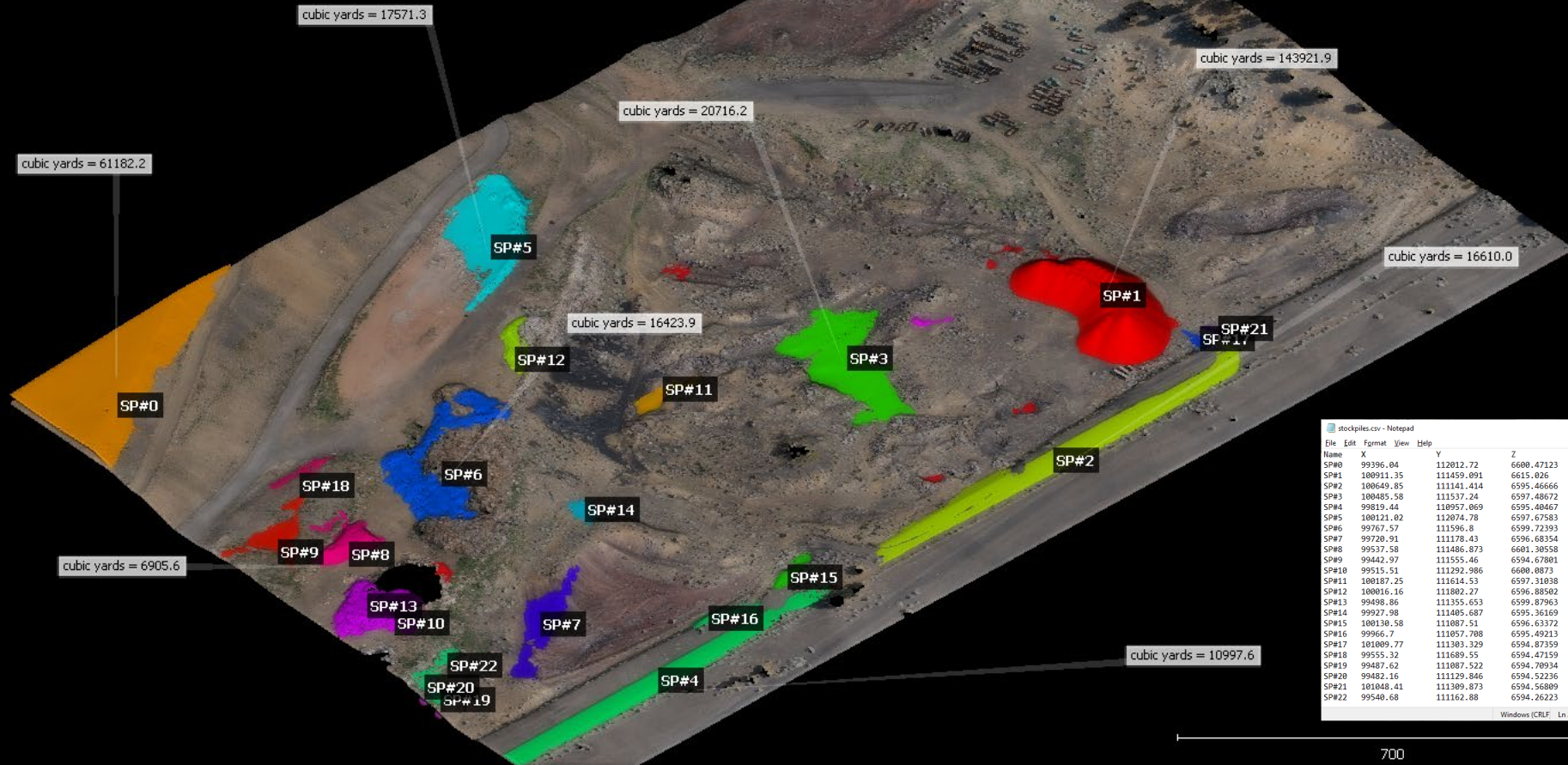
700



Applications—Asset Management

[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

Stockpile Analysis



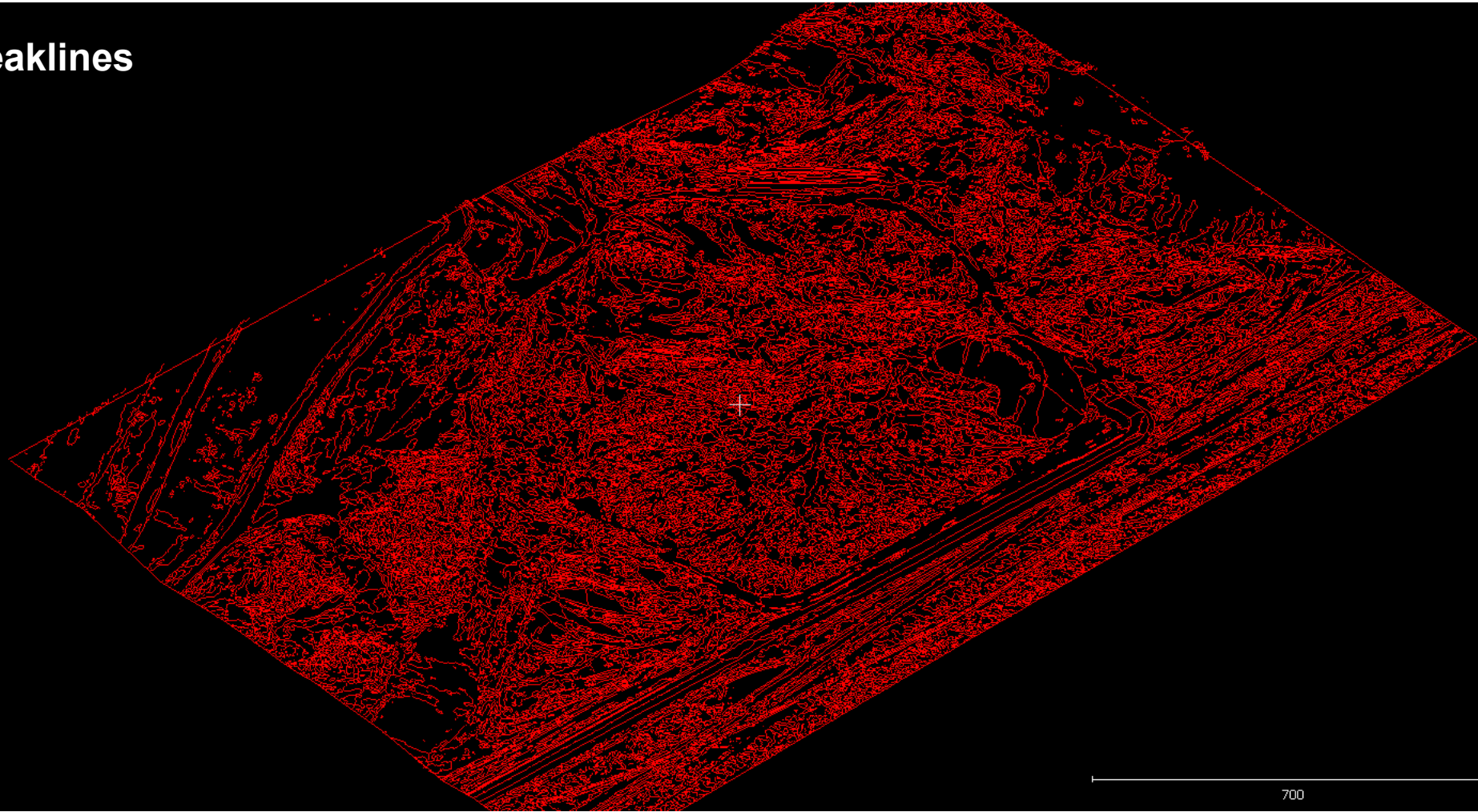
stockpiles.csv - Notepad

Name	X	Y	Z	Volume --cy
SP#0	99396.04	112012.72	6600.47123	61182.22222
SP#1	100911.35	111459.091	6615.026	143921.8519
SP#2	100649.85	111141.414	6595.46666	16610.03704
SP#3	100485.58	111537.24	6597.48672	20716.22222
SP#4	99819.44	110957.069	6595.40467	10997.62963
SP#5	100121.02	112074.78	6597.67583	17571.2963
SP#6	99767.57	111596.8	6599.72393	16423.85185
SP#7	99700.91	111178.43	6596.68354	4996.11111
SP#8	99537.58	111486.873	6601.30558	6905.592593
SP#9	99442.97	111555.46	6594.67801	1483.362963
SP#10	99515.51	111292.986	6600.0873	3789.333333
SP#11	100187.25	111614.53	6597.31038	2223.122222
SP#12	100016.16	111802.27	6596.88502	1549.740741
SP#13	99498.86	111355.653	6599.87963	1789.674074
SP#14	99927.98	111405.687	6595.36169	644.162963
SP#15	100130.58	111007.51	6596.63372	859.5481481
SP#16	99966.7	111057.708	6595.49213	599.5333333
SP#17	101009.77	111303.329	6594.87359	318.8637037
SP#18	99555.32	111689.55	6594.47159	255.8007407
SP#19	99487.62	111087.522	6594.70934	255.3944444
SP#20	99482.16	111129.846	6594.52236	203.6174074
SP#21	101048.41	111309.873	6594.56809	197.4985185
SP#22	99540.68	111162.88	6594.26223	159.3348148

700

Applications—Asset Management

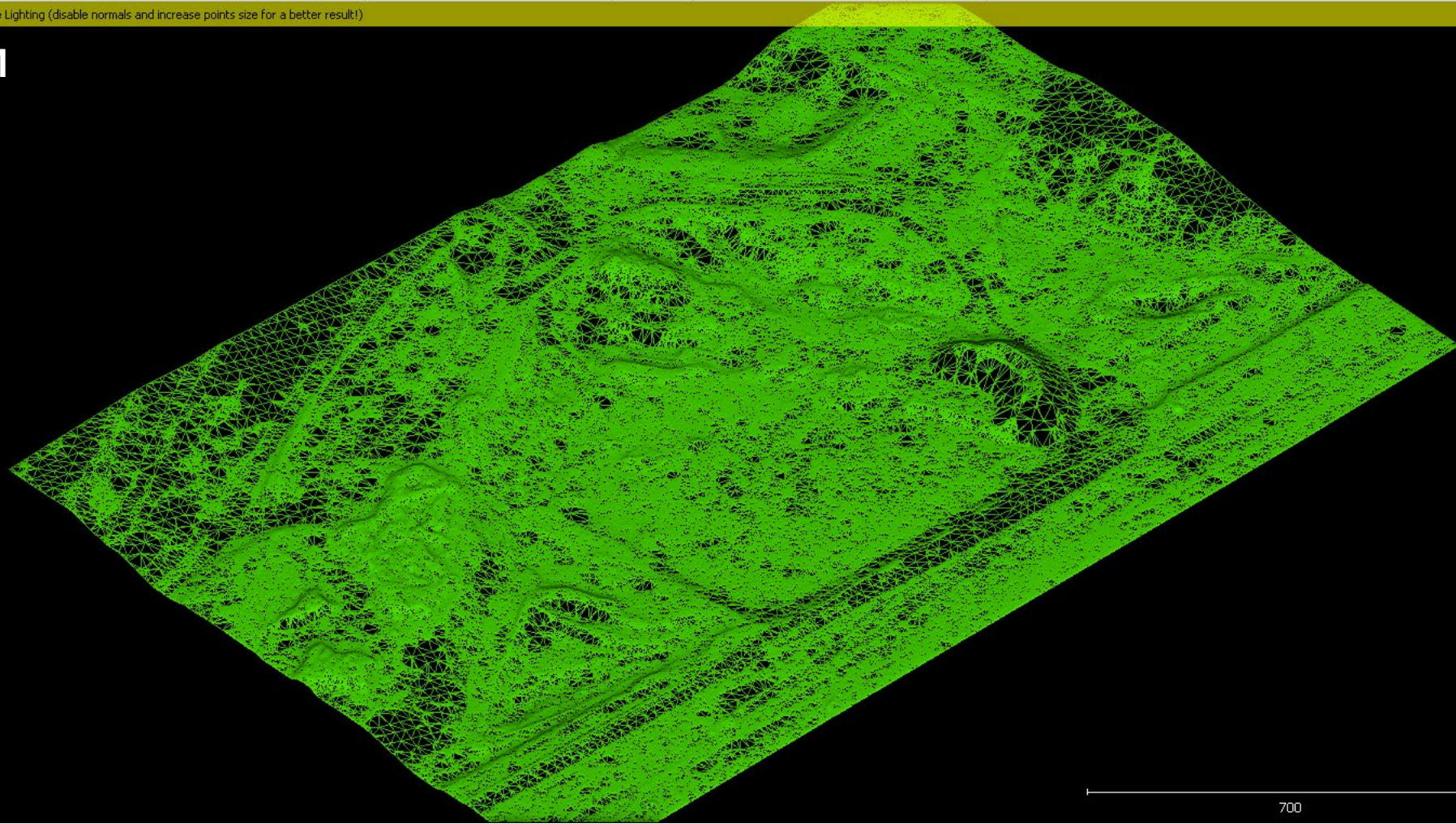
Breaklines



Applications—Asset Management

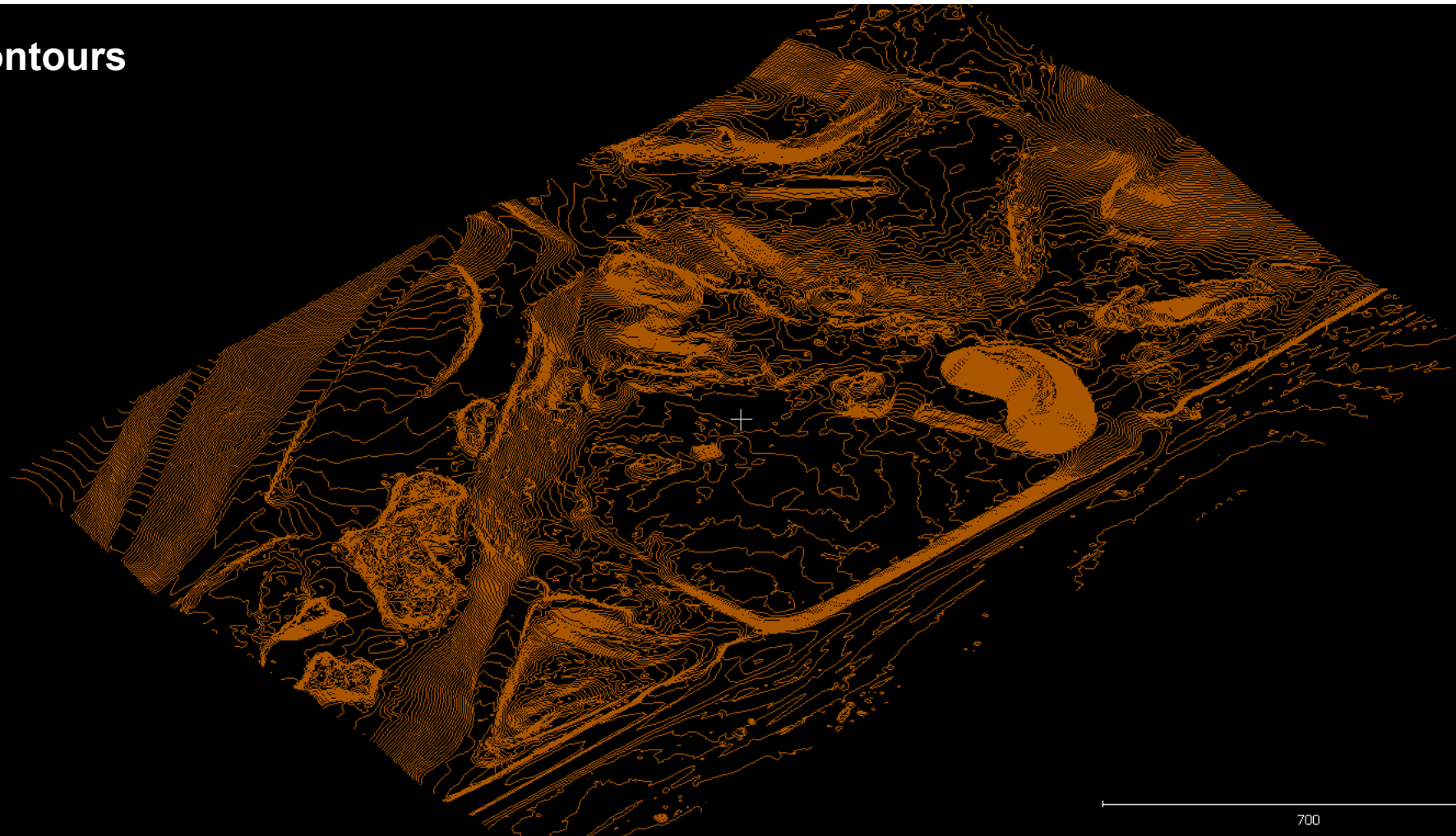
[GL filter] EyeDome Lighting (disable normals and increase points size for a better result!)

DTM



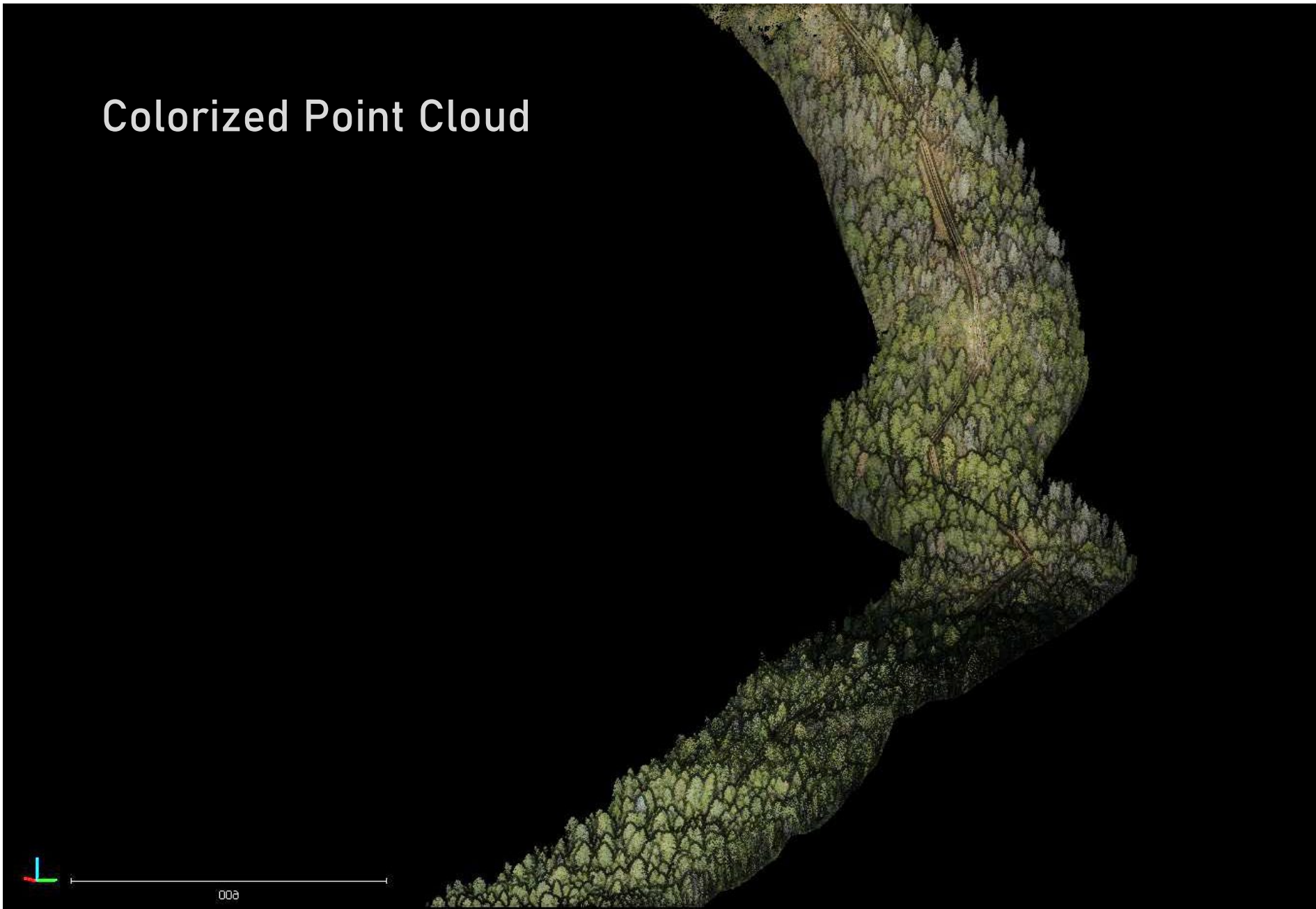
Applications—Asset Management

1' contours

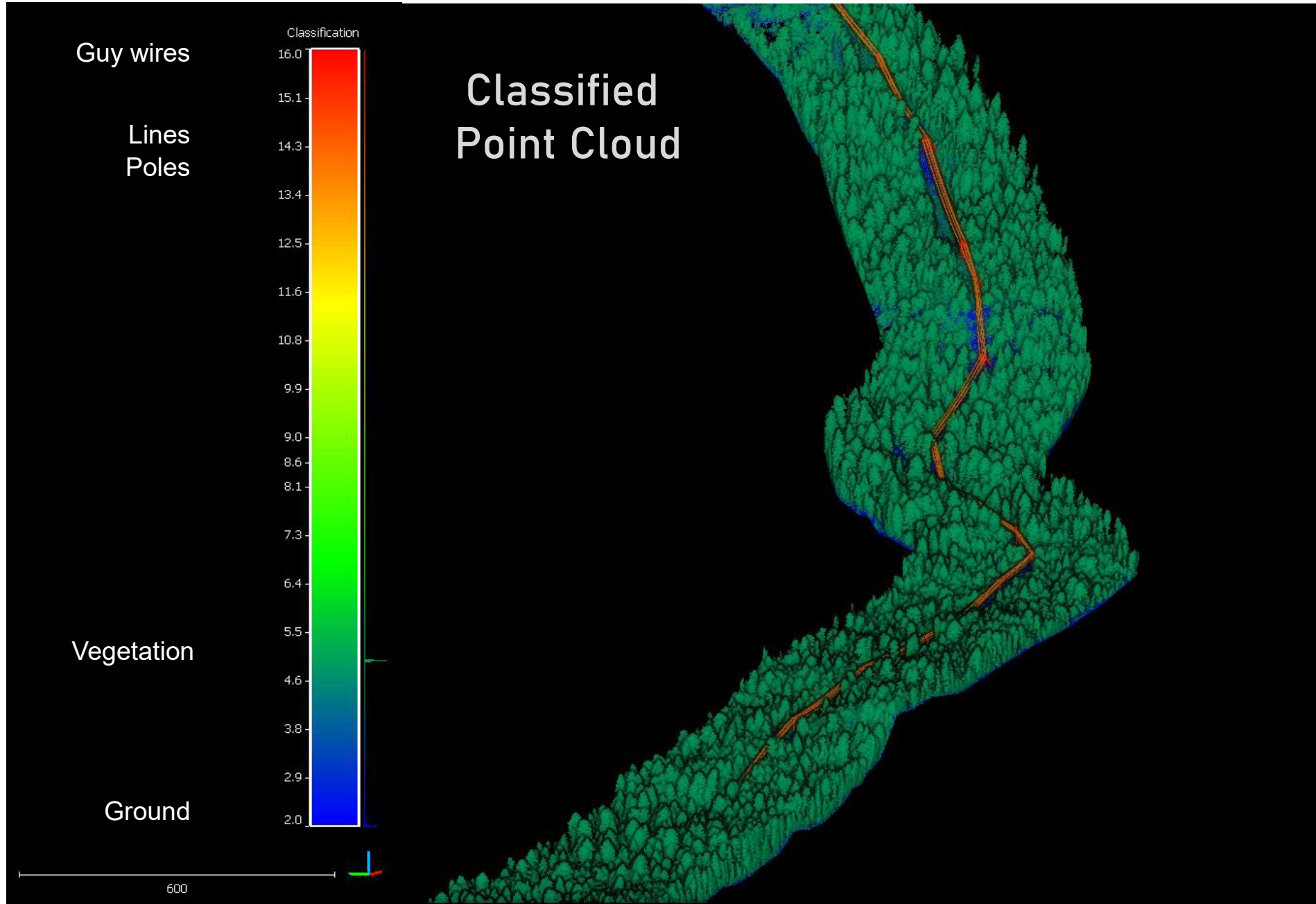


Applications—Asset Management

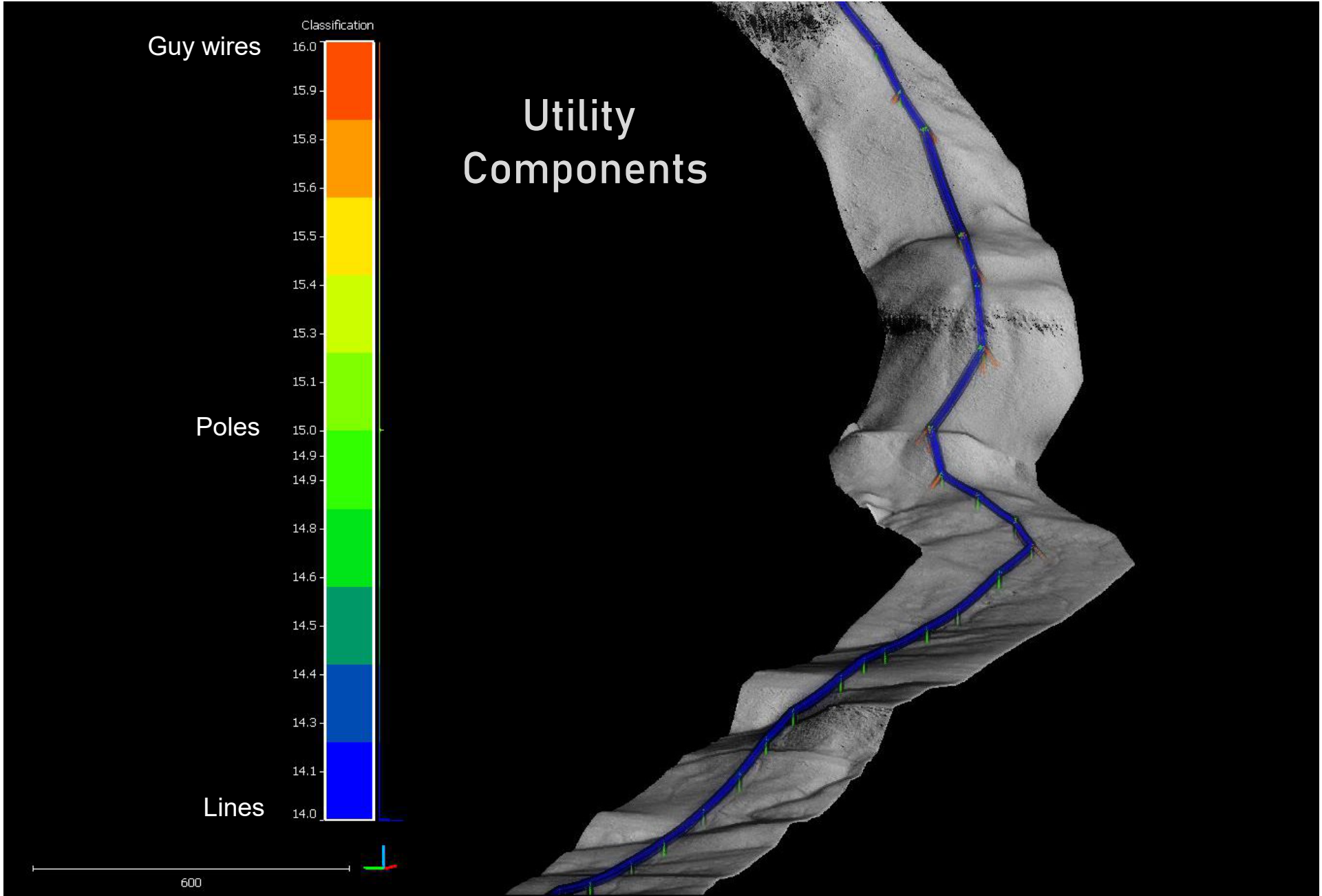
Colorized Point Cloud



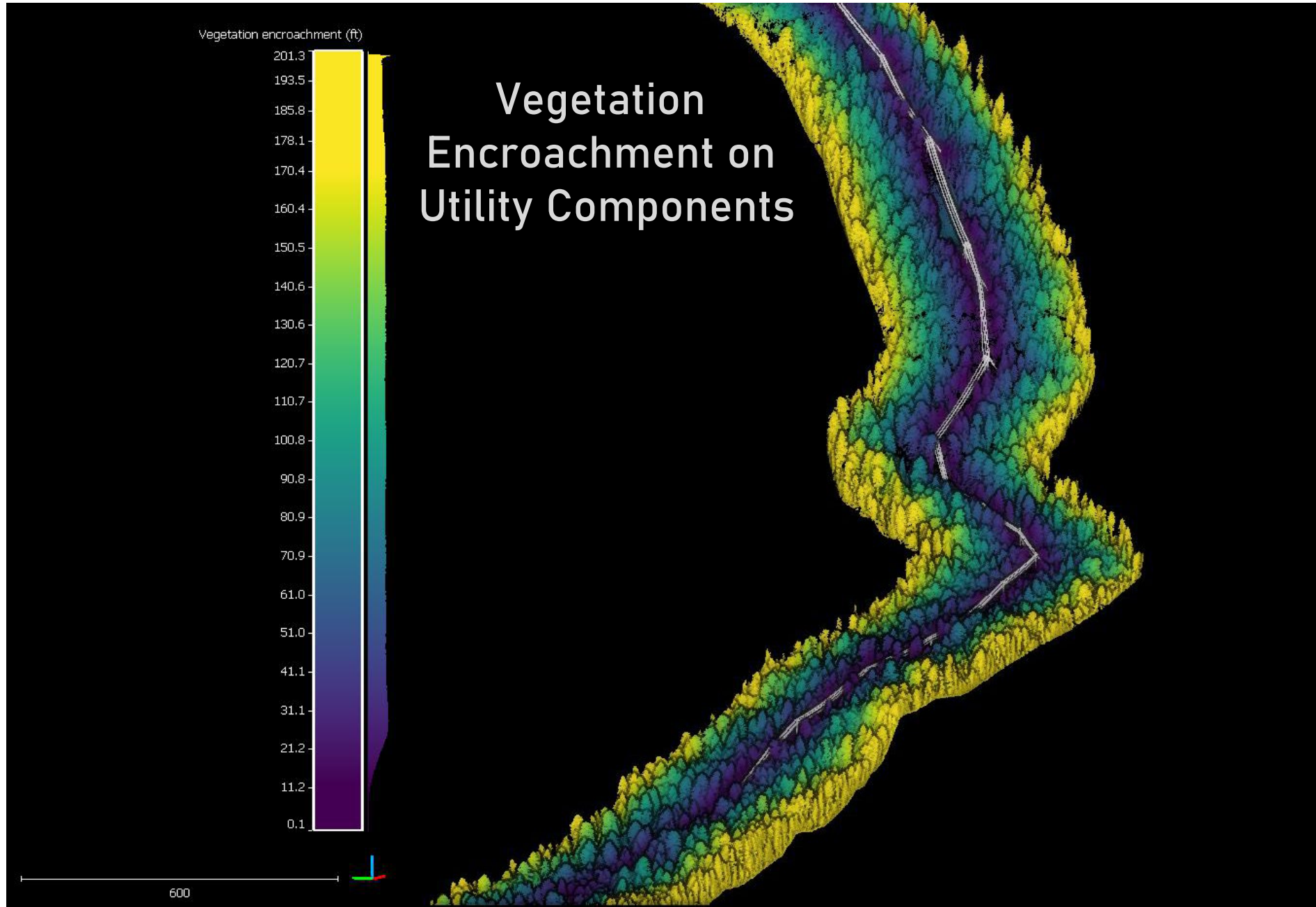
Applications—Asset Management



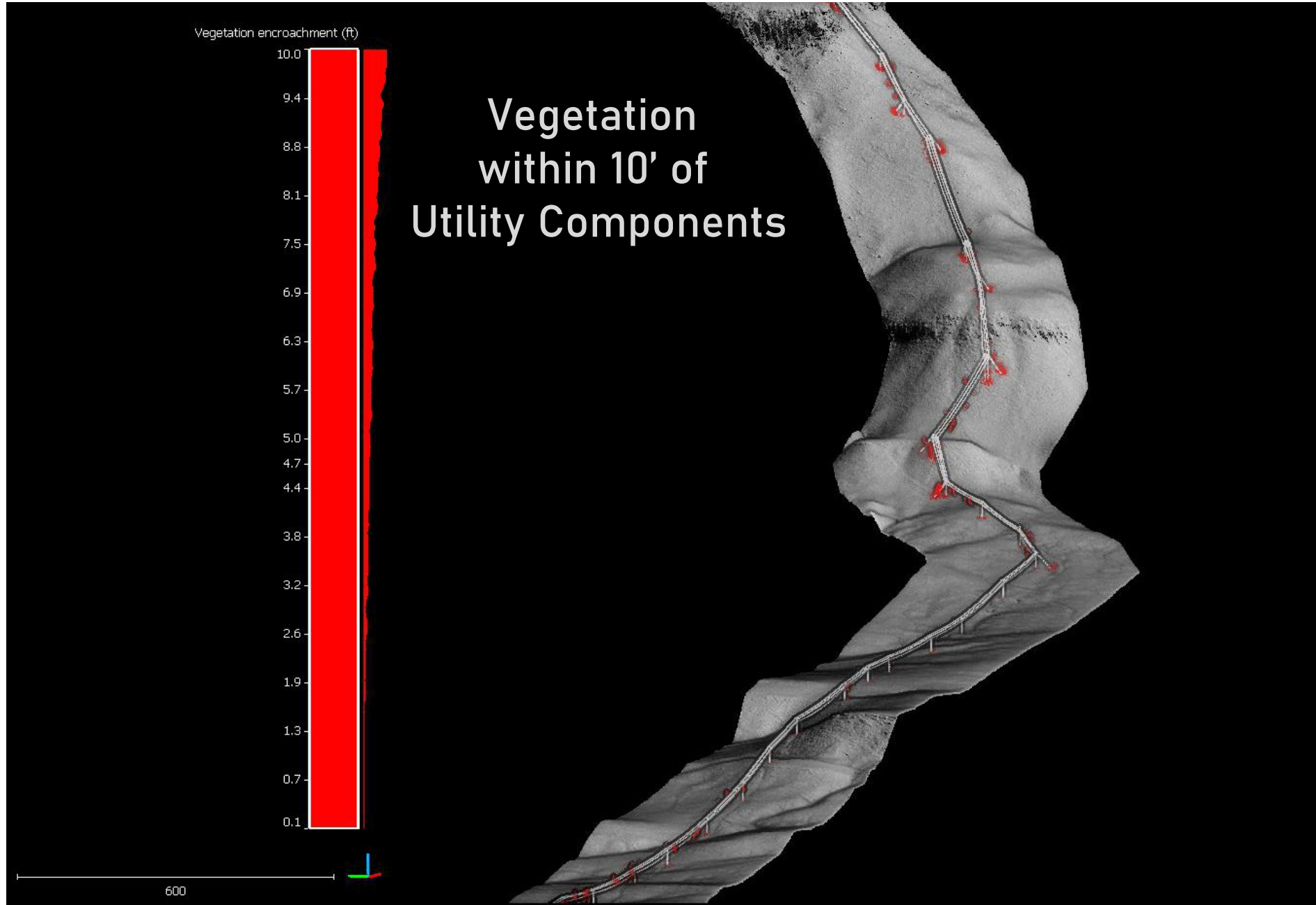
Applications—Asset Management



Applications—Asset Management

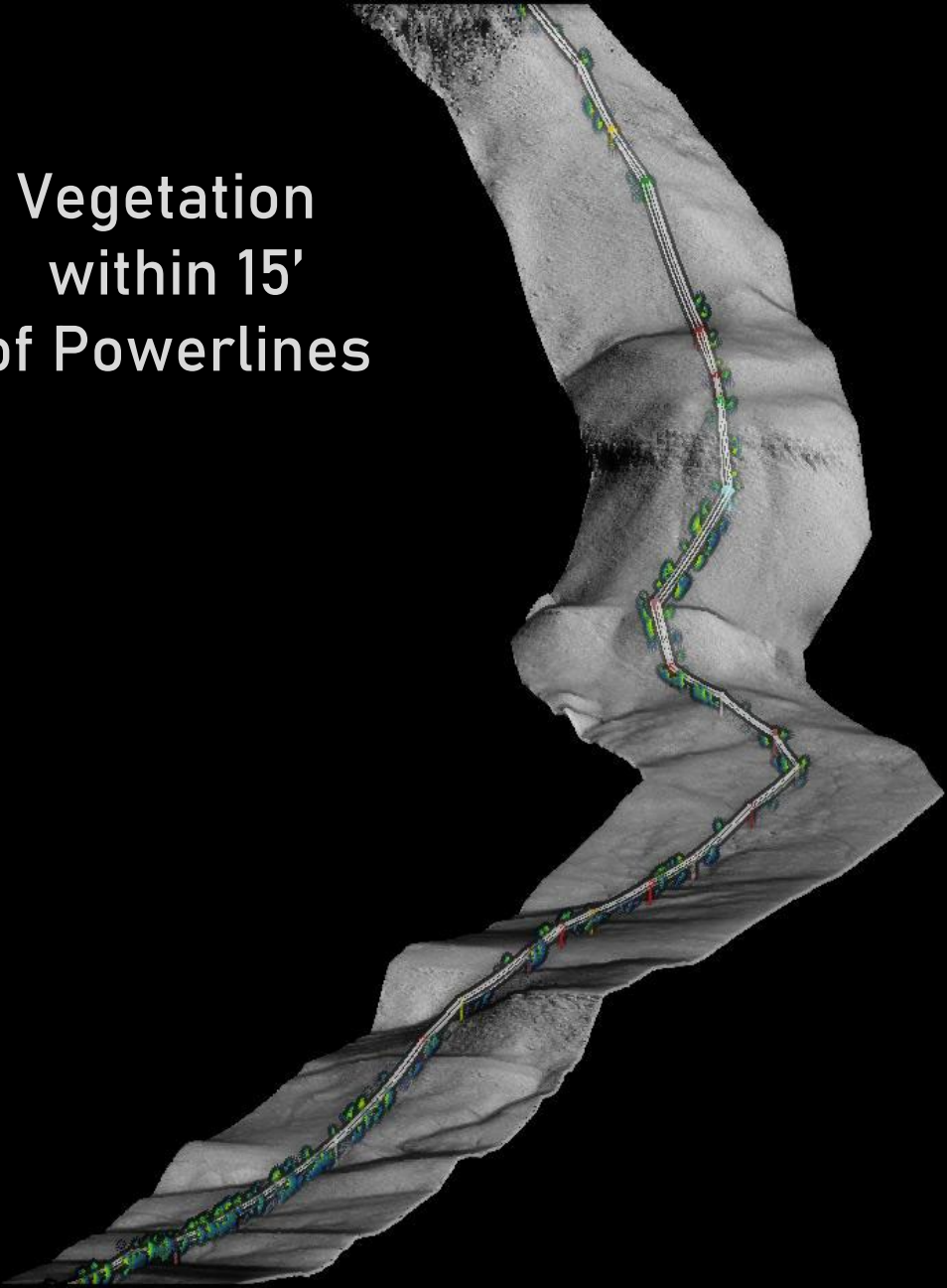
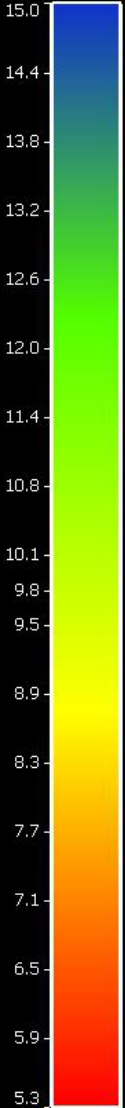


Applications—Asset Management

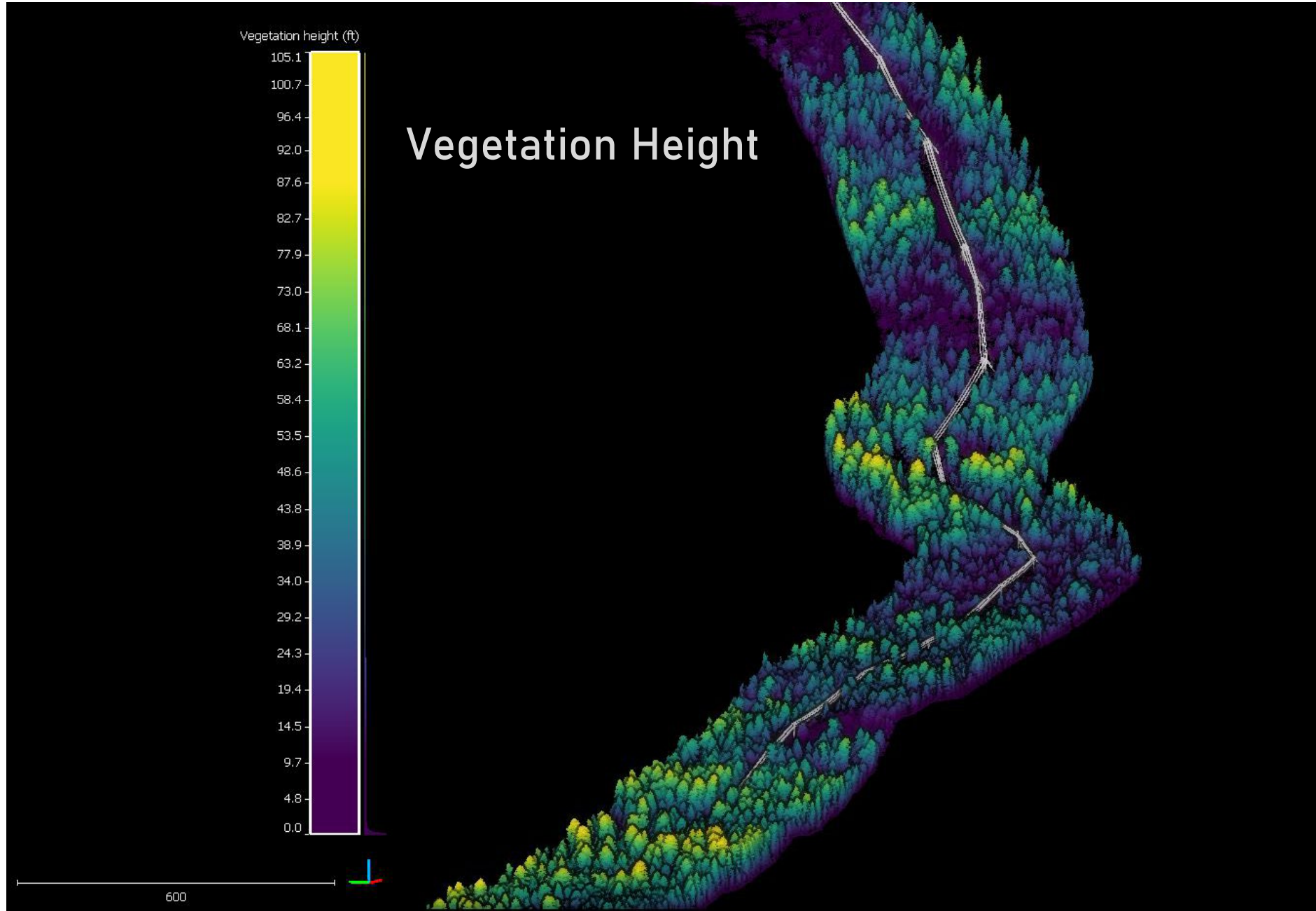


Vegetation within 15' of Powerlines

Powerline Encroachment (ft)

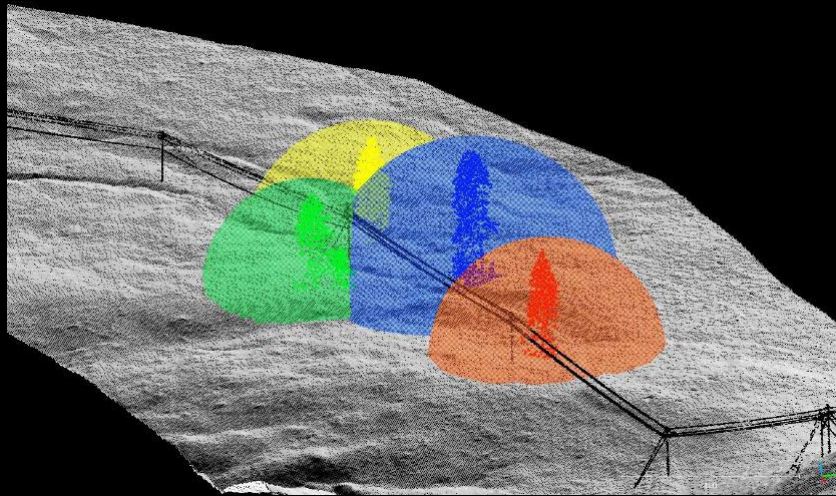


Applications—Asset Management

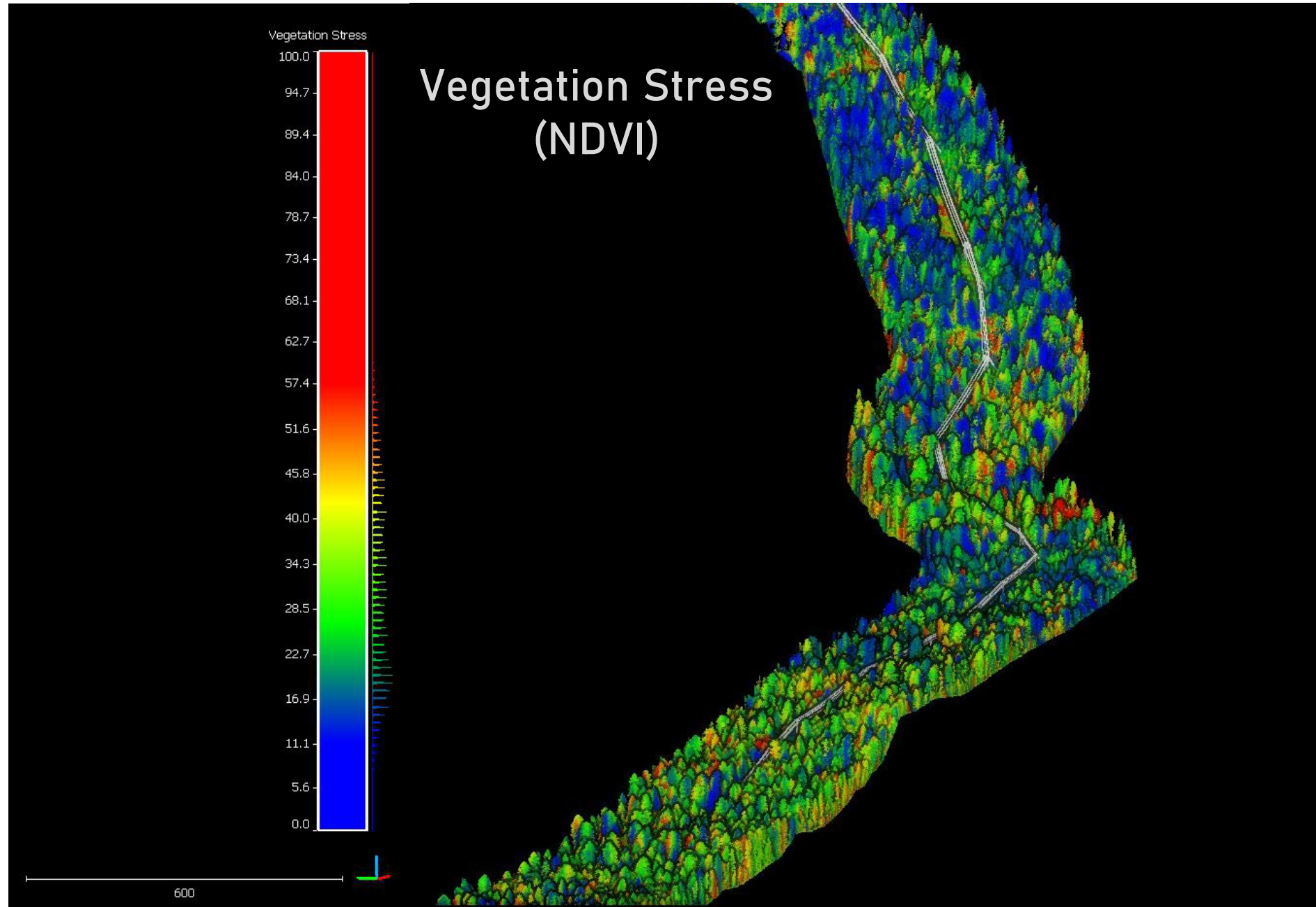


Applications—Asset Management

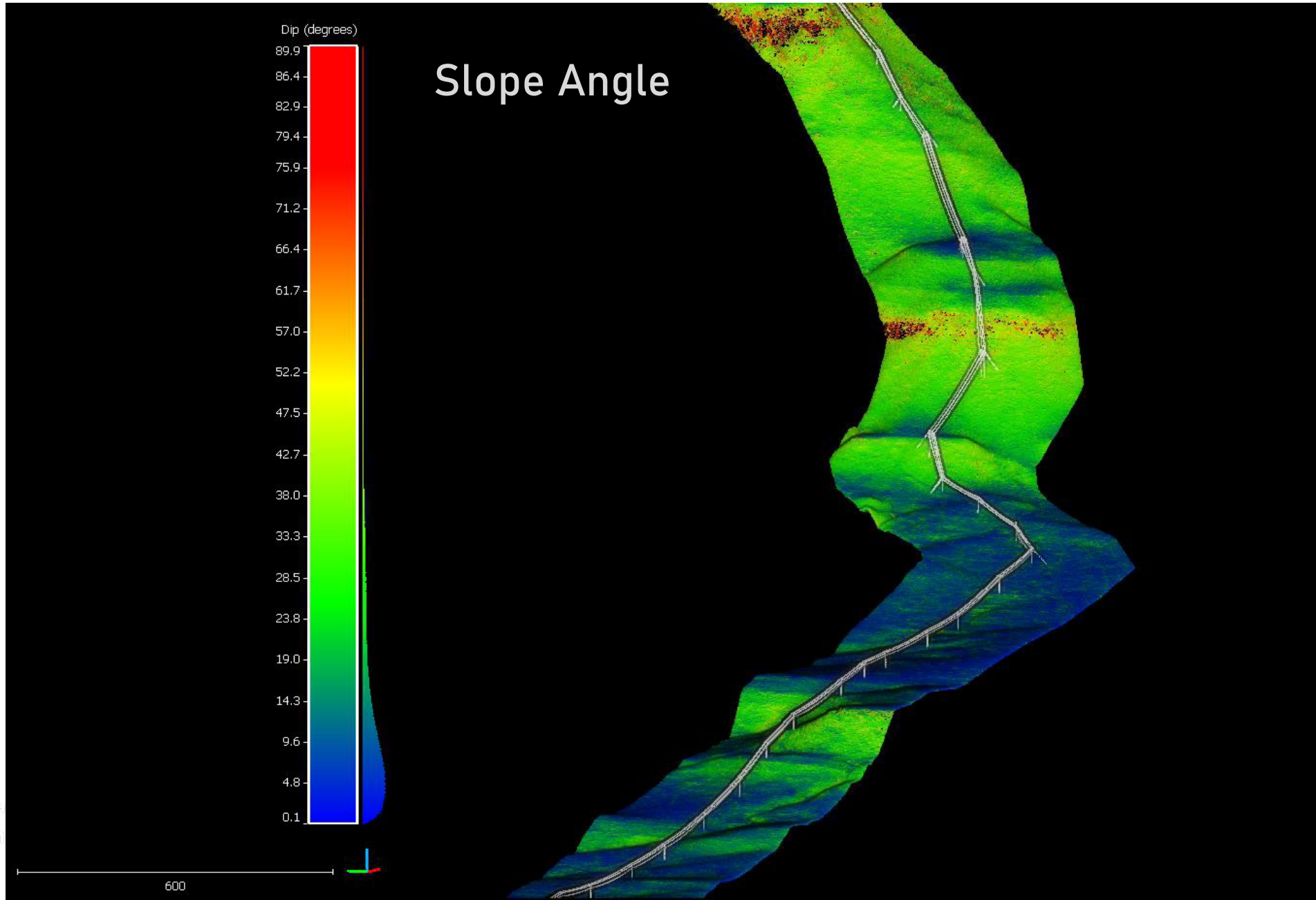
Danger Trees



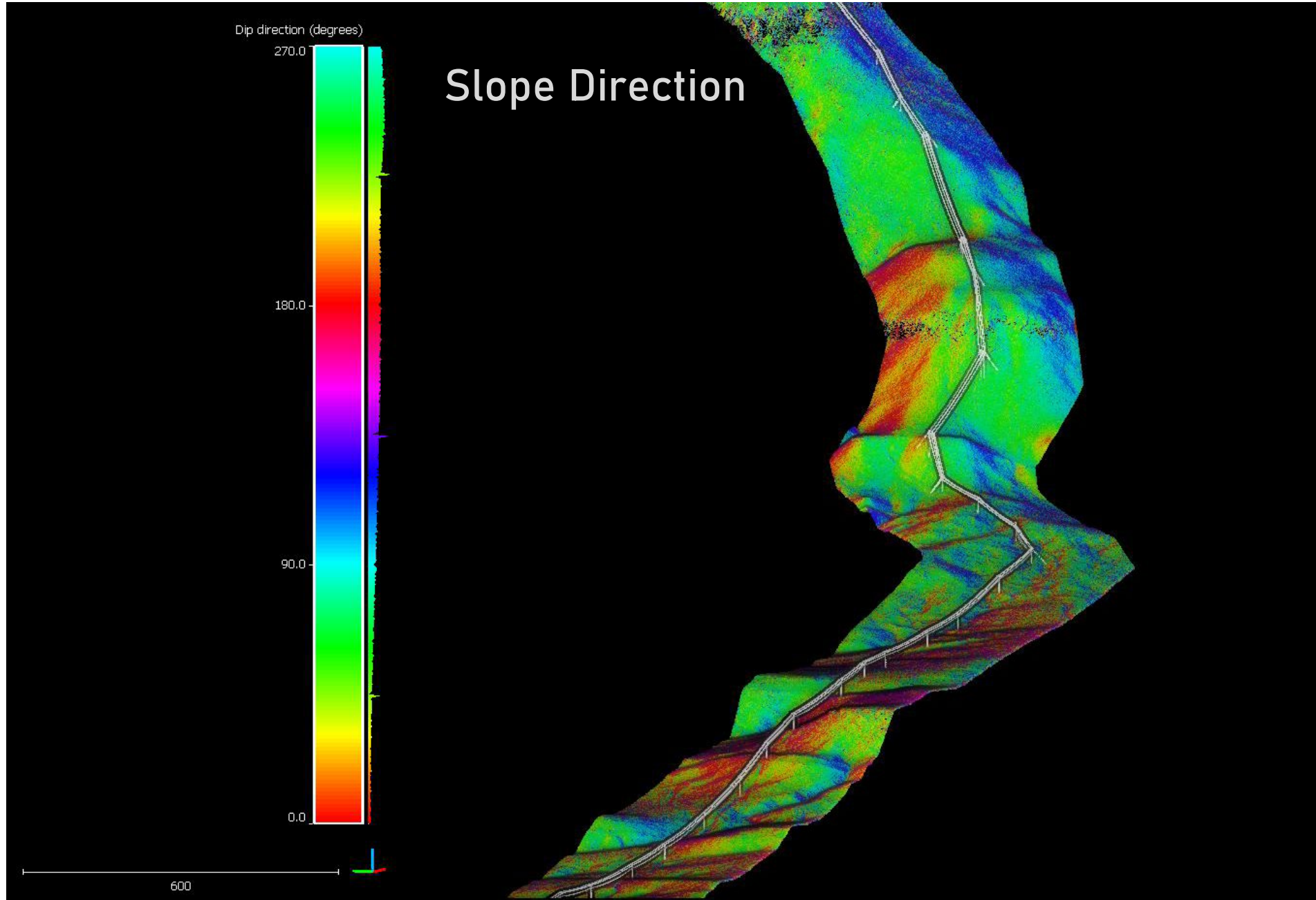
Applications—Asset Management



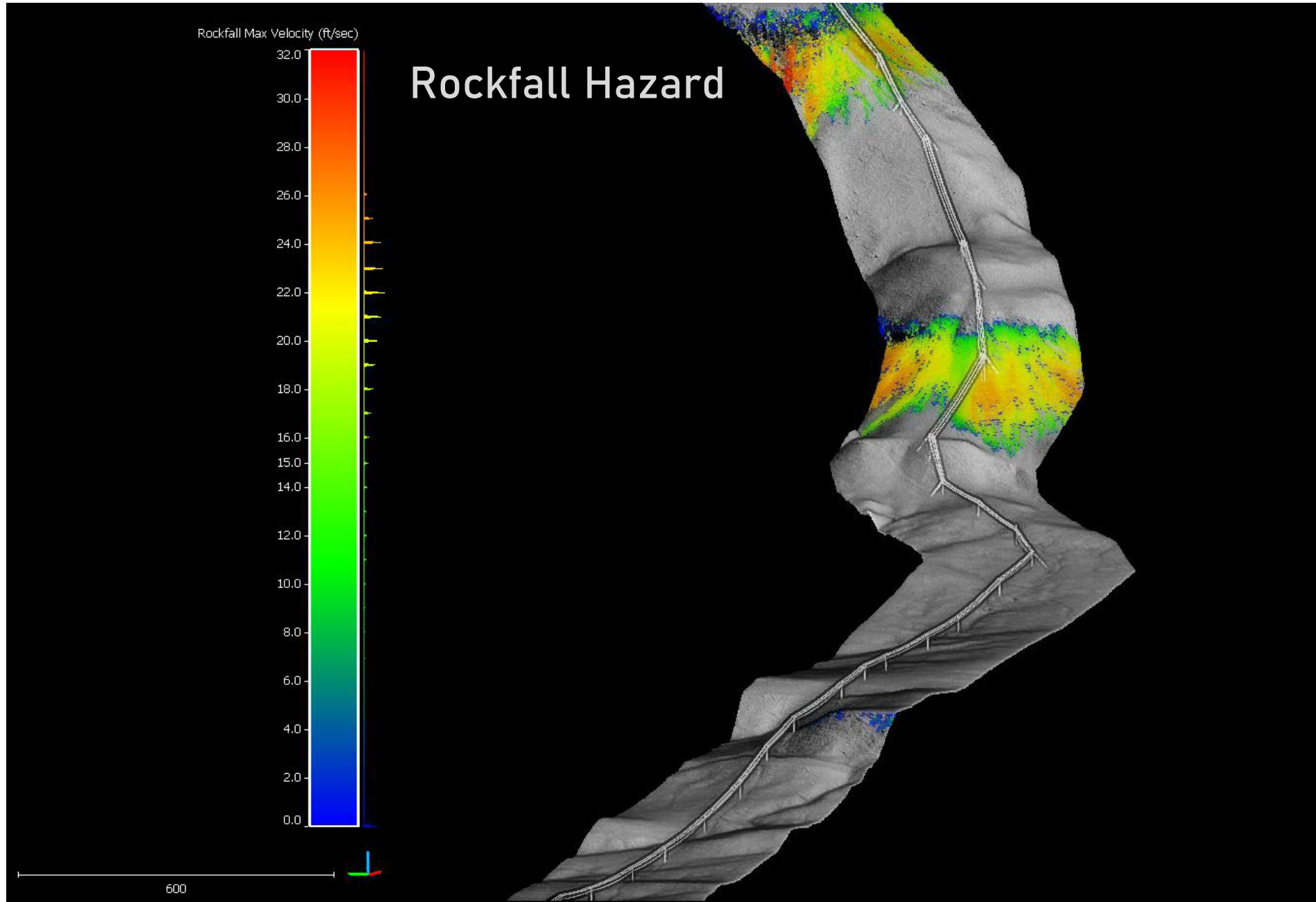
Applications—Asset Management



Applications—Asset Management

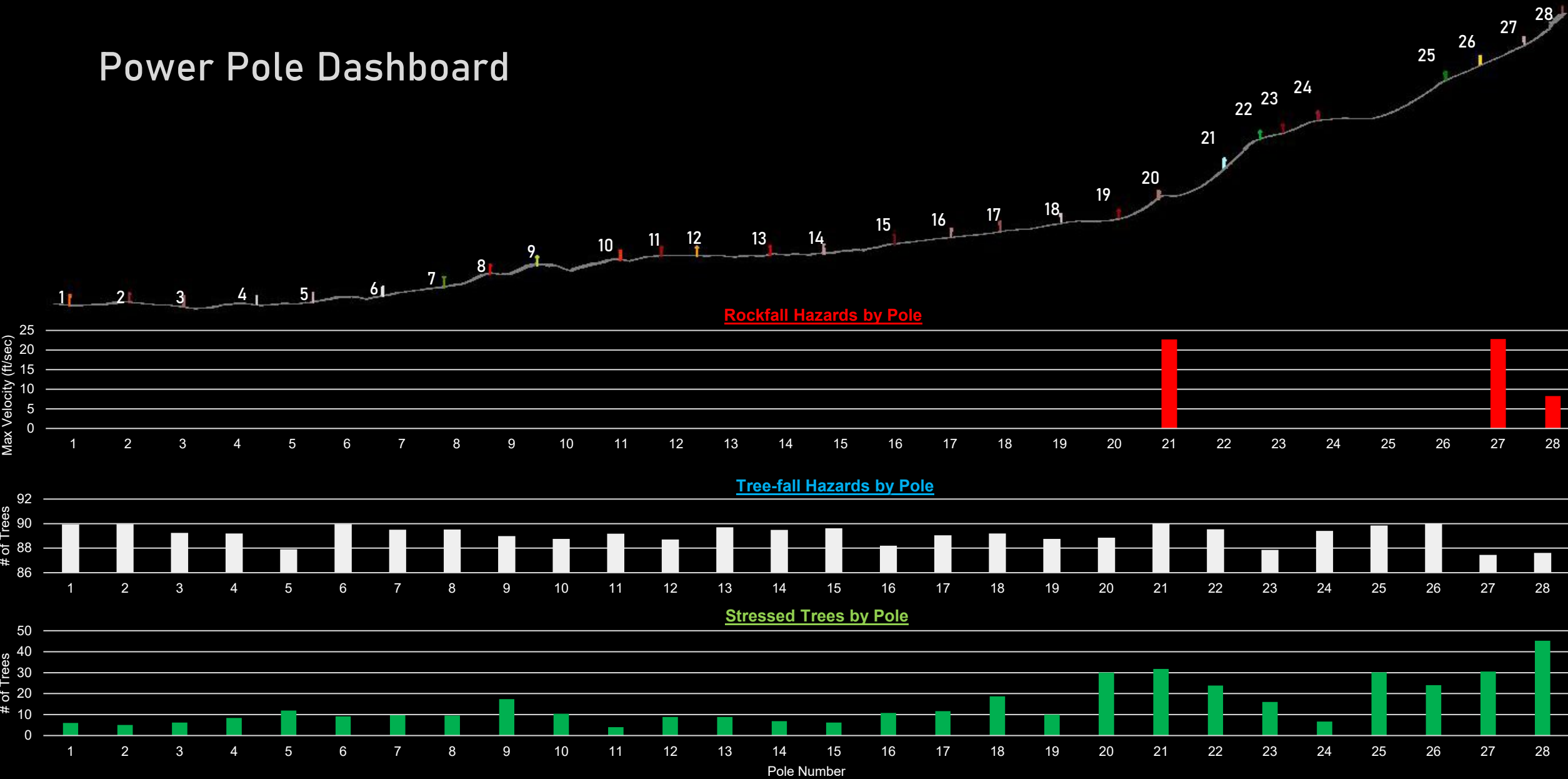


Applications—Asset Management



Applications—Asset Management

Power Pole Dashboard



Conclusions



Conclusions

XXX

TEAM

- Useful throughout the entire process from investigation to post-construction
- Useful at multiple scales: regional to site-level support
- Safe
- Accurate (survey/design grade with ground control)
- Quick turn-around time from capture to results
- Easy export to CAD and other formats

QUESTIONS?

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