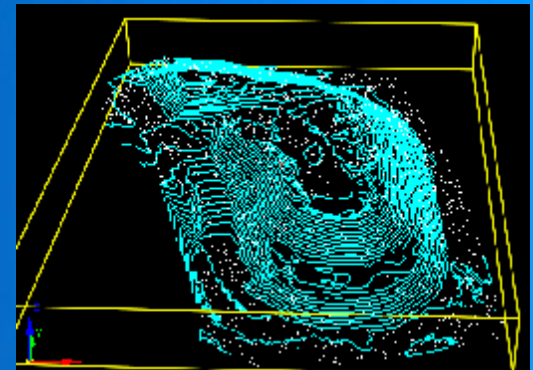
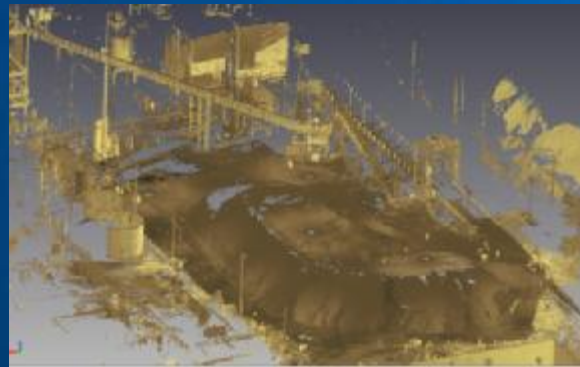


Coal Pile Volume Calculation

featuring the FARO Photon 120 3d laser scanner



Coal Pile Scanning

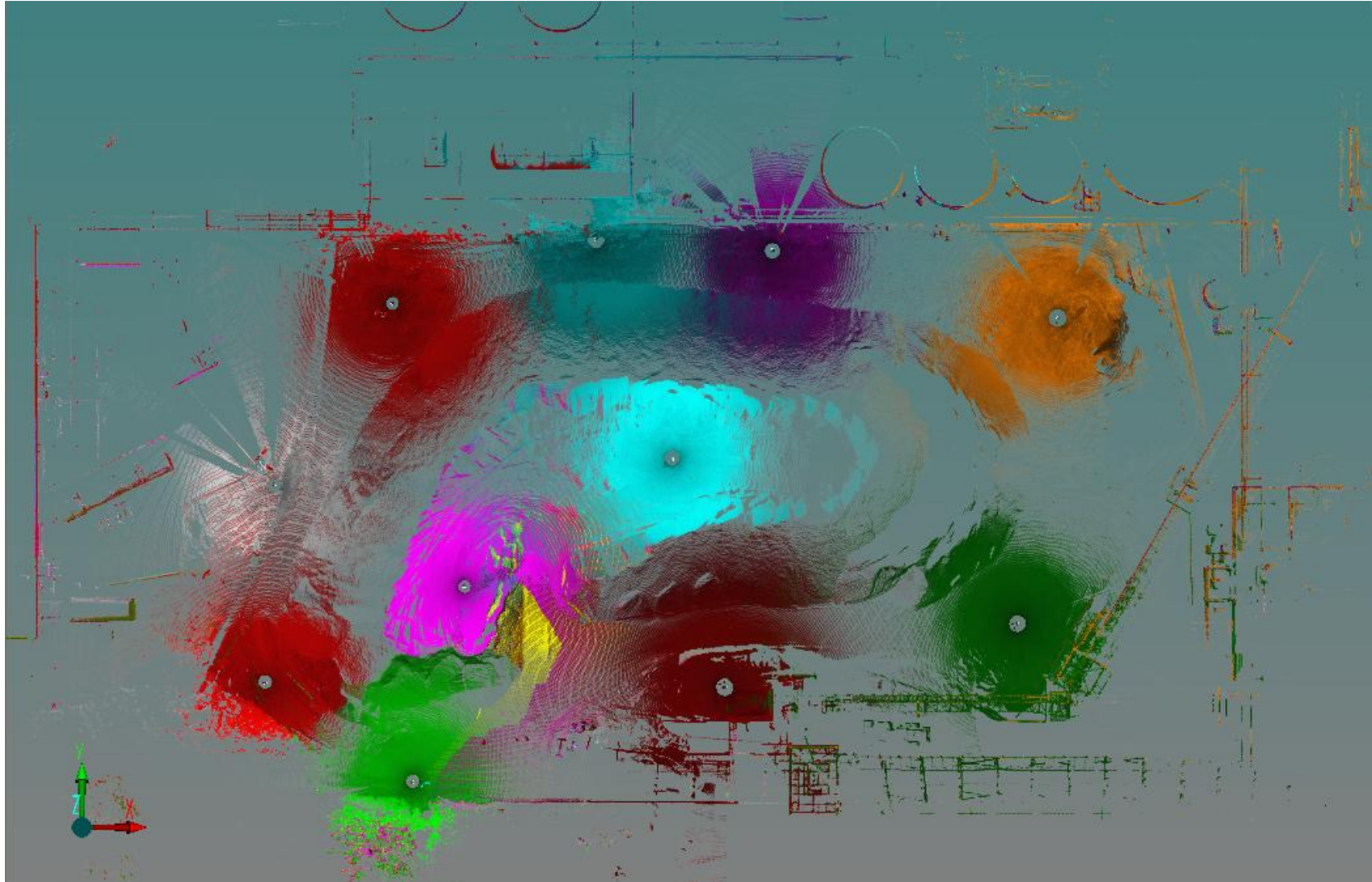
One of 12 Set-ups



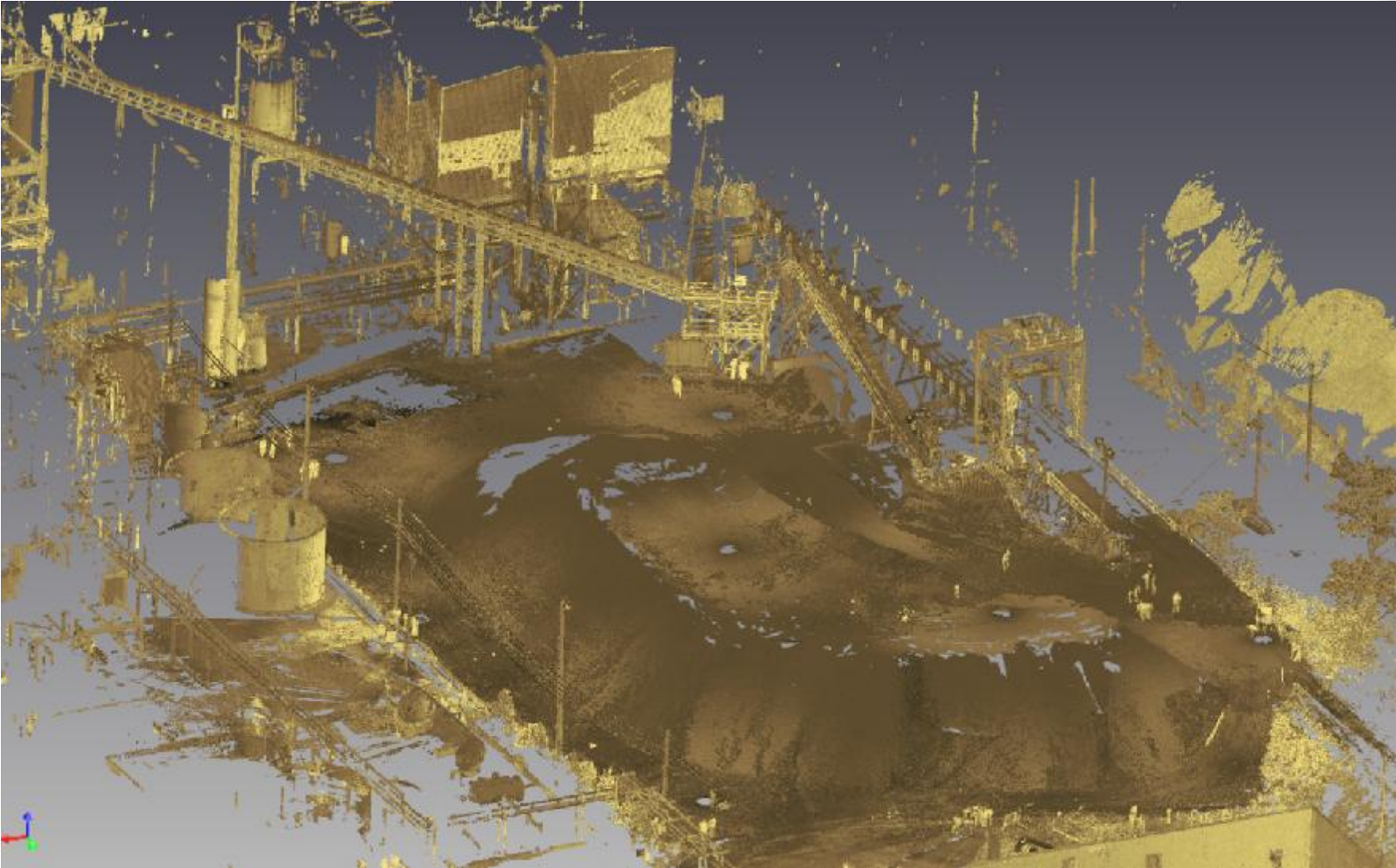
Registration Targets (to join scans into one point cloud)



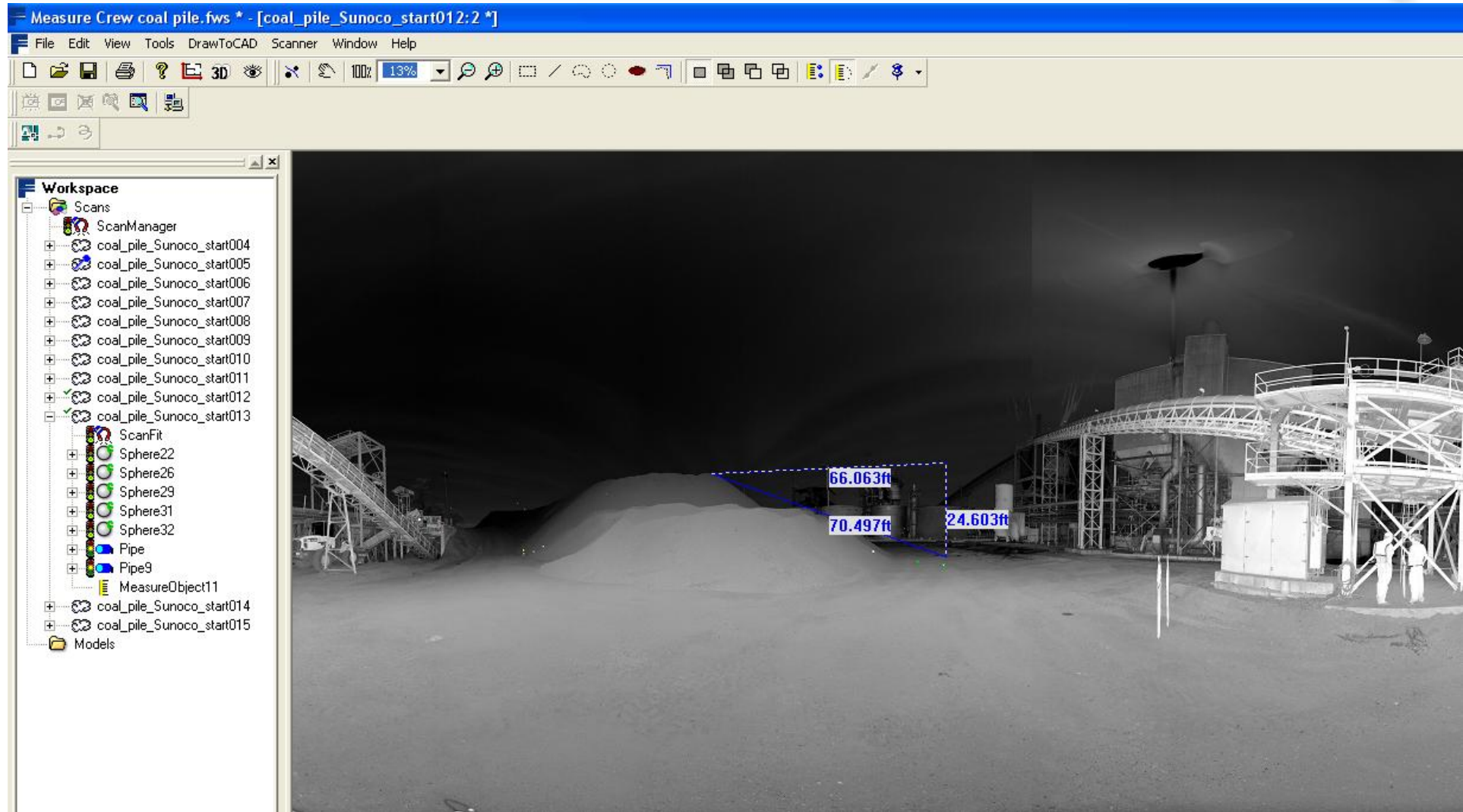
Aerial View of Scan Positions (473 million points)



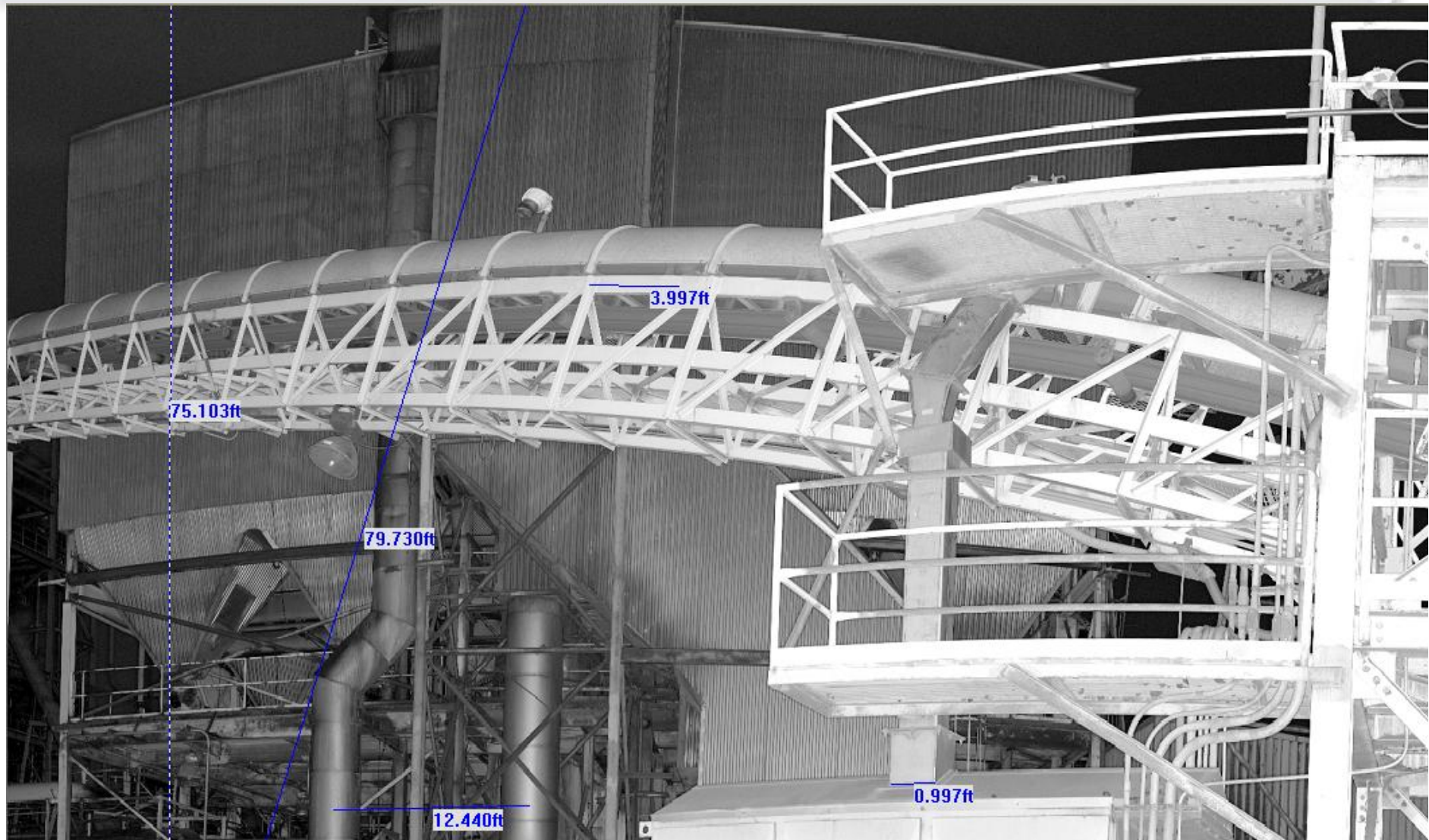
Full Scan Data Set



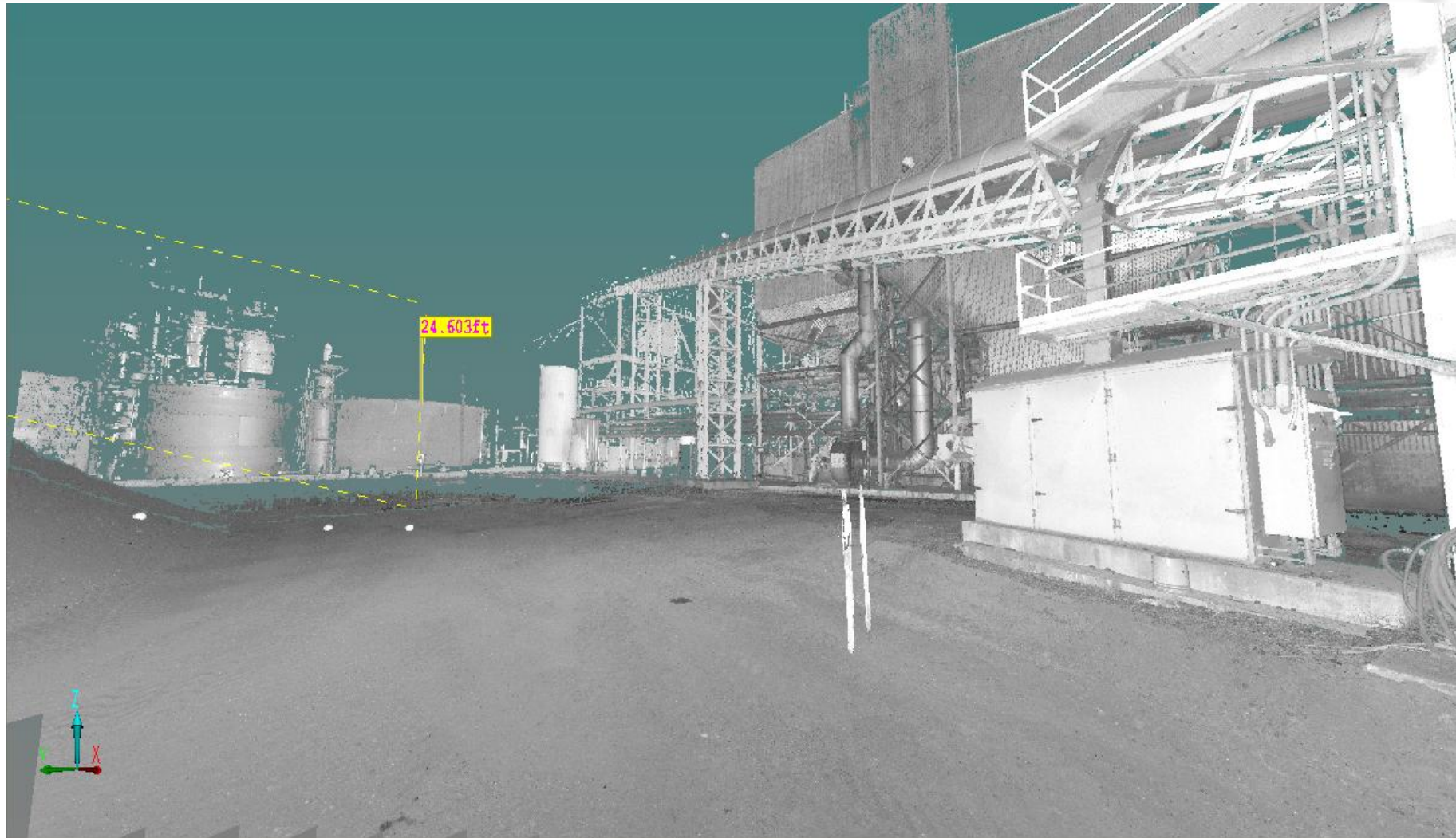
2d Planar View from One Scan Position



Close Up Showing Measurements



3d View from Scanner Vantage Point

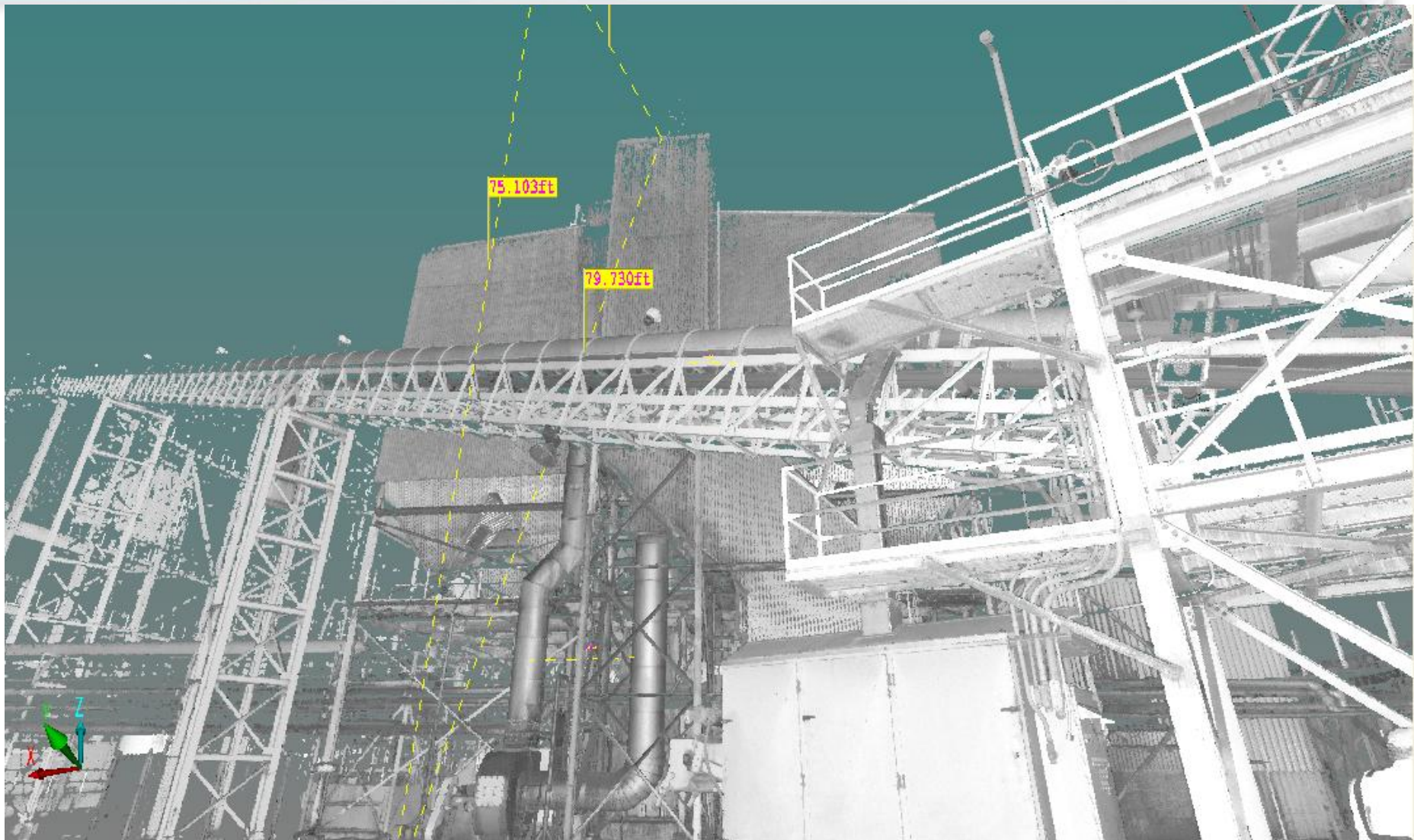


9

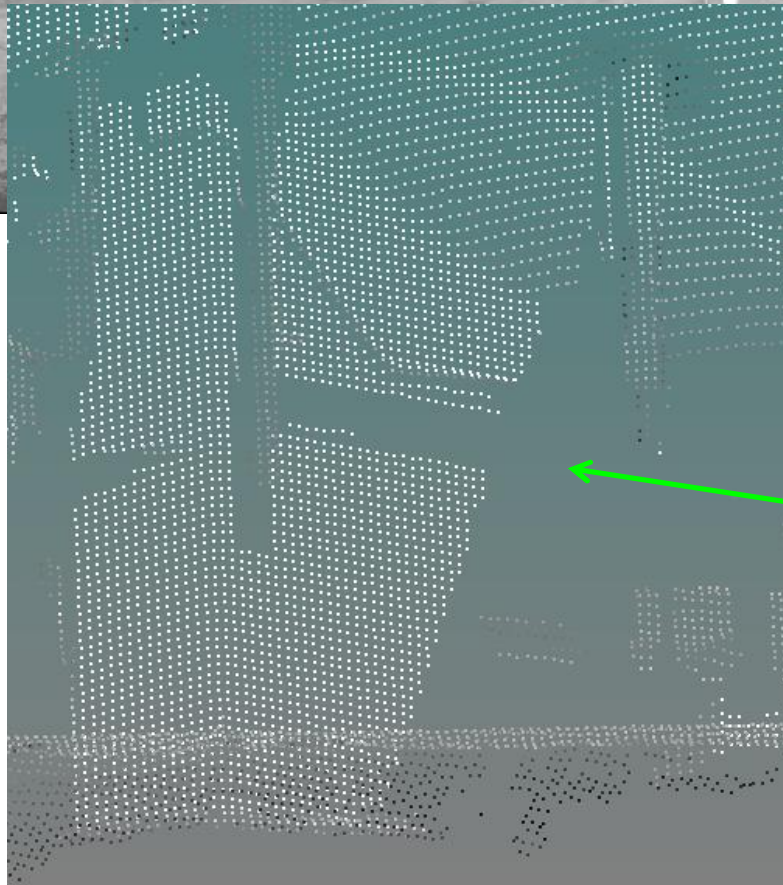
View: 54° 4' w: 121° Pos: 76.89 -14.28 -0.20 Detail: 100% Pts: 41M Plgs: 0

FARO

Close Up of 3d View

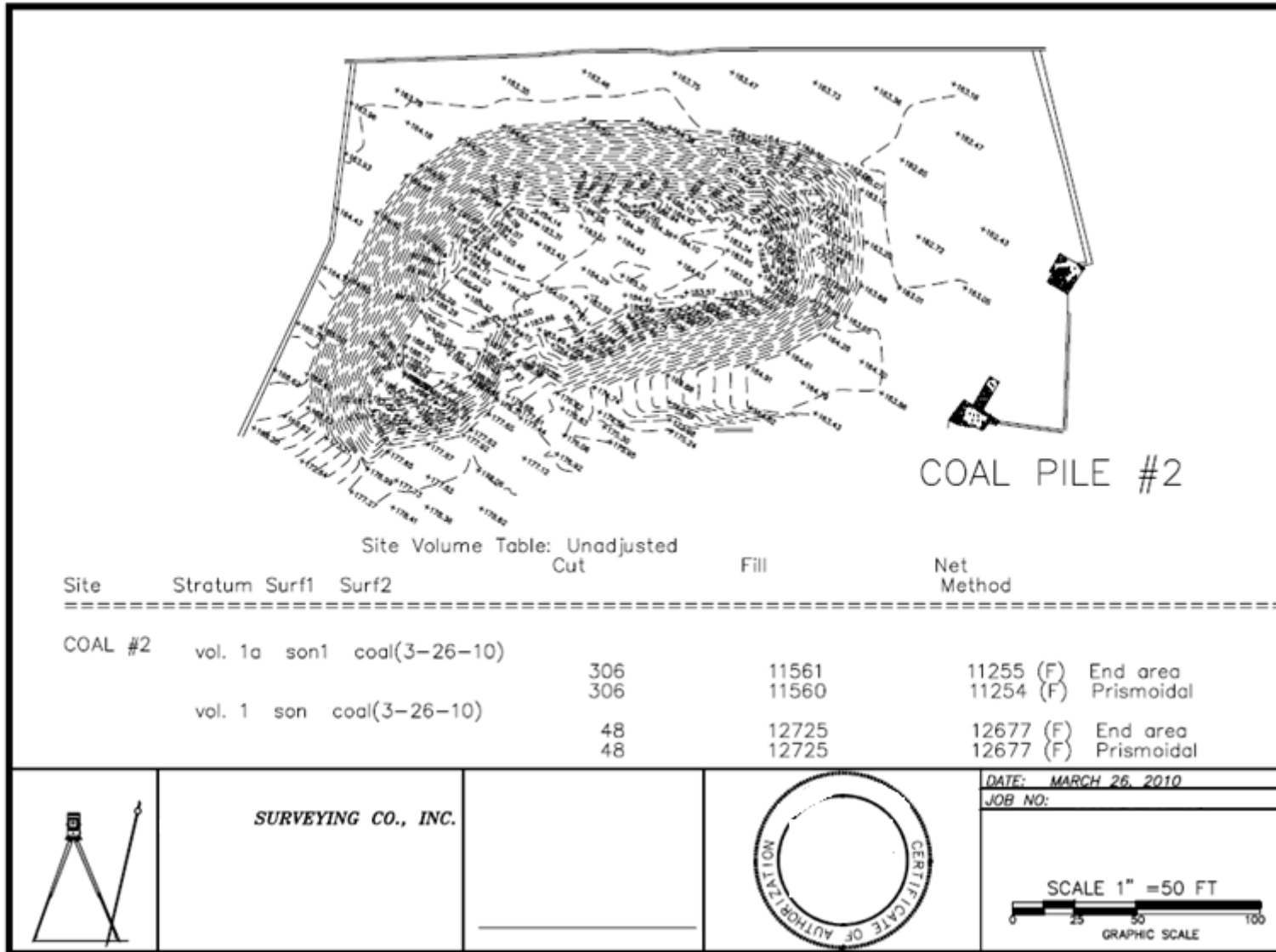


Individual Scan Points (244,000 measurements on tank)



Coal Pile Volume Calculation

Previous Survey Using Traditional Method (3/26)



SURVEYING CO., INC.

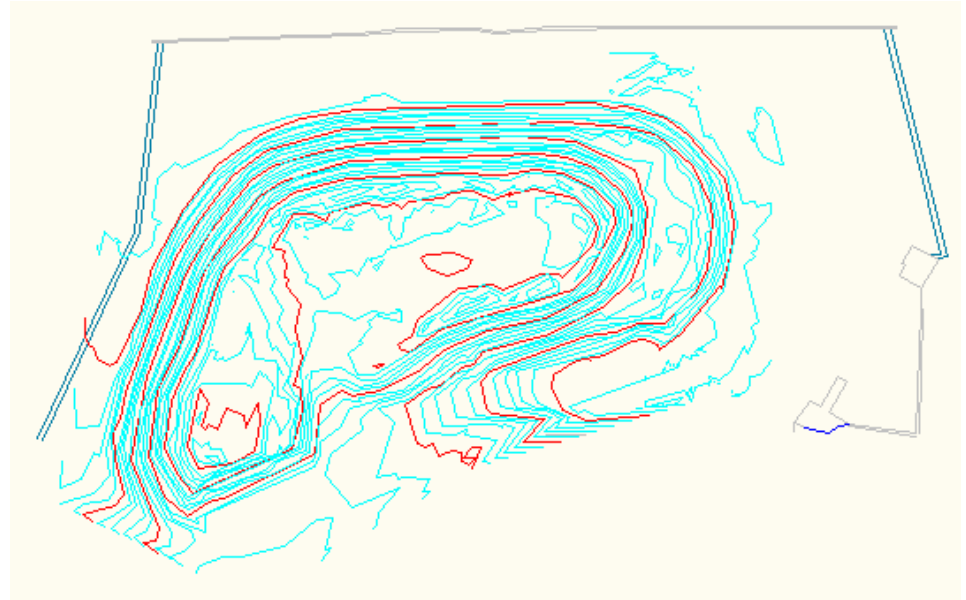
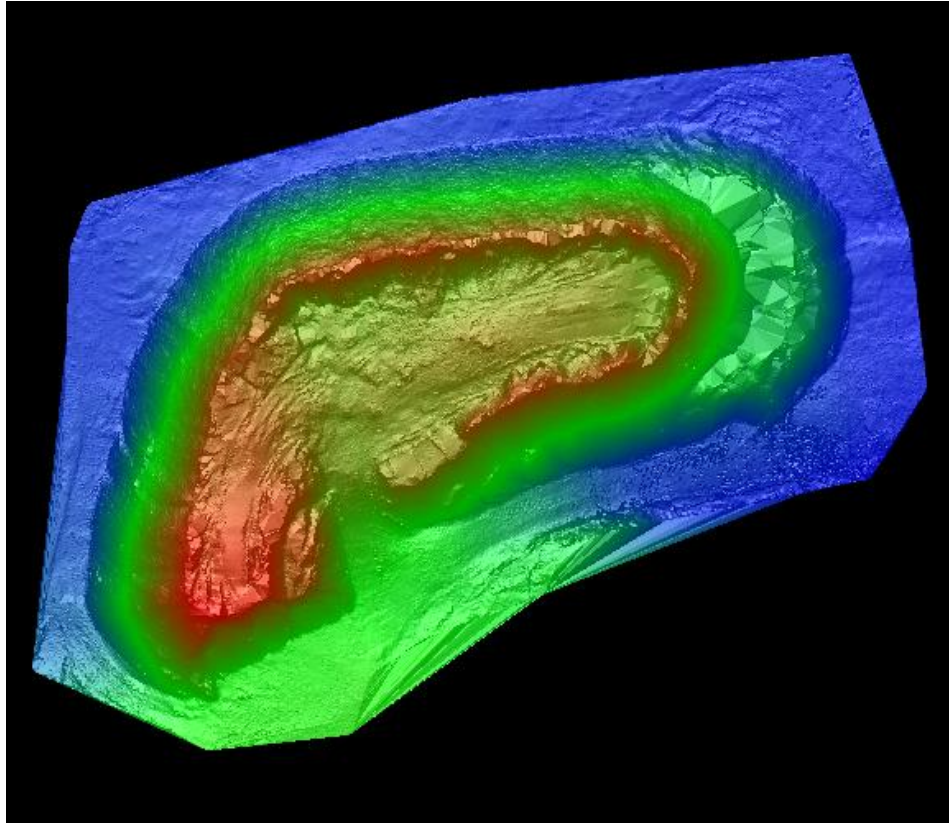


DATE: MARCH 26, 2010

JOB NO:



Laser Scan Results (4/13)



Cut volume: 1,844.5 C.F., 68.31 C.Y.
Fill volume: 308,378.5 C.F., 11,421.43 C.Y.



Carlson

Software for
Land Development
Professionals



FARO

Reports

Traditional Method 3/26/10

Site Volume Table: Unadjusted						
Site	Stratum	Surf1	Surf2	Cut	Fill	Net Method
COAL #2	vol. 1a	son1	coal(3-26-10)	306	11561	11255 (F) End area
				306	11560	11254 (F) Prismoidal
	vol. 1	son	coal(3-26-10)	48	12725	12677 (F) End area
				48	12725	12677 (F) Prismoidal

Laser Scan 4/13/10

```
Volumes by Triangulation (Prisms) Thu Apr 15 19:33:48 2010
Existing Surface: C:\Projects\Point Clouds\FARO\4-15-2010\Base.tin
Final Surface: C:\Projects\Point Clouds\FARO\4-15-2010\ALL.tin

Cut volume: 1,844.5 C.F., 68.31 C.Y.
Fill volume: 308,378.5 C.F., 11,421.43 C.Y.
11,353 yd^3 net

Area in Cut : 1,820.5 S.F., 0.04 Acres
Area in Fill: 28,353.7 S.F., 0.65 Acres
Area exactly in daylight: 11,425.5 S.F., 0.26 Acres
Total inclusion area: 41,599.7 S.F., 0.95 Acres

Average Cut Depth: 1.01 feet
Average Fill Depth: 10.88 feet
Cut to Fill ratio: 0.01
Import Volume: 11,353.1 C.Y.
Elevation Change To Reach Balance: -7.369
Volume Change Per .1 ft: 154.1 C.Y.

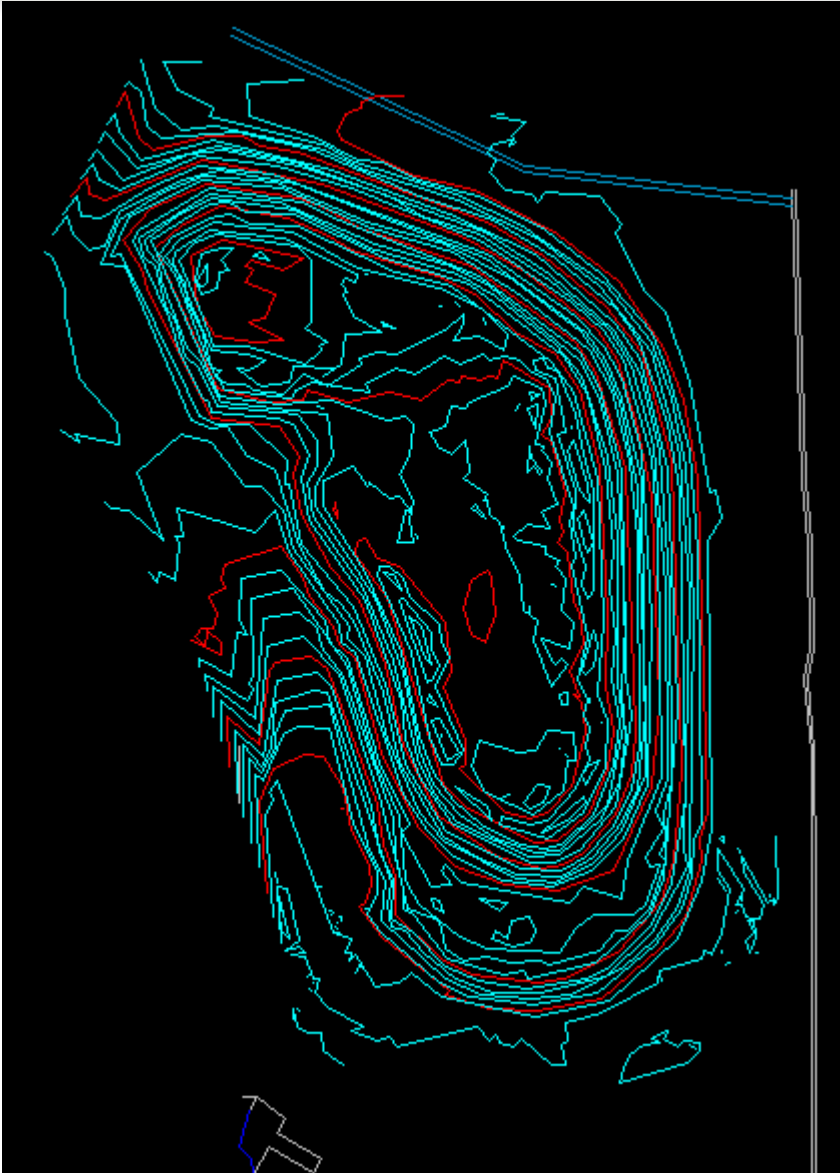
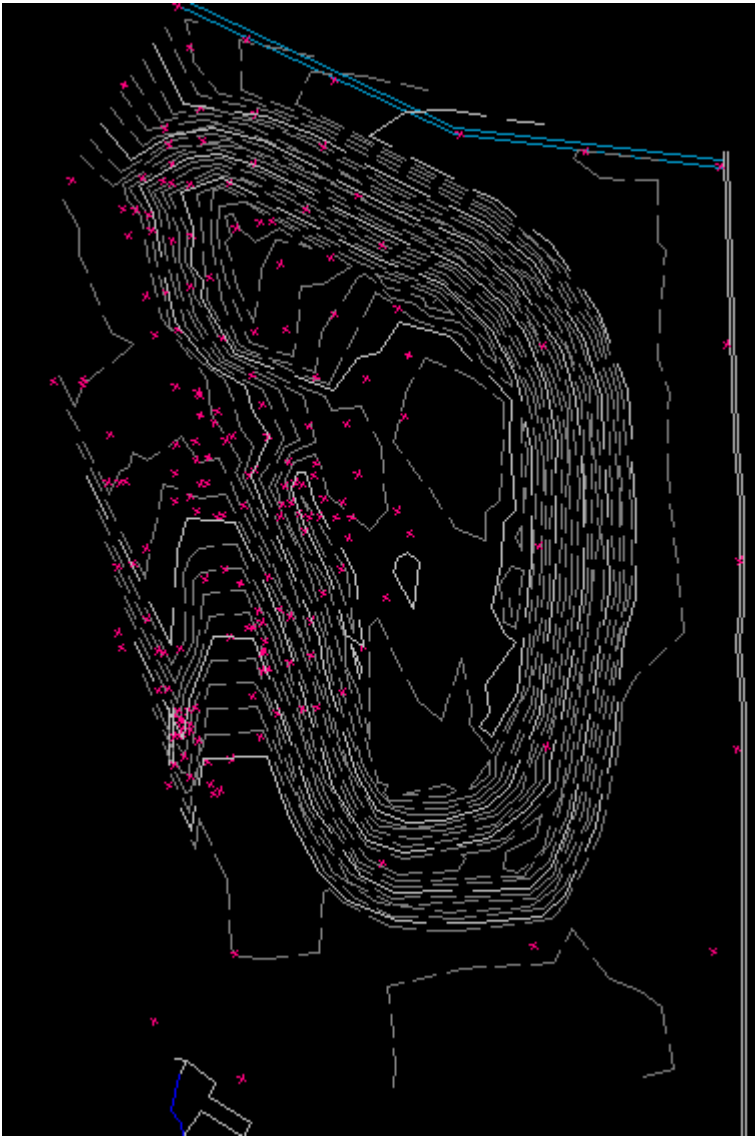
Cut (C.Y.) / Area (acres): 71.53
Fill (C.Y.) / Area (acres): 11959.65
```



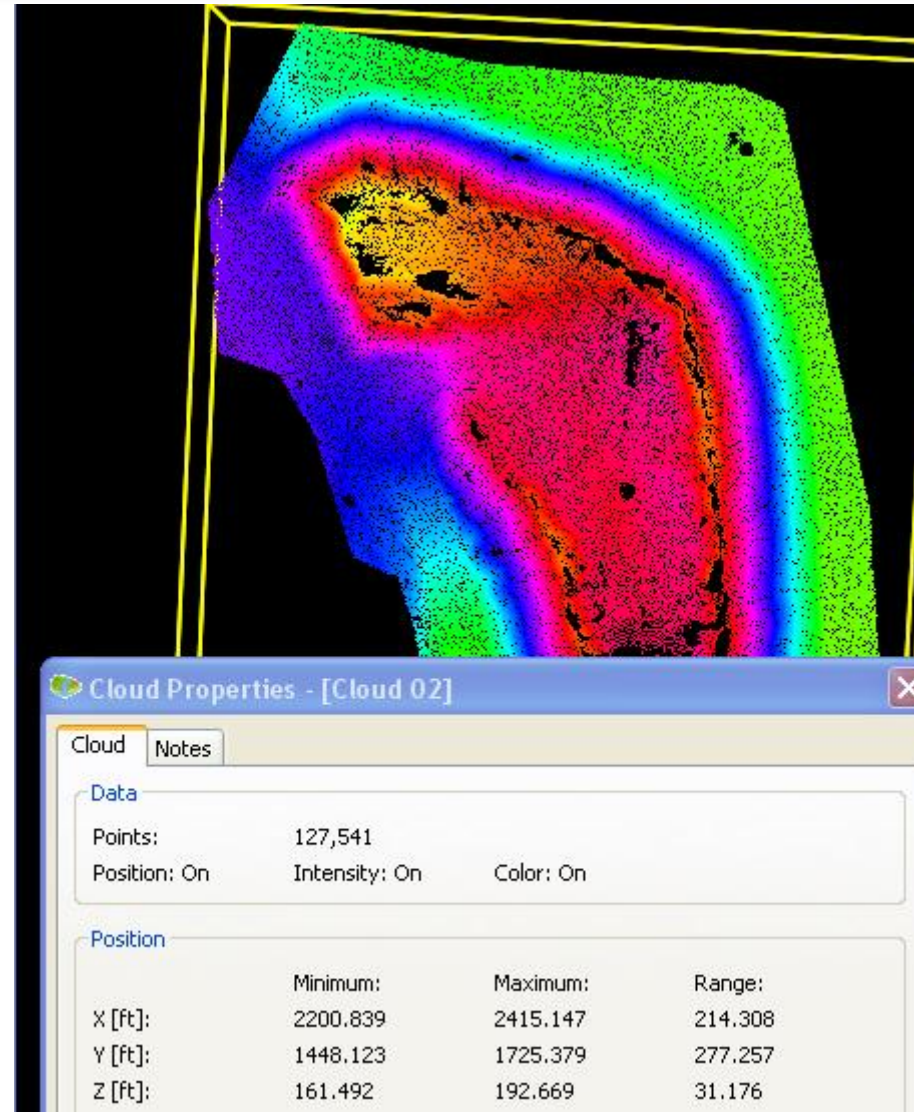
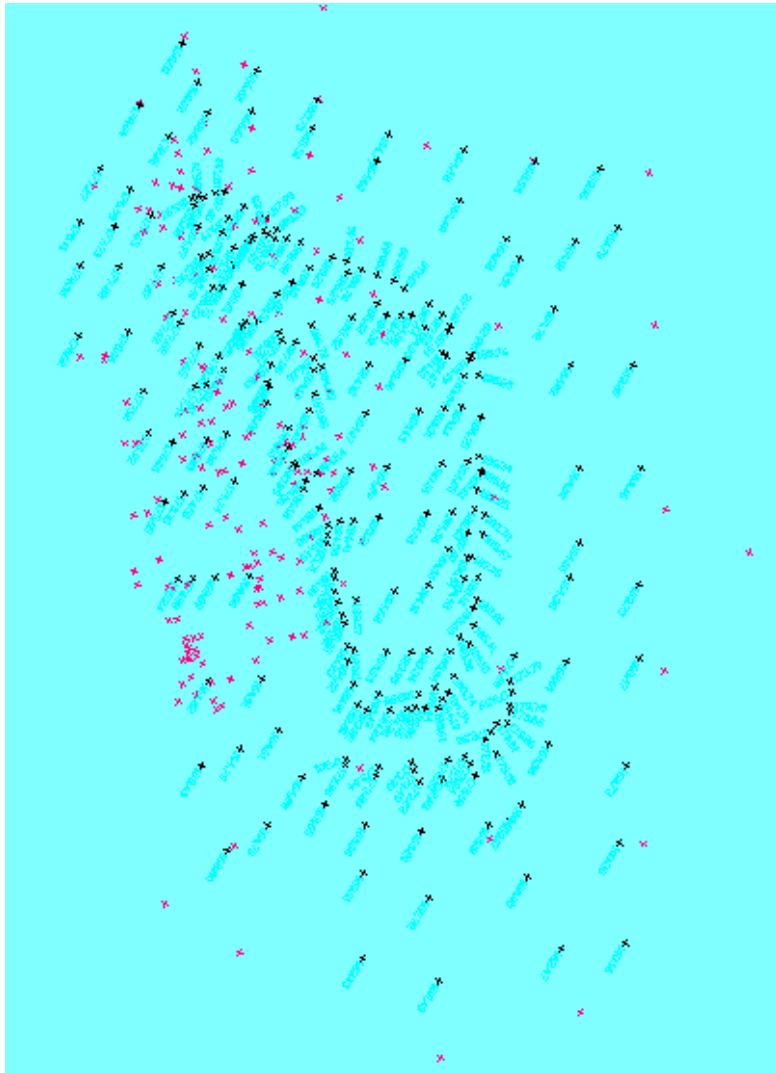
Volume Comparison

	C.Y.	Tons	Cost of Coal (at \$58/Ton)	% of laser scan volume
Traditional Method	12,677	9,447	\$547,920	
Net Use 3/26 to 4/13	<u>1,536</u>	1,145	\$66,388	
	11,141	8,302	\$481,532	98.10%
Laser Scanning	11,353	8,460	\$490,695	100.00%
Difference	212	158	\$9,163	1.90%

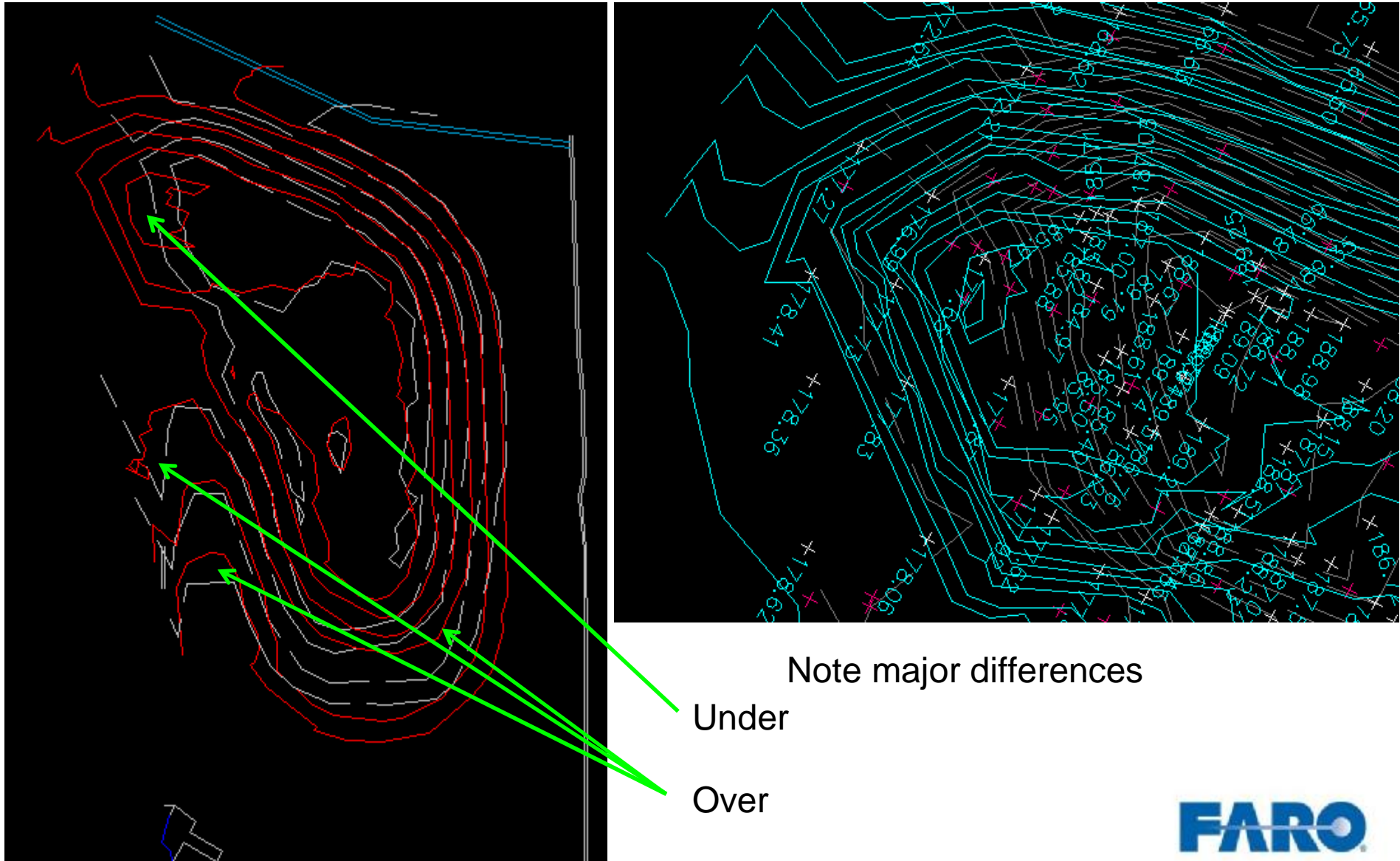
Traditional Method Versus Laser Scan



Traditional (436 points) vs. Laser Scanning (127,000 points used from an available 200+ million)



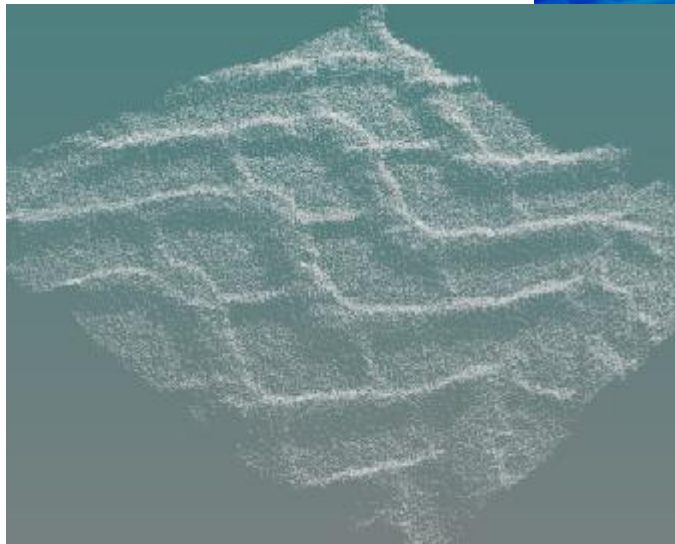
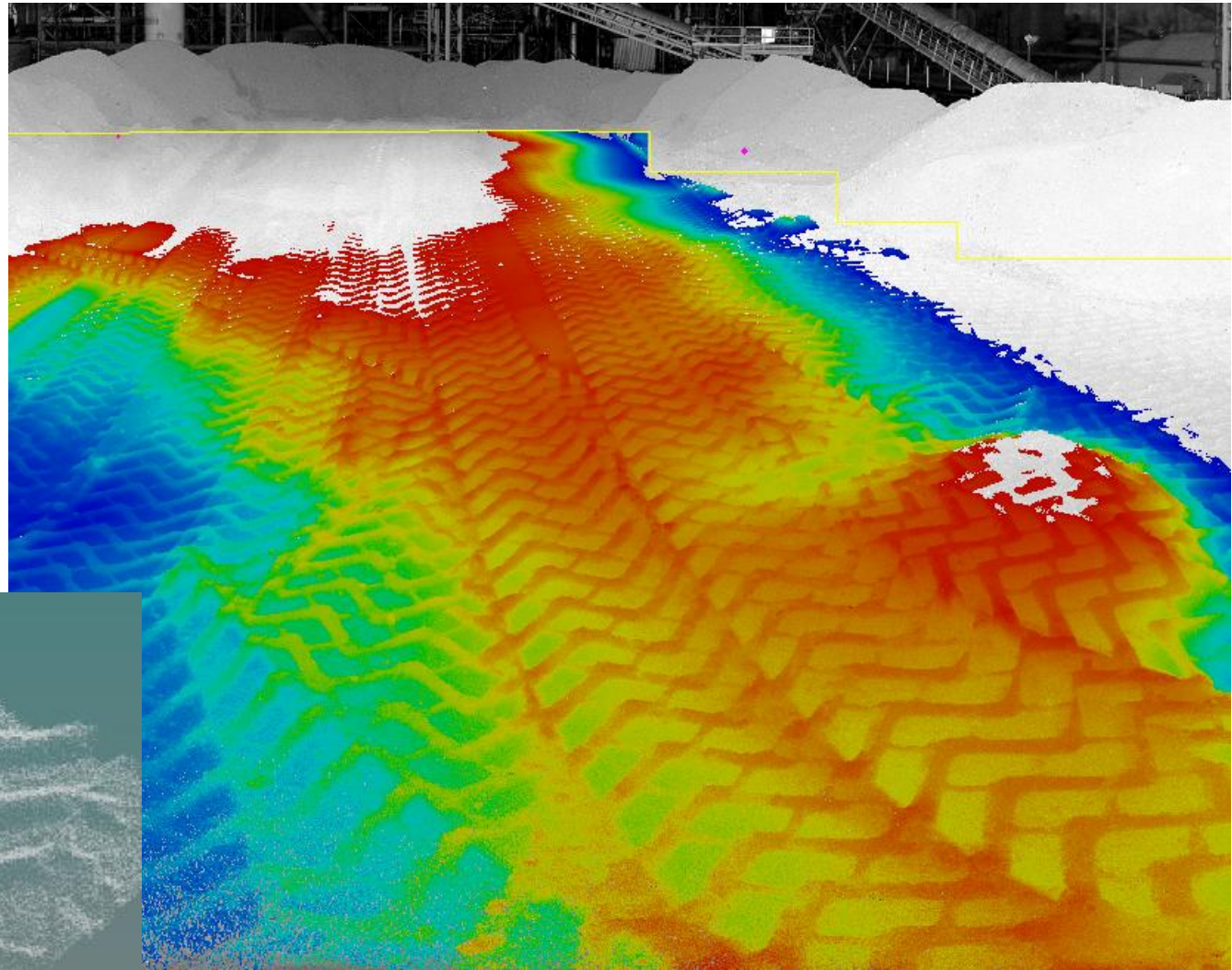
Traditional (gray) Versus Laser Scan (Red and Cyan)



Benefits of Laser Scanning

- **Very accurate**
millions of measurements at +/- 0.079 inch distance accuracy
- **Consistent volume measurements foster confidence in results**
sparse data from traditional method can result in error propagation
or cancellation
- **Safe**
No climbing on sloped areas
- **Fast**
Reduced time spent on-site, quick results

Detail Captured with the Photon Laser Scanner



Scanning Details

- 2.5 hours total field work including set-up, target placement, scanning, and tear down
- Conditions were full sun, mid-day
- 12 scans taken at ¼ resolution, 122kps (7 minutes per scan)
- Three clusters of three target spheres (7.25 cm radius) used
- First target cluster remained fixed and was used to close registration loop
- Remaining two clusters were leap-frogged with scanner
- Scanner to target cluster spacing approximately 17 paces (15-20m)
- Effective range 25 m (82 ft) on coal pile in full sun
- Automatic registration successful on first try

Registration Quality Feedback

The screenshot displays a software interface for point cloud registration quality feedback. The main window shows a 3D view of a coal pile with several registration spheres. A 'Scans' table lists the objects and their distances between two scans. A 'ScanManager' table shows the fit quality for various spheres. A 'SphereFit' dialog box is open, showing the fit parameters for Sphere17.

Scans Table:

Object	Distance [in]	Scan 1	Scan 2
Sphere3	0.09	coal_pile_Sunoco_start008	coal_pile_Sunoco_start011
Sphere10	0.08	coal_pile_Sunoco_start008	coal_pile_Sunoco_start009
Sphere10	0.12	coal_pile_Sunoco_start008	coal_pile_Sunoco_start011
Sphere1	0.15	coal_pile_Sunoco_start008	coal_pile_Sunoco_start009
Sphere1	0.47	coal_pile_Sunoco_start008	coal_pile_Sunoco_start010
Sphere27	0.10	coal_pile_Sunoco_start008	coal_pile_Sunoco_start009
Sphere27	0.43	coal_pile_Sunoco_start008	coal_pile_Sunoco_start010
Sphere9	0.18	coal_pile_Sunoco_start008	coal_pile_Sunoco_start009
Sphere9	0.41	coal_pile_Sunoco_start008	coal_pile_Sunoco_start010
Sphere9	0.19	coal_pile_Sunoco_start008	coal_pile_Sunoco_start011
Sphere3	0.36	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere3	0.07	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere10	0.10	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere1	0.38	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere9	0.25	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere9	0.03	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere27	0.44	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere9	0.23	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere3	0.29	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere29	0.02	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere26	0.02	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere31	0.02	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere22	0.06	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere32	0.04	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere11	0.63	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere15	0.39	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere15	0.69	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere24	0.33	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere18	0.20	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere18	0.33	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere16	0.23	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere16	0.37	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere23	0.30	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere15	0.32	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011
Sphere18	0.17	coal_pile_Sunoco_start009	coal_pile_Sunoco_start010
Sphere16	0.15	coal_pile_Sunoco_start009	coal_pile_Sunoco_start011

ScanManager Table:

Fit Object	Mean T...	Scan/Cli
ScanFit	0.0045	coal_pile
ScanFit	0.0040	coal_pile
ScanFit	0.0040	coal_pile
ScanFit	0.0035	coal_pile
ScanFit	0.0027	coal_pile
ScanFit	0.0024	coal_pile
ScanFit	0.0023	coal_pile
ScanFit	0.0014	coal_pile
ScanFit	0.0011	coal_pile
ScanFit	0.0010	coal_pile
ScanFit	0.0003	coal_pile
ScanFit	0.0001	coal_pile

SphereFit Dialog Box:

Global Coordinates:

Sphere Name: Sphere17

Name: SphereFit

Radius: 0.237861 [ft]

Position: 28.945087 -7.579774 -5.6491 [ft]

Number of scan points: 163

Radius deviation: 0 [in]

Position deviation: 0 [in]

Scan point distance: 0.036295 [in]

Scan point drift: -0.001715 [in]

OK Cancel

Post Processing

Time (minutes)	Task	Software	User or Computer Intensive
5	Copy scans to laptop, backup	Web browser and Windows OS	user
20	Auto-registration	FARO Scene	computer
5	Delete unwanted points, decimate	FARO Scene	user
10	Extract bare earth, generate mesh	Carlson Pointcloud	user
20	Calculate volume	Carlson Civil	computer

60

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www.faro.com

