Lifecycle of a 3D Heavy Civil Construction Model (Reloaded)

CL11775

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Class summary

As the horizontal construction world continues to catch up with the vertical world, we will once again dive into the use of 3D heavy civil construction models and the workflow associated with them. We will cover the benefits of using a 3D model, starting at the bid, going through construction, as-builts and finally operations and maintenance. Shown through the eyes of a contractor, we will share both field and office experiences while displaying project examples. We will discuss creating models for bidding, procuring field data to support 3D models, including UAV's (unmanned aerial vehicles) and laser scanning, using AutoCAD Civil 3D software to build excavation models for quantification, AMG (Automated Machine Guidance), modeling to determine means and methods, utilizing the 3D model in the field for stake less layout, and using Navisworks software. We will also cover VDC (Virtual Design Coordination) with owners and subcontractors, decreased turnaround time on requests for information / change orders, safety benefits, point clouds, and fabrication plans.

Who are we and what do we do?

Brian K. Smith
Director of Technology

Oversees VDC, BIM, IT, GPS & Survey
18 Years in Civil Construction
Hydroelectric, Water/Wastewater
Roads, Bridges, Airports
Instructor at Washington Engineering Institute

Sam Kloes AKA “Satellite Whisper”
GPS / Survey Manager

Oversees GPS, Survey and AMG Program
14 Years in Civil Construction
Transportation /
Water / Wastewater / Heavy Civil
Instructor at Washington Engineering Institute
NCCER certified instructor

Key Learning Objectives

- Learn why building 3D model for the life of the project is important
- Discover how UAV's and laser scanning are used to supplement field data procurement
- Discover how the use of 3D models helps every general contractor
- Discover the benefits of 4D modeling and Virtual Design and Construction

Building 3D Models for Construction

When building a model the level of detail and accuracy is determined by the individual task, available data, and resource allocation.

Areas we use 3D models:

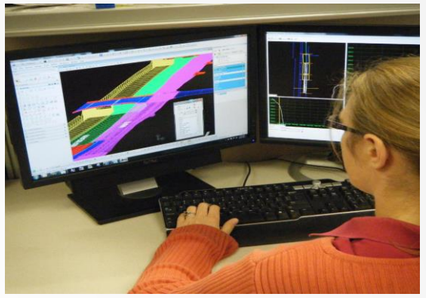
- Quantity Takeoffs
- Planning
- Construction Ready Model
- Rework
- As Builts

We start with a process we have coined "**Forensic Plan Reading**"

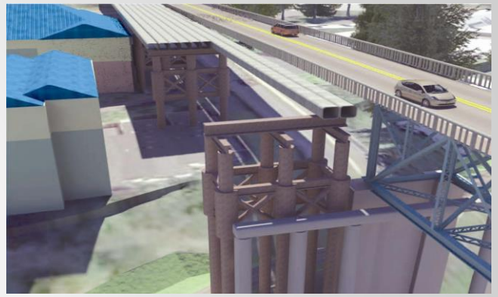
From the Office to the Field Workflow

Analyze Data

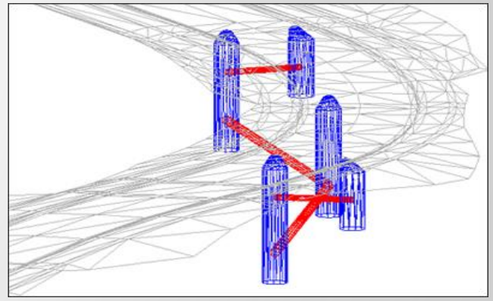
Meet with Project Managers



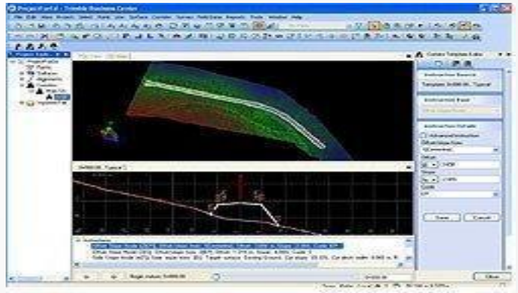
Supplement/ recreate data



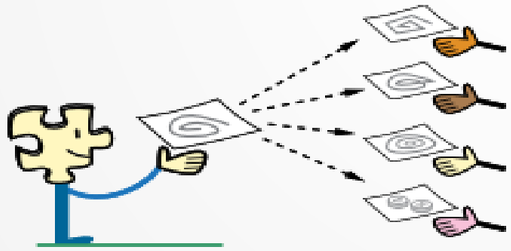
Review Means & Methods



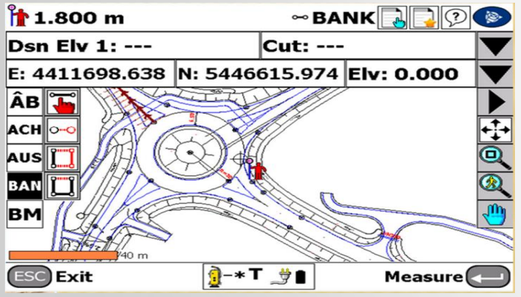
Create Grading & Utility Models



Review & Back-check Models



Share models with Engineering and Subcontractors



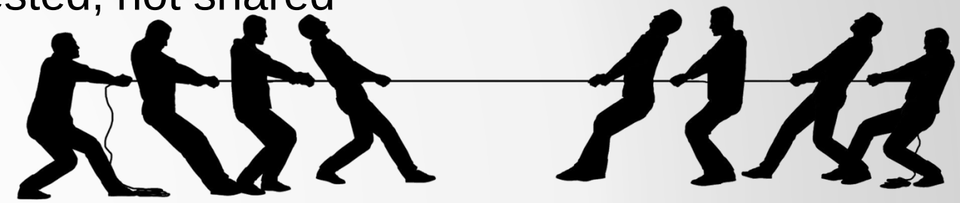
Migrate Data to the Field

What Data is Typically Shared and When?

Typical Electronic Data Shared

Pre Bid

- PDF's of Plans and Specifications (at minimum for all projects)
- Electronic CAD files are rarely offered and even when requested, not shared



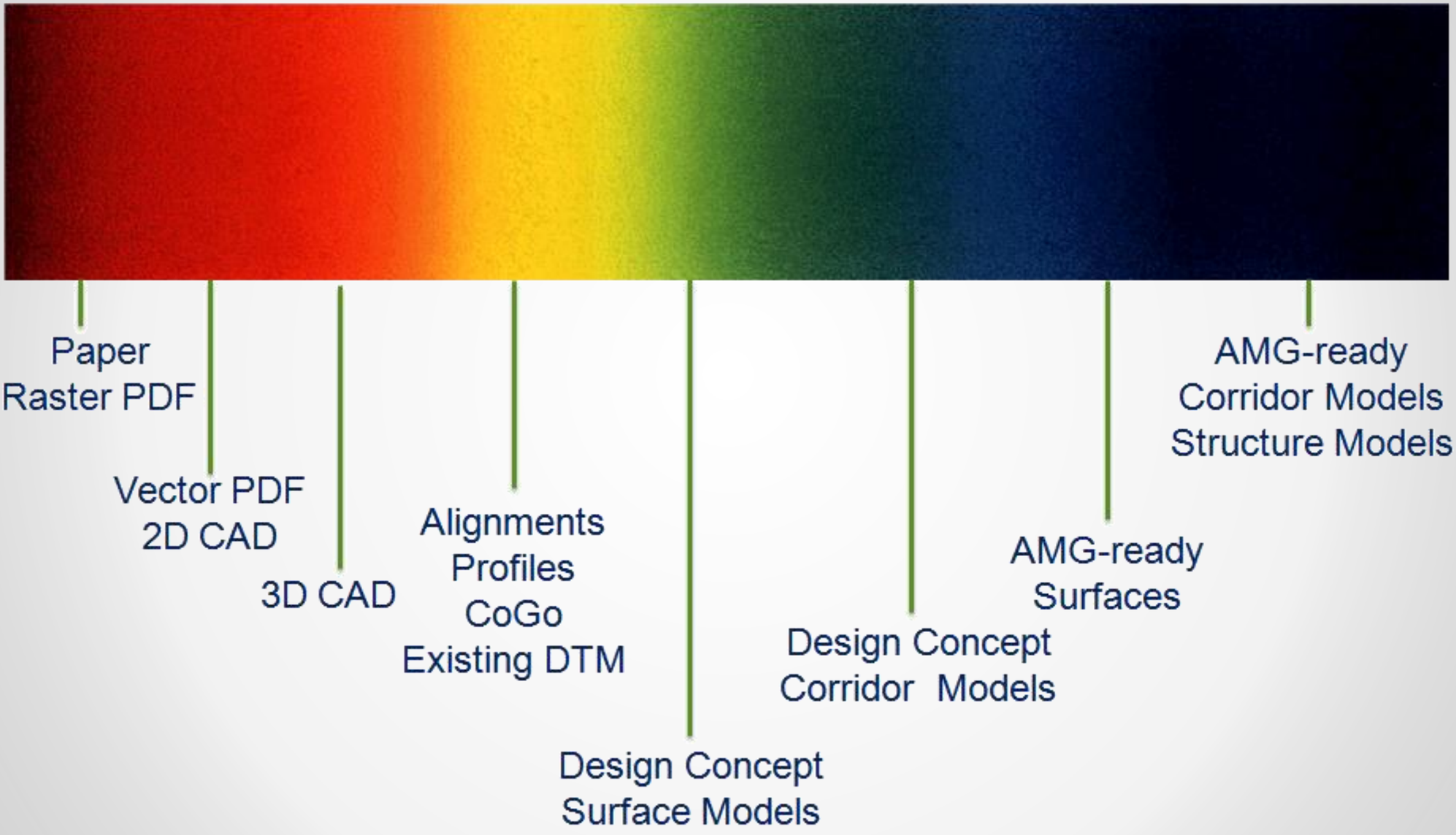
Post Award

- PDF's of Plans and Specifications
- Electronic CAD and design data are received for most contracts
- 3D Models (very few)
- Sharing of information is greatly increased, but still reserved

Private, Design Build, RFP, and Negotiated Contracts

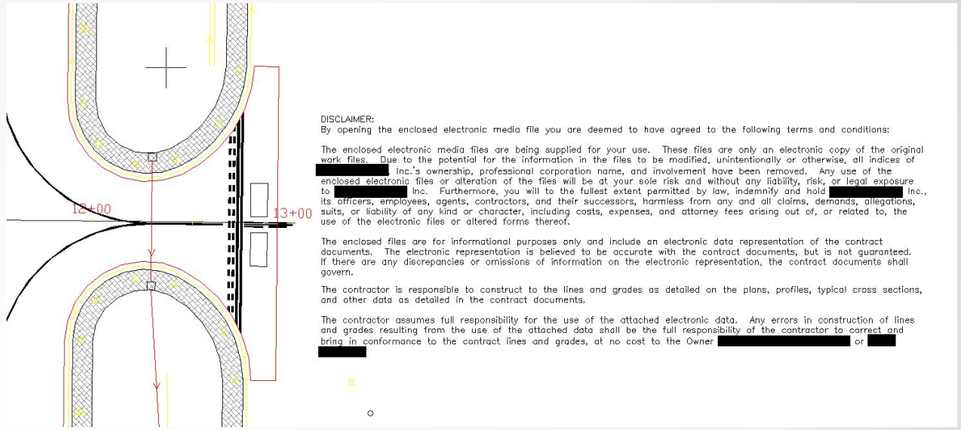
- PDF's of Plans and Specifications
- Electronic CAD and design data are received for most contracts
- 3D Models
- Sharing of information is more free flowing and collaborative

Types of Data Received for Contractors



Types of Data Received for Contractors

Electronic CAD and Design Data Files



CAD formats (DWG, DGN, DXF, RVT, SHP)

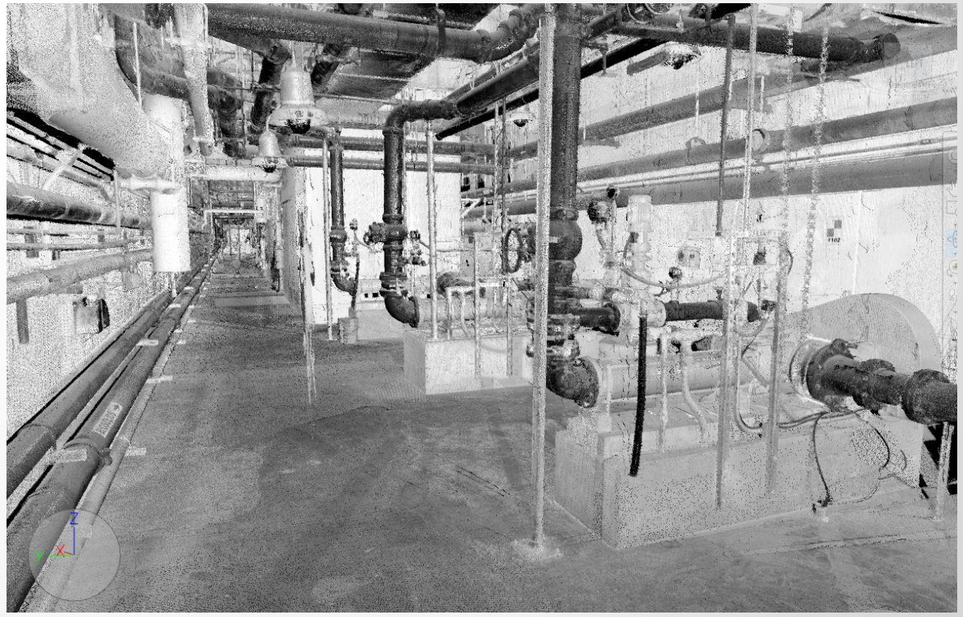
- 2D & 3D files
- 3D polylines
- Surfaces
- Design information (profiles and assemblies)

3D model exchange formats

- XML's (landXML, gbXML)
- DTM, TIN, NED (3D surface files)
- LAS (3D point cloud data)

BIM Models

- Mainly Structural, Revit/Tekla



Types of Data Received for Contractors

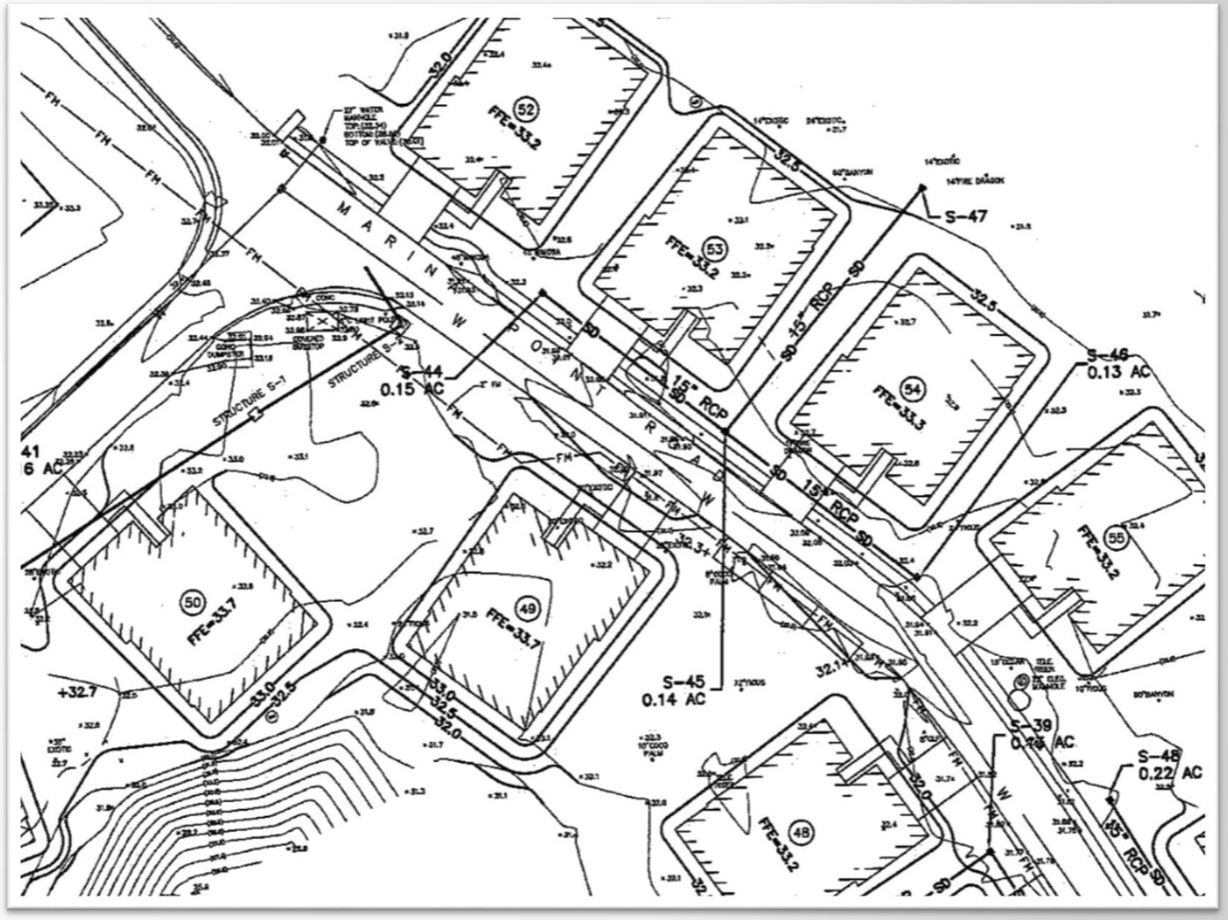
For a General Contractor there are mainly two different types of data received

- PDF’s (Raster and Vectorized)
- Electronic CAD and design files

Types of Data Received for Contractors

Raster Adobe PDF's

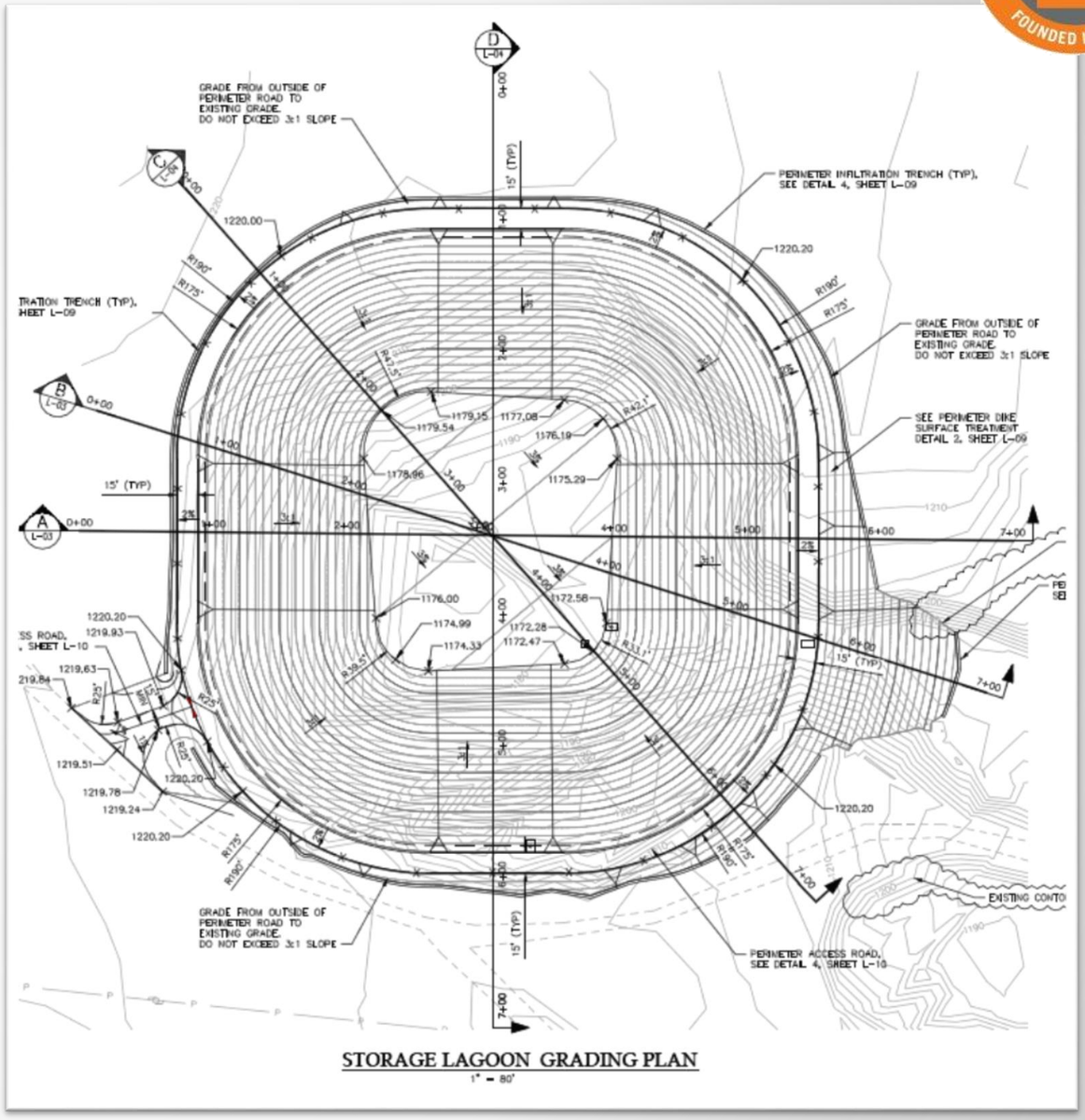
- No tangible electronic data
- Pixilated data
- Must digitize using software to import to CAD
- Lowest quality of data to import
- Typically from scans of plots



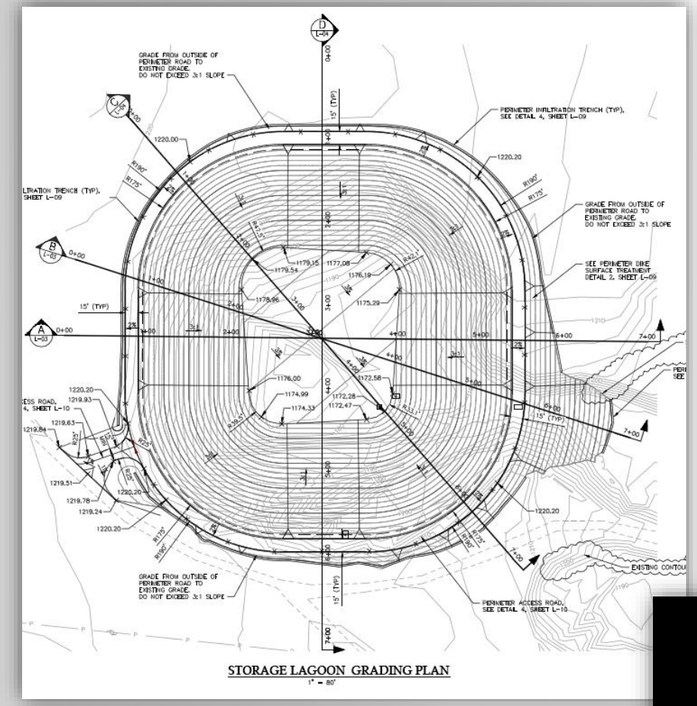
Building a Model for Earthwork Takeoff

Vectorized Adobe PDF's

- Contains data with numerical values for lines, curves, etc.
- Direct export from design software
- Fastest turnaround to tangible 3D data

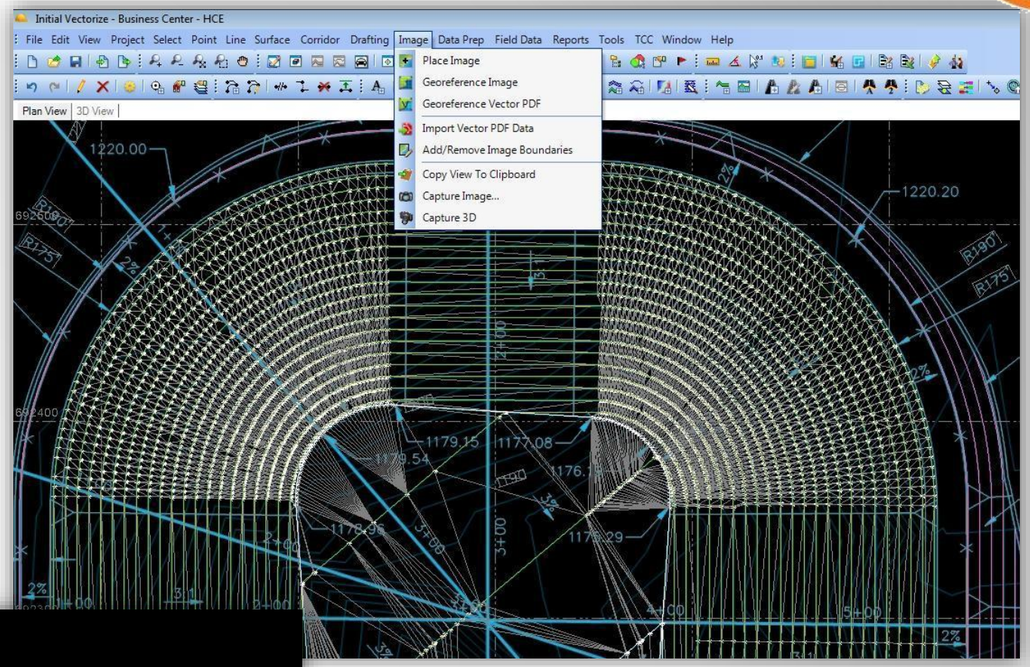


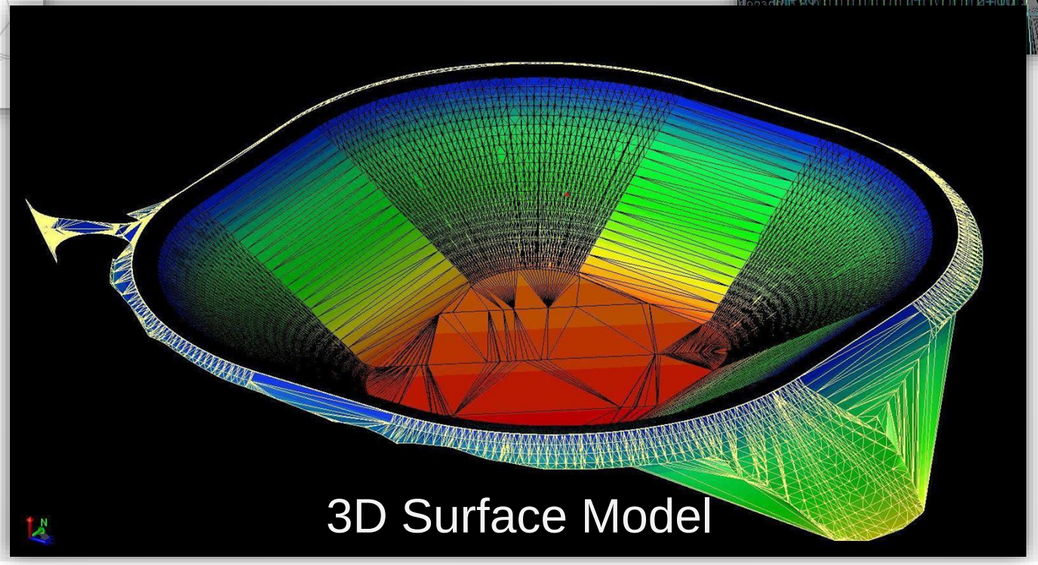
Vectorized PDF Data



Vectorized PDF

TIN Model





3D Surface Model

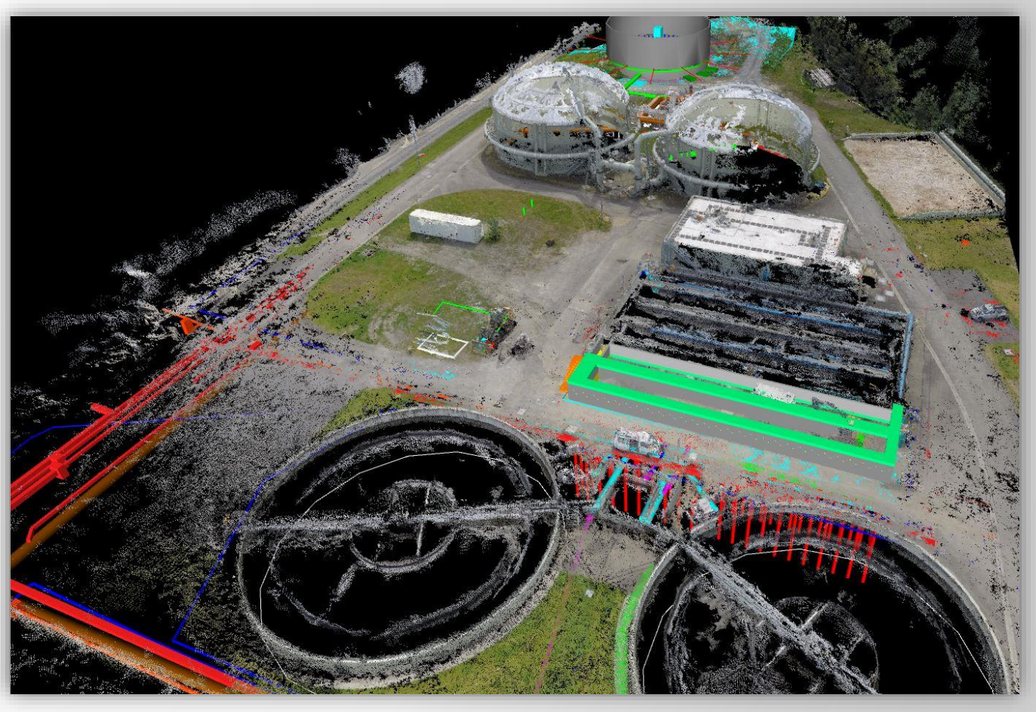
Contractor Survey Data to Support 3D Model

- Collect additional physical data for construction and laydown (GPS/Conventional Survey, Laser Scan, UAV)
- Determine Construction means and methods
- Identify any discrepancies or deficiencies in the engineered plans
- Improves construction accuracy

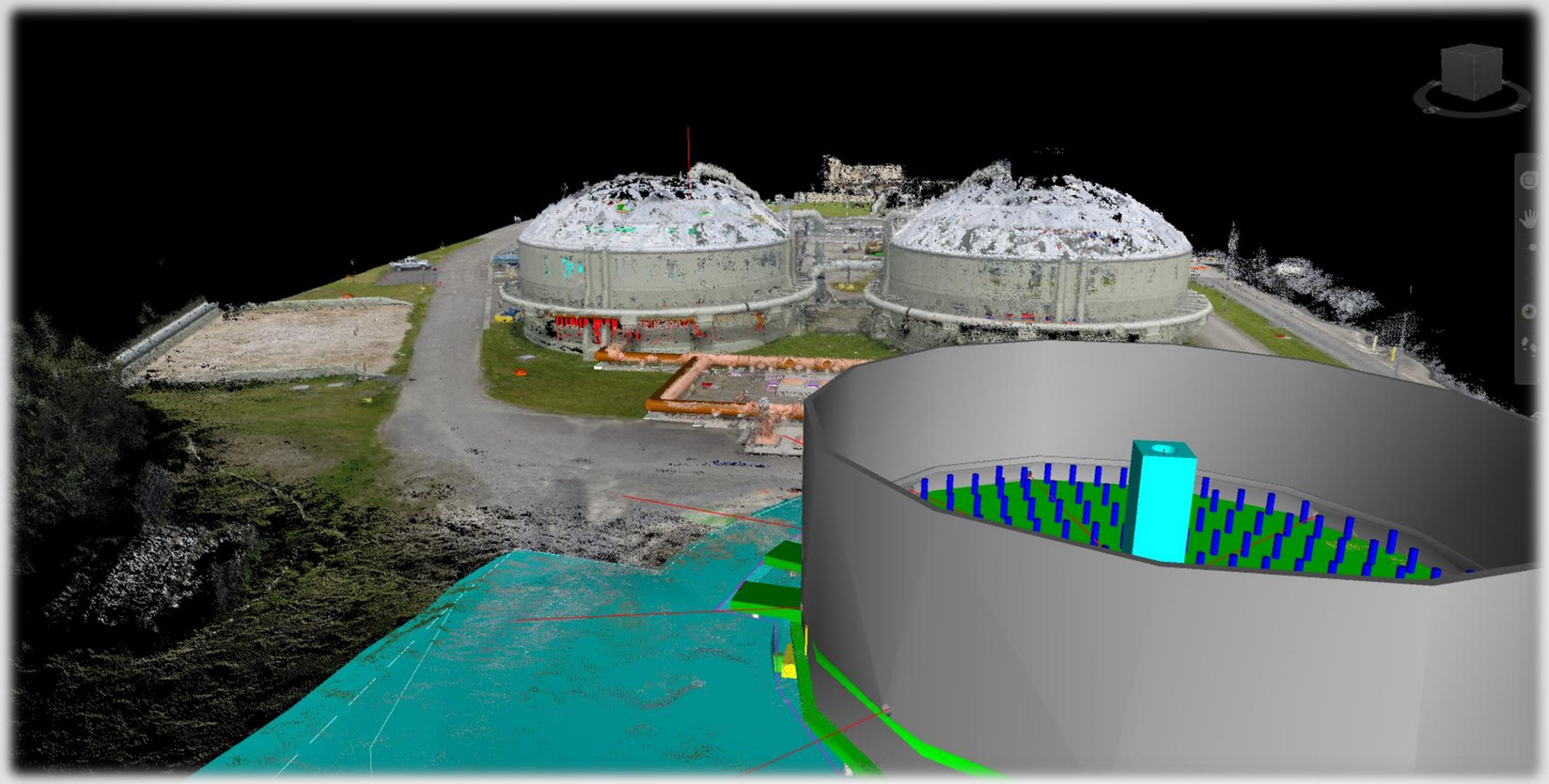
Communication

A 3D Model Simply and Clearly Communicates Revisions & Issues

- Share models and issues with engineers and subcontractors
- Review issues in 3D Design or requested changes
- Meet with Project Managers
- Propose resolution
- Proposed revision made to in-house drawing
- Send revised drawing with RFI to Design Engineer
- Receive authorization to proceed (faster turn-around)
- Migrate data to field

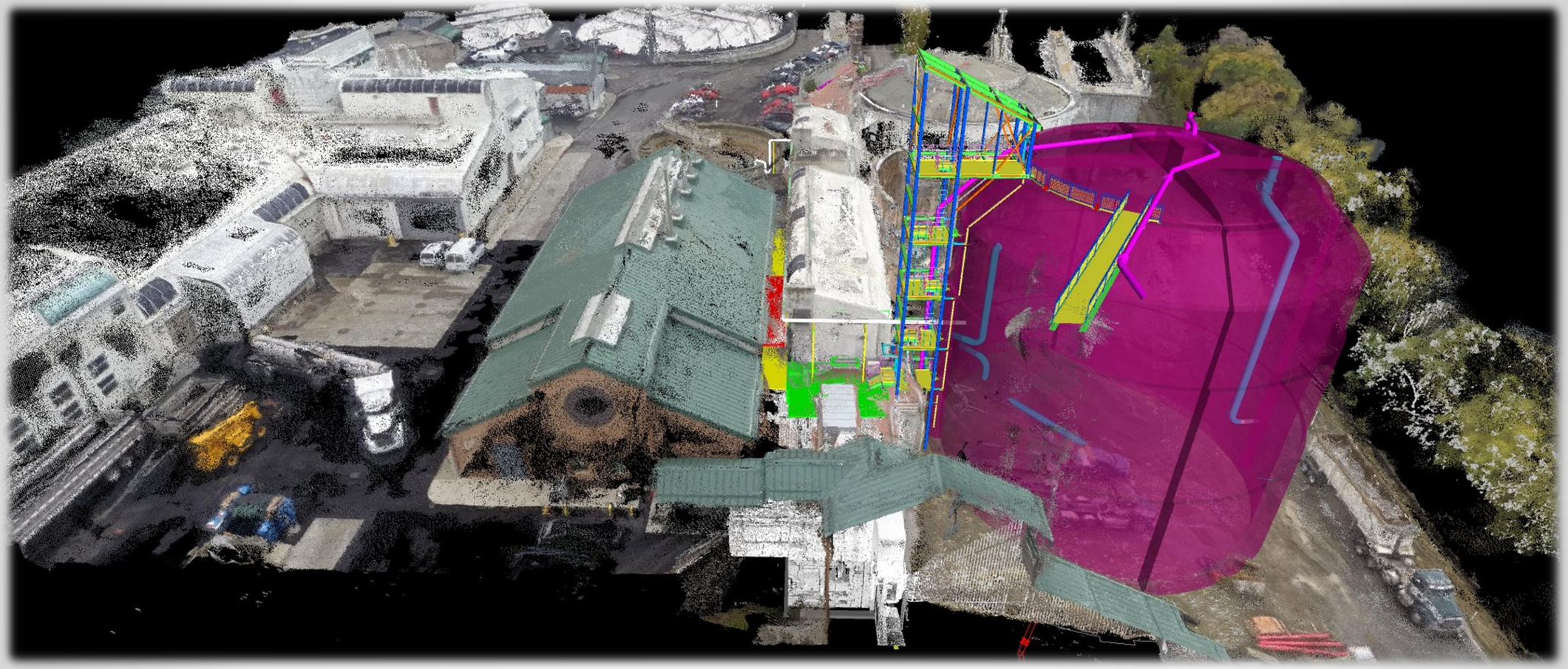


Self Performing BIM In-House on Alternative Delivery Projects



- Provides complete project oversight
- Reduces time on RFI’s and change orders
- Clearly shows the plans in a non-engineering format
- 4D modeling with P6 for scheduling impacts to project

Modeling Existing and Future Utilities, Structures



- Accurate planning, staging and construction
- Intelligent data is embedded in the model
- Model is used on site with the owner and subcontractor

Taking BIM/CIM to the Field

- Full project stakeless layout for excavation and installation
- Allows for design changes with little down time

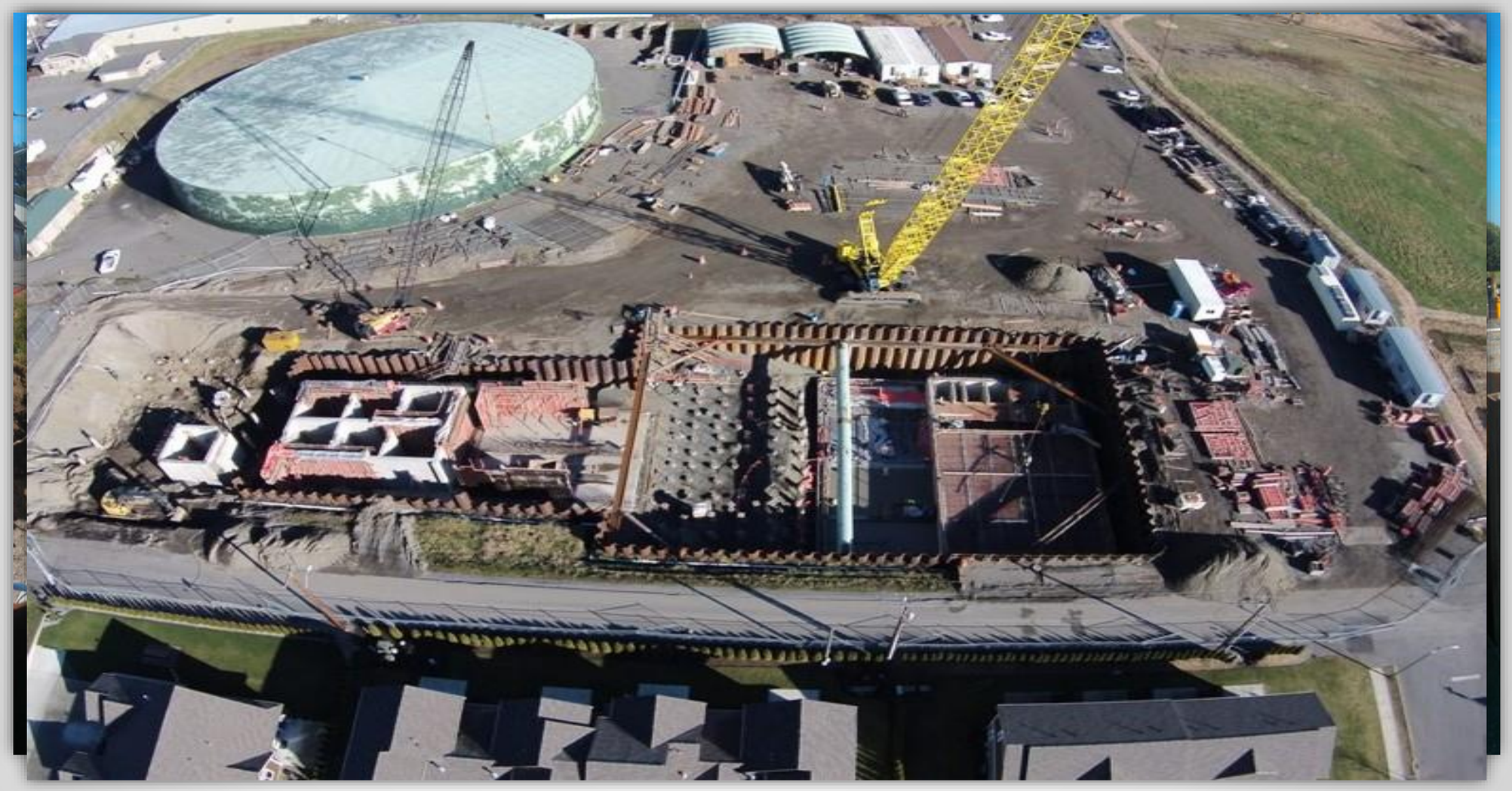
3D Modeling of All Aspects Allows for Detailed Means, Methods and Finite Hazard/Clash Anticipation

Modeling proposed and Shoring

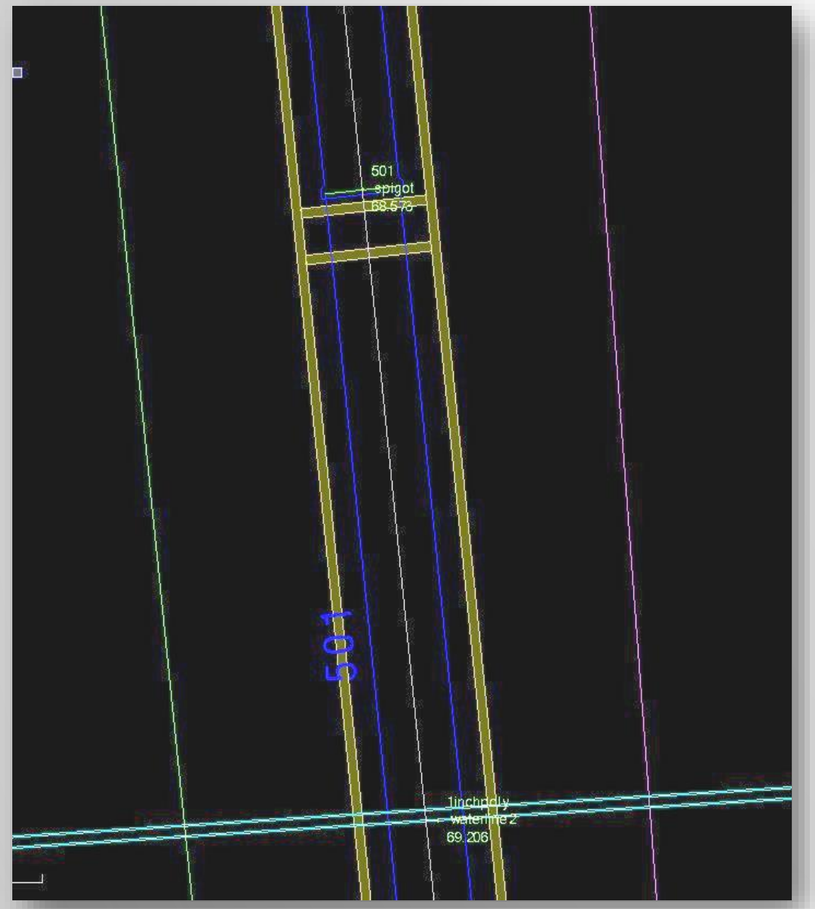
Modeling proposed and Utility Conflicts

Using 3D Scan Data

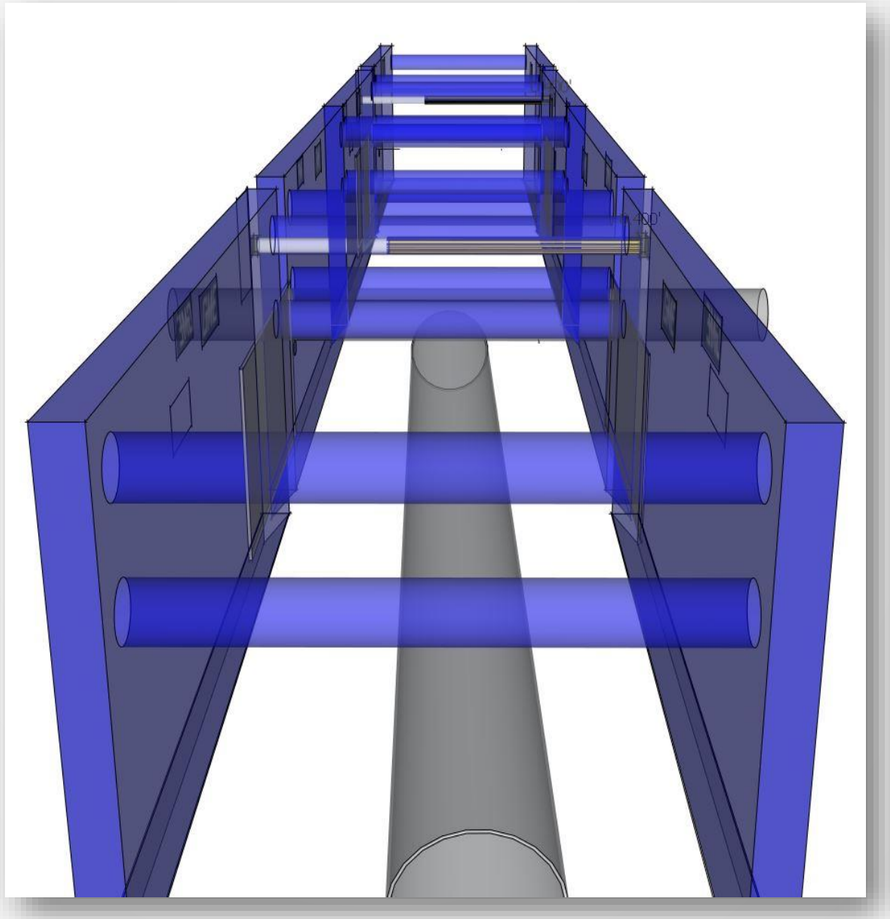
Modeling Every Aspect of a Project from Shoring to Pan Decking Saves Time and Money



Modeling and Potholing to Develop Means and Methods



Hydro Excavation / Pot Holing and Survey

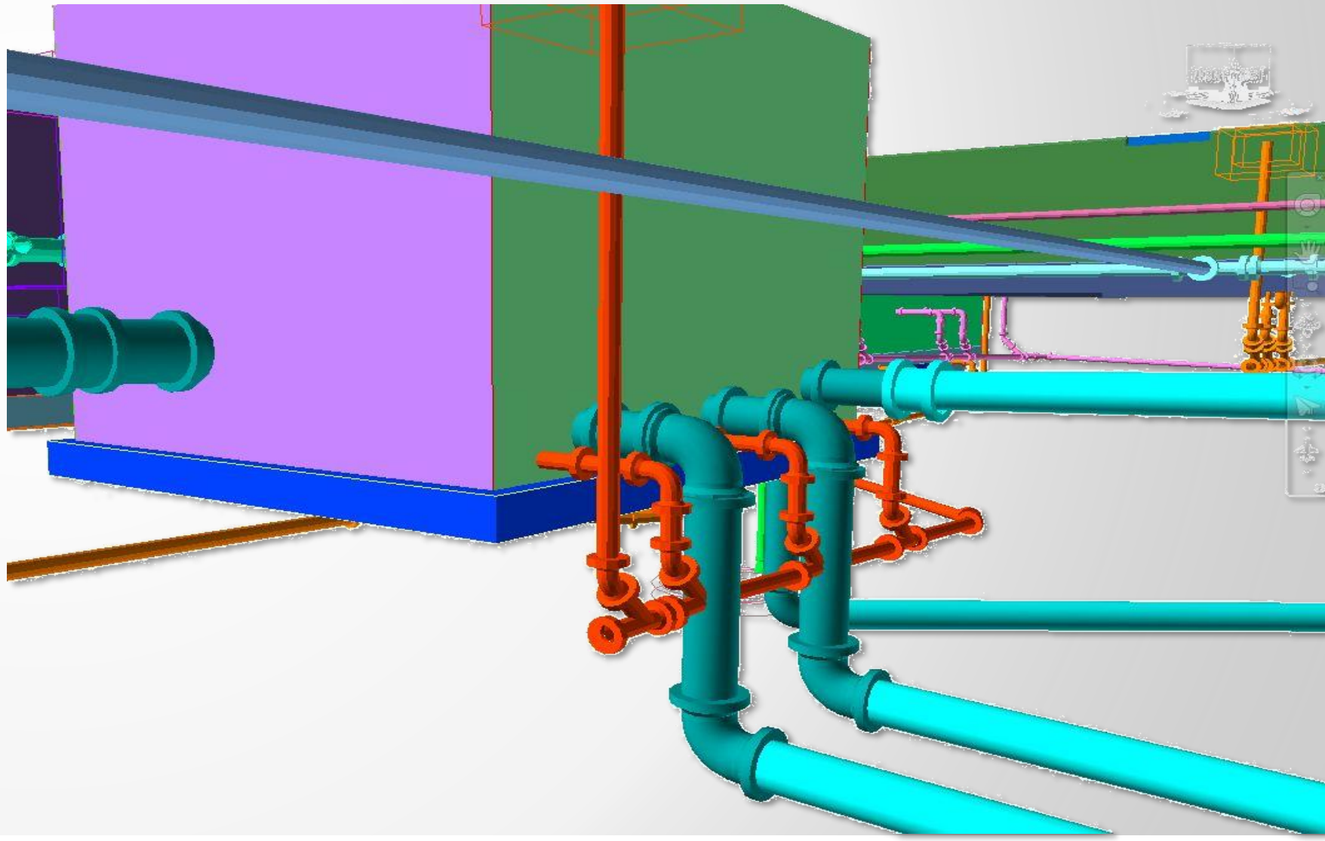


Shoring Pre Design Specific to areas of conflict

Managing Revisions

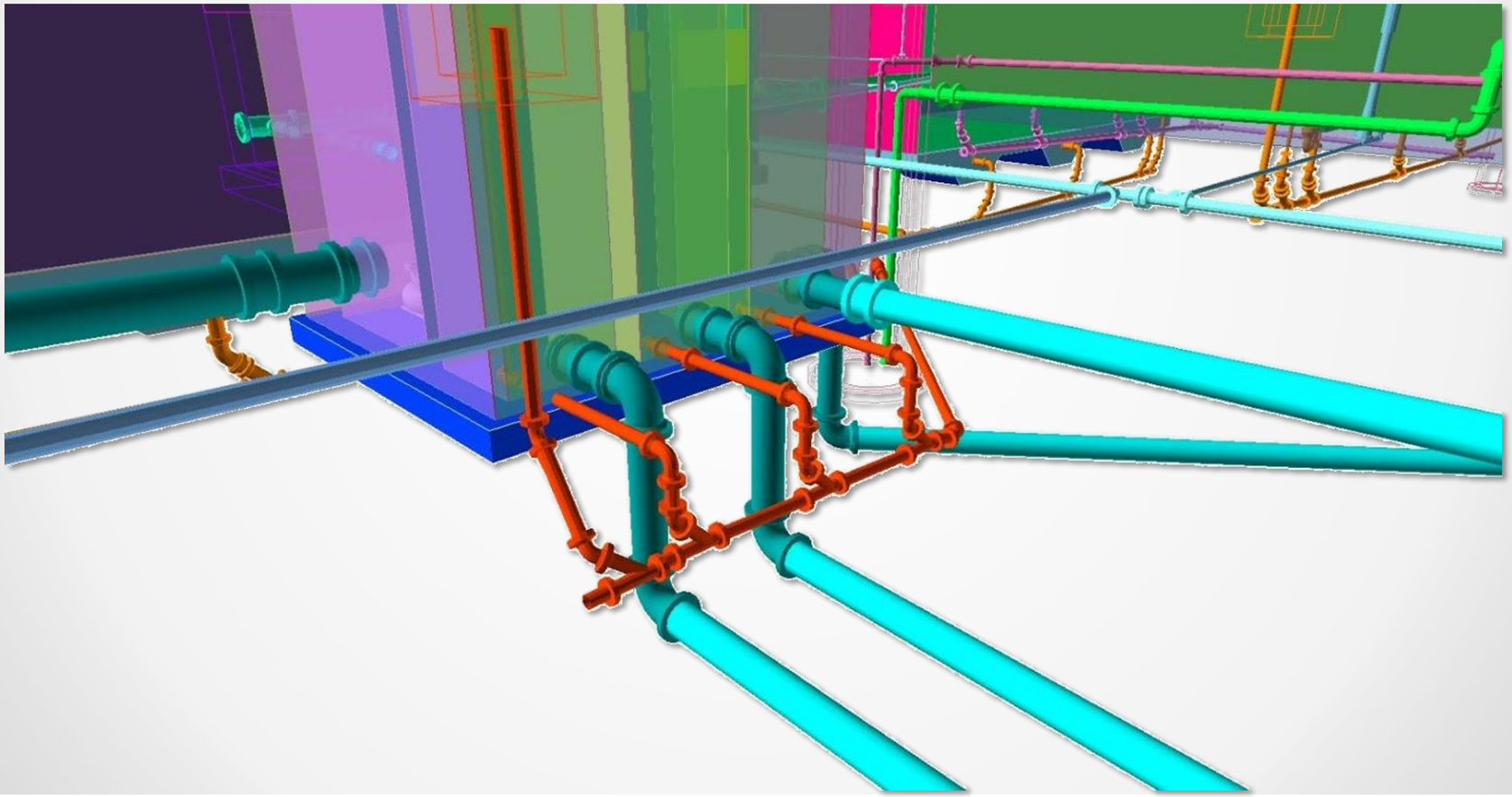
A 3D Model Simply and Clearly Communicates Revisions & Deficiencies

- Share models and changes with engineering and subcontractors
- Review errors in 3D Design or requested changes
- Meet with Project Managers
- Propose resolution
- Migrate data to field



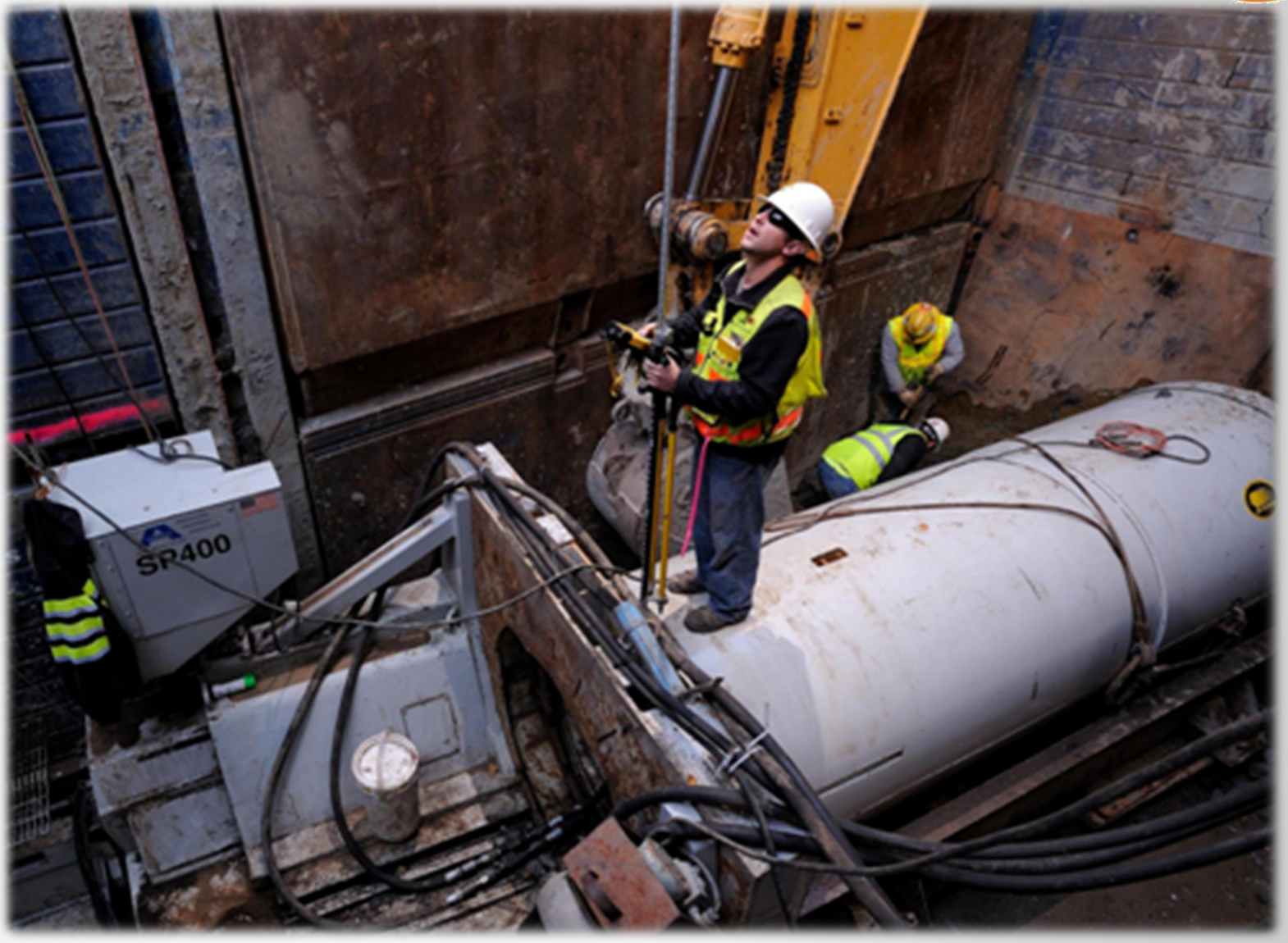
Managing Revisions

- Revision made in-house to Design Drawing
- Sent revised DWG with RFI to Design Engineer
- Received authorization to proceed as proposed within ten minutes of detecting the clash

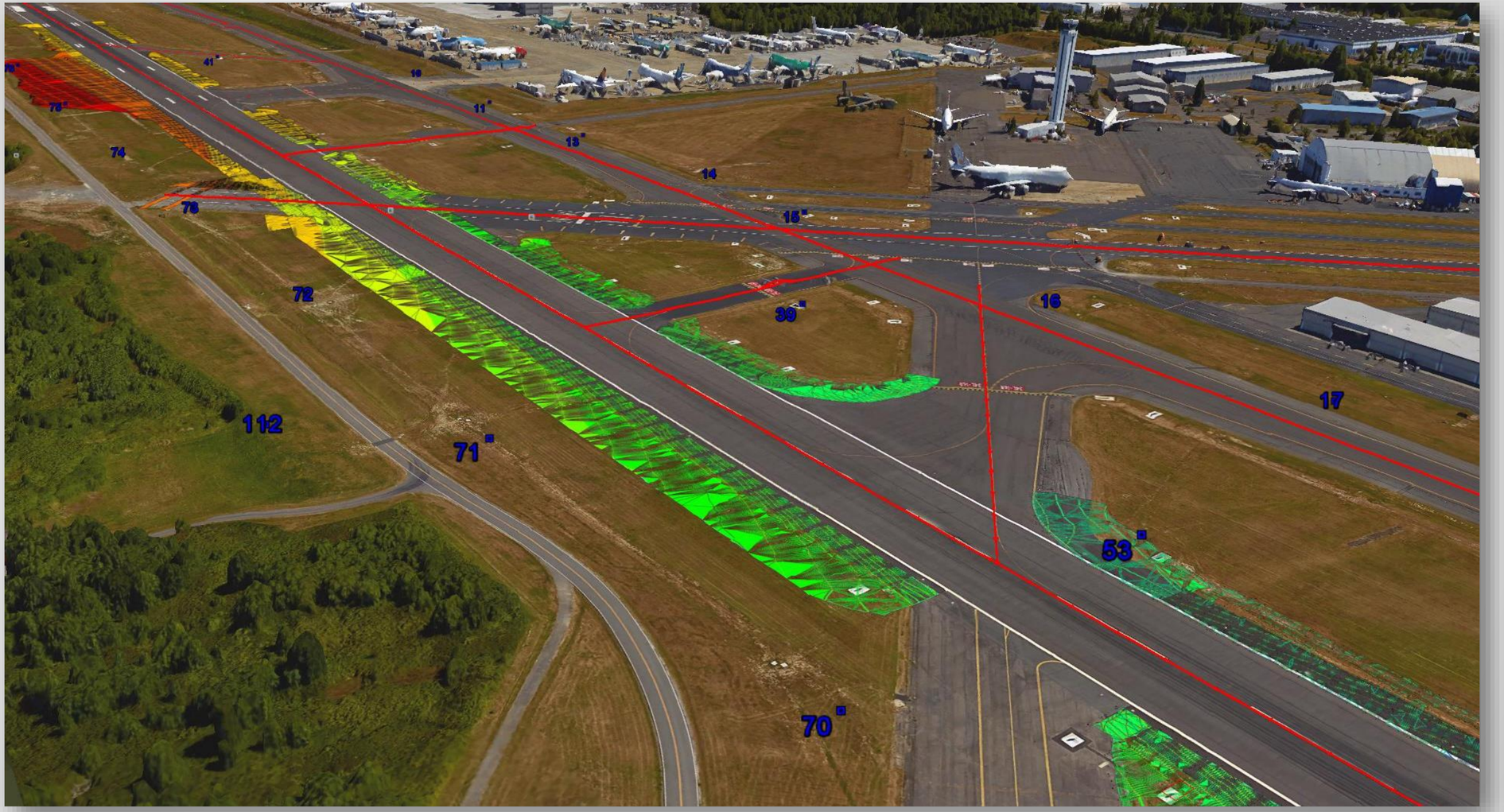


Adaptability of 3D Model to Overcome Unforeseen Conditions

Construction Ready Data
Models have a very high level of accuracy and detail. They are easily revised in the event of a change of condition or change order directive.



Easily Adapted and Re-Exported to the Field for AMG



- Fast turn around with change orders using 3D modeling & full AMG
- 3D modeling allows for owners to see the changes with accurate imagery

This is what a stake less site looks like

Easily Adapted and Re-Exported to the Field for AMG

Additional Head count		Conventional Way	New Way	Gain
	Foreman	Full Time **24:32 hours**	Full Time **11:50 hours**	**Half time**
	Operators (x4)	98:08 hours	47:20 hours	**Half time**
	Surveyor	18:14 hours	00:54 hours	**95 % of time saved**
	Worker	18:14 hours	-	**1 person less**

Accuracy		Conventional Way % in Tolerance of ± 3 cm	New Way % in Tolerance of ± 2 cm
	Subgrade	35%	86%
	Base course	45%	98%

TIME		Conventional Way	New Way AccuGrade	Productivity Gain
Staking		07:31	00:54	6:37 hours saved
Bulk Earthmoving	**D6N** **330D**	04:40 02:23	04:18 01:53	+ 9 % + 27 %
Subgrade grading	**D6N** **330D**	03:48 02:56	01:28 02:43	+ 159 % + 8 %
Base Course grading	**D6N**	02:24	00:53	+ 172 %
Base course fine grading	**140H**	01:49	00.32	+ 241%
Total		**24:32**	**11:50**	**+ 101%**

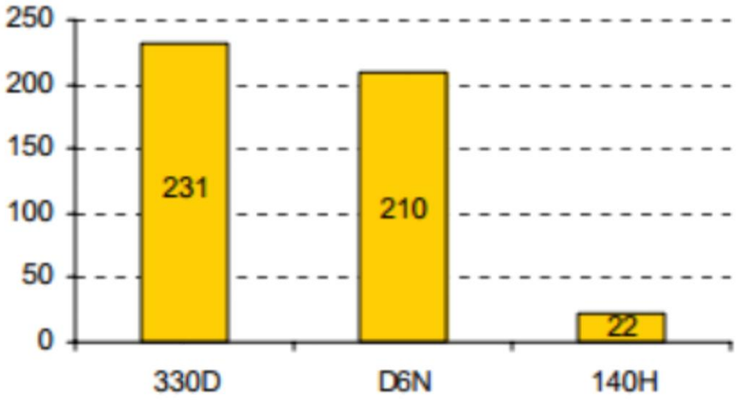
- Reduced layout times
- Increased Accuracy
- Quantifiable Cost Savings

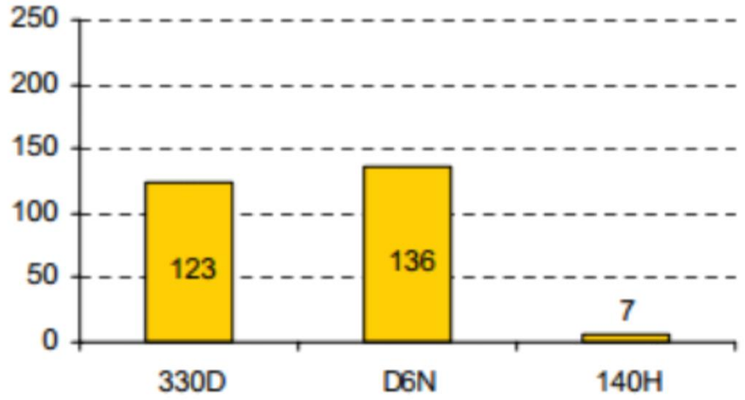
Automated Machine Guidance using 3D models

Minimized Environmental Impact & Decreasing Fuel Costs

3.9 – Fuel consumption

Conventional Way	New Way – AccuGrade
Design: SouthRoad	**Design**: NorthRoad





AMG Automated Machine Guidance using 3D models

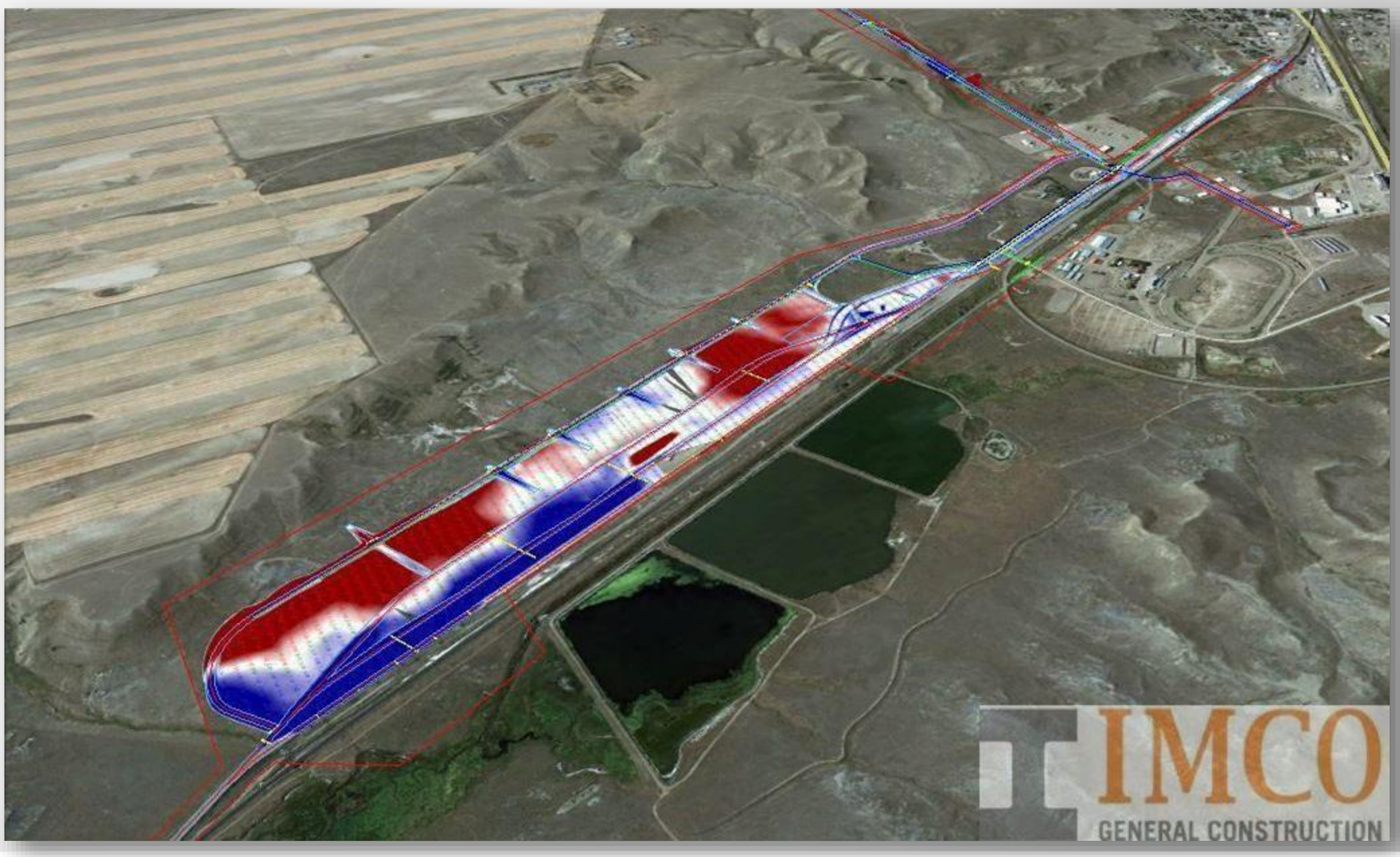
Improved Safety and Reduced Exposure to Hazards

Prefabrication from the 3D Model

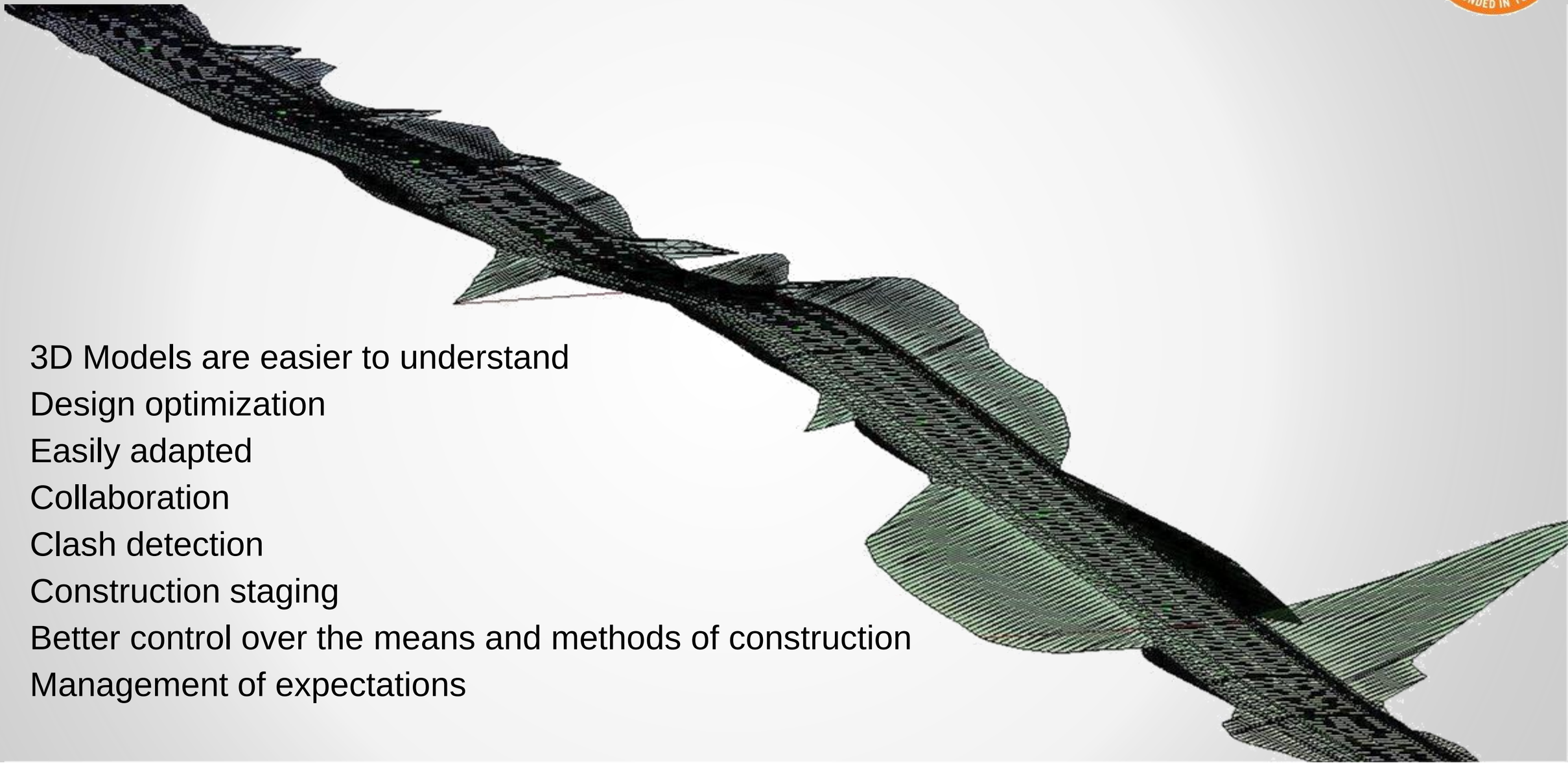
- Faster installation
- Complicated connections and parts assembled prior to shut down
- Ten minute virtual walk through of team member responsibilities alleviates real world delays
- Reduces exposure to risk

Benefits of Sharing Models with Owners and Stakeholders

100+ acre project cut, fill and utility mapping exported to Google Earth for utilization by owner and project team.



Benefits of Sharing Models with Owners & Subcontractors



- 3D Models are easier to understand
- Design optimization
- Easily adapted
- Collaboration
- Clash detection
- Construction staging
- Better control over the means and methods of construction
- Management of expectations

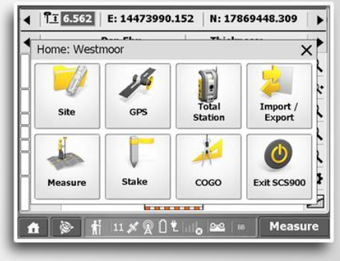
From the Field to the Office Workflow

Procure data during construction in Field

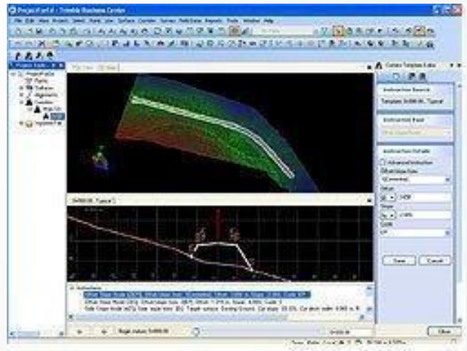
Using GPS and Conventional Survey

Monitoring

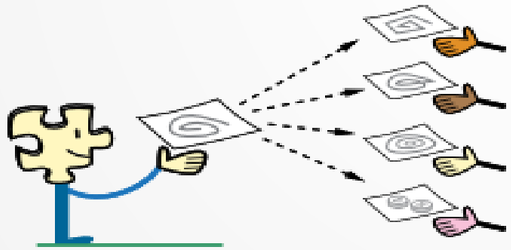
UAV & Scanning



Migrate Data to the Office



Review & Back-check As Built data

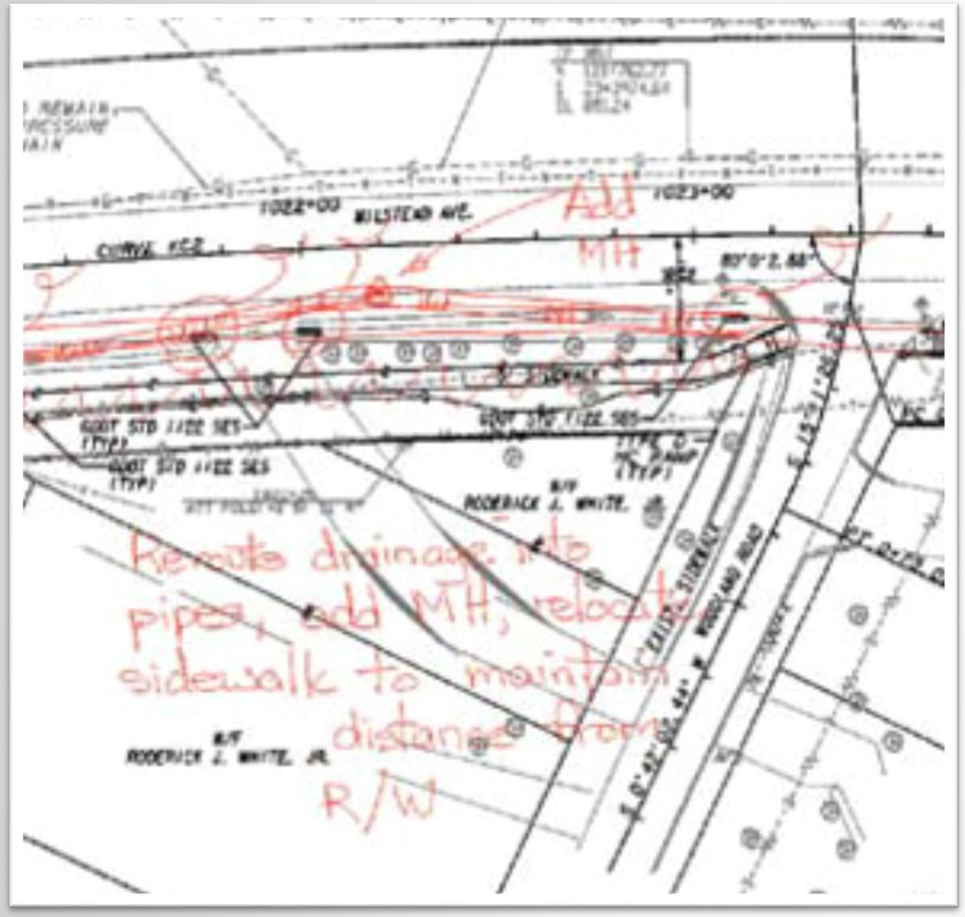


Share models with Engineers and Subcontractors

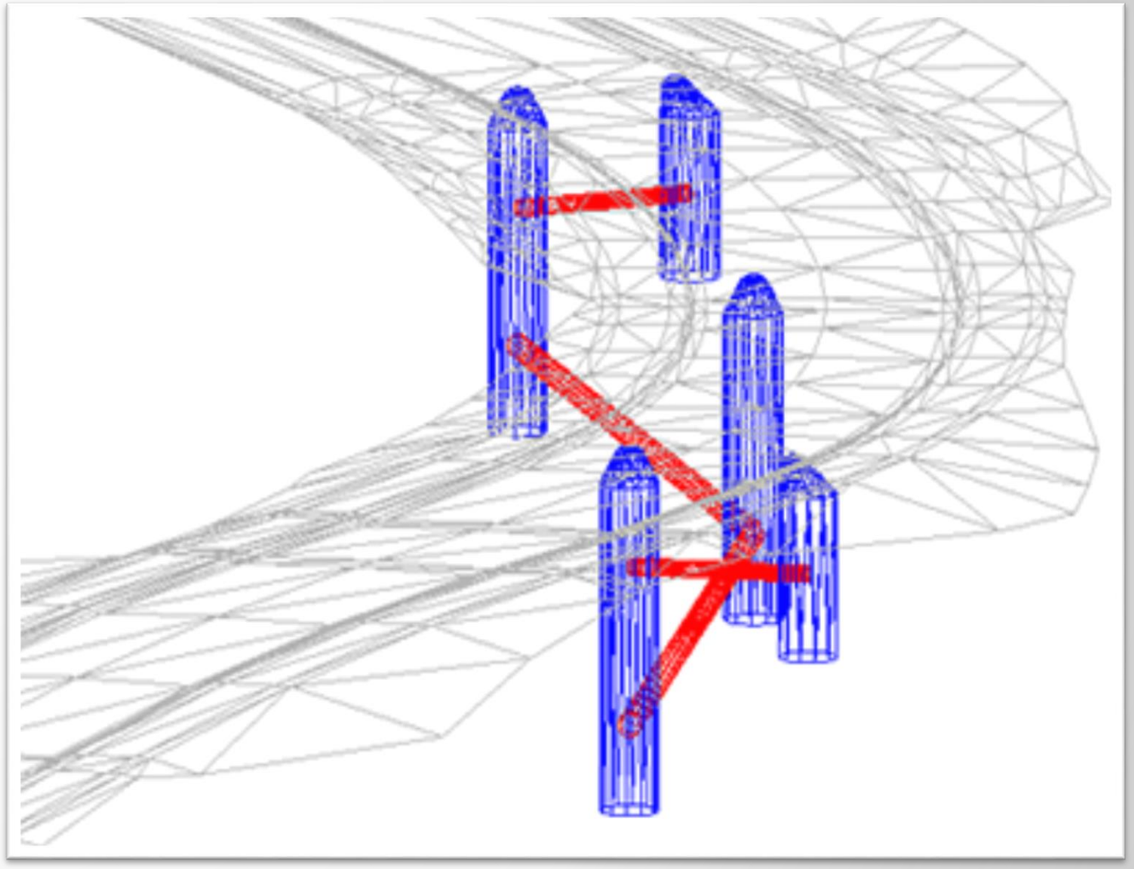
Final As Builts (Electronic CAD & Data rich files)

Added Value to Owners Beyond the Duration of a Project

As Builts

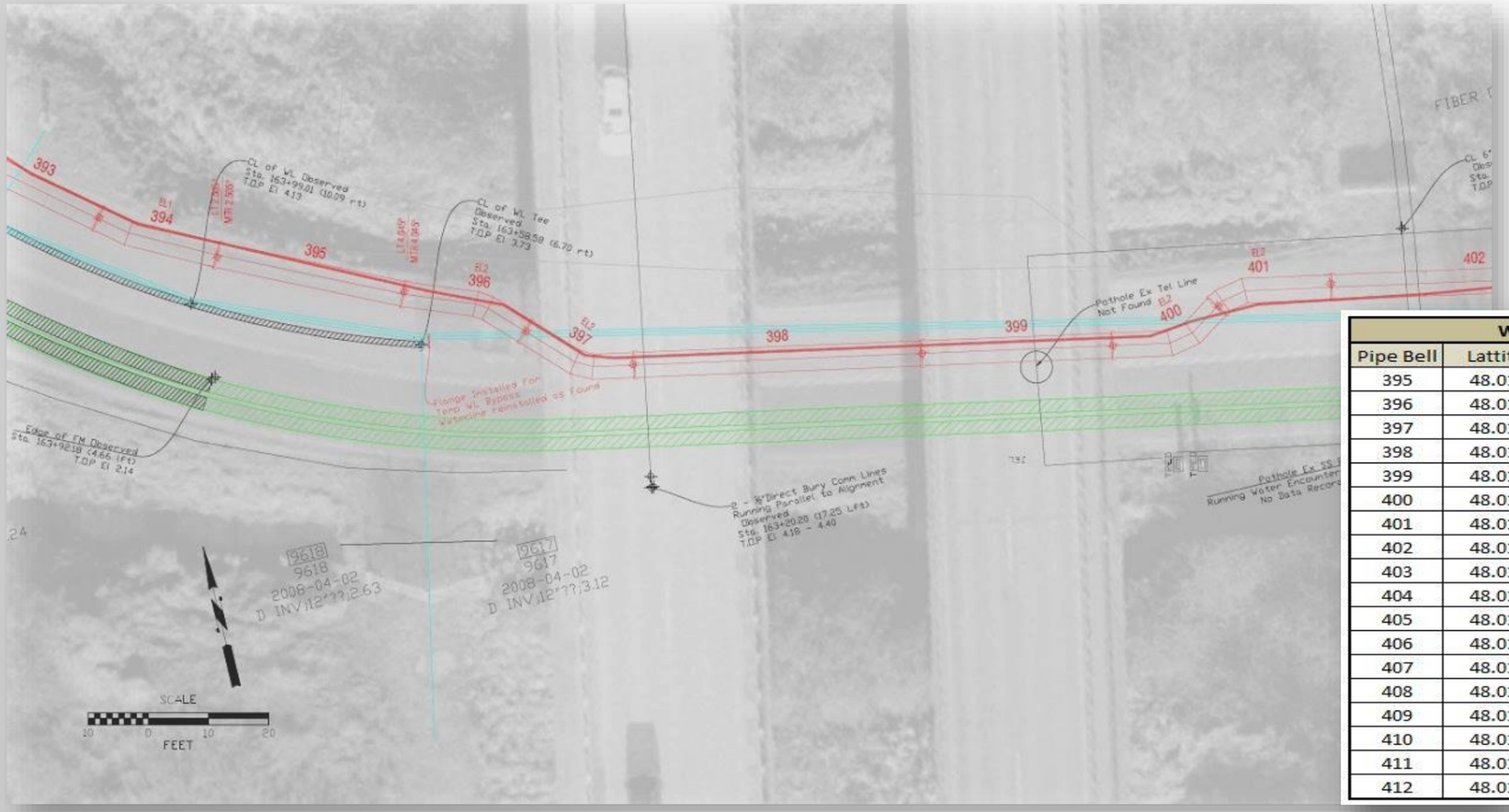


VS



Electronic As Built Data Management and Sharing

- Recording newly constructed features during construction using GPS and managing the data using Civil 3D
- Provide owners benefit for future expansion and input to the city GIS data base

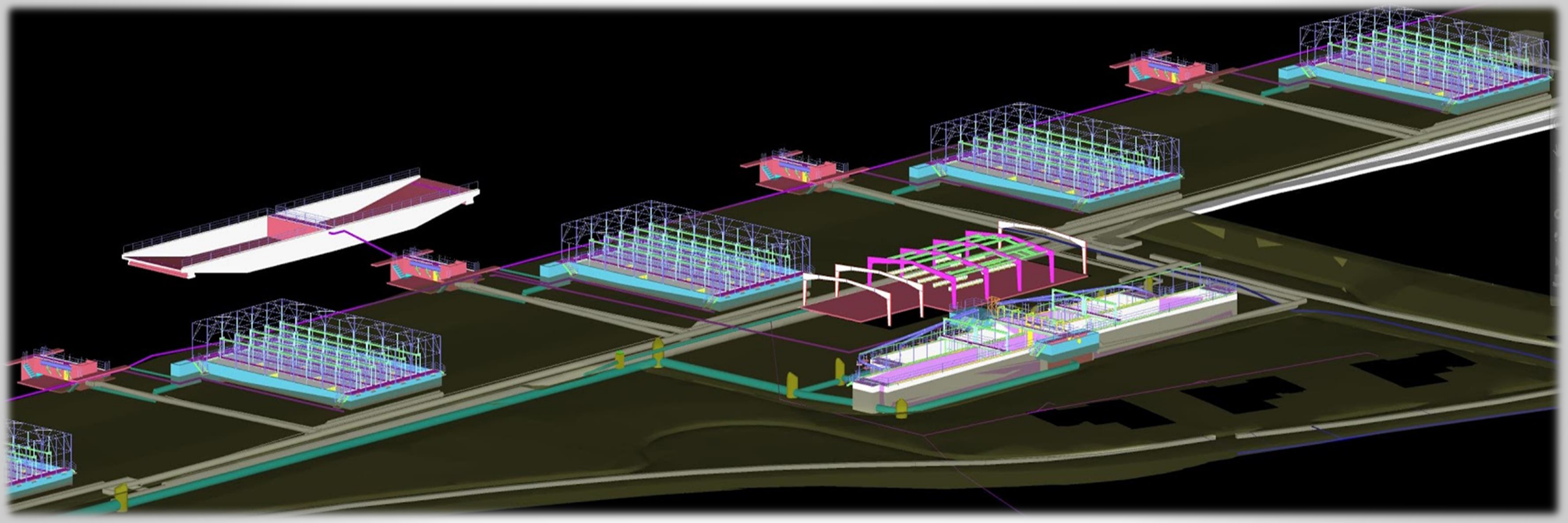


WGSN Coordinates			
Pipe Bell	Lattitude	Longitiude	Elevation
395	48.01873	-122.18745	2.49
396	48.01870	-122.18737	2.45
397	48.01868	-122.18731	2.43
398	48.01865	-122.18712	2.38
399	48.01863	-122.18699	2.33
400	48.01864	-122.18691	2.28
401	48.01864	-122.18683	2.08
402	48.01861	-122.18664	2.26
403	48.01859	-122.18645	2.68
404	48.01856	-122.18626	2.92
405	48.01853	-122.18607	2.94
406	48.01852	-122.18591	3.25
407	48.01850	-122.18583	3.22
408	48.01850	-122.18575	3.28
409	48.01850	-122.18567	3.33
410	48.01851	-122.18559	3.46
411	48.01853	-122.18552	3.51
412	48.01856	-122.18545	3.48

Local Coordinates			
Pipe Bell	Northing	Easting	Elevation
395	23491.979	9348.757	2.49
396	23480.885	9366.980	2.45
397	23471.423	9382.987	2.43
398	23462.081	9430.129	2.38
399	23455.987	9461.289	2.33
400	23458.324	9479.886	2.28
401	23457.644	9498.922	2.08
402	23448.006	9545.635	2.26
403	23438.570	9592.479	2.68
404	23429.455	9639.489	2.92
405	23419.917	9686.372	2.94
406	23412.876	9725.554	3.25
407	23408.981	9744.748	3.22
408	23407.312	9764.401	3.28
409	23407.362	9783.912	3.33
410	23411.871	9802.885	3.46
411	23419.135	9821.204	3.51
412	23430.422	9836.940	3.48

Project Delivery of Electronic Data to the Owner

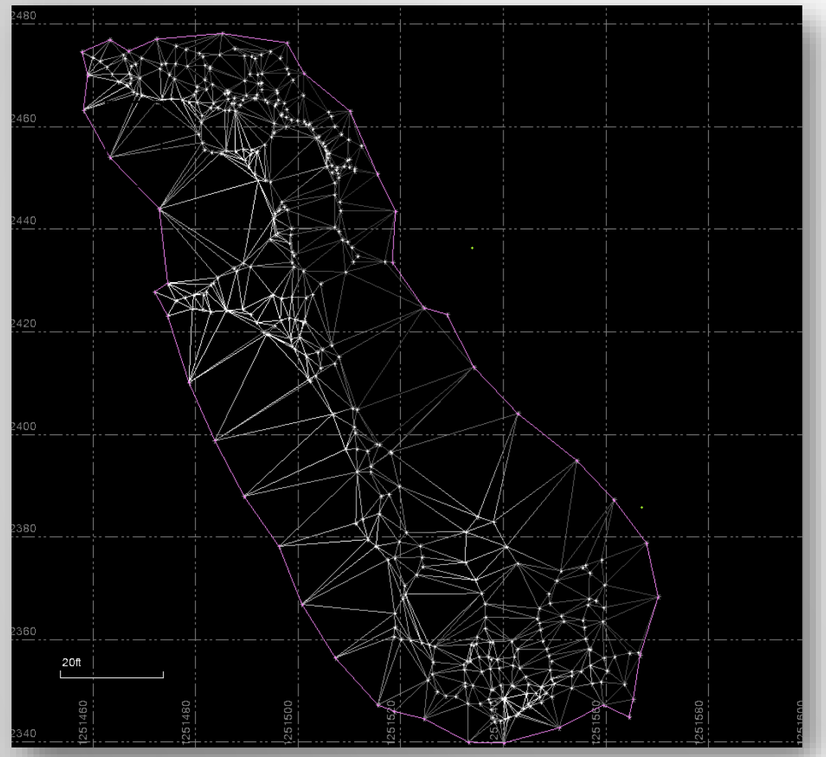
- Recording newly constructed features during construction using GPS and managing the data using IDS
- Provide owners benefit for future expansion and input to the city GIS data base

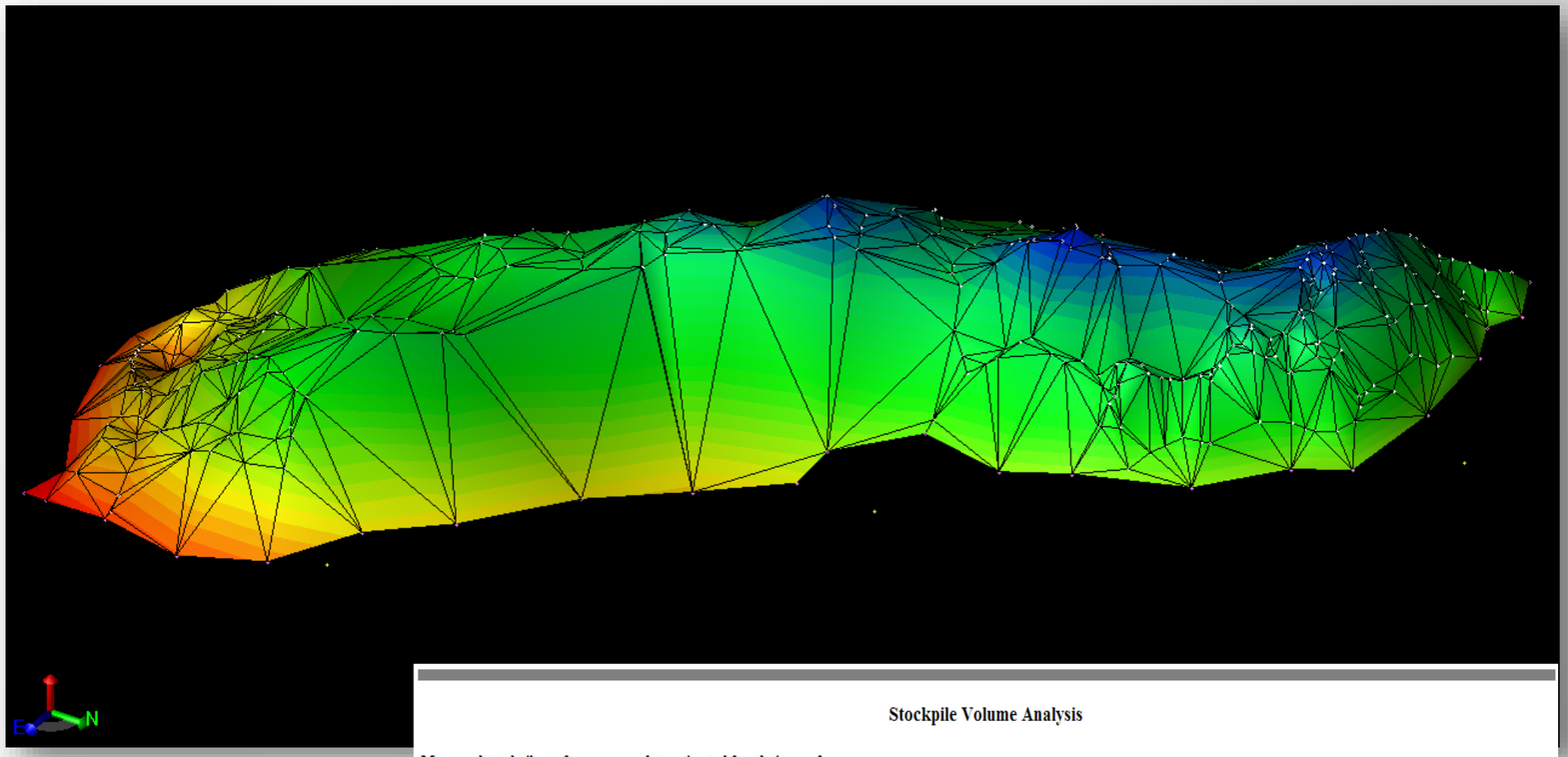


Using New Technologies

UAV Data procurement allows for increased accuracy and reduced processing time

Conventional Stockpile Topo





Stockpile Volume Analysis

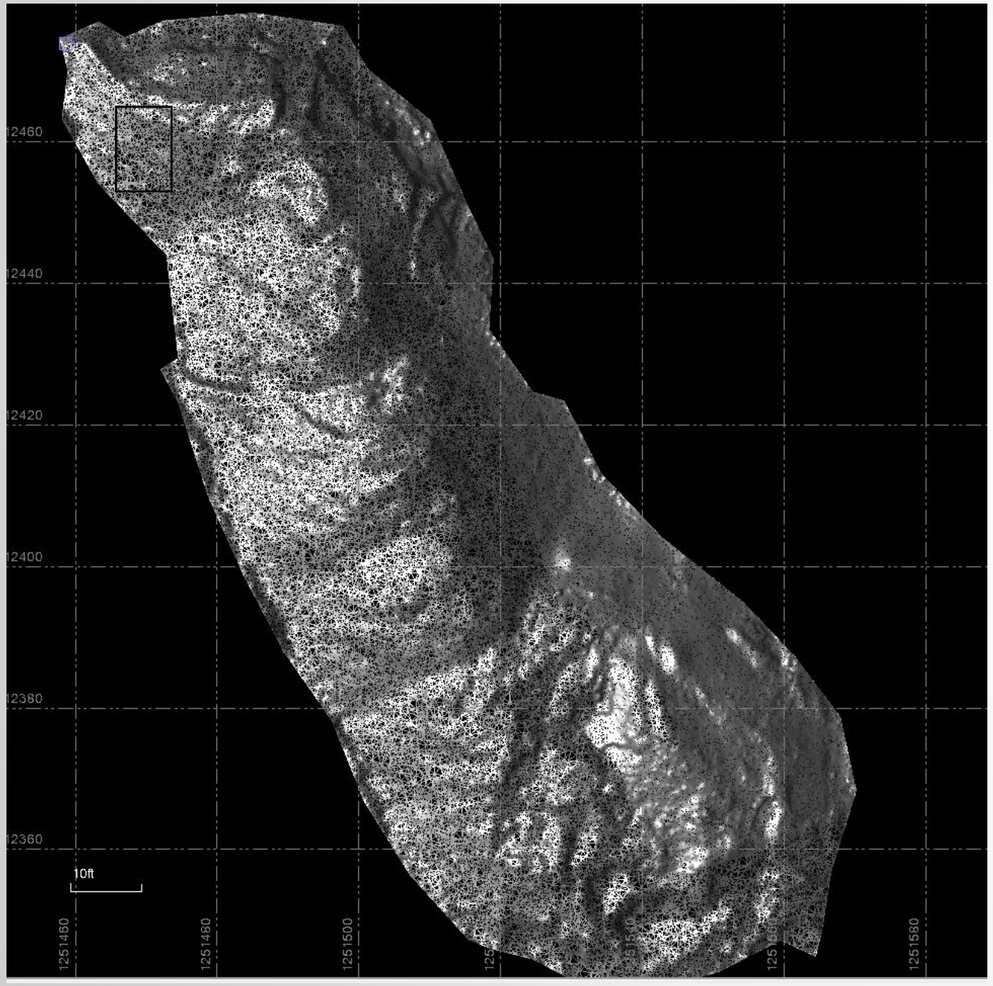
Measured stockpile surface compared to estimated foundation surface

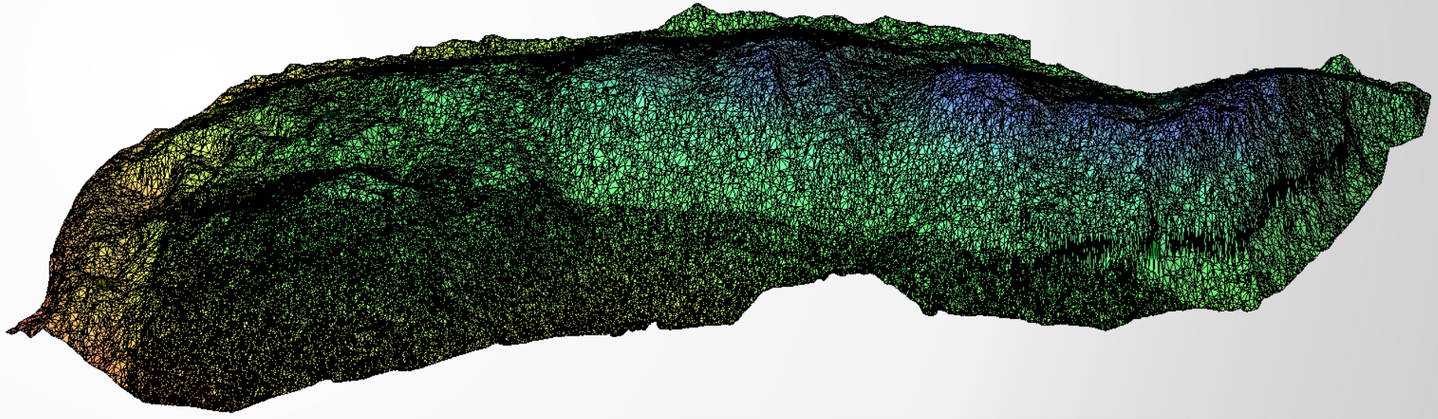
Surfaces	
peat stockpile 04-25-14	Classification: Unclassified

Volumes from Surface Geometry	
Approximate stockpile volume:	1,687.0 yd³

UAV Stockpile Analysis Using Recap

Recap registration of Stockpile





Stockpile Volume Analysis

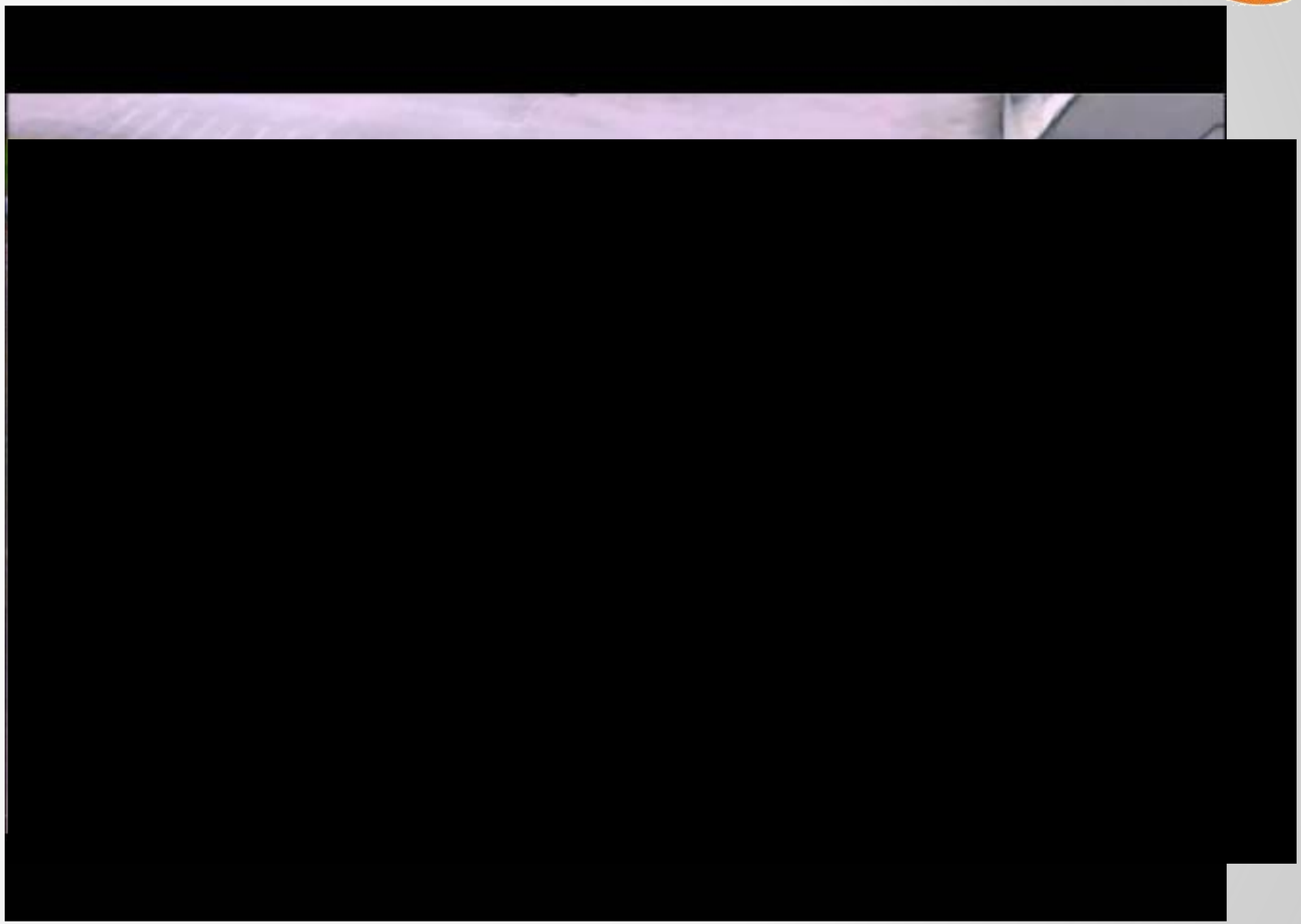
Measured stockpile surface compared to estimated foundation surface

Surfaces	
stockpile2	Classification: Unclassified

Volumes from Surface Geometry	
Approximate stockpile volume:	1,668.0 yd³

UAV Stockpile Analysis Using Recap

- Recap Registration of Stockpile

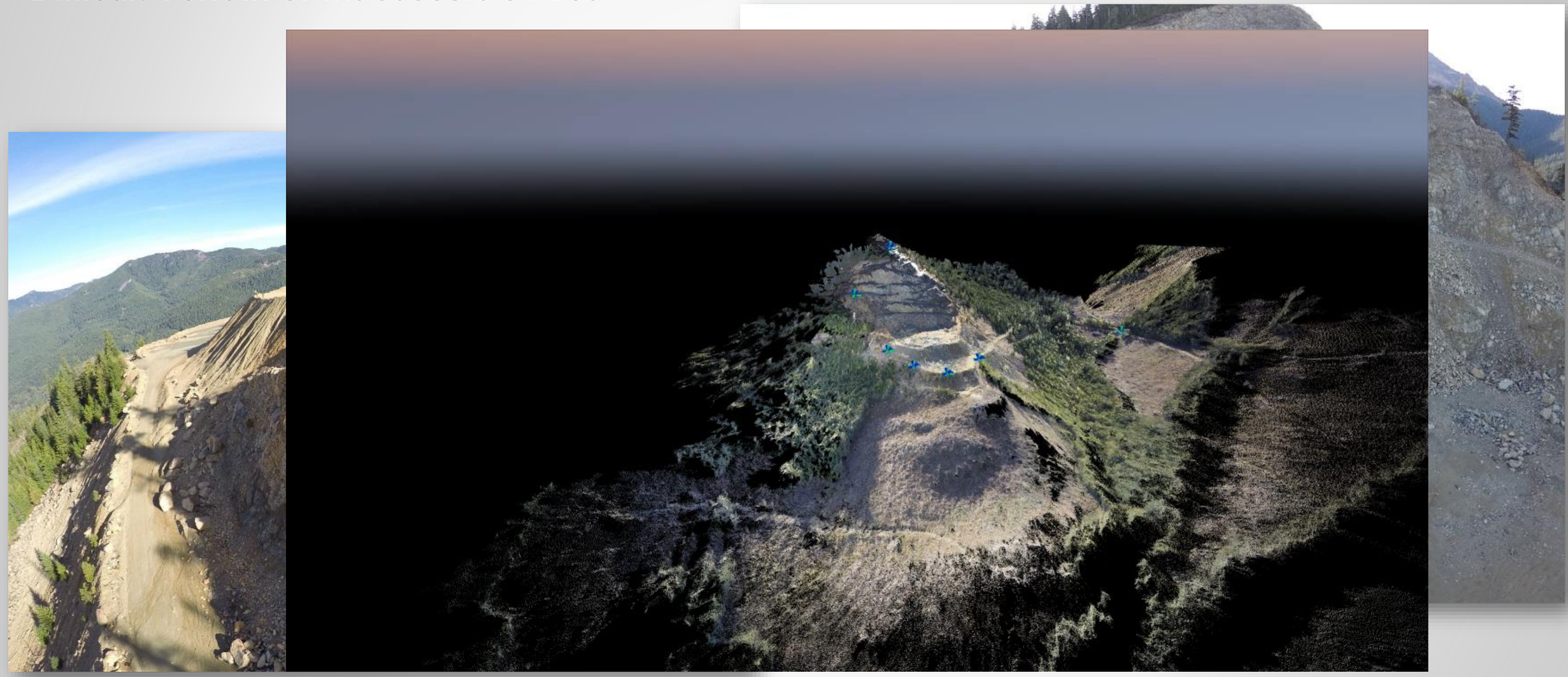


Large Scale Photogrammetry

Difficult Terrain or Inaccessible Area

Large Scale Photogrammetry

Difficult Terrain or Inaccessible Area



Accurate Point Cloud of Existing Structures

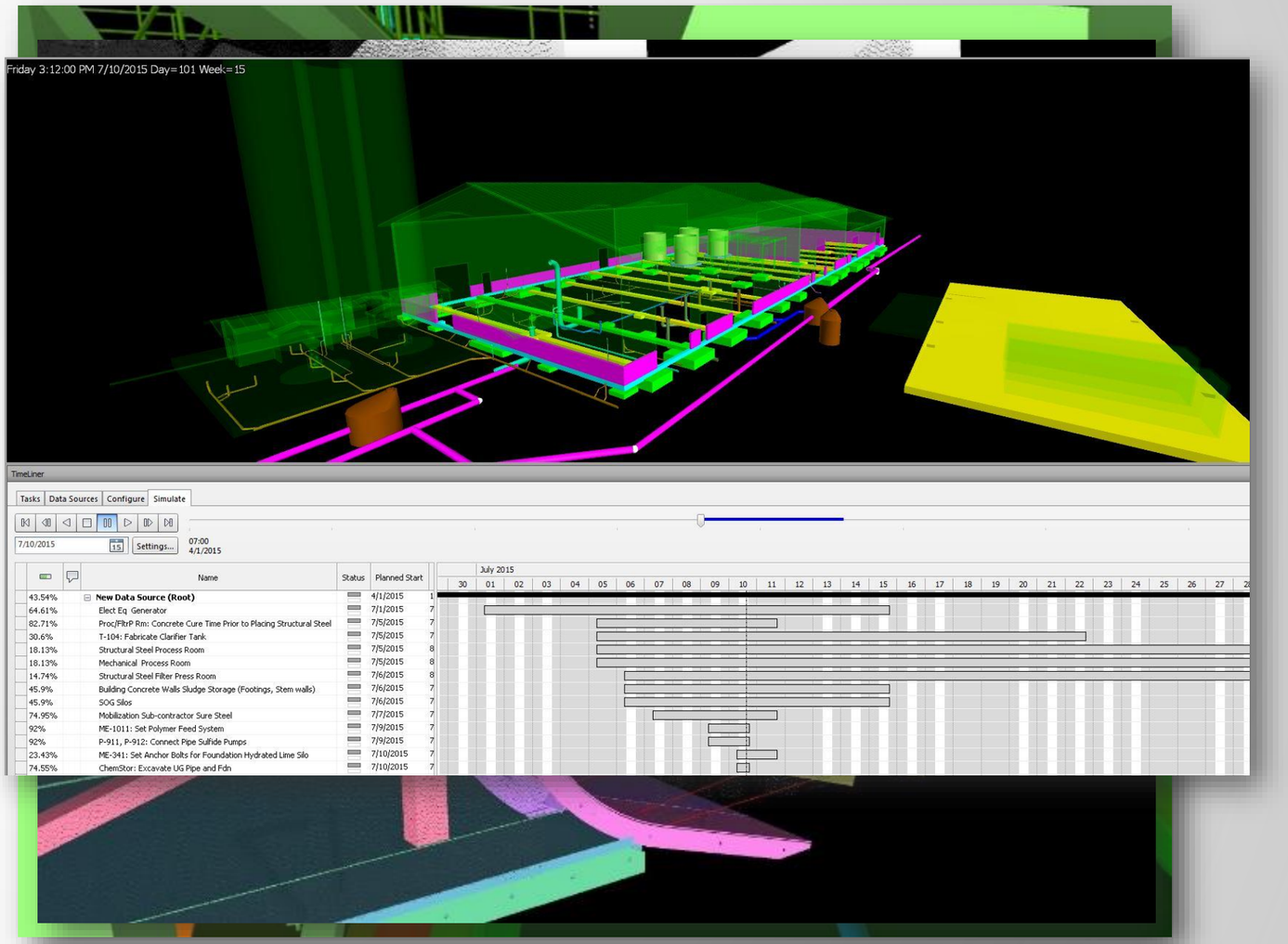
Inaccessible area represented through UAV procured point cloud

Accurate Point Cloud of Existing Structures

Large areas flown quickly, accurately, and safely with UAV

Why 4D Modeling?

- What is 4D?
  - Schedule
    - Productivity impacts
    - Phasing impacts
  - Improved Communication between all stakeholders
  - Use of the visual 4D model with schedule helps get buy in



Don’t be Afraid of Data

This is a 5mb hard drive in 1952 being “uploaded”

Time for Questions and Answers!

Contact Information

Thank You! Please feel free to contact either of us directly.

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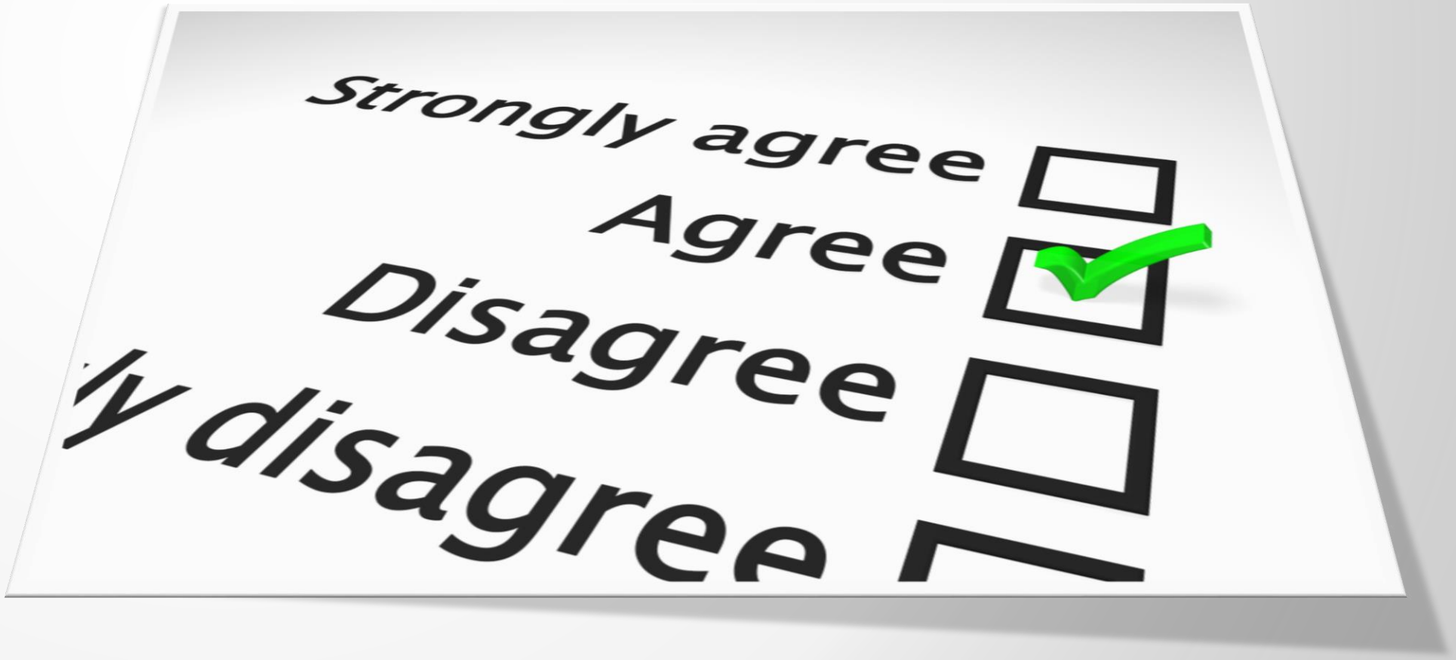

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