Lifecycle of a 3D Heavy Civil Construction Model From the Office to the Field and Back

CO6498

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Sam Kloes

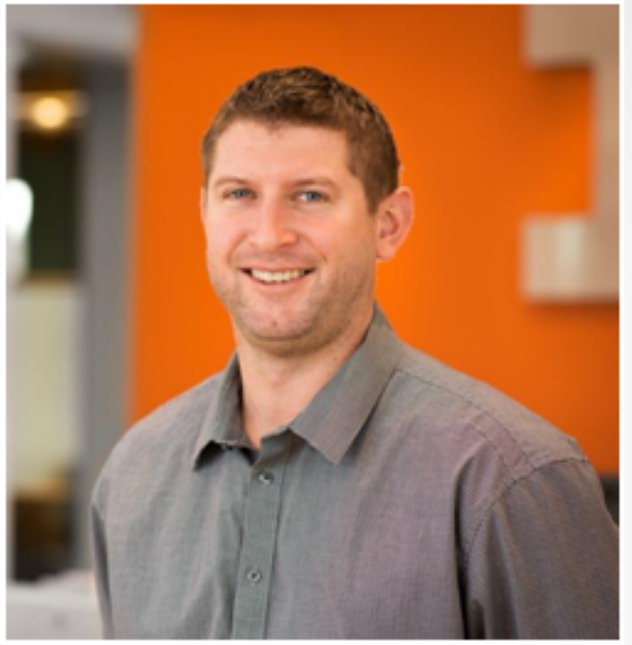
Class summary

The use of 3D models on a construction site and the workflow that starts at bidding and goes through construction and final as-builts, all from the perspective of a contractor. Professional presenters will share both field and office experiences while displaying project examples. We will discuss importing PDFs, importing CAD files for bidding, using contractor surveying to support 3D models, using AutoCAD Civil 3D software to build excavation models for quantification and automated machine guidance (AMG), modeling to determine means and methods, using the model for collaborative design with owners and subcontractors, using AMG for increased safety, and utilizing the 3D model in the field for layout and the collection of additional as-built data. Other areas we will cover include using clash in Navisworks project review software, decreasing turnaround time on change orders and requests for information, gaining safety benefits, developing fabrication plans from the models, and performing stockpile modeling using an unmanned aerial vehicle.

Who are we and what do we do?

Brian K. Smith
Director of Technology

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



Sam Kloes aka Satellite Whisper
GPS / Survey Manager

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

Key learning objectives

- How we build heavy civil construction models with the available data
- Identify effective practices used to create heavy civil quantity takeoff models
- Alternative methods of data procurement to supplement what is provided
- How AMG is used from 3D heavy civil construction models
- The benefits of using 3D models and data from the office to the field and back

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:

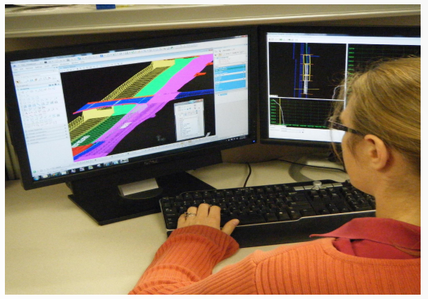
- Quantity Takeoffs
- Planning
- Construction Ready Model
- Rework
- As Builts

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

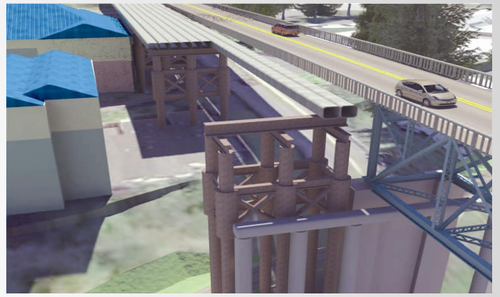
From the Office to the Field Workflow

Analyze Data

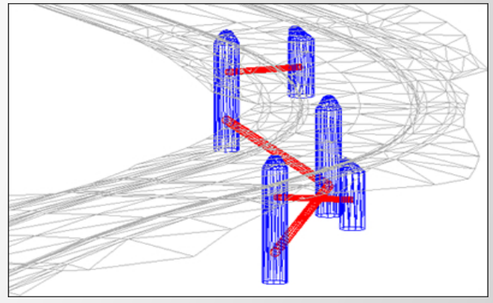
Meet with Project Managers



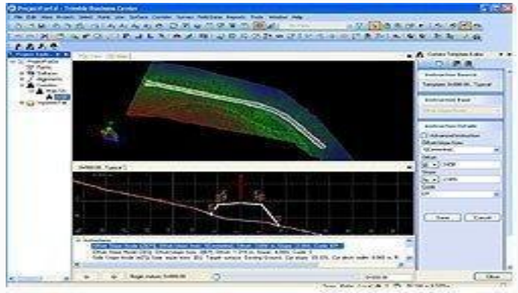
Supplement/ recreate data



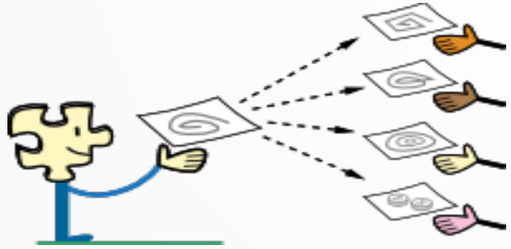
Review Means & Methods



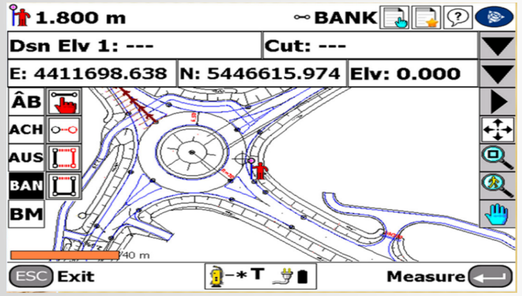
Create Grading & Utility Models



Review & Back-check Models



Share models with Engineering and Subcontractors



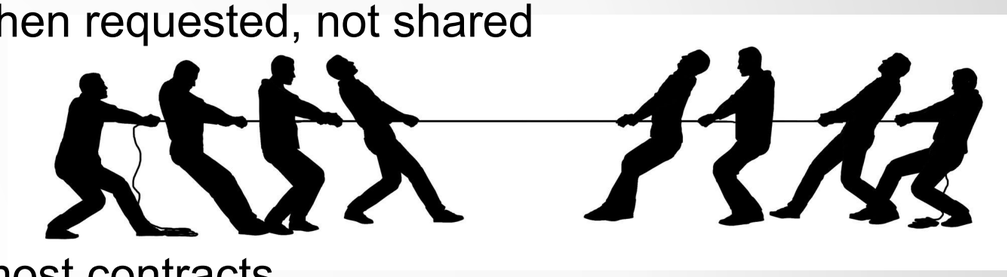
Migrate Data to the Field

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



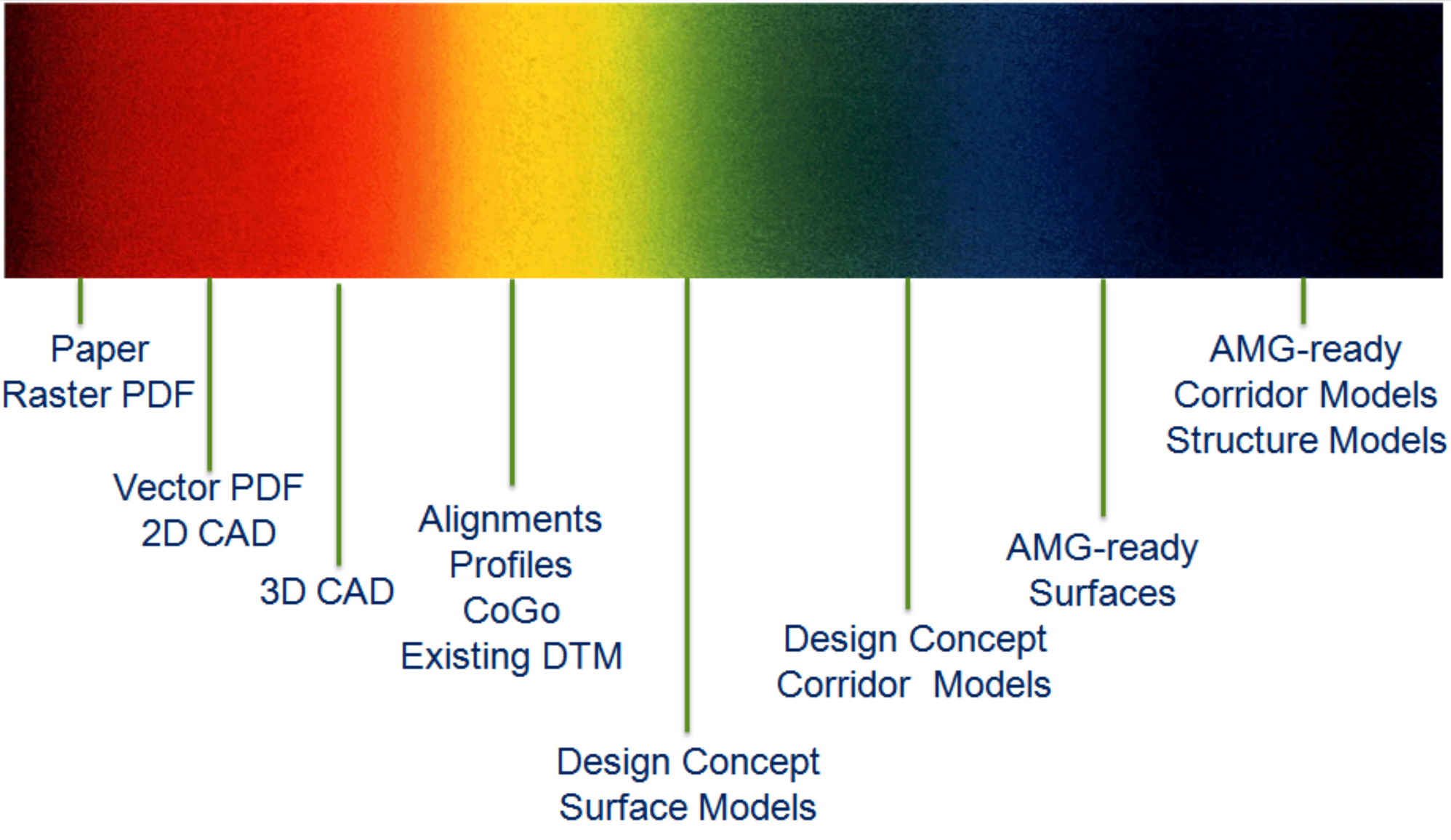
Post Award

- 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

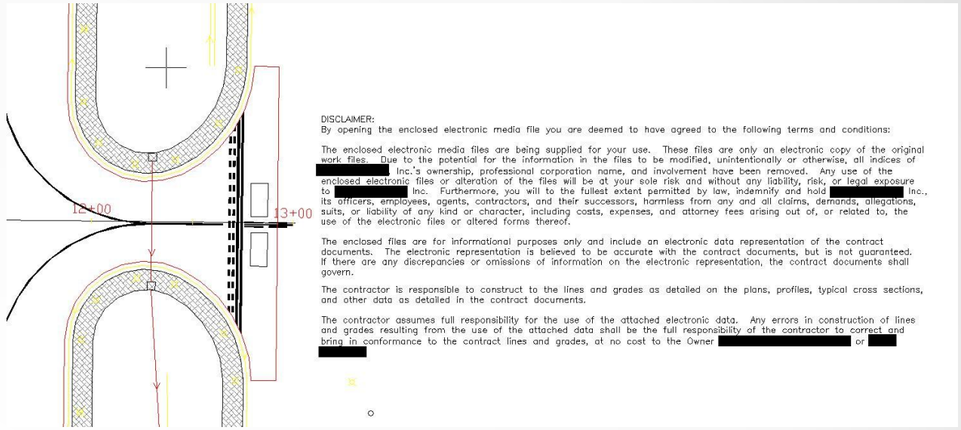
Electronic CAD and Design Data Files

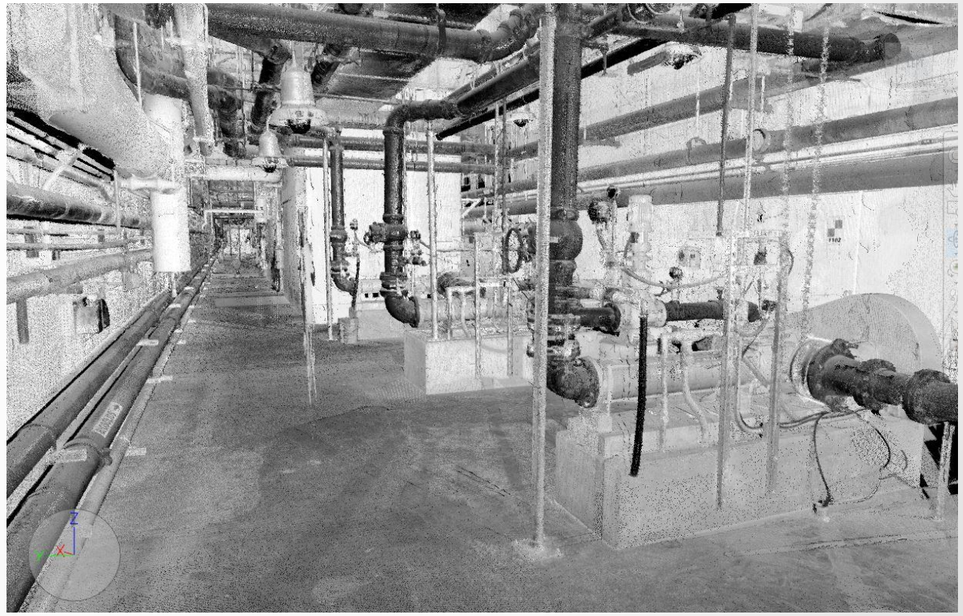
CAD formats (DWG, DGN, DXF, RVT, SHP)

- 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)





Types of Data Received for Contractors

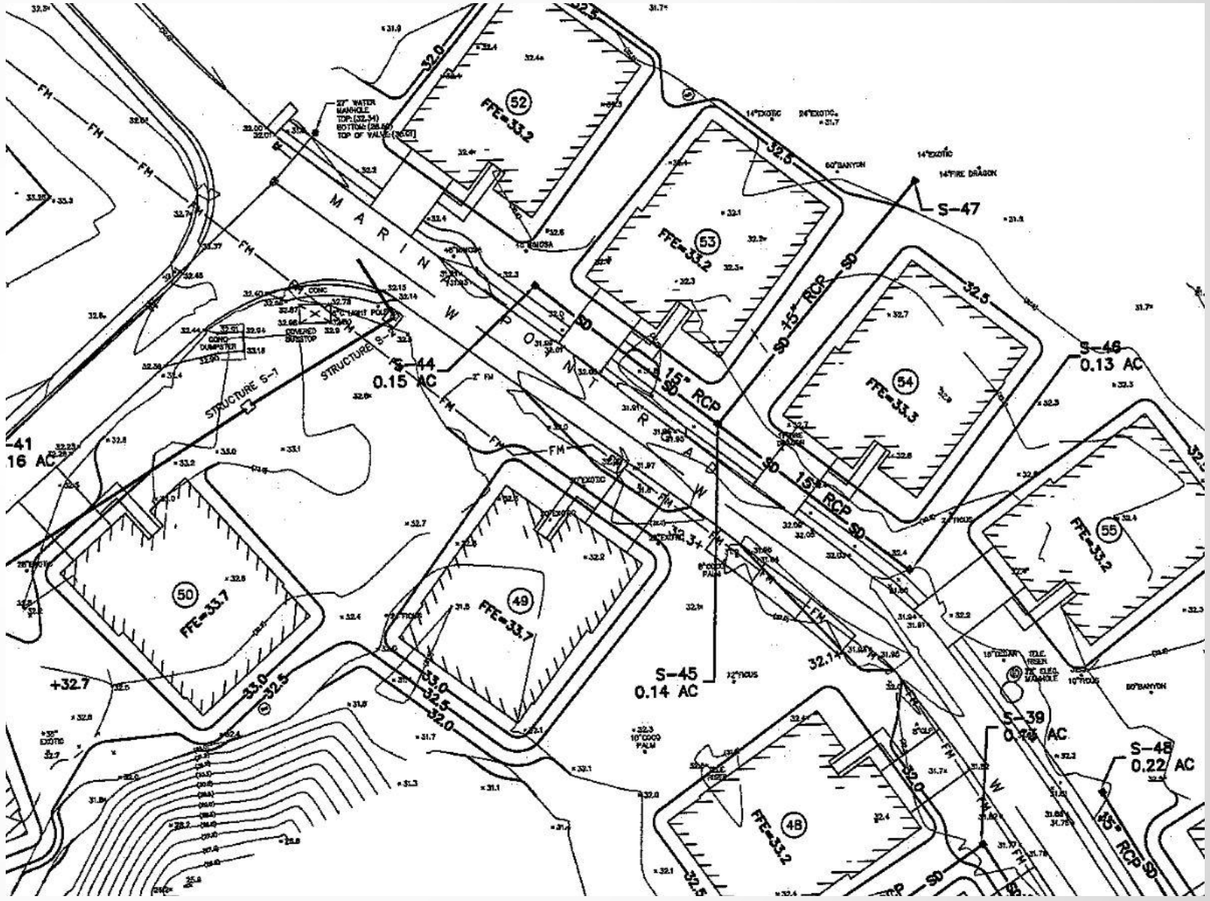
For a General Contractor there are mainly two different types of data received.

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

Types of Data Received for Contractors

Raster Adobe PDF's

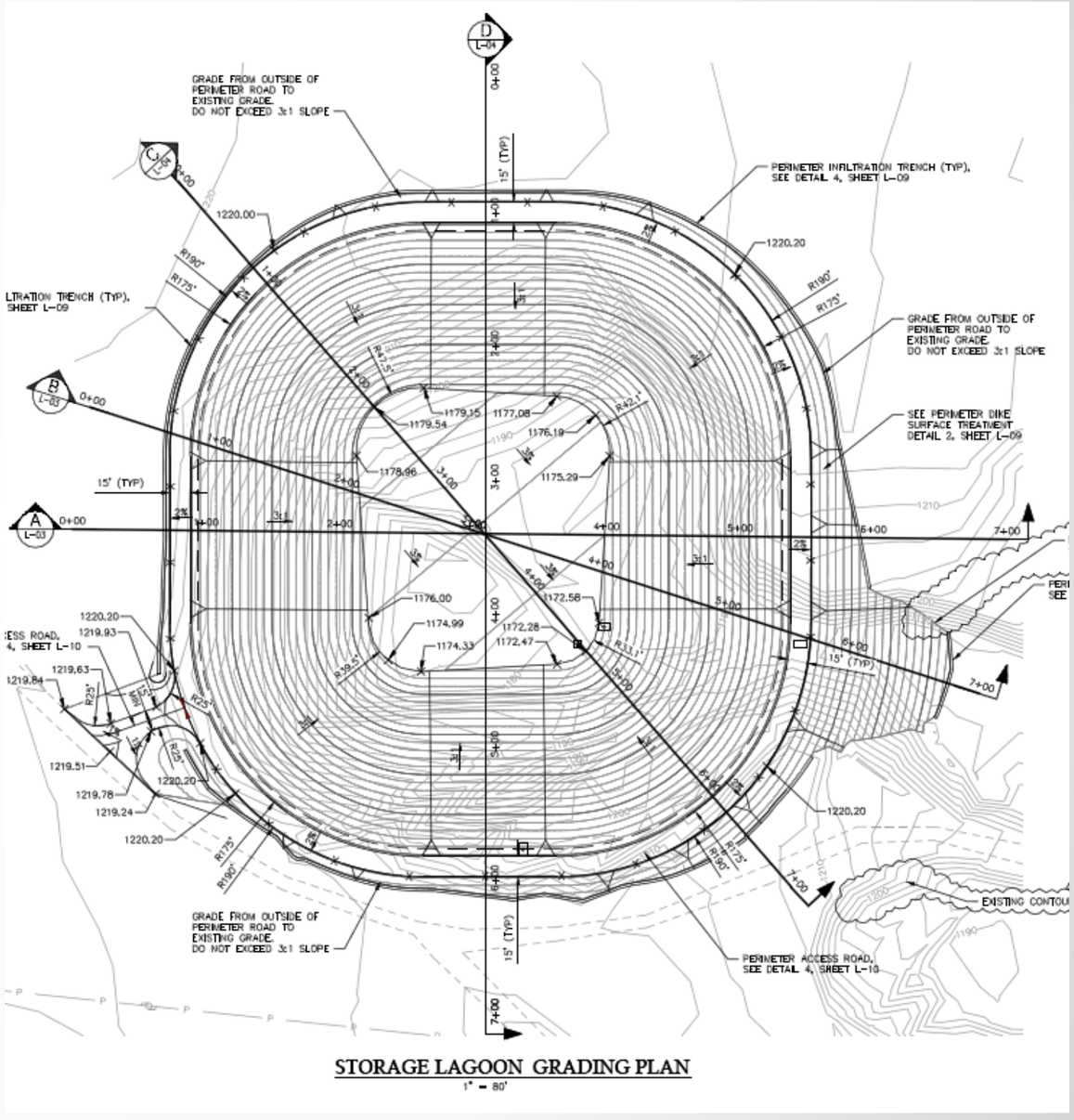
- No tangible electronic data
- Pixelized data
- Must digitize using software to import to CAD
- Lowest quality of data to import
- Typically from scans of plots



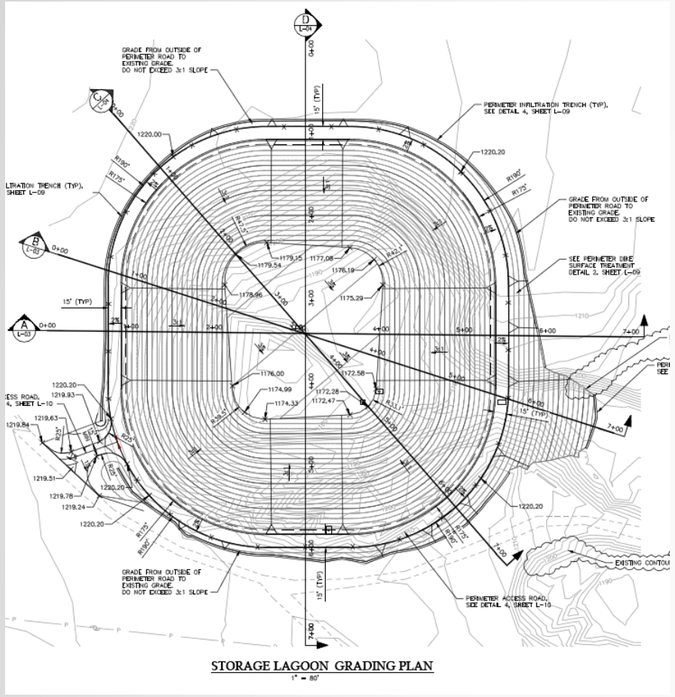
Building a Model for Earthwork Takeoff

Vectorized Adobe PDF's

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

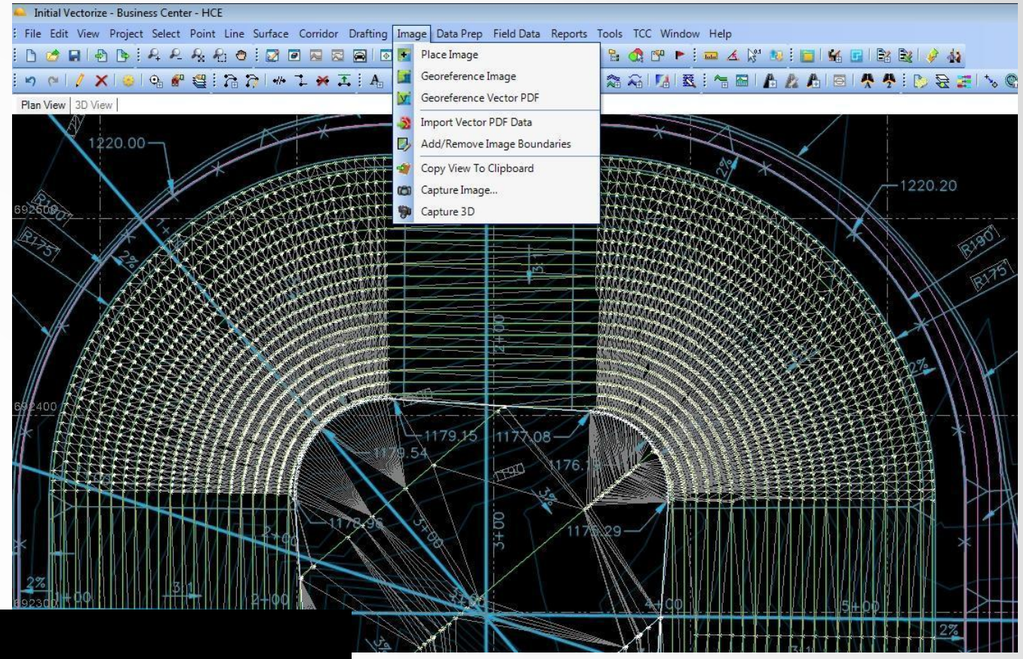


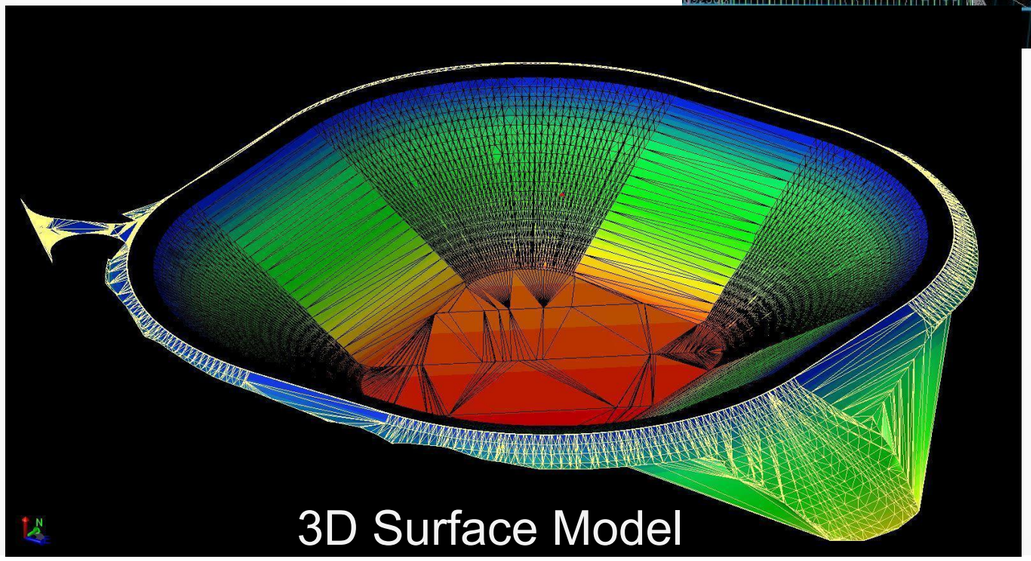
Vectorized PDF Data



Vectorized PDF

TIN Model





3D Surface Model

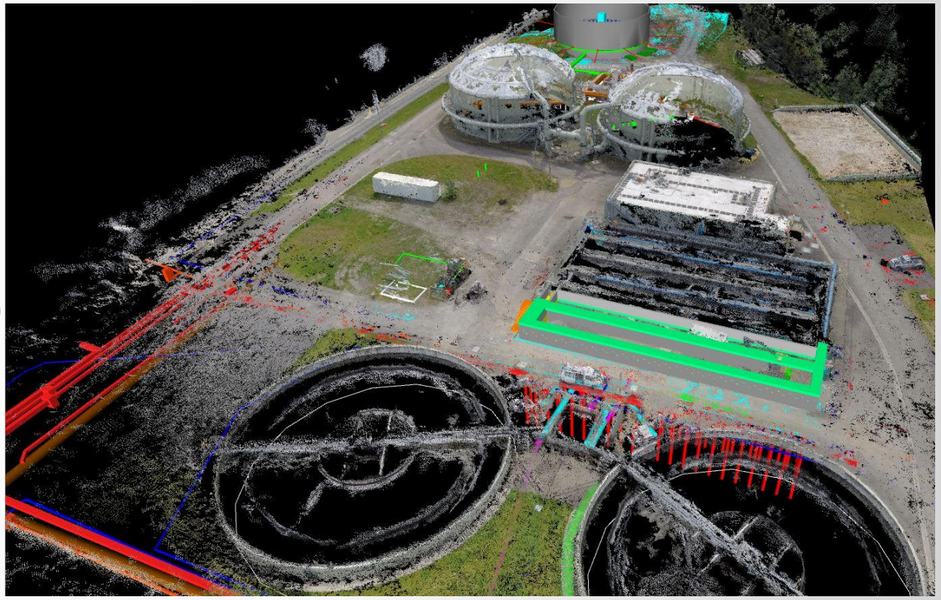
Contractor Survey Data to Support 3D Model

- 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

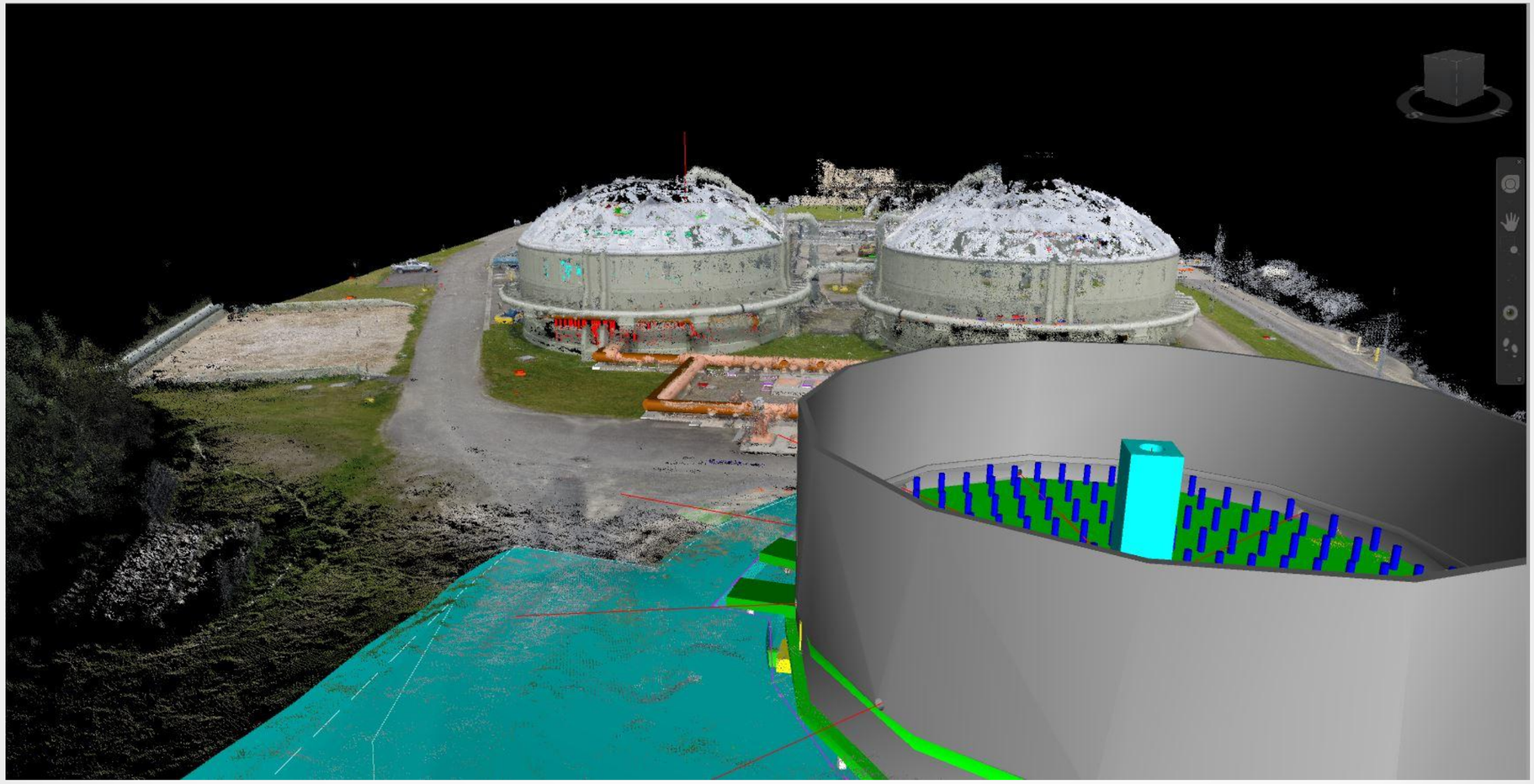
Communication

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

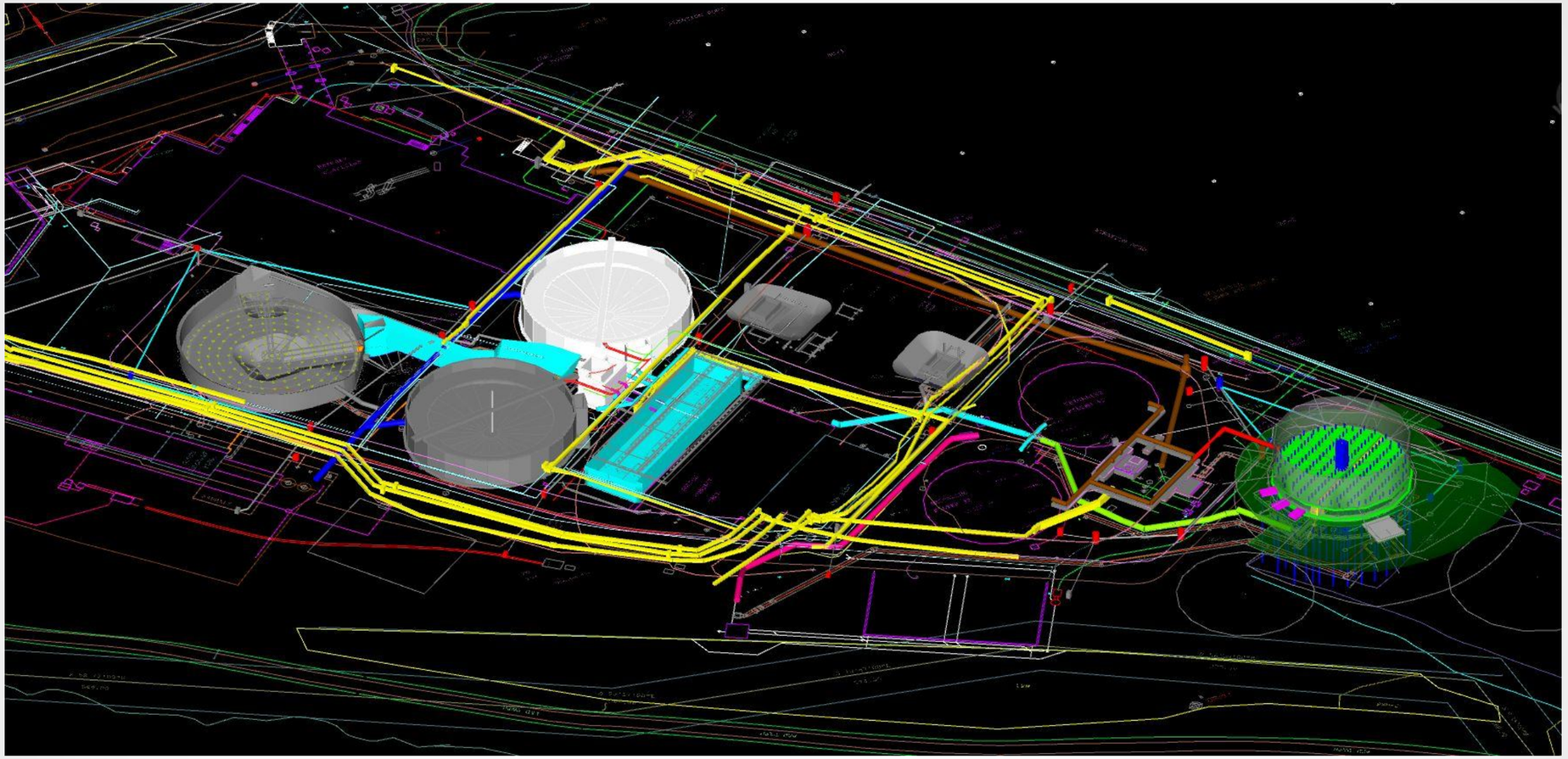


Self Performing BIM in House on Alternative Delivery Projects



- 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

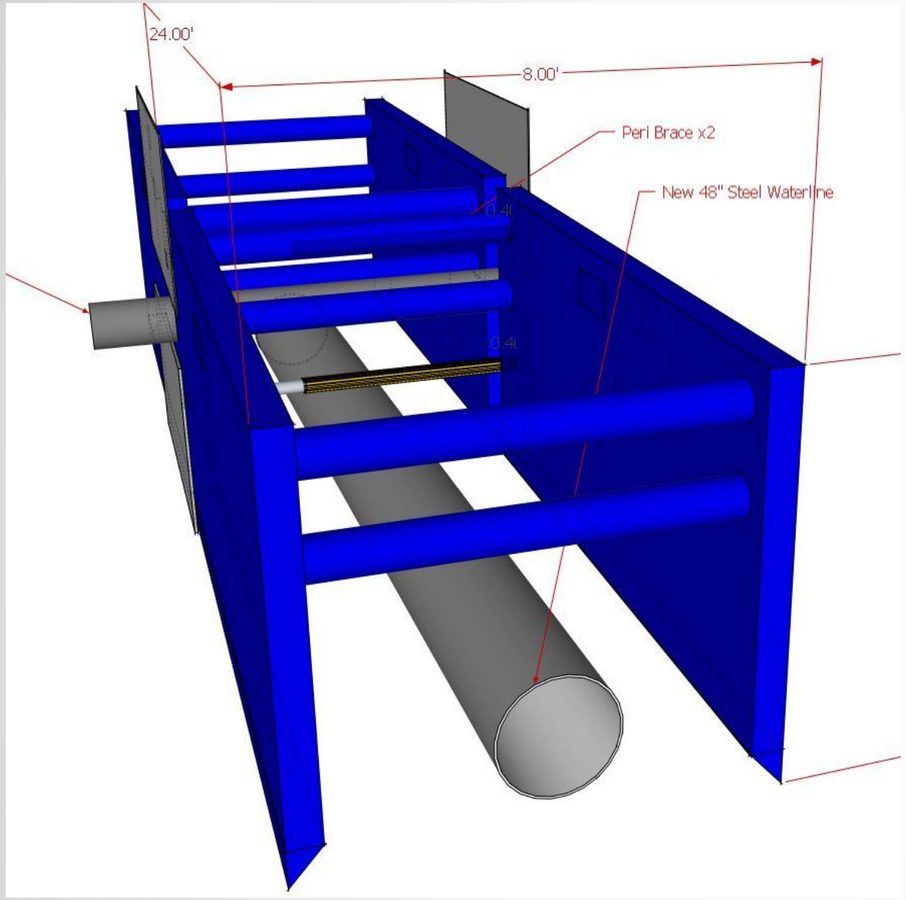
Modeling proposed and Shoring

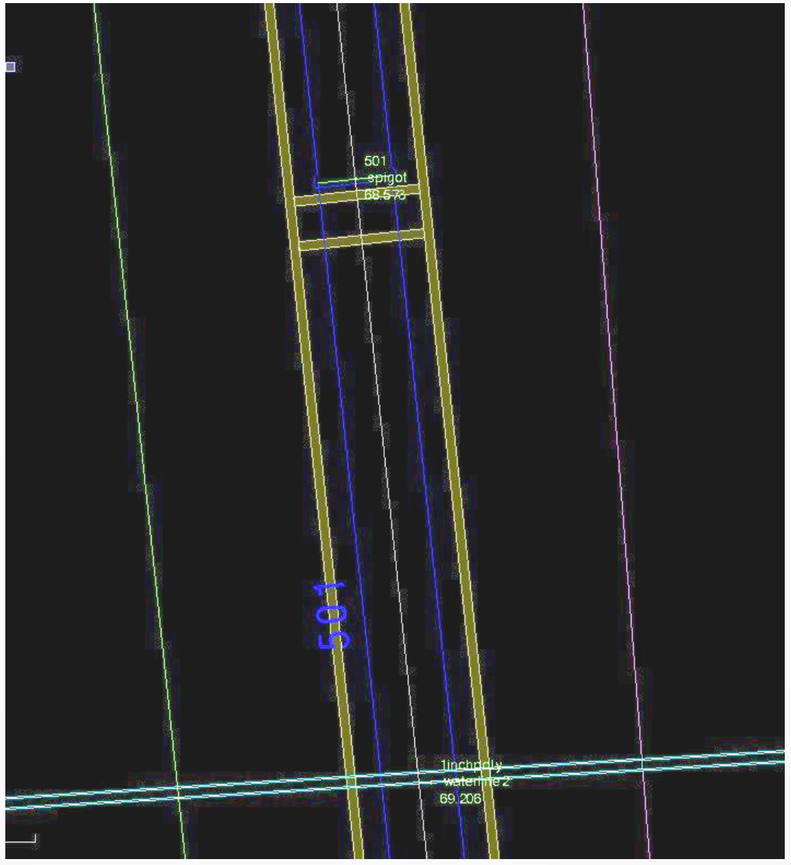
Modeling proposed and Utility Conflicts

Using 3D Scan Data

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

Modeling and Potholing to Develop Means and Methods





Managing Revisions

A 3D Model Simply and Clearly Communicates Revisions & Deficiencies

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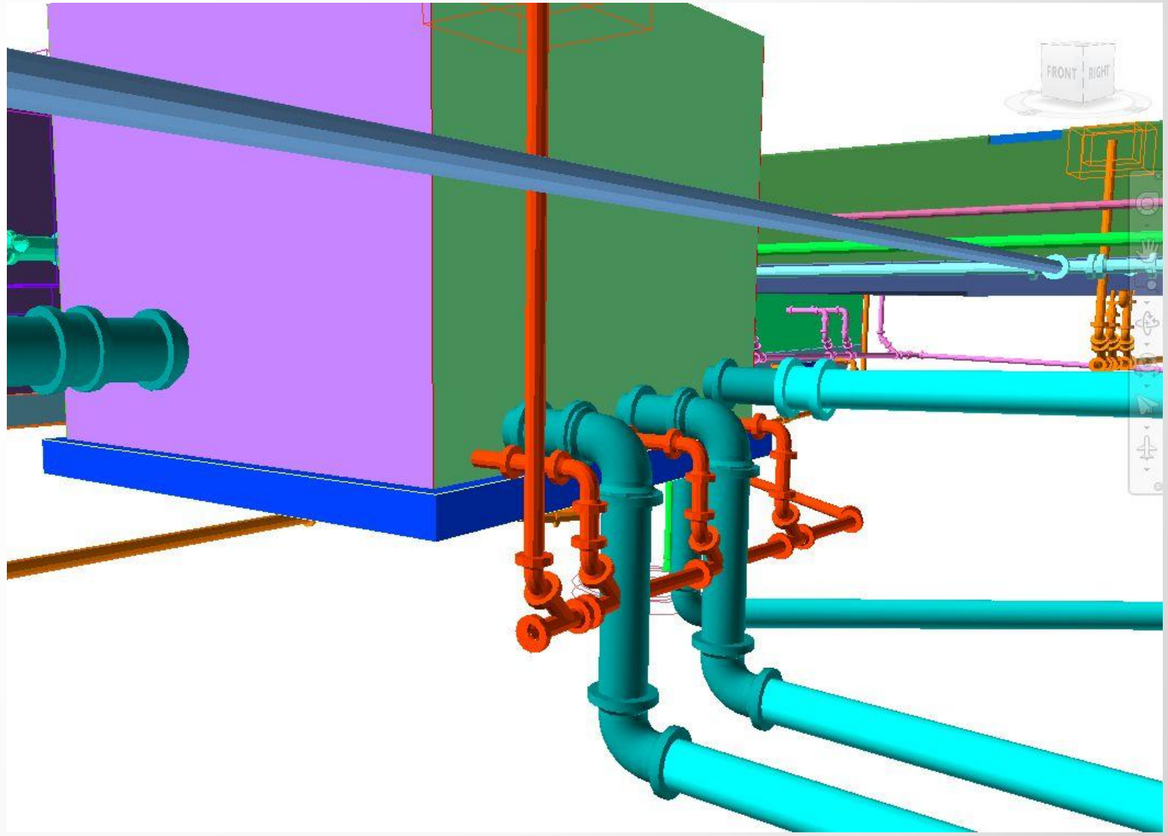
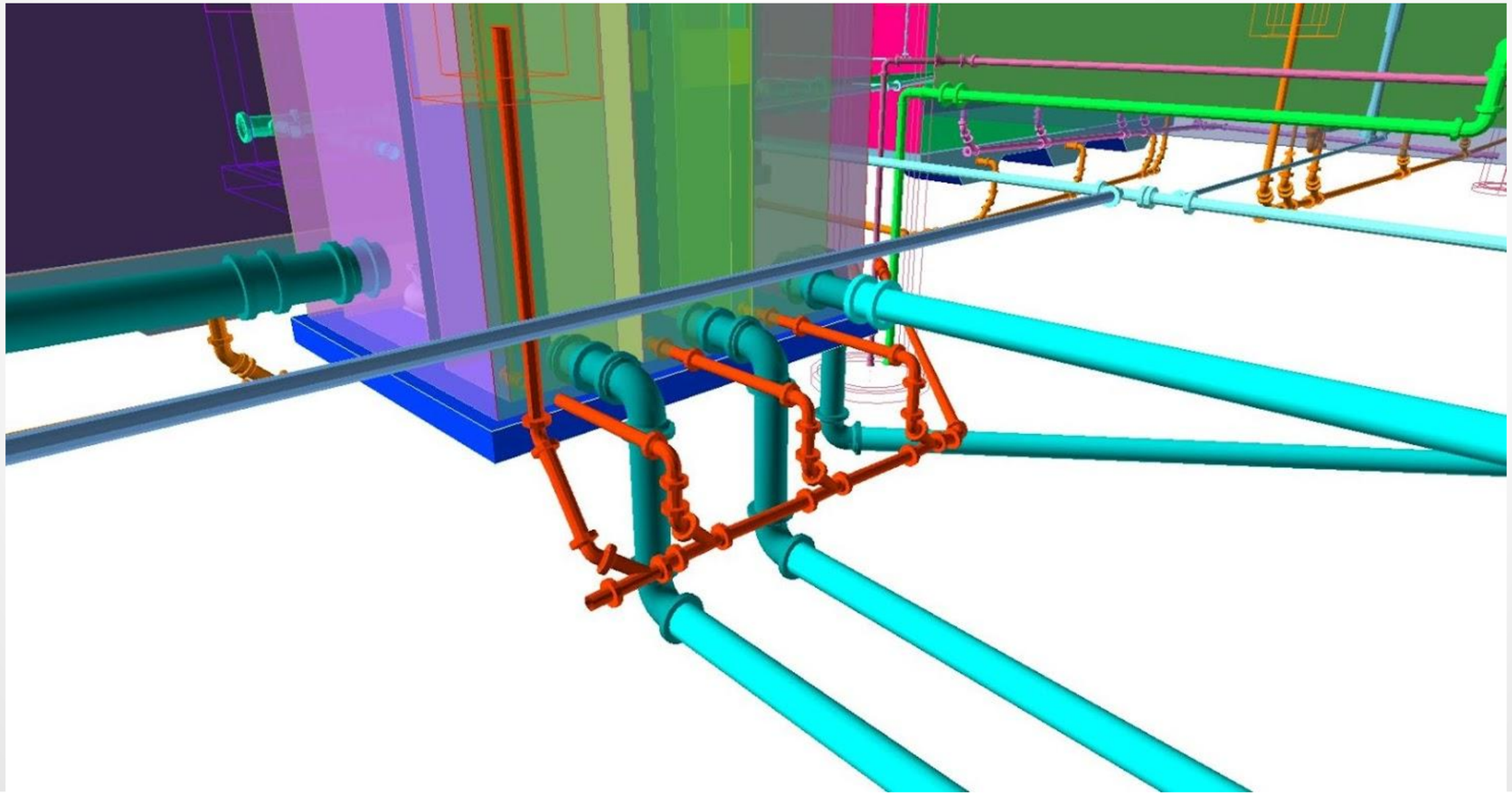
- Meet with Project Managers
- Propose resolution
- Migrate data to Field



Managing Revisions

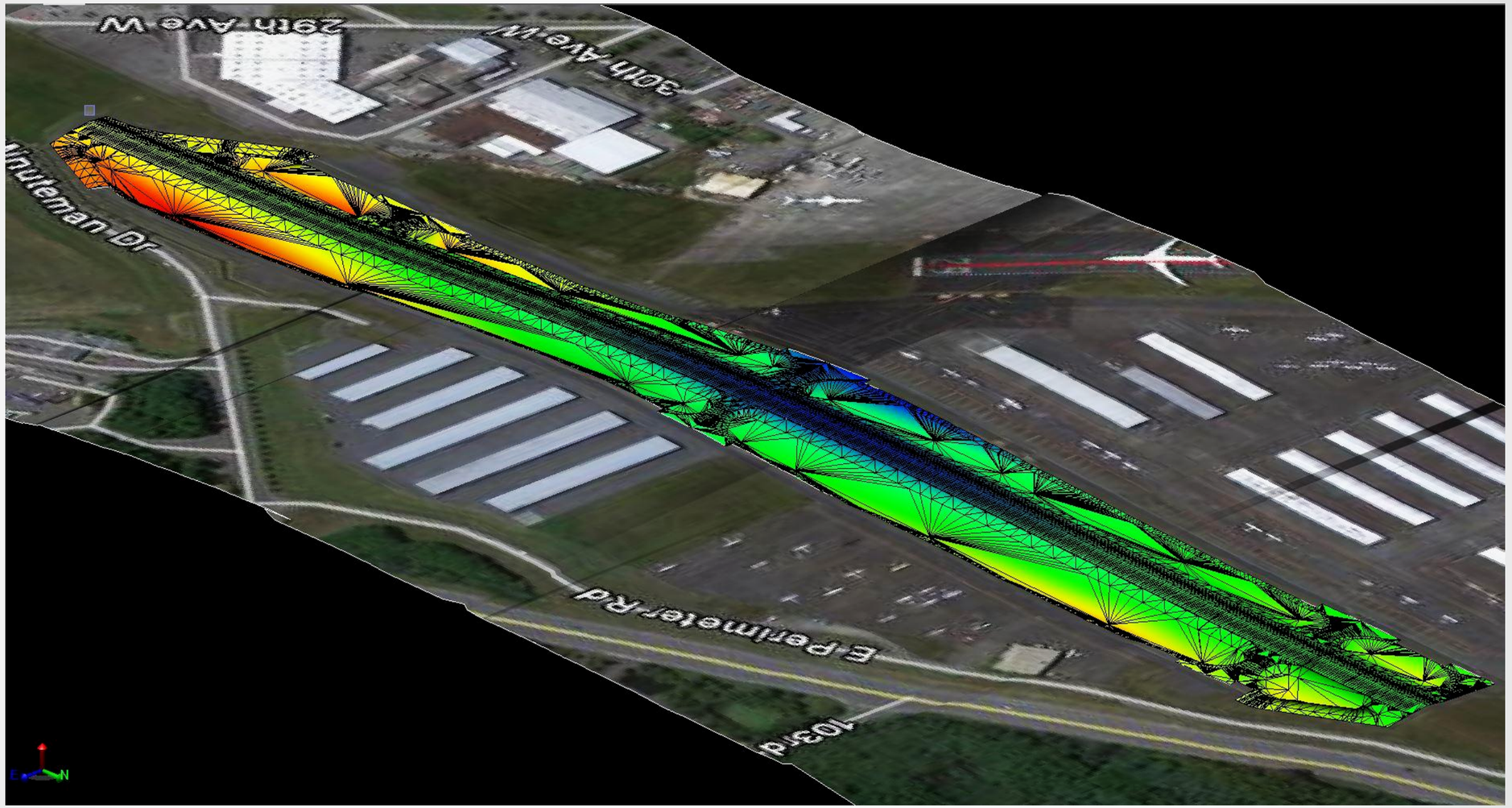
- Revision made In House to Design Drawing
- Sent revised DWG with RFI to Design Engineer
- Received authorization to proceed as proposed within ten minutes of detecting the clash



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 stakeless 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%**

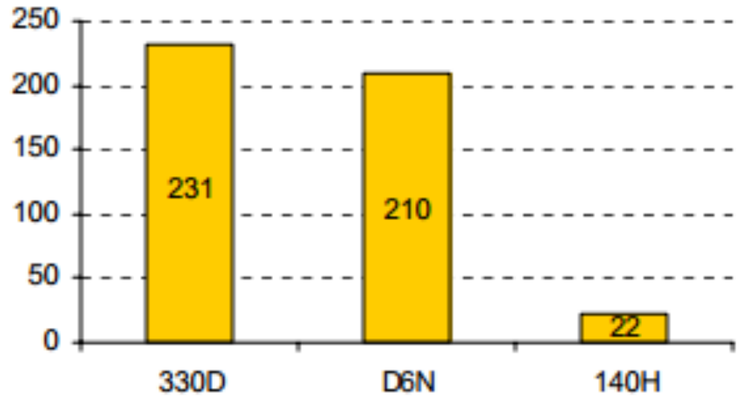
- Reduced layout times
- Increased Accuracy
- Quantifiable Cost Savings

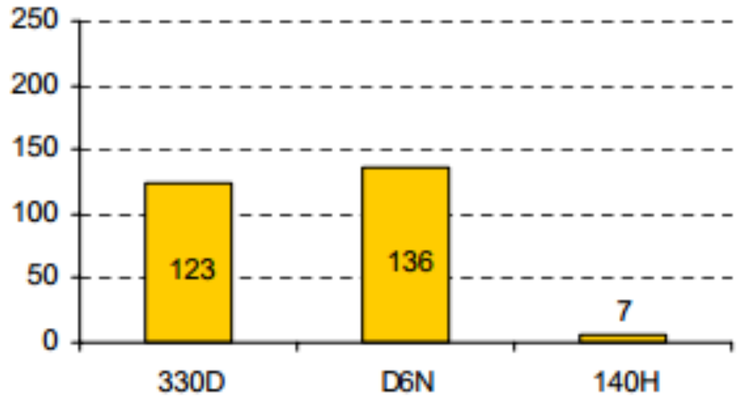
Automated Machine Guidance using 3D models

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

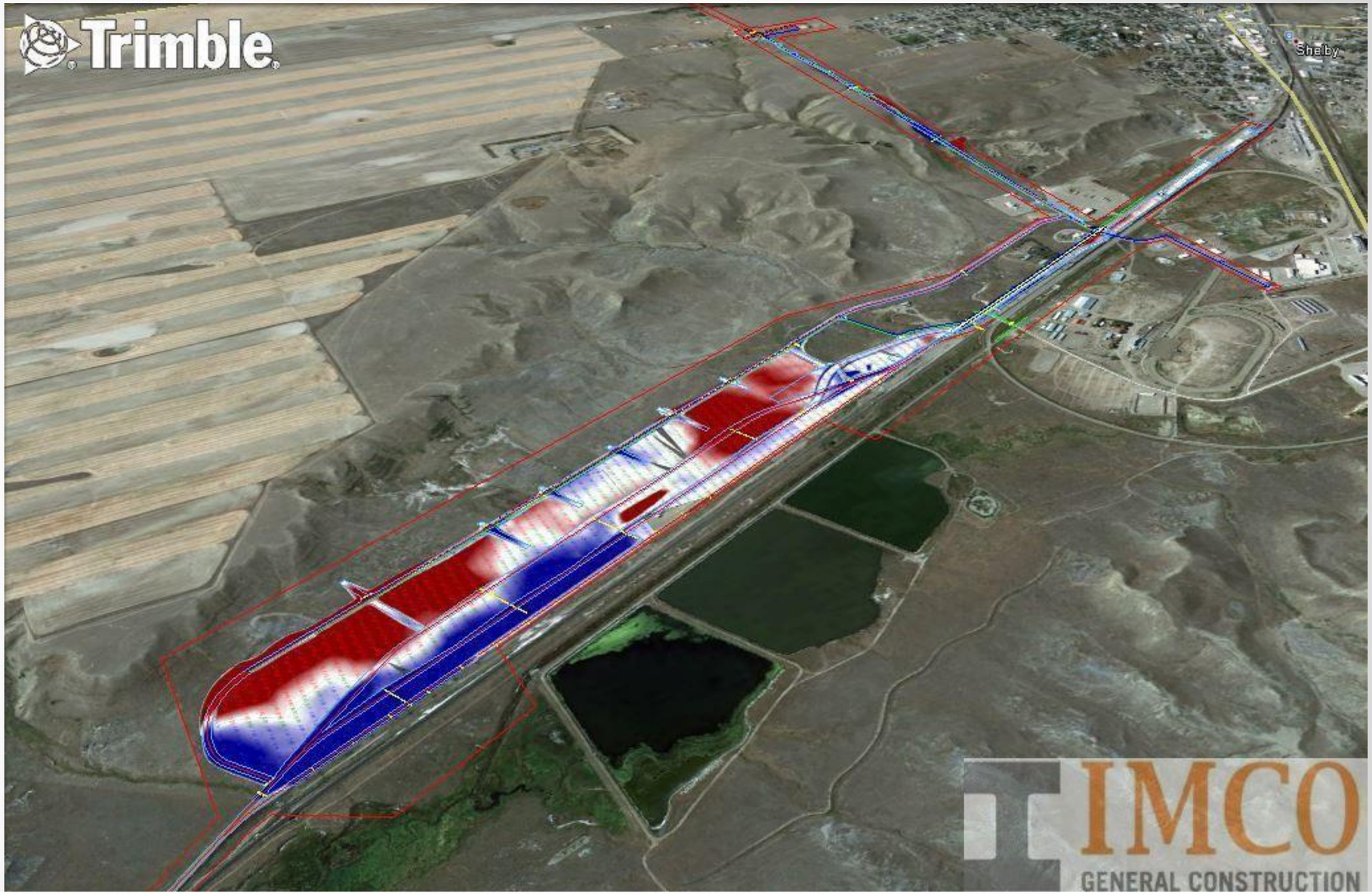
Improved Safety and Reduced Exposure to Hazards

Prefabrication from the 3D Model

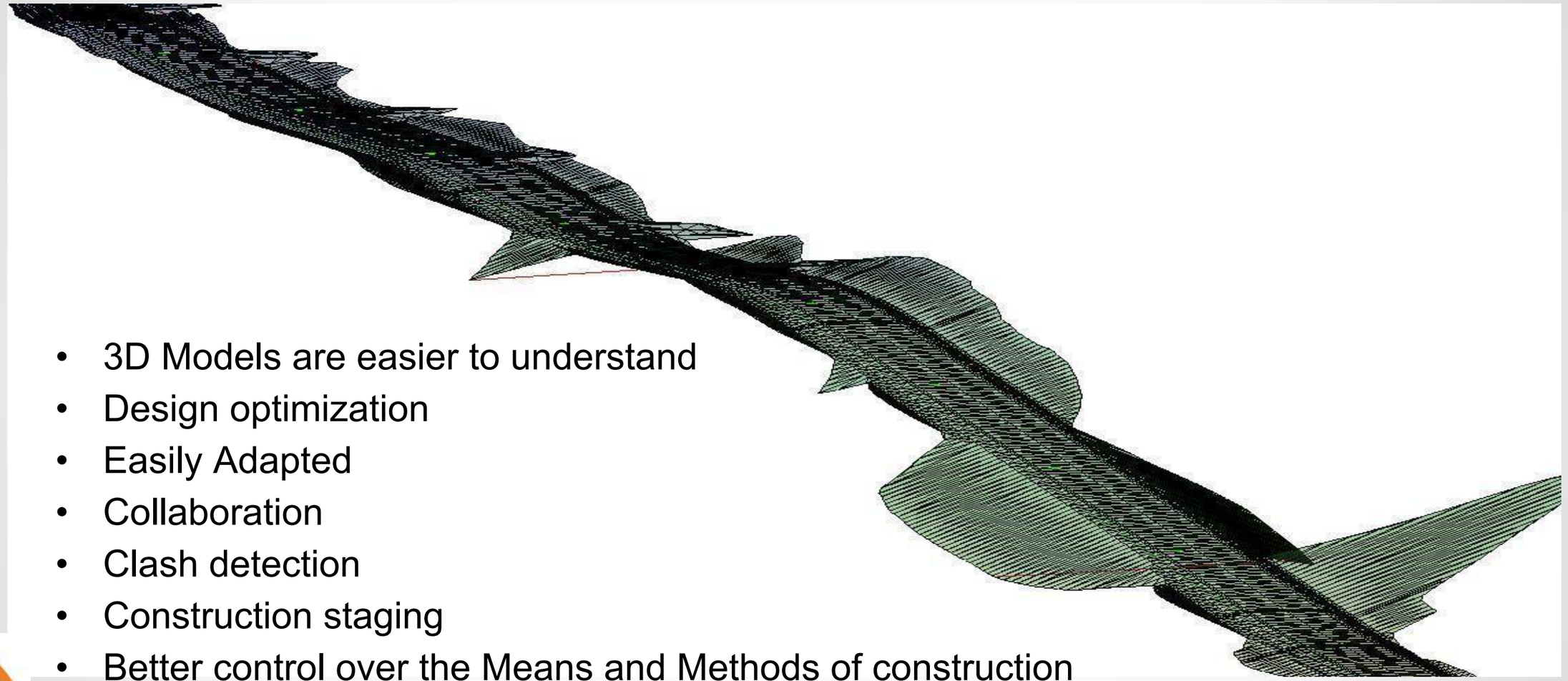
- Faster installation
- Complicated connections and parts assembled prior to shut down
- Ten minute virtual walk through of team member responsibilities alleviates real world delays
- Reduces exposure to risk

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

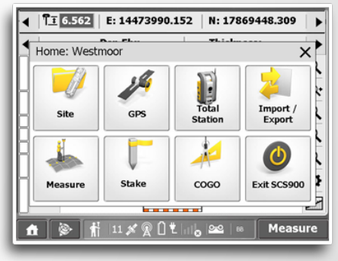
From the Field to the Office Workflow

Procure data during construction in Field

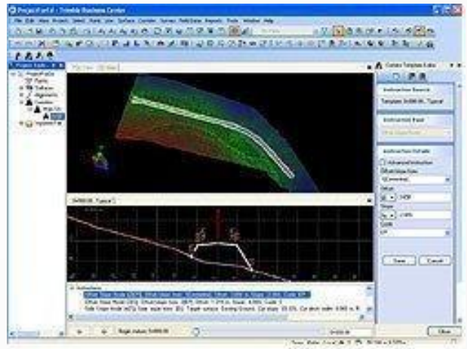
Using GPS and Conventional Survey

Monitoring

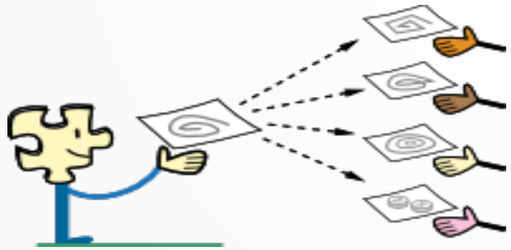
Scanning



Migrate Data to the Office



Review & Back-check As Built data

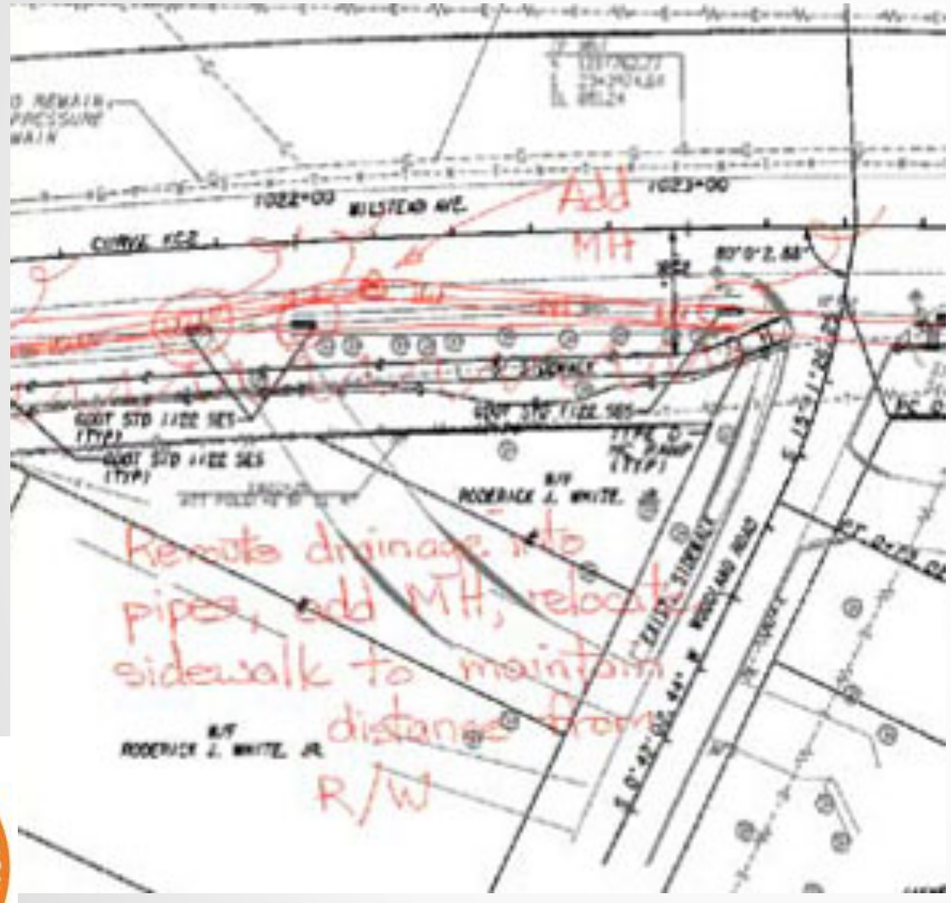


Share models with Engineers and Subcontractors

Final Asbuillts (Electronic CAD & Data rich files)

Added Value to Owners Beyond the Duration of a Project

As-Builts



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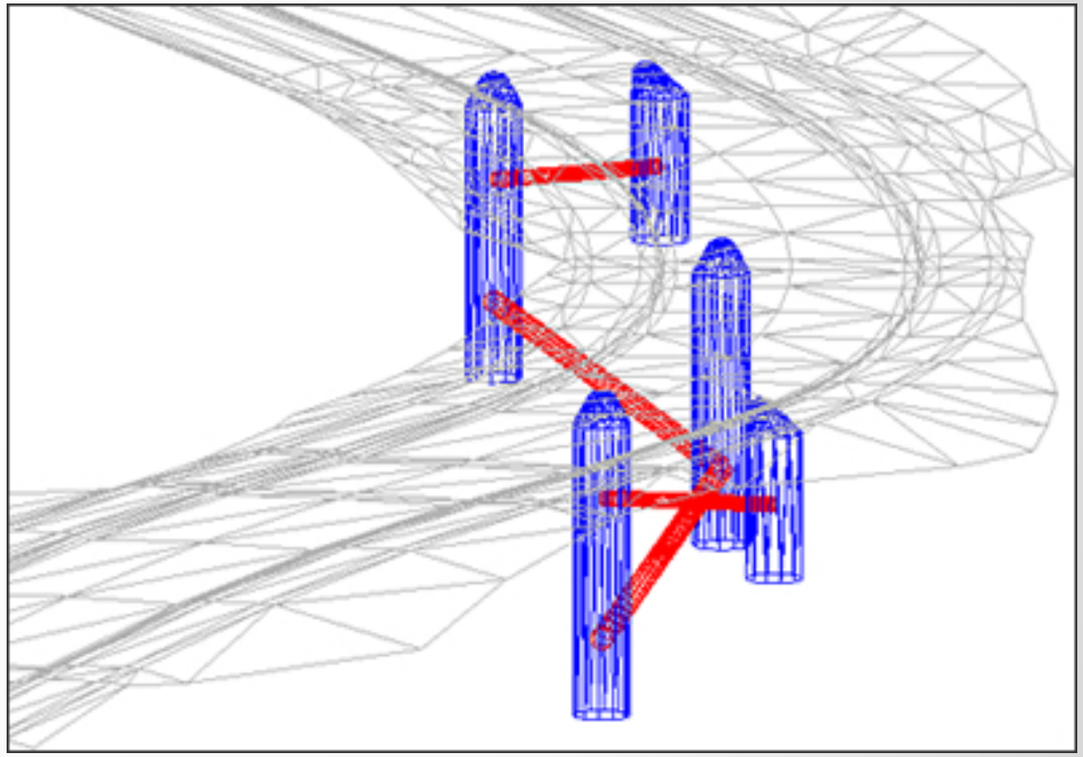
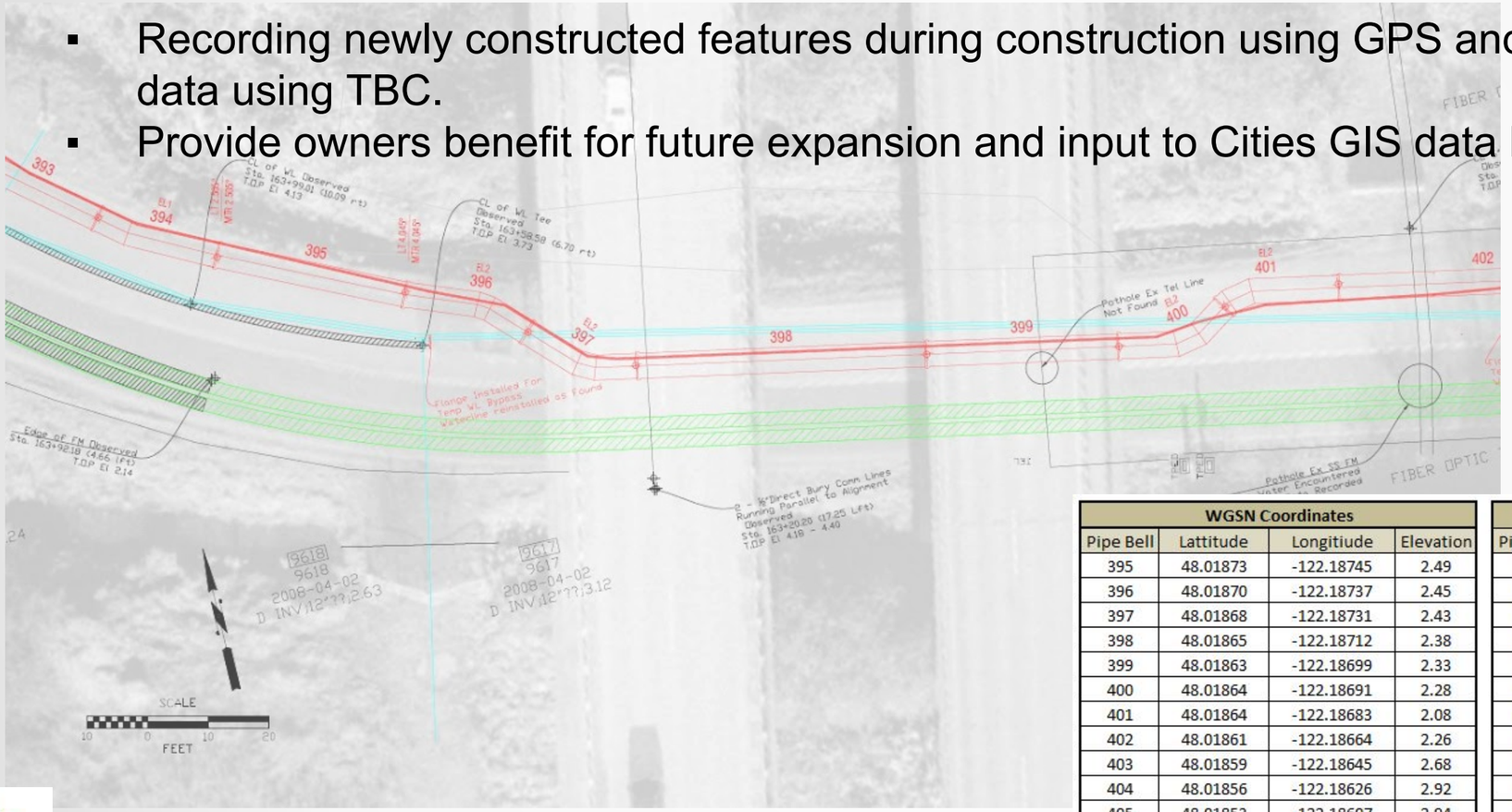


Electronic As-Built Data Management and Sharing

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



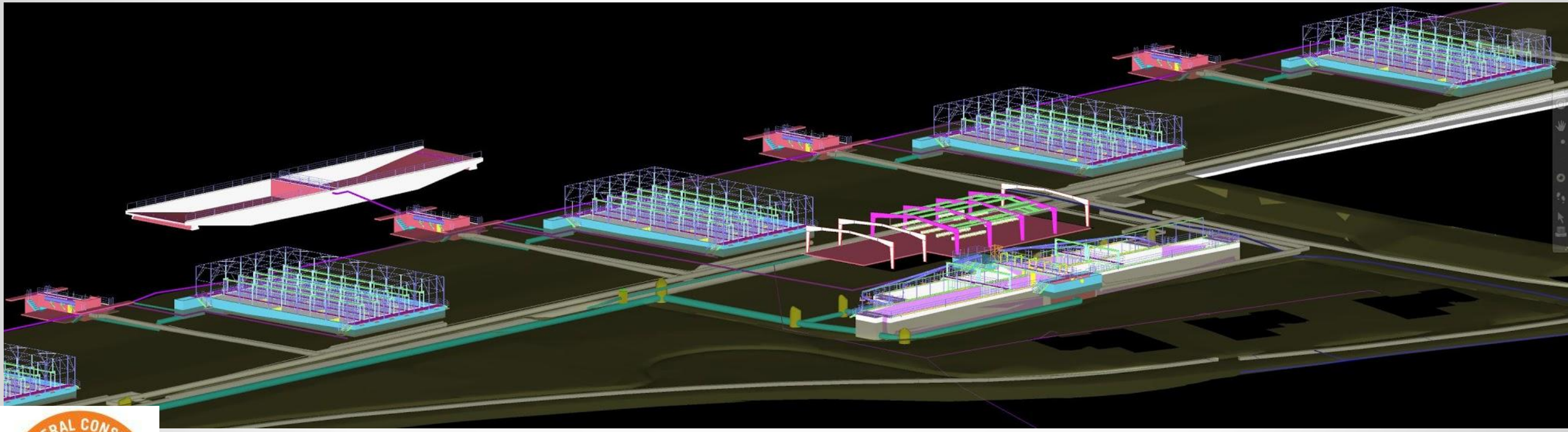
WGSN Coordinates			
Pipe Bell	Lattitude	Longitiude	Elevation
395	48.01873	-122.18745	2.49
396	48.01870	-122.18737	2.45
397	48.01868	-122.18731	2.43
398	48.01865	-122.18712	2.38
399	48.01863	-122.18699	2.33
400	48.01864	-122.18691	2.28
401	48.01864	-122.18683	2.08
402	48.01861	-122.18664	2.26
403	48.01859	-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

IMCO GENERAL CONSTRUCTION IMCO FOUNDED IN 1978

Project Delivery of Electronic Data to the Owner

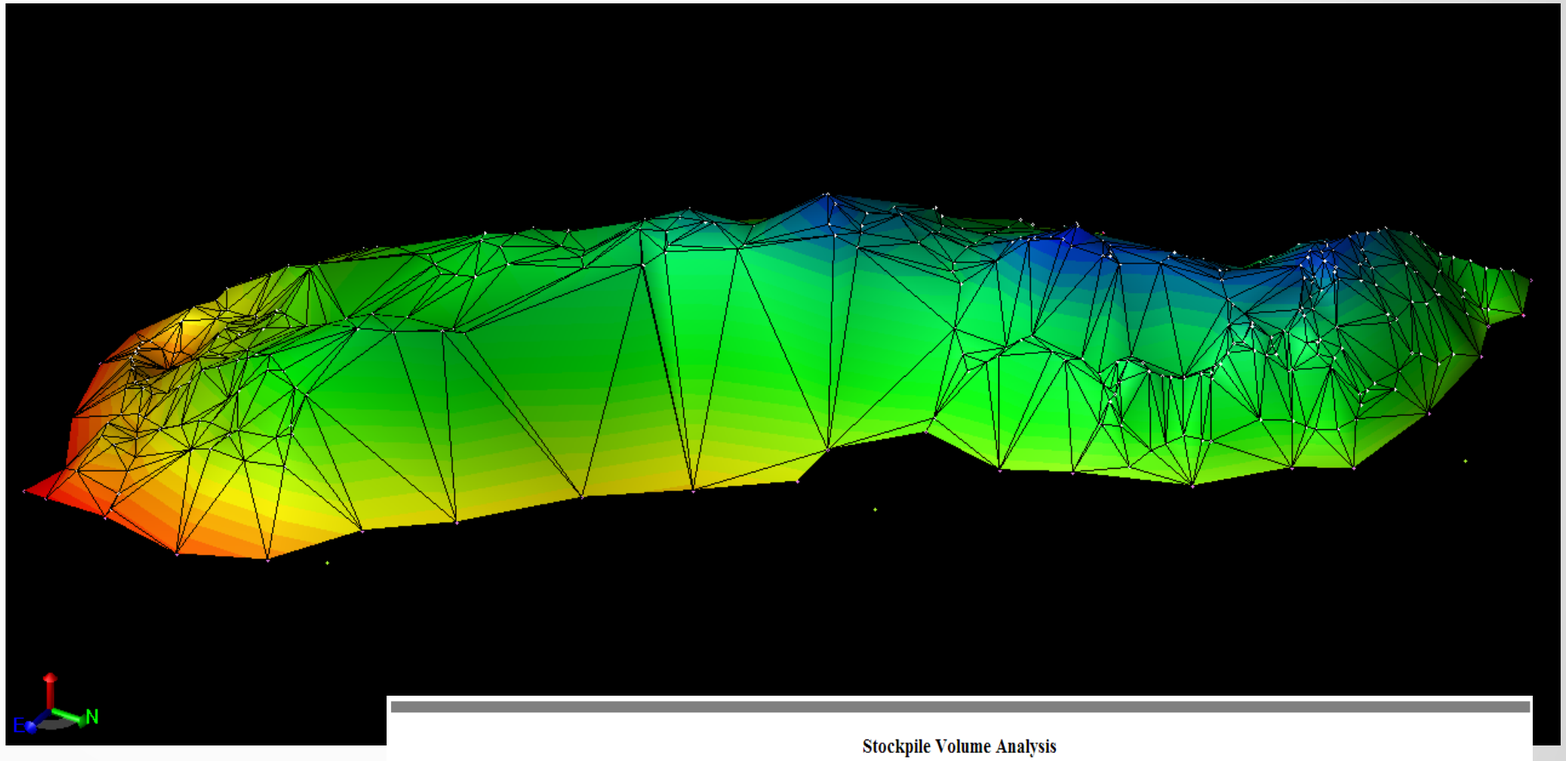
- Recording newly constructed features during construction using GPS and managing the data using TBC.
- Provide owners benefit for future expansion and input to Cities GIS data base



Using New Technologies

UAV Data procurement allows for increased accuracy and reduced processing time.

Conventional Stockpile Topo



Stockpile Volume Analysis

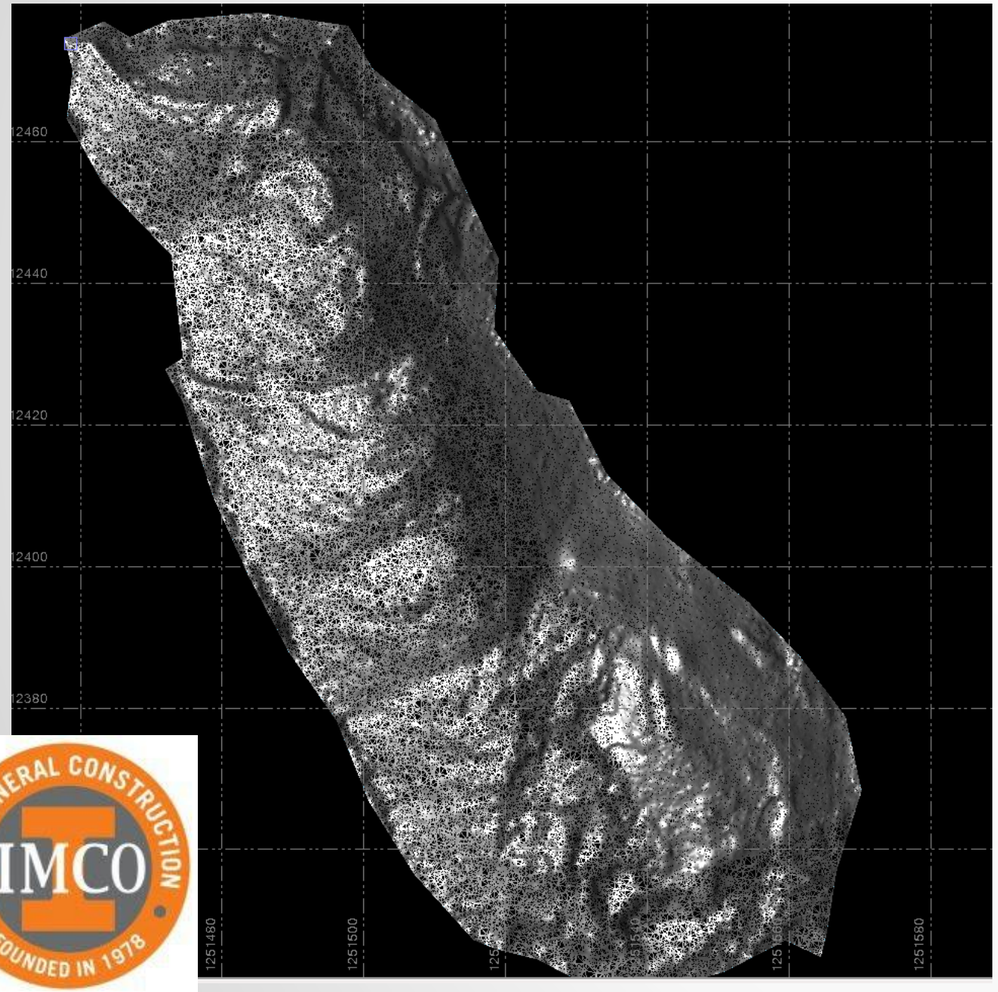
Measured stockpile surface compared to estimated foundation surface

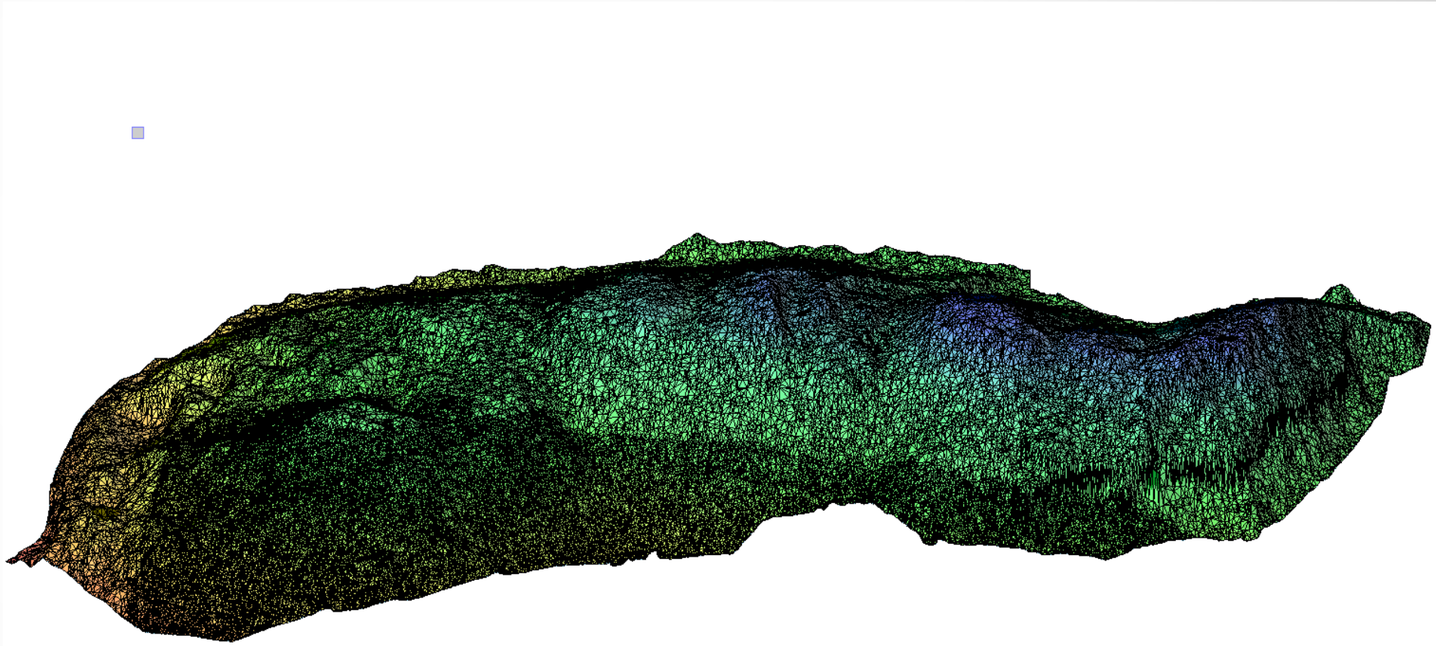
Surfaces	
peat stockpile 04-25-14	Classification: Unclassified

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 Testing for Future Implementation

Difficult Terrain or Inaccessible Area

Accurate Point Cloud of Existing Structures

Inaccessible Area represented through RPV generated point cloud

Don’t be Afraid of Data

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

Contact Information

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