Assessment of Drilled Shaft Capacity and QA/QC from Measuring While Drilling BED31-977-09

GRIP Meeting

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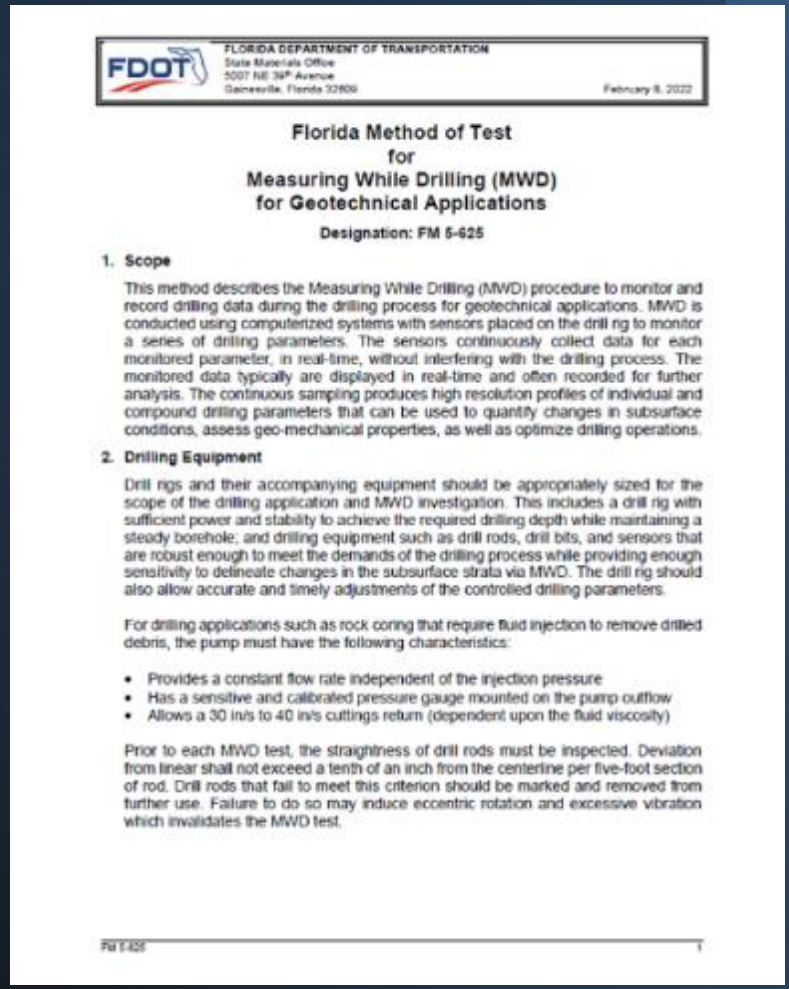
August 18, 2023

Introduction

- The FDOT has developed and applied measuring while drilling (MWD) for the assessment of in situ rock strength for bored piles (ACIP piles and drilled shafts) and site investigation purposes (rock coring)
- Significant advancements in geotechnical exploration
- A better understanding of Florida's highly variable geology
- Improvements in deep foundation design and construction
- A new FDOT test method was developed
- "Measuring While Drilling (MWD) for Geotechnical Applications", designated FM 5-625



FLORIDA DEPARTMENT OF TRANSPORTATION
State Materials Office
5007 NE 39th Avenue
Gainesville, Florida 32609
February 8, 2022

Florida Method of Test
for
Measuring While Drilling (MWD)
for Geotechnical Applications

Designation: FM 5-625

1. Scope

This method describes the Measuring While Drilling (MWD) procedure to monitor and record drilling data during the drilling process for geotechnical applications. MWD is conducted using computerized systems with sensors placed on the drill rig to monitor a series of drilling parameters. The sensors continuously collect data for each monitored parameter, in real-time, without interfering with the drilling process. The monitored data typically are displayed in real-time and often recorded for further analysis. The continuous sampling produces high resolution profiles of individual and compound drilling parameters that can be used to quantify changes in subsurface conditions, assess geo-mechanical properties, as well as optimize drilling operations.

2. Drilling Equipment

Drill rigs and their accompanying equipment should be appropriately sized for the scope of the drilling application and MWD investigation. This includes a drill rig with sufficient power and stability to achieve the required drilling depth while maintaining a steady borehole; and drilling equipment such as drill rods, drill bits, and sensors that are robust enough to meet the demands of the drilling process while providing enough sensitivity to delineate changes in the subsurface strata via MWD. The drill rig should also allow accurate and timely adjustments of the controlled drilling parameters.

For drilling applications such as rock coring that require fluid injection to remove drilled debris, the pump must have the following characteristics:

- Provides a constant flow rate independent of the injection pressure
- Has a sensitive and calibrated pressure gauge mounted on the pump outflow
- Allows a 30 in/s to 40 in/s cuttings return (dependent upon the fluid viscosity)

Prior to each MWD test, the straightness of drill rods must be inspected. Deviation from linear shall not exceed a tenth of an inch from the centerline per five-foot section of rod. Drill rods that fail to meet this criterion should be marked and removed from further use. Failure to do so may induce eccentric rotation and excessive vibration which invalidates the MWD test.

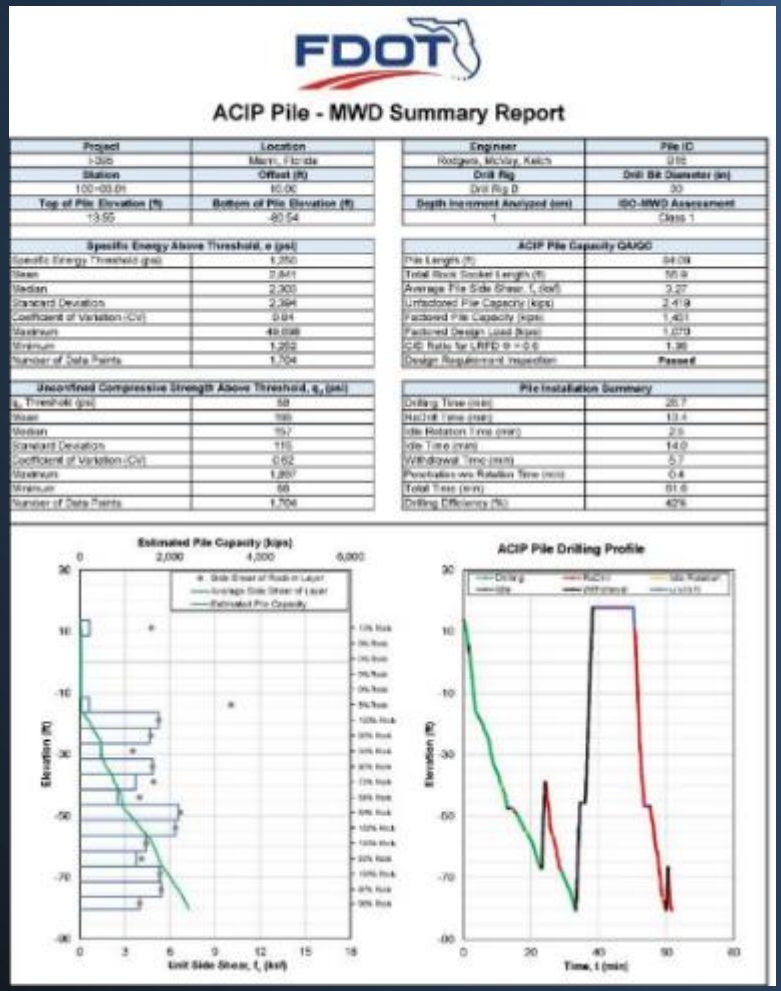
FM 5-625 1

Introduction

- Test method provides:
  - Overview of the general MWD approach
  - Guidance for developing MWD guidelines and procedures
  - Details the format in which MWD data should be reported
- Multiple variations of data recording and reporting may be generated
  - Various commercial and on-board drill rig monitoring systems
- Further investigation required to develop a universal format of analysis for all Florida bored pile QA/QC applications

Project Background

- FDOT investigated the use of MWD for Auger Cast Piles (ACP) to provide QA/QC during pile installations in Miami-Dade
  - BDV31-977-125
- A new analysis tool was developed
  - Transformed time-referenced data collected from AME to depth-referenced data that is compatible for MWD strength assessment
- For ACPs, a time-referenced data format collected from AME is most commonly used in Florida, and the ACP analysis tool was developed specifically to accommodate the data format



Project Background

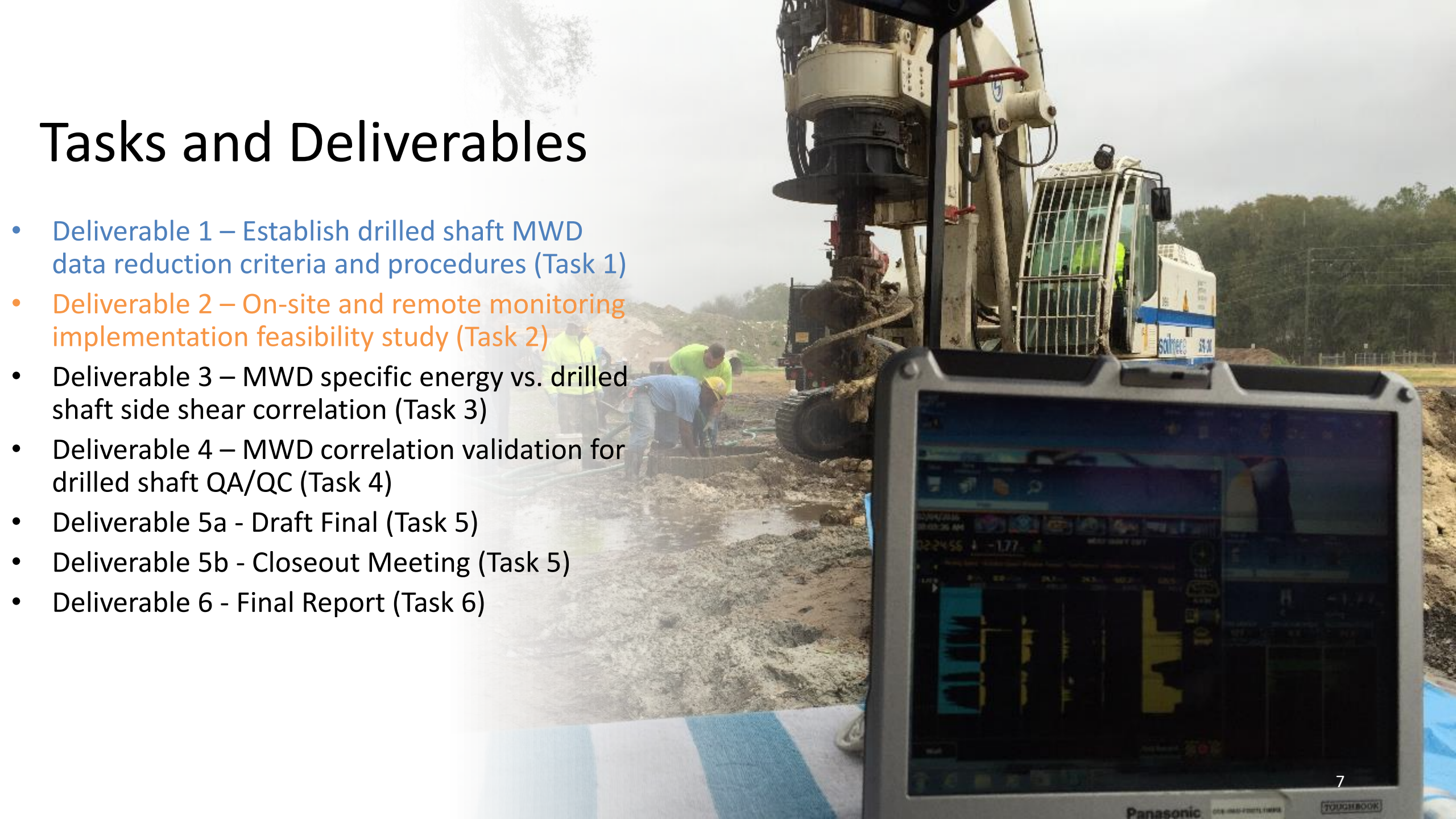
- For drilled shaft MWD…
  - Time-referenced data
  - Depth-referenced data
  - Both data formats
- A new analysis tool needed to be developed to accommodate the possible variations in raw data recording and reporting
- Provide the FDOT with a reliable method of drilled shaft QA/QC analysis, regardless of the monitoring system used
- Contractors can utilize a variety of MWD systems
  - System does not have to produce depth-referenced data
  - Current constraint for full drilled shaft MWD implementation
- On-site and remote monitoring should be explored to improve the quality control portion of the of the QA/QC tool
  - Providing real time strength assessments that can be viewed by all stakeholders

Project Objectives

1. Using FDOT MWD criteria (FM 5-625), develop a versatile data analysis tool that will be used to provide drilled shaft MWD QA/QC
2. Conduct a feasibility study to identify the requirements of providing on-site and remote monitoring capabilities to enhance the QA/QC method
3. Monitor at least one load tested shaft and three production shafts at three independent sites to develop correlations for QA/QC purposes
4. Provide a QA/QC report for all shafts monitored during the research
5. Compare test results with previously derived correlations

Tasks and Deliverables

- Deliverable 1 – Establish drilled shaft MWD data reduction criteria and procedures (Task 1)
- Deliverable 2 – On-site and remote monitoring implementation feasibility study (Task 2)
- Deliverable 3 – MWD specific energy vs. drilled shaft side shear correlation (Task 3)
- Deliverable 4 – MWD correlation validation for drilled shaft QA/QC (Task 4)
- Deliverable 5a - Draft Final (Task 5)
- Deliverable 5b - Closeout Meeting (Task 5)
- Deliverable 6 - Final Report (Task 6)



Task 1 – Establish Drilled Shaft MWD Data Reduction Criteria and Procedures for QA

- Task 1 has two subtasks
  - (1a) Developing specification language
  - (1b) Developing a new versatile data analysis tool for drilled shaft QA/QC purposes (Beta Version)
  - Purchase of new MWD system (LIM)
- Provides the FDOT…
  - Necessary spec language to convey proper MWD requirements to the contractor during bidding, or prior to construction
  - Necessary data analysis tool to process and evaluate the raw MWD data received from the contractor to provide quality assurance (QA)

Task 1a – Development of Specification Language

- Identify MWD systems currently available
  - On-board, in-house, and commercially available systems
- Develop spec language that includes data recording and data formatting requirements
- Specification language will detail construction requirements for the contractor
  - Ensures each drill rig has the appropriate monitoring equipment installed and calibrated
  - Data logging capabilities to supply the FDOT with the necessary electronic records for drilled shaft MWD QA.

Task 1a – Development of Specification Language

- On-board MWD Systems
  - Bauer's B-tronic System
  - Liebehrr's Litronic System
  - Soilmec's Drilling Mate System (DMS)
- Commercially Available MWD Systems
  - Jean Lutz' DIALOG MX System
  - LiM's PocketLIM System
  - Gamperl & Hatlapa's DaVis Systems
  - DAT Instruments' WideLog or TinyLog Systems
  - Pile Dynamics' Pile Installation Recorder (PIR) System
- In-house MWD Systems
  - Keller's Pile Installation Monitoring System (PIMS)
- Every system can produce time-referenced data at 1Hz
  - FM 5-625 requirement for FDOT Bored Pile Class 1

Task 1a – Development of Specification Language

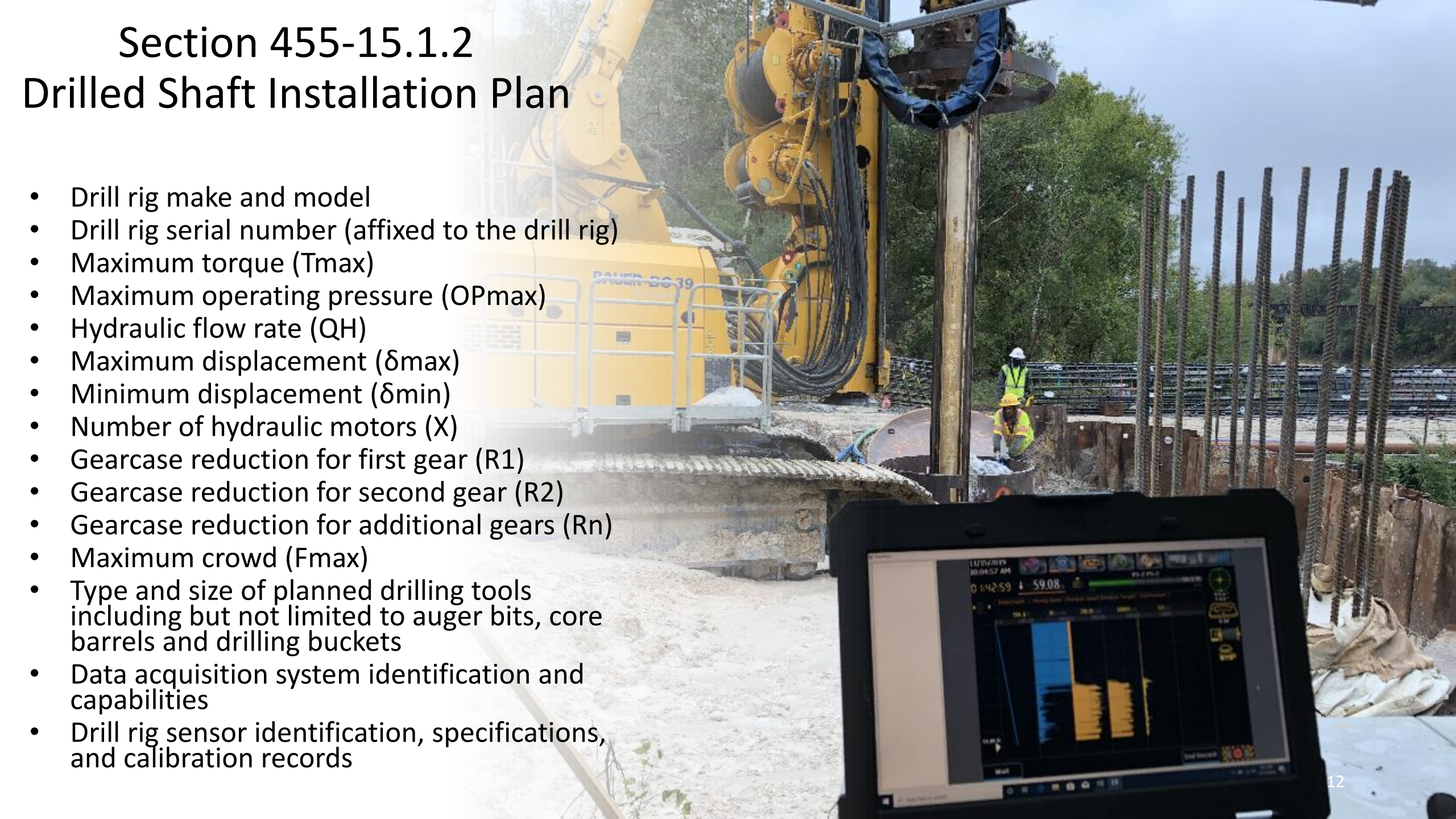
- UF Researchers submitted draft spec language for Drilled Shaft MWD:

- FDOT Standard Specifications for Road and Bridge Construction – Section 455
  - Section 455-15.1.2 – Drilled Shaft Installation Plan (DSIP)
  - Section 455-15.1.3.1 – Measuring While Drilling (MWD)
  - Section 455-15.10.5 – MWD Equipment
  - Section 455-15.10.6 – MWD Measurements

- Florida Method of Test (FM 5-625)
  - Section 3.6.1 – Minimum Accuracy of Measured Values

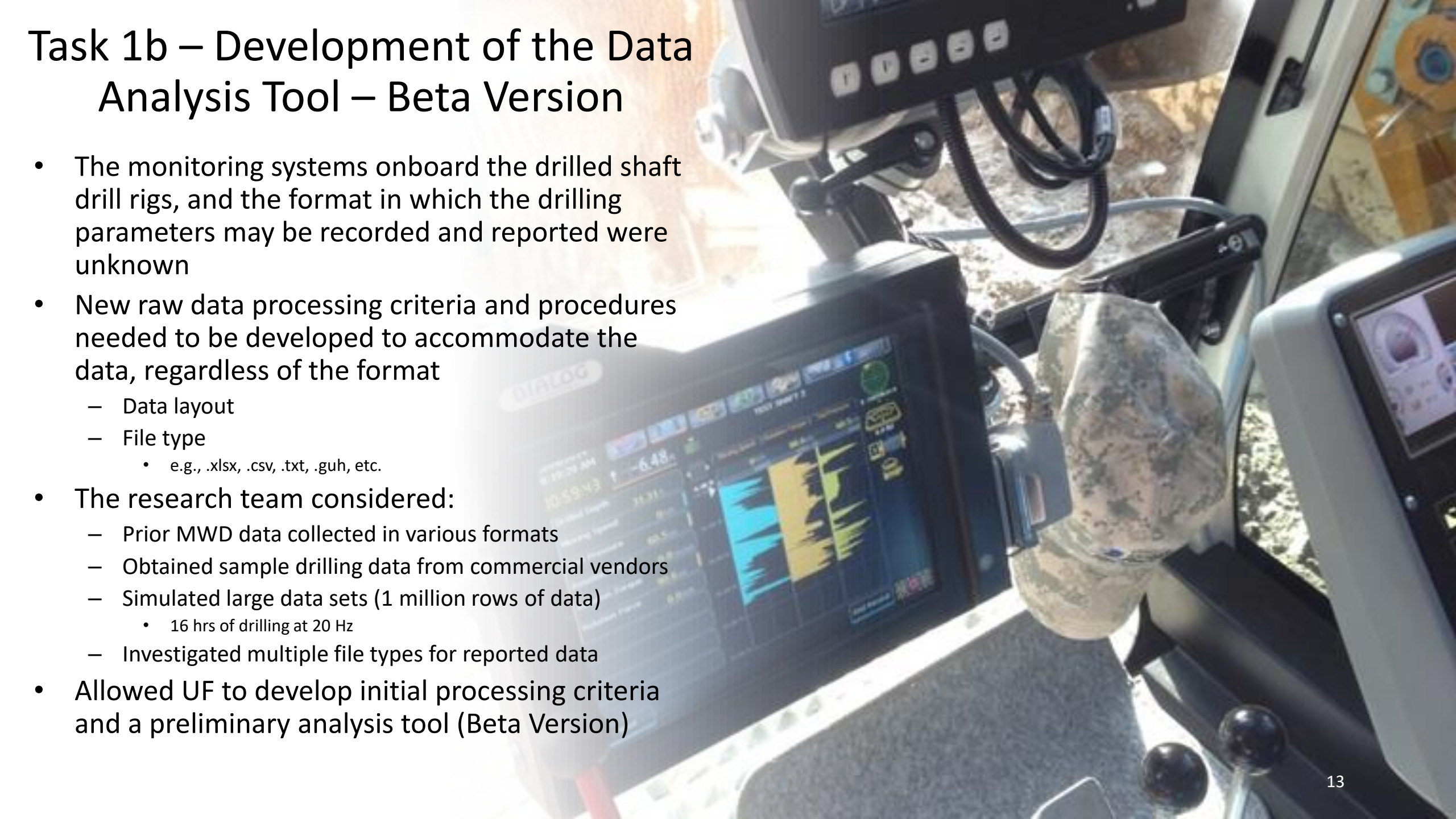
Section 455-15.1.2
Drilled Shaft Installation Plan

- Drill rig make and model
- Drill rig serial number (affixed to the drill rig)
- Maximum torque (Tmax)
- Maximum operating pressure (OPmax)
- Hydraulic flow rate (QH)
- Maximum displacement (δmax)
- Minimum displacement (δmin)
- Number of hydraulic motors (X)
- Gearcase reduction for first gear (R1)
- Gearcase reduction for second gear (R2)
- Gearcase reduction for additional gears (Rn)
- Maximum crowd (Fmax)
- Type and size of planned drilling tools including but not limited to auger bits, core barrels and drilling buckets
- Data acquisition system identification and capabilities
- Drill rig sensor identification, specifications, and calibration records



Task 1b – Development of the Data Analysis Tool – Beta Version

- The monitoring systems onboard the drilled shaft drill rigs, and the format in which the drilling parameters may be recorded and reported were unknown
- New raw data processing criteria and procedures needed to be developed to accommodate the data, regardless of the format
  - Data layout
  - File type
    - e.g., .xlsx, .csv, .txt, .guh, etc.
- The research team considered:
  - Prior MWD data collected in various formats
  - Obtained sample drilling data from commercial vendors
  - Simulated large data sets (1 million rows of data)
    - 16 hrs of drilling at 20 Hz
  - Investigated multiple file types for reported data
- Allowed UF to develop initial processing criteria and a preliminary analysis tool (Beta Version)



ACIP Pile Analysis Tool

Advantages

- The Excel-based graphical user interface (GUI) is easy to navigate and understood by most engineers, which is ideal for consultants who are new to MWD
- FDOT geotechnical engineers have received prior training and are familiar with the auger-cast pile analysis tool layout. It would be ideal to keep as much functionality as possible to alleviate confusion
- Efficient for customized layer analyses
- Worked well when the number of data rows to be considered prior to analysis is low
- Capable of analyzing up to ten piles in a short amount of time

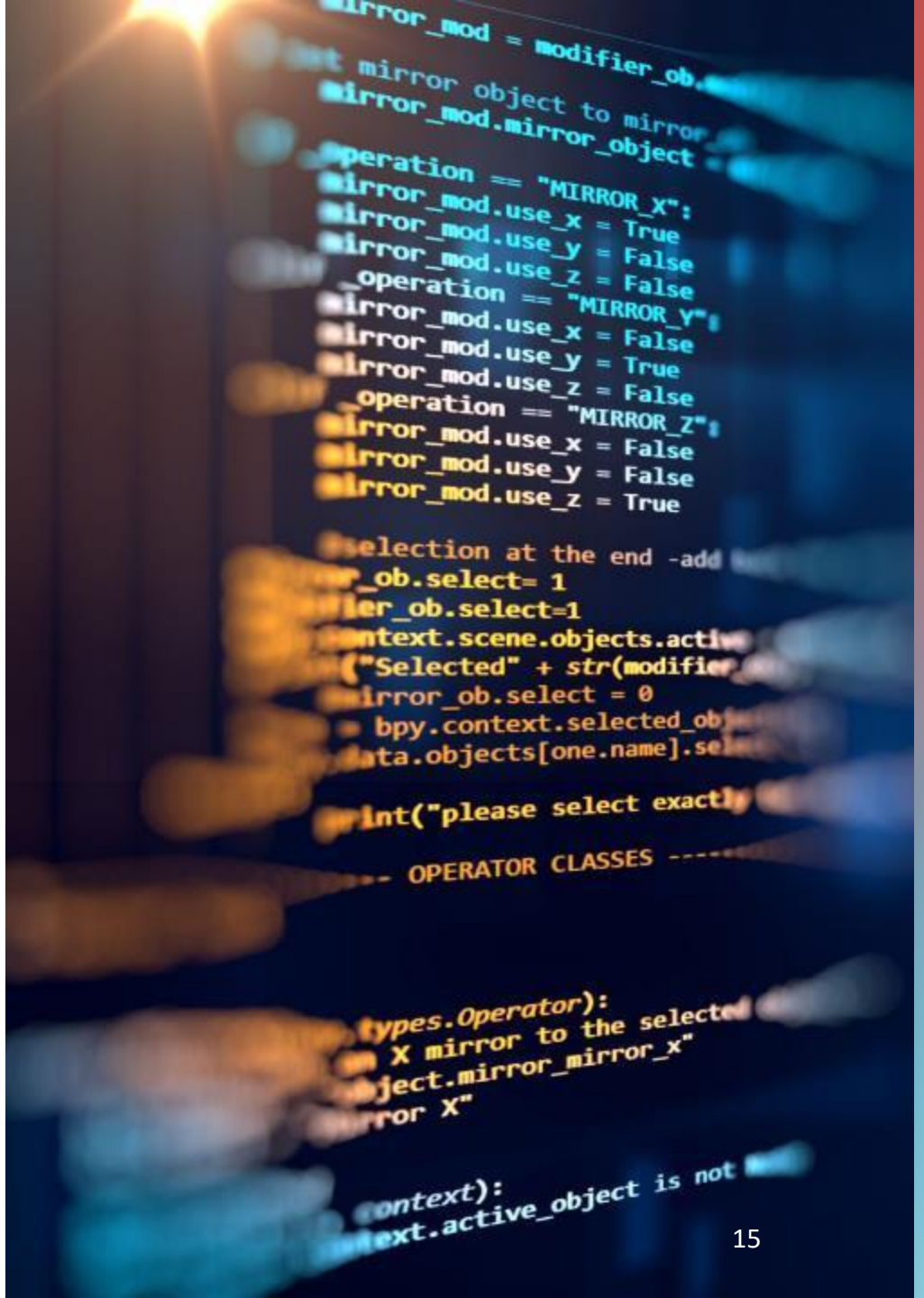
Disadvantages

- Large data sets with a significant amount of data rows degraded functionality and often result in a crash
- Each raw data set had to be manually dropped into the excel sheet which can be time consuming and leaves room for error
- Debugging programming issues was very difficult and time consuming
- Tracking multiple versions for various levels of analysis was very difficult and time consuming to manage when upgrades or fixes are needed
- Not ideal for increased sampling rates
- File sizes of the prior analysis tool are too large
  - 40 to 50 MB
- Not ideal for real time on-site and remote QC monitoring implementation

***Excel-based analysis tool should be developed but with a standalone executable added as an extension to handle much larger data sets, perform complex calculations, reduce complex Excel functions, and to provide compatibility for future real time on-site and remote QC monitoring**

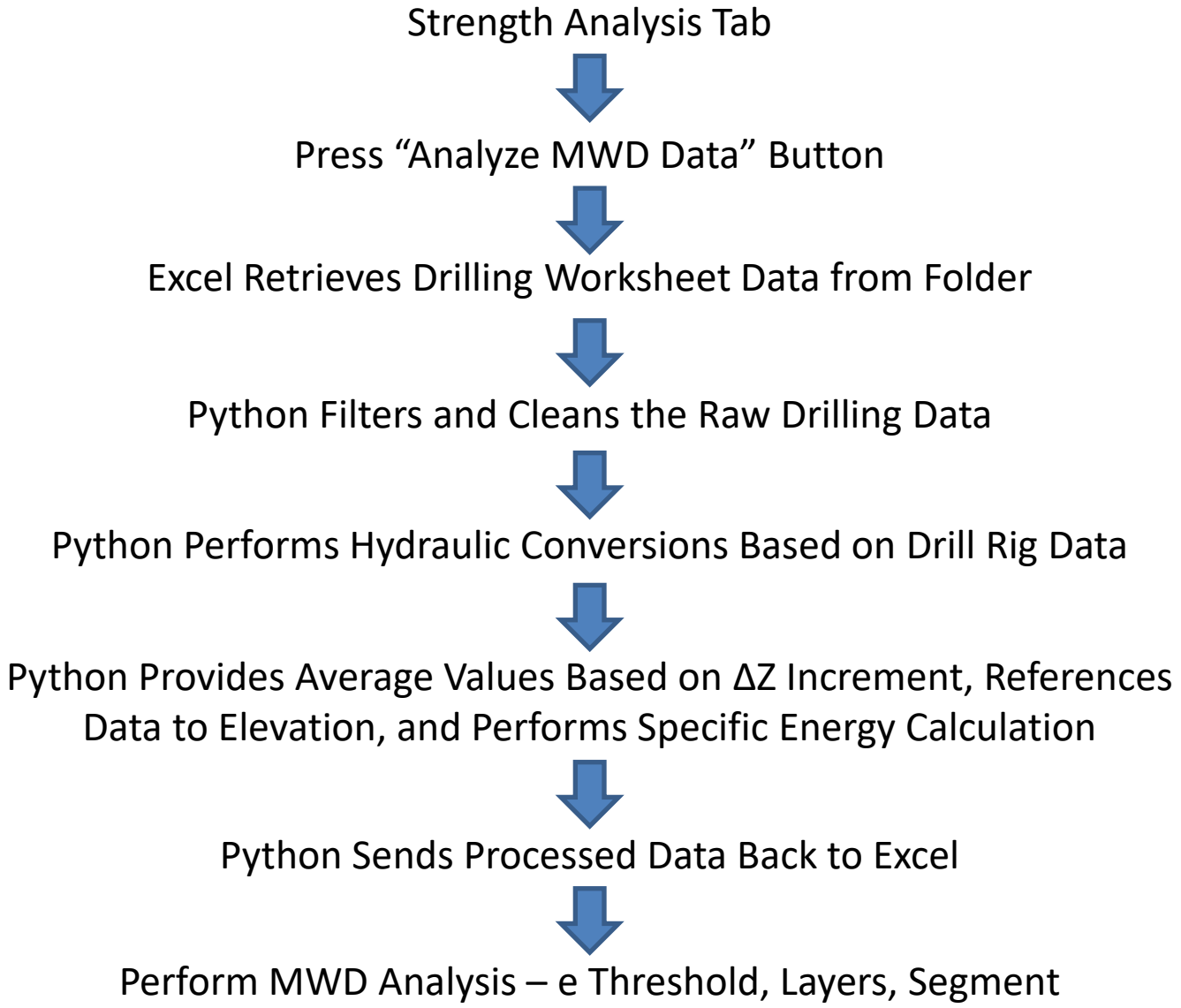
FLMWD Analysis Tool

- UF research team assessed programming languages and decided **Python** was the most ideal for the current state of MWD analyses and for future development
  - Versatile and powerful programming language that offers several benefits
  - Easy to learn and read, has clean and readable syntax, which allowed us to quickly write code and focus on problem-solving
    - Offers a significant collection of libraries and modules that speed up development
  - Can be used for web development, data analysis, scientific computing, artificial intelligence, machine learning, and automation
  - Can seamlessly integrate with Microsoft Excel, providing enhanced capabilities
    - Data processing and analysis, automation of repetitive tasks, advanced analysis, custom functionality, and scalability



FLMWD Analysis Tool Workflow

- New MWD analysis tool utilizes python to perform the background calculations
  - No longer have to copy and paste data or files into analysis tool
    - Imports all data and files from folders
    - Never have to open a single drilling file to analyze your MWD data
  - Much smaller file sizes
    - > 3MB compared to 40 to 50 MB
  - Easier to track changes during upgrades and modifications
- Provides a similar user interface (UI) to ACIP analysis tool
  - Specific energy threshold and layers can be adjusted without triggering the program to reanalyze the data



Agreement

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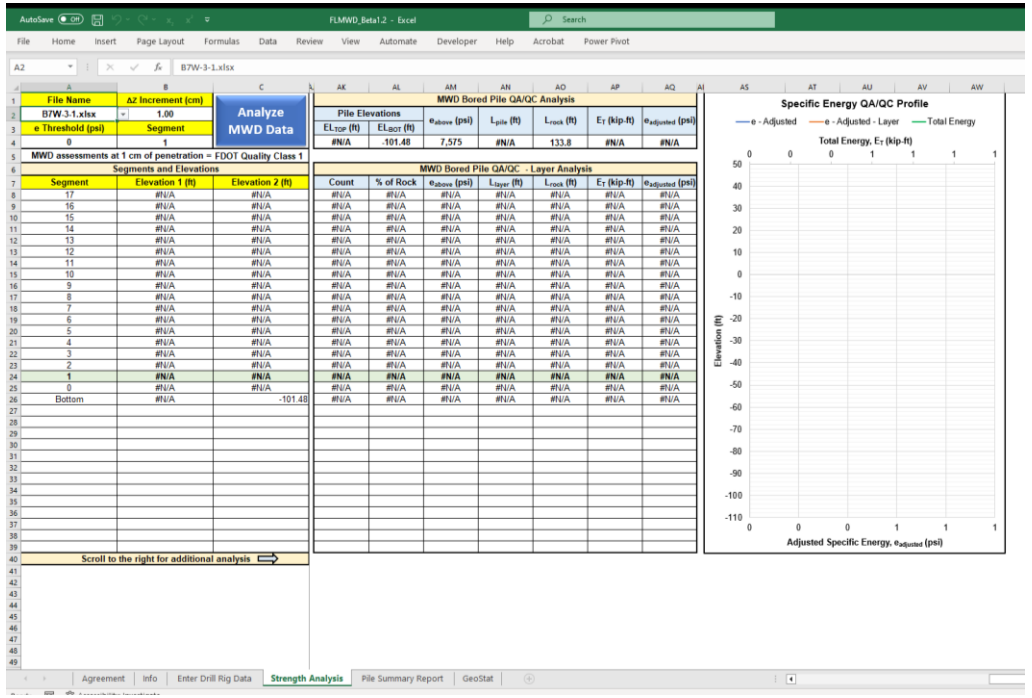
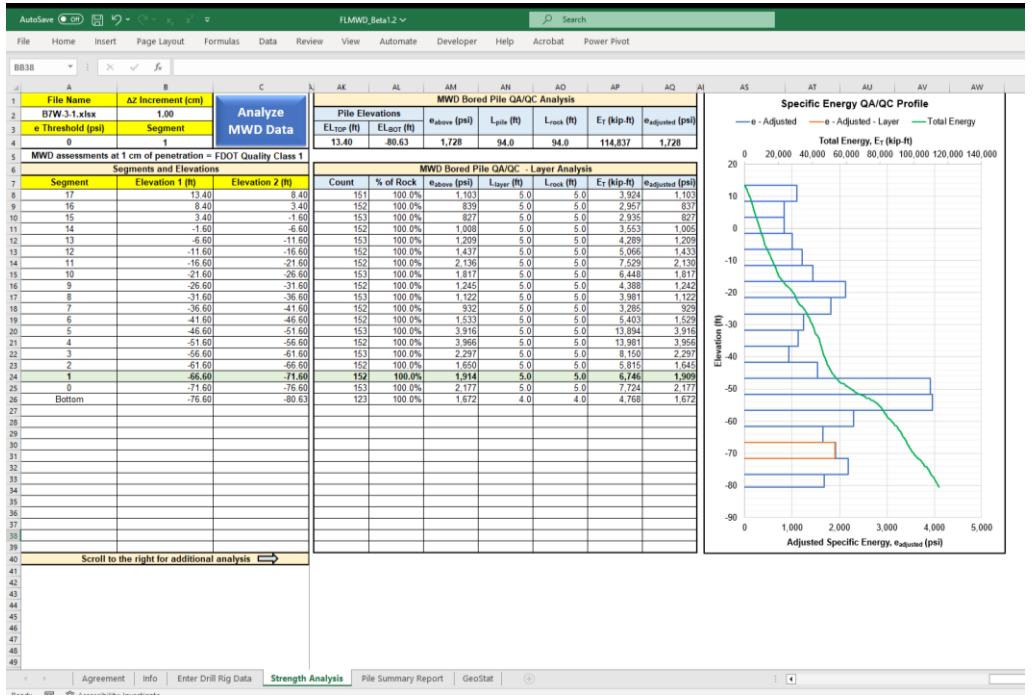
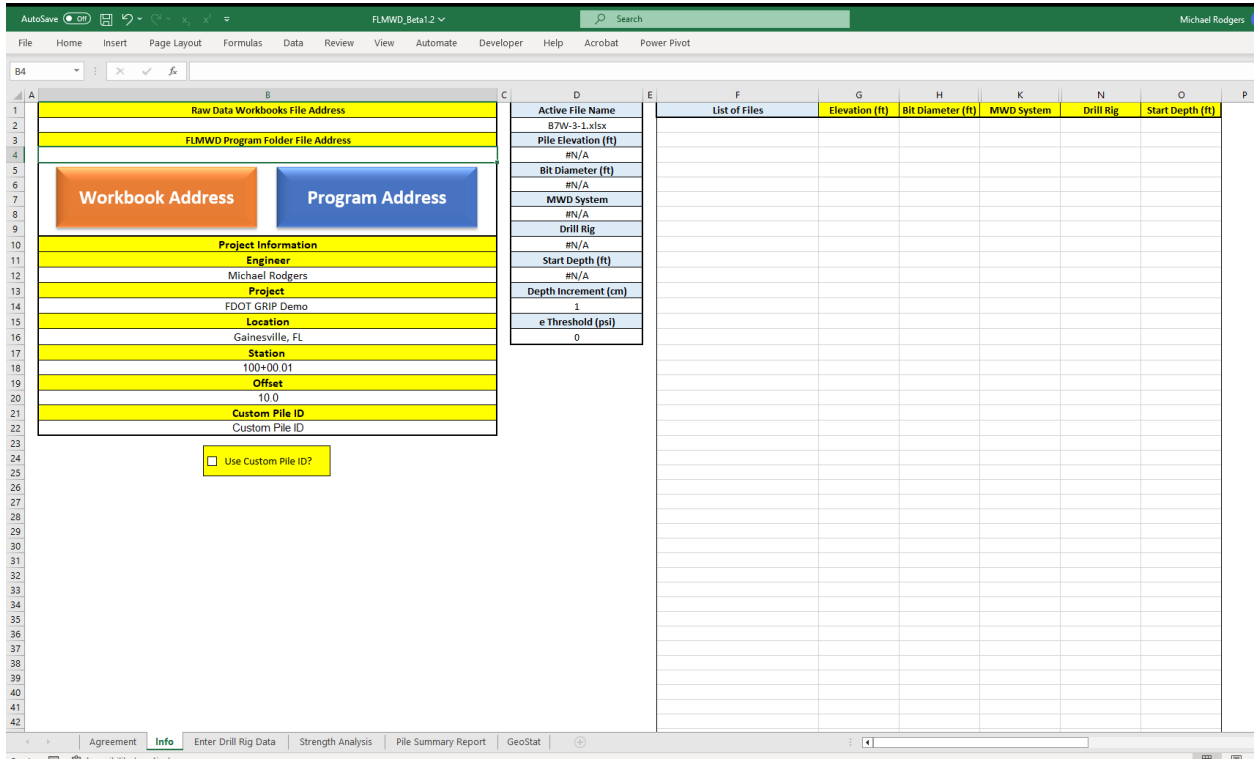
☑ I Agree





Info Sheet


Raw Data Workbooks File Address
FLMWD Program Folder File Address
Workbook Address
Program Address
Project Information
Engineer
Michael Rodgers
Project
FDOT GRIP Demo
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Gainesville, FL
Station
100+00.01
Offset
10.0
Custom Pile ID
Custom Pile ID
Use Custom Pile ID?
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Bit Diameter (ft)
#N/A
MWD System
#N/A
Drill Rig
#N/A
Start Depth (ft)
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Depth Increment (cm)
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e Threshold (psi)
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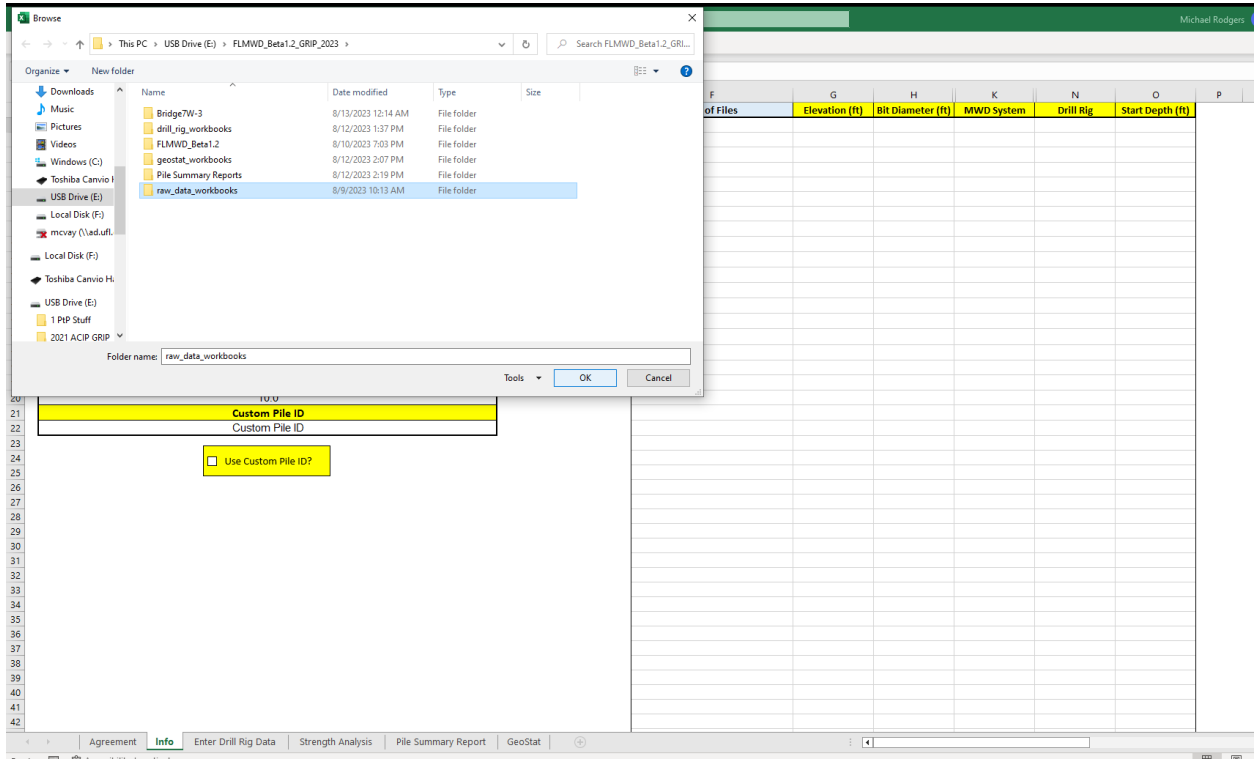
Elevation (ft)
Bit Diameter (ft)
MWD System
Drill Rig
Start Depth (ft)
Agreement
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat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This PC
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Organize
New folder
Downloads
Music
Pictures
Videos
Windows (C:)
USB Drive (E:)
Local Disk (F:)
Name
Date modified
Type
Size
Bridge7W-3
drill_rig_workbooks
FLMWD_Beta1.2
geostat_workbooks
Pile Summary Reports
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Use Custom Pile ID?
Agreement
Info
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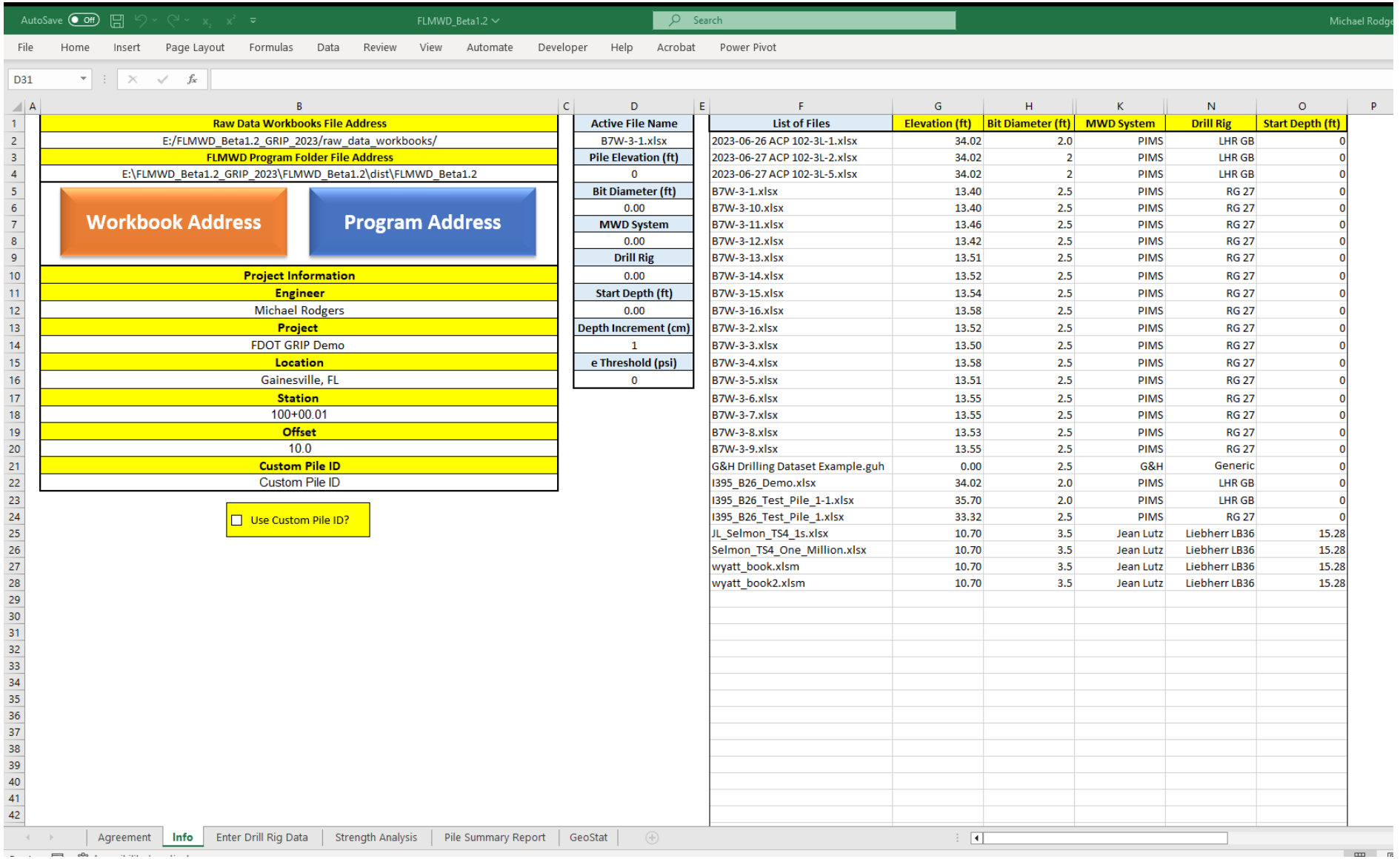
Pile Summary Report
GeoStat

Info Sheet



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FLMWD Program Folder File Address
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Workbook Address | Program Address

Project Information
Engineer
Michael Rodgers
Project
FDOT GRIP Demo
Location
Gainesville, FL
Station
100+00.01
Offset
10.0
Custom Pile ID
Custom Pile ID

☐ Use Custom Pile ID?

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Bit Diameter (ft)
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MWD System
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Drill Rig
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Start Depth (ft)
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Depth Increment (cm)
1
e Threshold (psi)
0

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2023-06-27 ACP 102-3L-2.xlsx	34.02	2	PIMS	LHR GB	0
2023-06-27 ACP 102-3L-5.xlsx	34.02	2	PIMS	LHR GB	0
B7W-3-1.xlsx	13.40	2.5	PIMS	RG 27	0
B7W-3-10.xlsx	13.40	2.5	PIMS	RG 27	0
B7W-3-11.xlsx	13.46	2.5	PIMS	RG 27	0
B7W-3-12.xlsx	13.42	2.5	PIMS	RG 27	0
B7W-3-13.xlsx	13.51	2.5	PIMS	RG 27	0
B7W-3-14.xlsx	13.52	2.5	PIMS	RG 27	0
B7W-3-15.xlsx	13.54	2.5	PIMS	RG 27	0
B7W-3-16.xlsx	13.58	2.5	PIMS	RG 27	0
B7W-3-2.xlsx	13.52	2.5	PIMS	RG 27	0
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I395_B26_Test_Pile_1-1.xlsx	35.70	2.0	PIMS	LHR GB	0
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wyatt_book2.xlsm	10.70	3.5	Jean Lutz	Liebherr LB36	15.28

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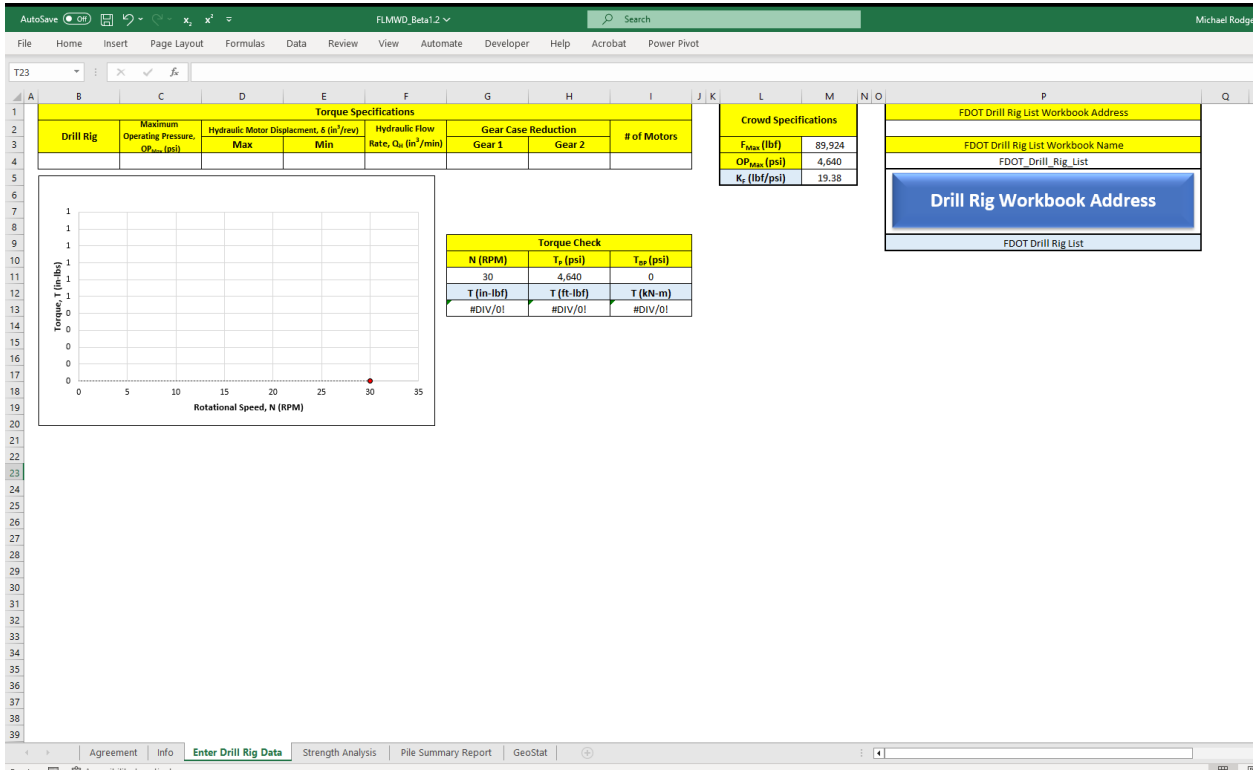

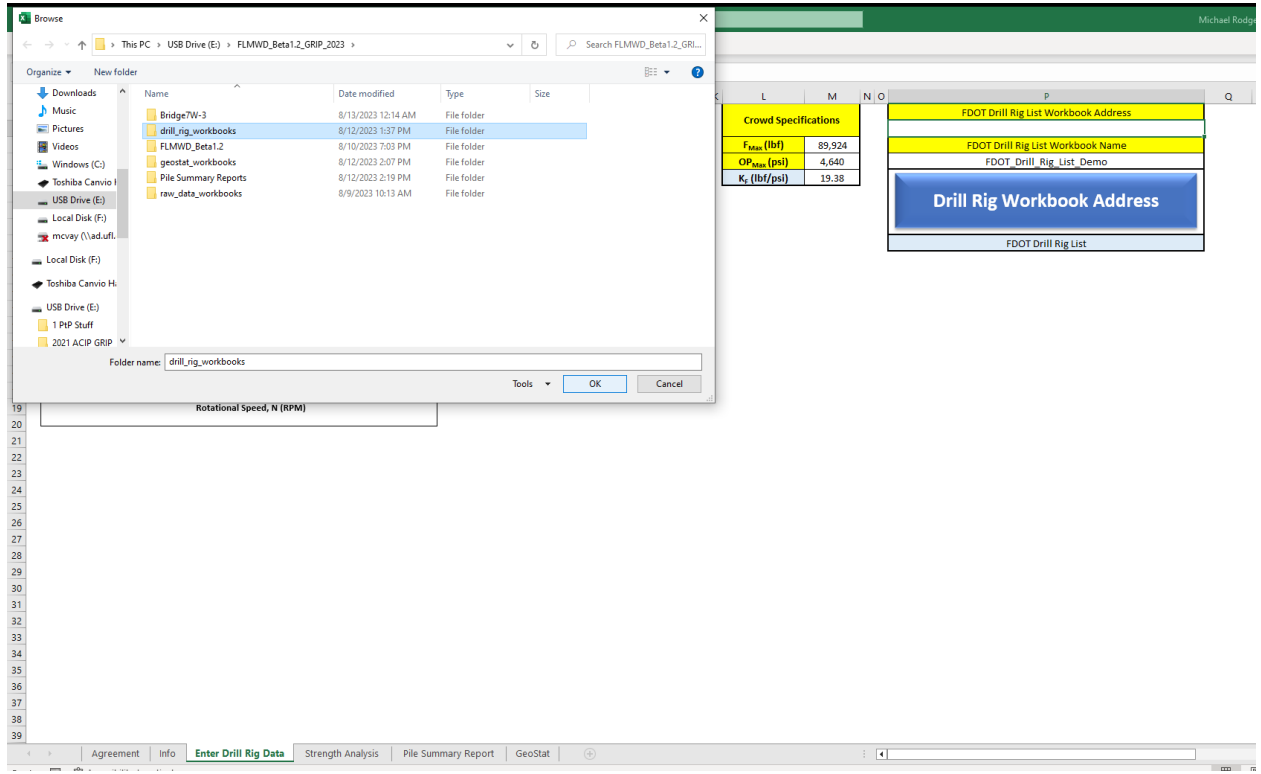

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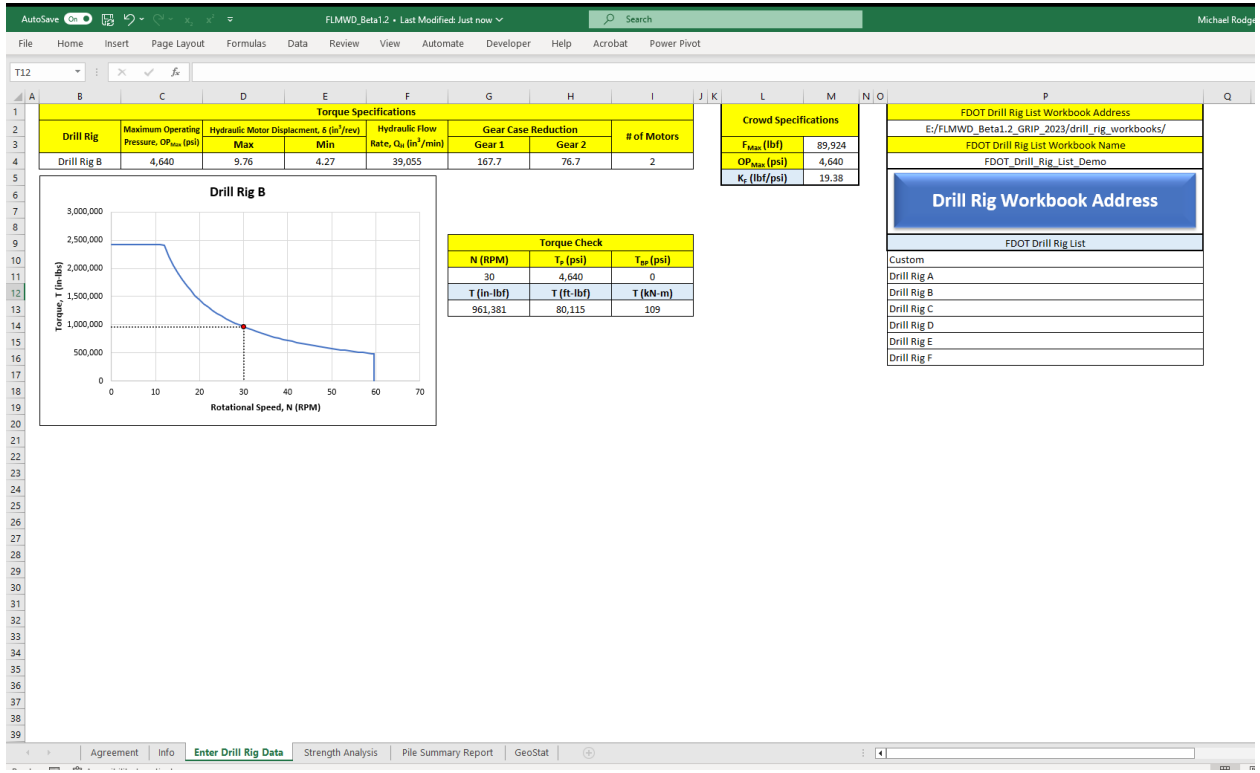
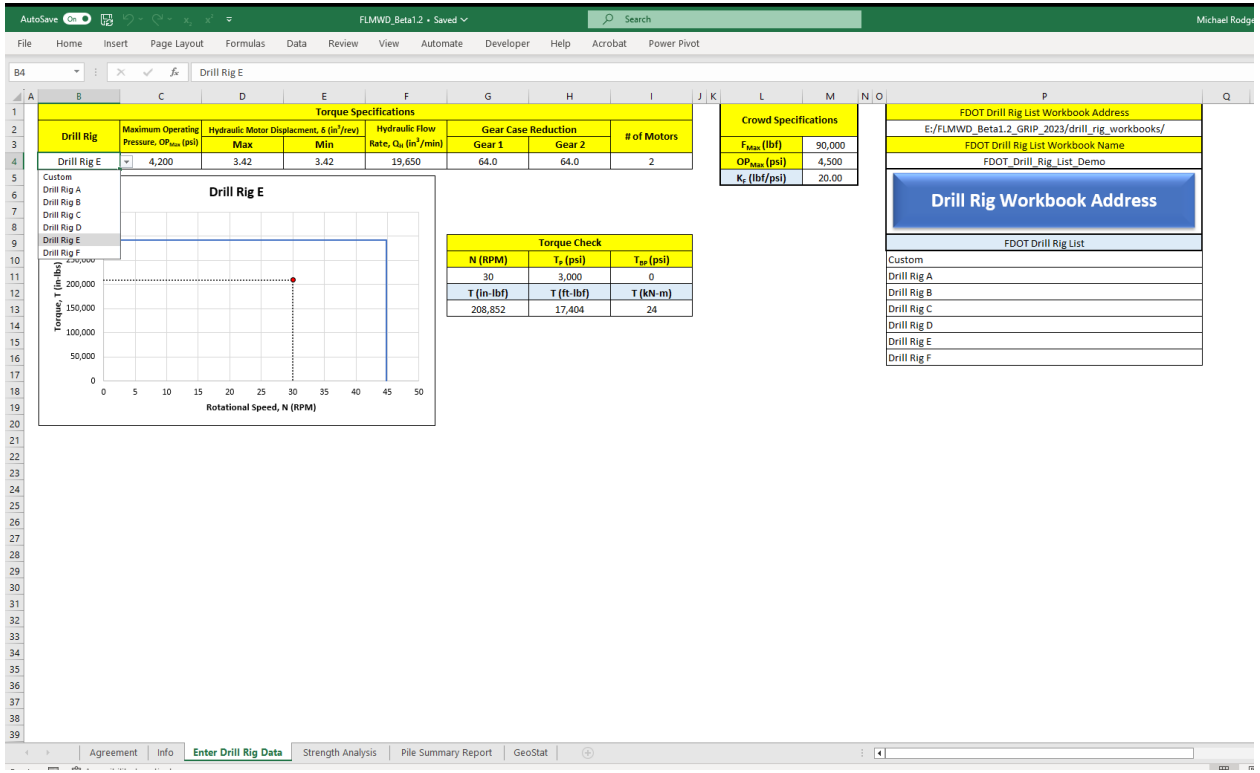
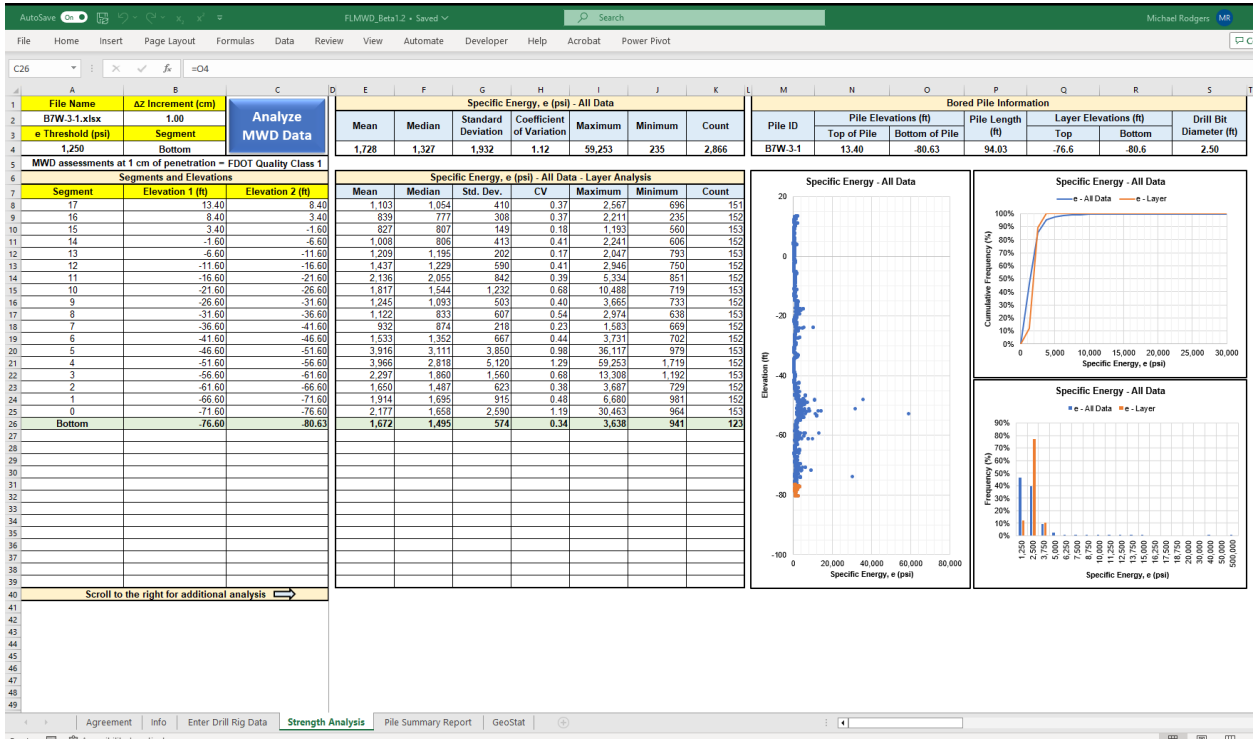
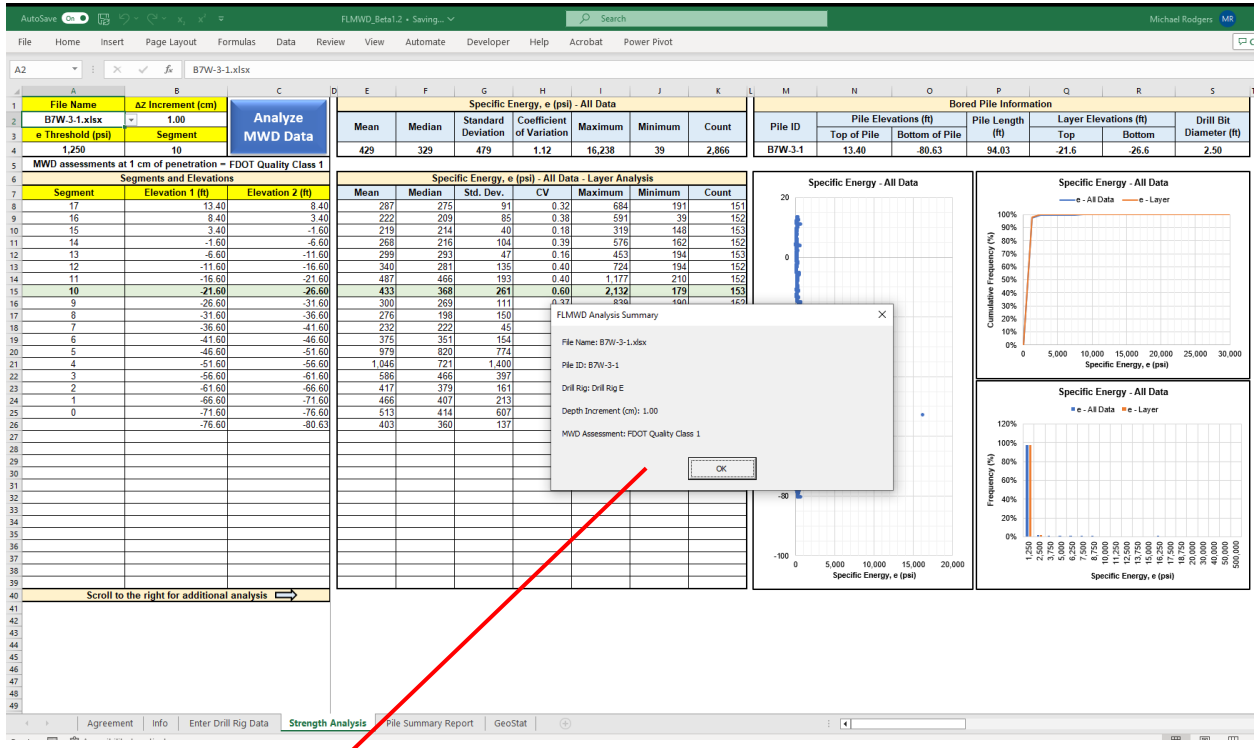
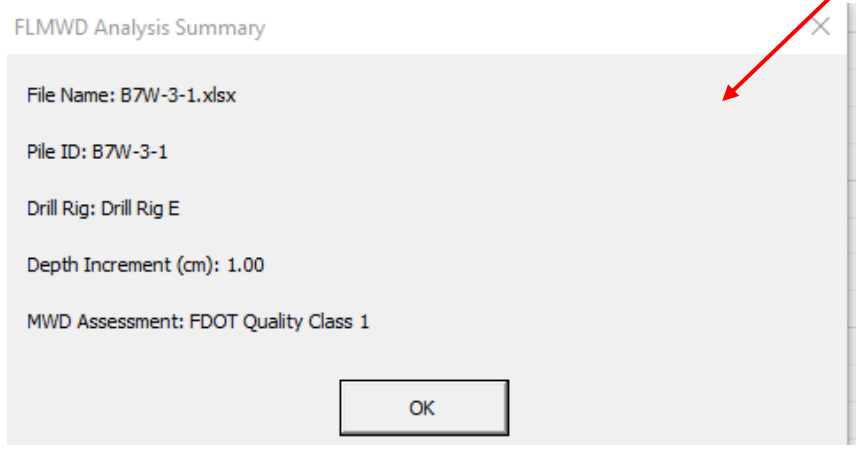




Strength Analysis

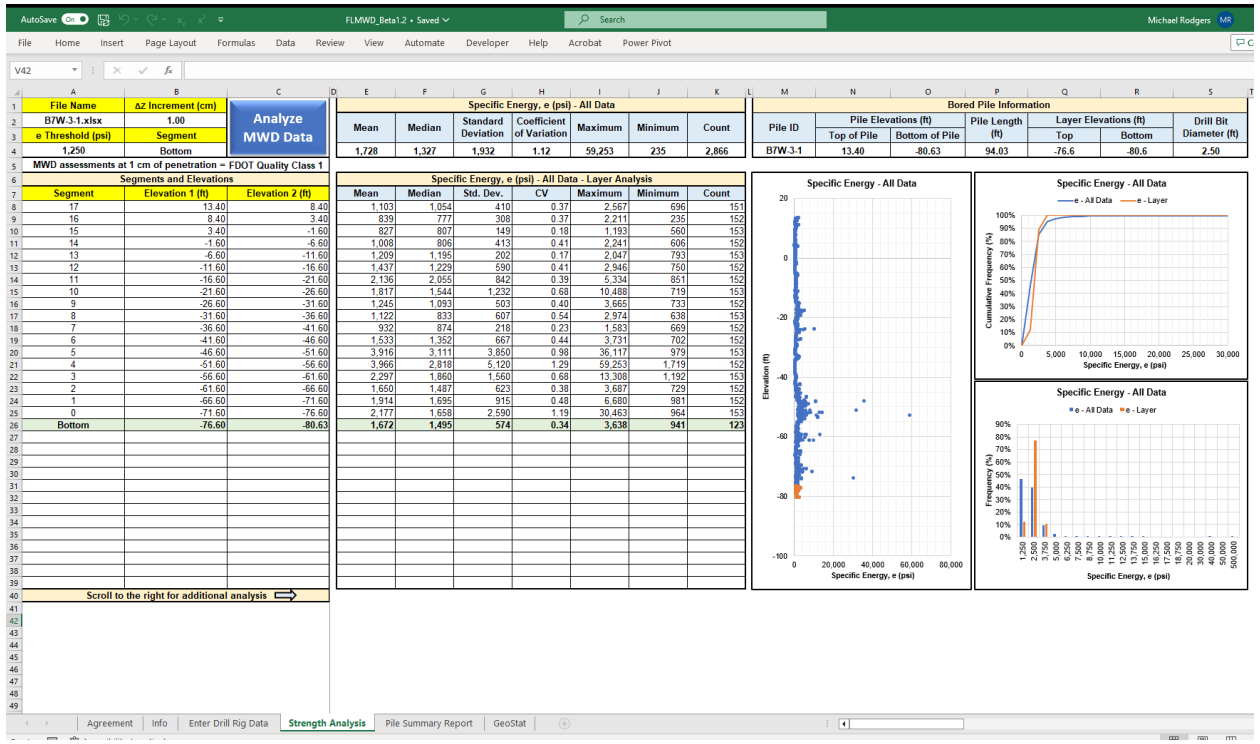






Strength Analysis – Specific Energy Threshold

All Specific Energy Data



File Name	Δz Increment (cm)
B7W-3-1.xlsx	1.00
e Threshold (psi)	Segment
1,250	Bottom

Analyze MWD Data

MWD assessments at 1 cm of penetration = FDOT Quality Class 1

Segments and Elevations

Segment	Elevation 1 (ft)	Elevation 2 (ft)
17	13.40	8.40
16	8.40	3.40
15	3.40	-1.60
14	-1.60	-6.60
13	-6.60	-11.60
12	-11.60	-16.60
11	-16.60	-21.60
10	-21.60	-26.60
9	-26.60	-31.60
8	-31.60	-36.60
7	-36.60	-41.60
6	-41.60	-46.60
5	-46.60	-51.60
4	-51.60	-56.60
3	-56.60	-61.60
2	-61.60	-66.60
1	-66.60	-71.60
0	-71.60	-76.60
Bottom	-76.60	-80.63

Scroll to the right for additional analysis

Specific Energy, e (psi) - All Data

Mean	Median	Standard Deviation	Coefficient of Variation	Maximum	Minimum	Count
1,728	1,327	1,932	1.12	59,253	235	2,866

Specific Energy, e (psi) - All Data - Layer Analysis

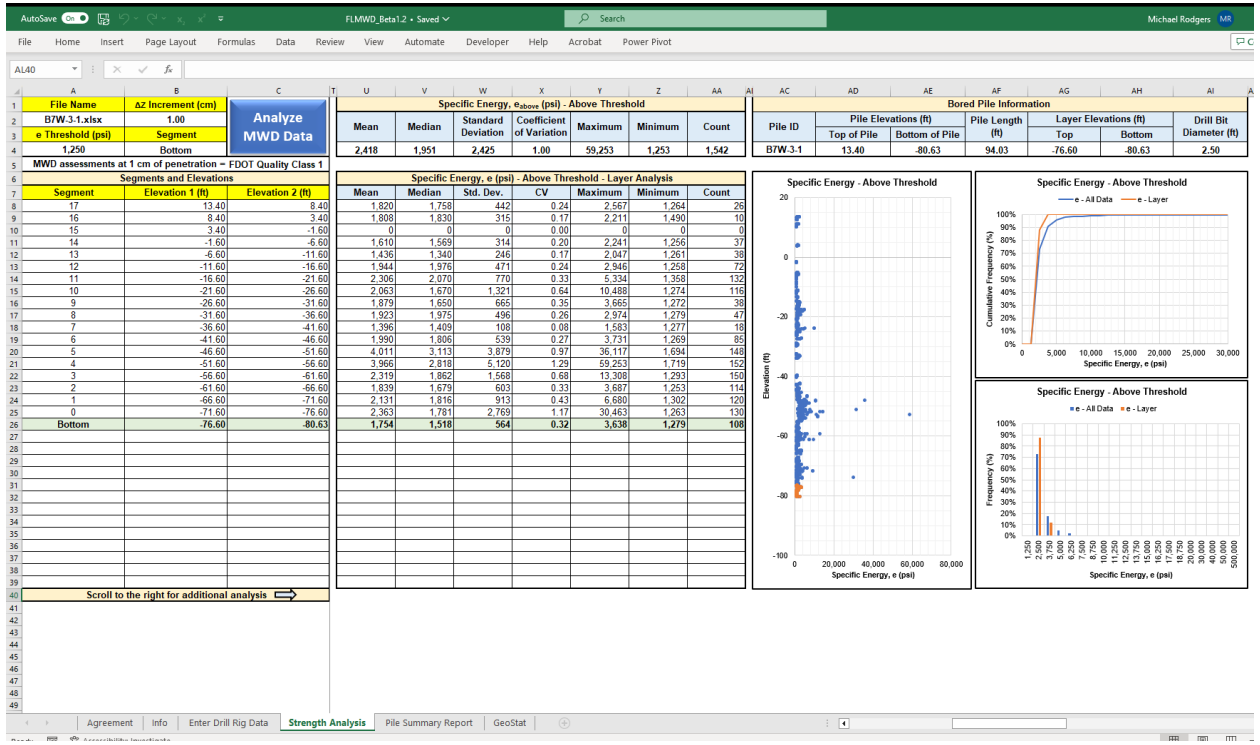
Segment	Mean	Median	Std. Dev.	CV	Maximum	Minimum	Count
17	1,103	1,054	410	0.37	2,567	696	151
16	839	777	308	0.37	2,211	235	152
15	827	807	149	0.18	1,193	560	153
14	1,008	806	413	0.41	2,241	606	152
13	1,209	1,195	202	0.17	2,047	793	153
12	1,437	1,229	590	0.41	2,946	750	152
11	2,136	2,055	842	0.39	5,334	851	152
10	1,817	1,544	1,232	0.68	10,488	719	153
9	1,245	1,093	503	0.40	3,665	733	152
8	1,122	833	607	0.54	2,974	638	153
7	932	874	218	0.23	1,583	669	152
6	1,533	1,352	667	0.44	3,731	702	152
5	3,916	3,111	3,850	0.98	36,117	979	153
4	3,966	2,818	5,120	1.29	59,253	1,719	152
3	2,297	1,860	1,560	0.68	13,308	1,192	153
2	1,650	1,487	623	0.38	3,687	729	152
1	1,914	1,695	915	0.48	6,680	981	152
0	2,177	1,658	2,590	1.19	30,463	964	153
Bottom	1,672	1,495	574	0.34	3,638	941	123

Bored Pile Information

Pile ID	Pile Elevations (ft)		Pile Length (ft)	Layer Elevations (ft)		Drill Bit Diameter (ft)
	Top of Pile	Bottom of Pile		Top	Bottom	
B7W-3-1	13.40	-80.63	94.03	-76.6	-80.6	2.50

Agreement | Info | Enter Drill Rig Data | Strength Analysis | Pile Summary Report | GeoStat

Only Specific Energy Data Above Threshold



File Name	Δz Increment (cm)
B7W-3-1.xlsx	1.00
e Threshold (psi)	Segment
1,250	Bottom

Analyze MWD Data

MWD assessments at 1 cm of penetration = FDOT Quality Class 1

Segments and Elevations

Segment	Elevation 1 (ft)	Elevation 2 (ft)
17	13.40	8.40
16	8.40	3.40
15	3.40	-1.60
14	-1.60	-6.60
13	-6.60	-11.60
12	-11.60	-16.60
11	-16.60	-21.60
10	-21.60	-26.60
9	-26.60	-31.60
8	-31.60	-36.60
7	-36.60	-41.60
6	-41.60	-46.60
5	-46.60	-51.60
4	-51.60	-56.60
3	-56.60	-61.60
2	-61.60	-66.60
1	-66.60	-71.60
0	-71.60	-76.60
Bottom	-76.60	-80.63

Scroll to the right for additional analysis

Specific Energy, e_{above} (psi) - Above Threshold

Mean	Median	Standard Deviation	Coefficient of Variation	Maximum	Minimum	Count
2,418	1,951	2,425	1.00	59,253	1,253	1,542

Specific Energy, e (psi) - Above Threshold - Layer Analysis

Segment	Mean	Median	Std. Dev.	CV	Maximum	Minimum	Count
17	1,820	1,758	442	0.24	2,567	1,264	26
16	1,808	1,830	315	0.17	2,211	1,490	10
15	0	0	0	0.00	0	0	0
14	1,610	1,569	314	0.20	2,241	1,256	37
13	1,436	1,340	246	0.17	2,047	1,261	38
12	1,944	1,976	471	0.24	2,946	1,258	72
11	2,306	2,070	770	0.33	5,334	1,358	132
10	2,063	1,670	1,321	0.64	10,488	1,274	116
9	1,879	1,650	665	0.35	3,665	1,272	38
8	1,923	1,975	496	0.26	2,974	1,279	47
7	1,396	1,409	108	0.08	1,583	1,277	18
6	1,990	1,806	539	0.27	3,731	1,269	85
5	4,011	3,113	3,879	0.97	36,117	1,694	148
4	3,966	2,818	5,120	1.29	59,253	1,719	152
3	2,319	1,862	1,568	0.68	13,308	1,293	150
2	1,839	1,679	603	0.33	3,687	1,253	114
1	2,131	1,816	913	0.43	6,680	1,302	120
0	2,363	1,781	2,769	1.17	30,463	1,263	130
Bottom	1,754	1,518	564	0.32	3,638	1,279	108

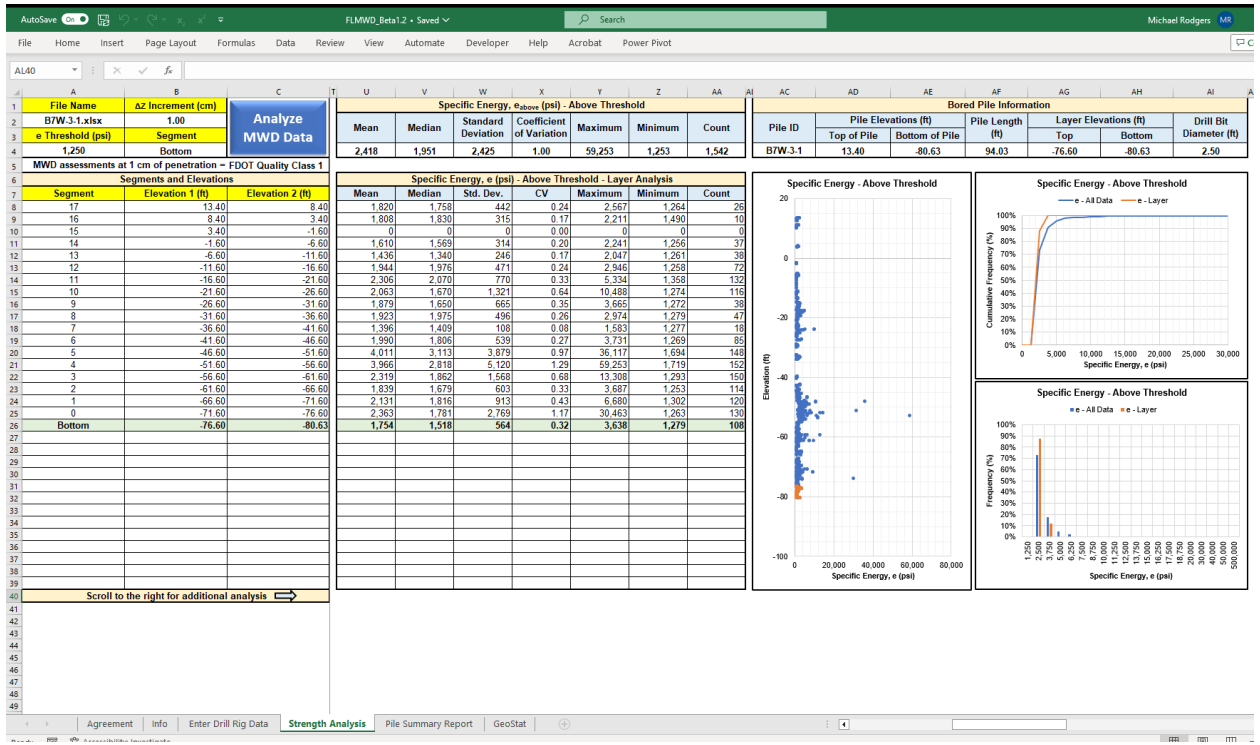
Bored Pile Information

Pile ID	Pile Elevations (ft)		Pile Length (ft)	Layer Elevations (ft)		Drill Bit Diameter (ft)
	Top of Pile	Bottom of Pile		Top	Bottom	
B7W-3-1	13.40	-80.63	94.03	-76.60	-80.63	2.50

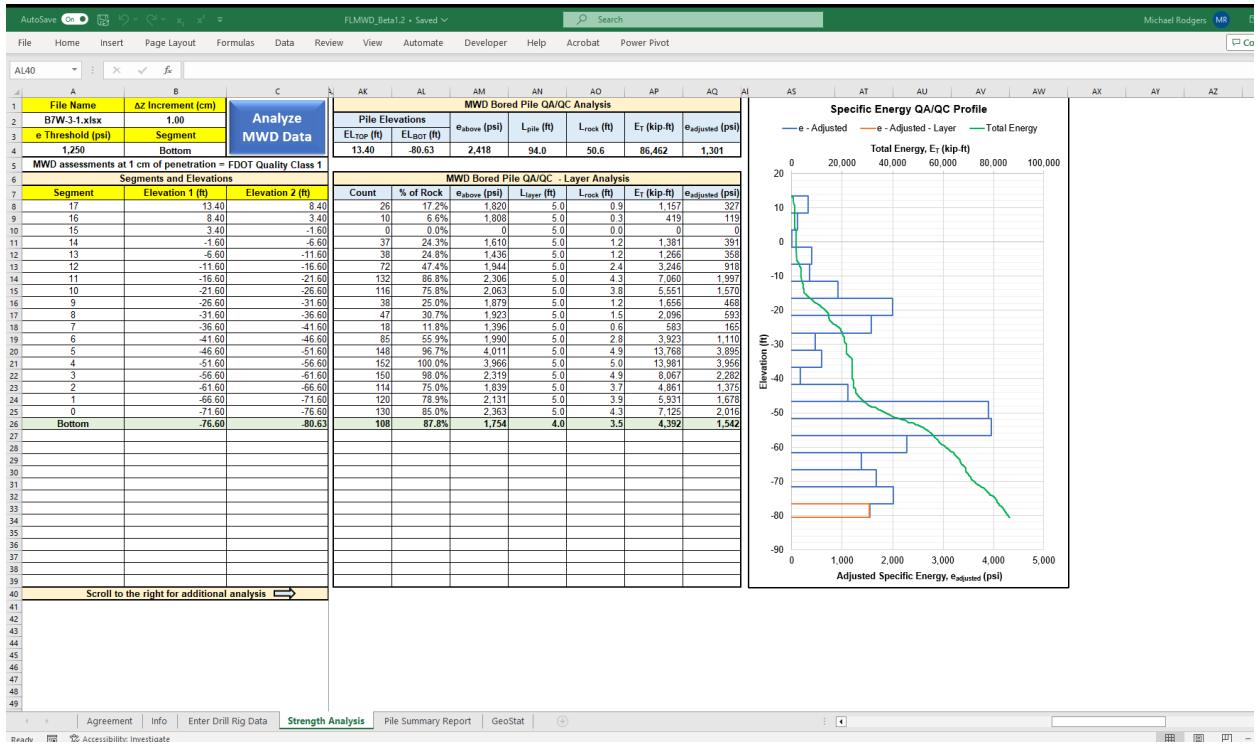
Agreement | Info | Enter Drill Rig Data | Strength Analysis | Pile Summary Report | GeoStat

Strength Analysis – Specific Energy Threshold

Only Specific Energy Data Above Threshold



Bored Pile QA/QC Analysis



Pile Summary Report

MWD Summary Report

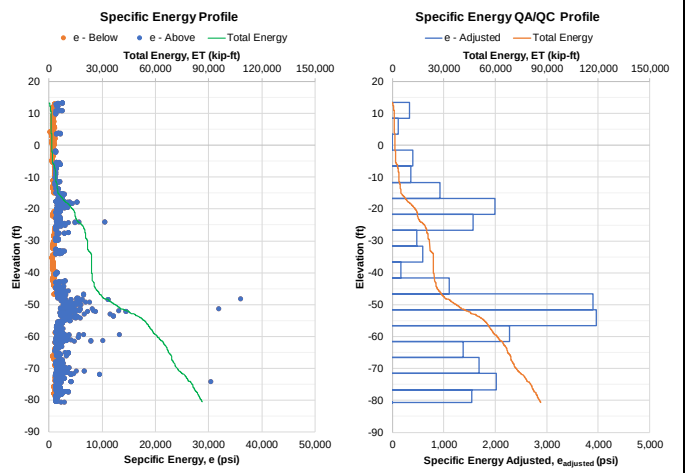
Engineer	Pile ID	Drill Rig	Drill Bit Diameter (in)
Michael Rodgers	B7W-3-1	Drill Rig B	30
Project	**Location**	**Top of Pile Elevation (ft)**	**Bottom of Pile Elevation (ft)**
UF Demo	Gainesville, FL	13.40	-80.63
Station	**Offset (ft)**	**Depth Increment Analyzed (cm)**	**MWD Assessment**
100+00.01	10.00	1.00	FDOT Quality Class 1

Specific Energy, e (psi) - All Data	
Mean	1,728
Median	1,327
Standard Deviation	1,932
Coefficient of Variation (CV)	1.12
Maximum	59,253
Minimum	235
Number of Data Points	2,866

Specific Energy, e_{above} (psi) - Above Threshold	
Mean	2,418
Median	1,951
Standard Deviation	2,425
Coefficient of Variation (CV)	1.00
Maximum	59,253
Minimum	1,253
Number of Data Points	1,542

ACIP Pile QA/QC - Rock Socket Length Assessment	
Pile Length (ft)	94.03
Total Rock Socket Length (ft)	50.59
Pile Pecentage of Rock (%)	54%

ACIP Pile QA/QC - Specific Energy Assessment	
Specific Energy Threshold (psi)	1,250
Spcific Energy, $e_{adjusted}$ (psi)	1,301
Total Energy, E_T (kip-ft)	86,462



Notes:

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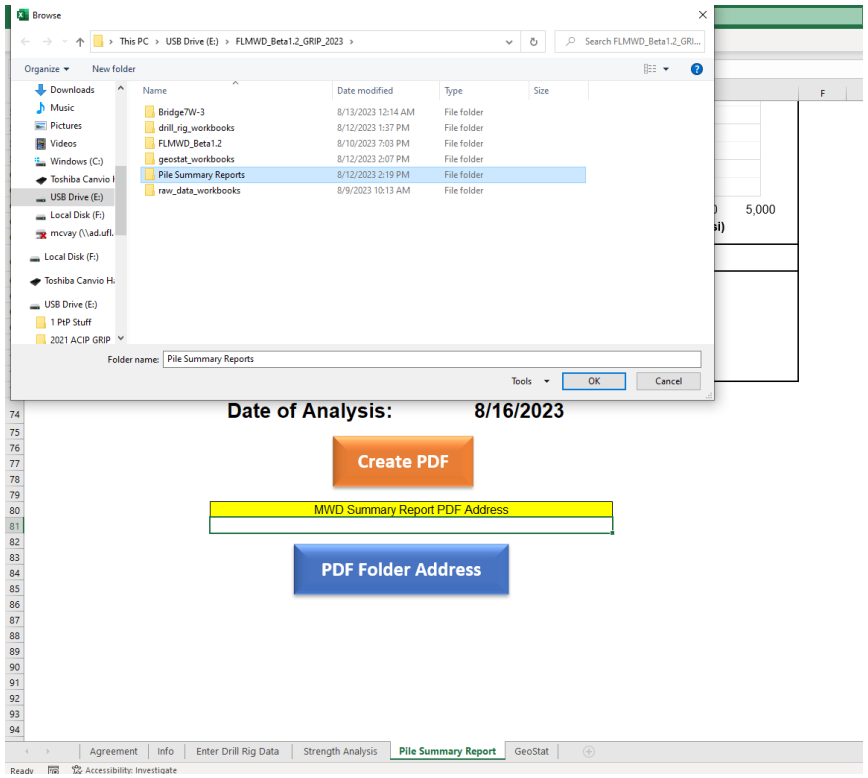
Date of Analysis: 8/16/2023

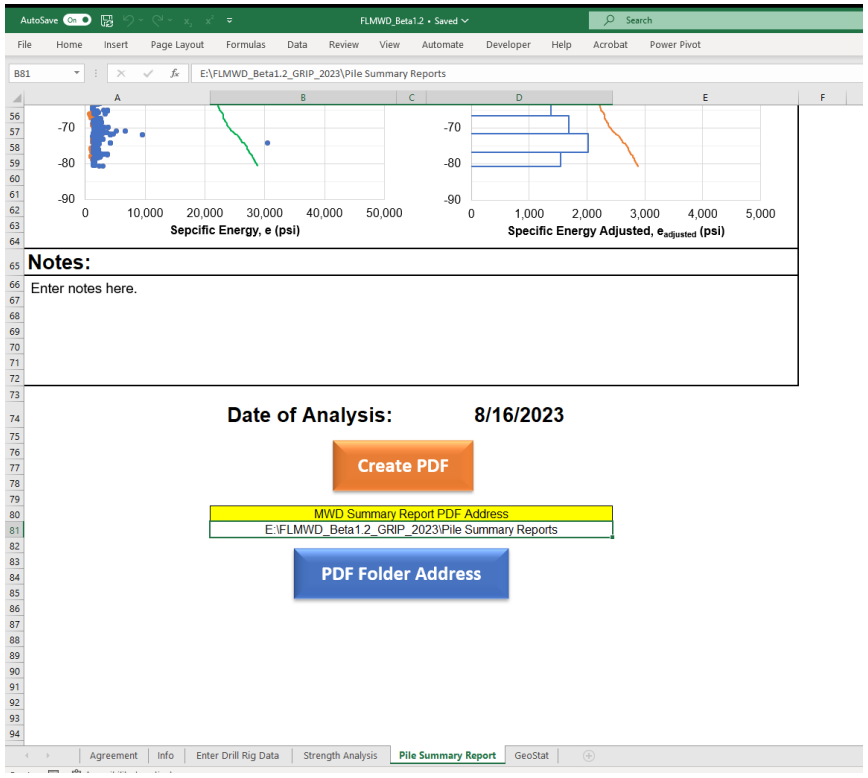
Create PDF

MWD Summary Report PDF Address

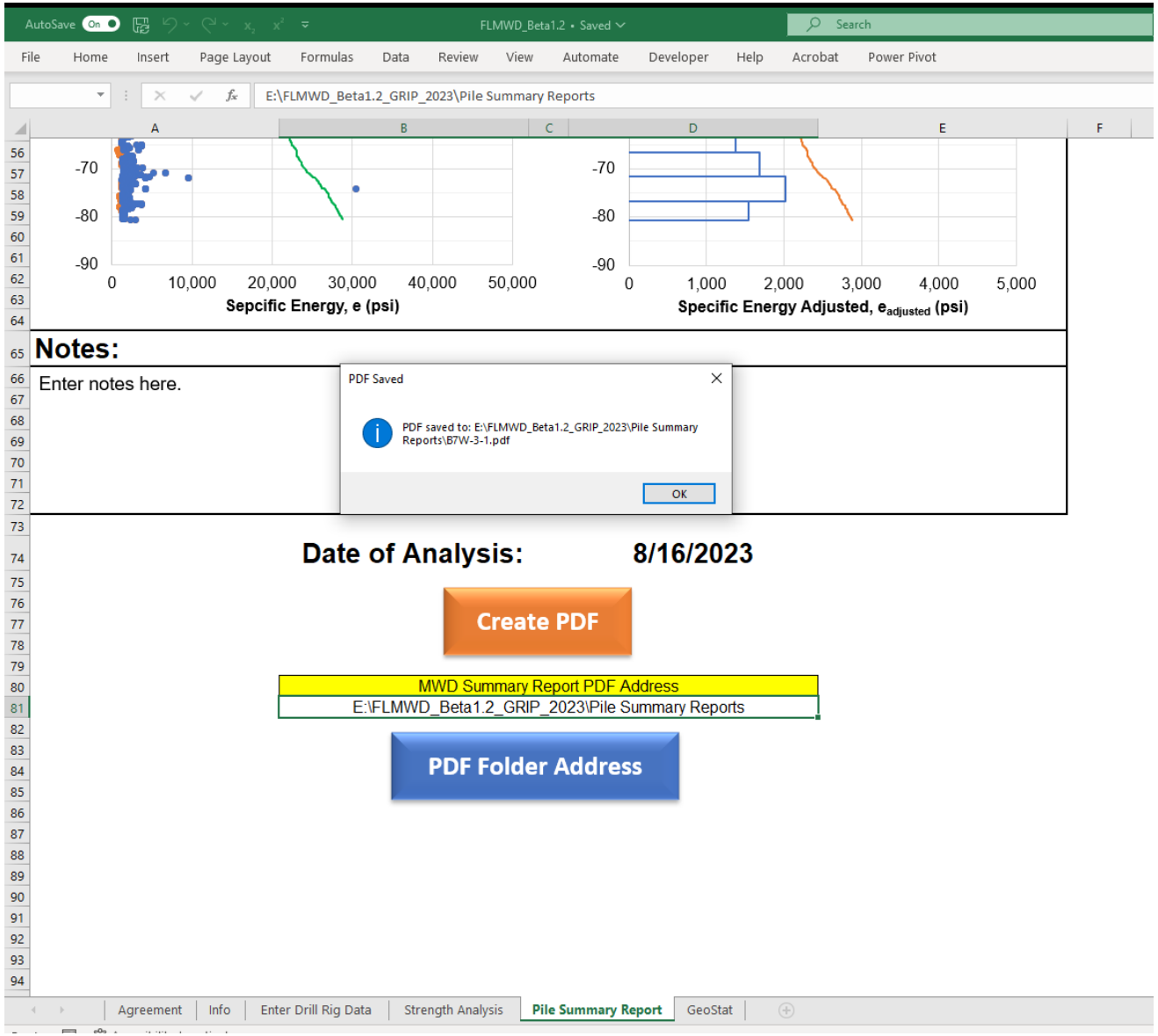
E:\FLMWD_Beta1.2_GRIP_2023\Pile Summary Reports

PDF Folder Address





Pile Summary Report



FDOT

MWD Summary Report

Engineer	Pile ID	Drill Rig	Drill Bit Diameter (in)
Michael Rodgers	B7W-3-1	Drill Rig B	30
Project	**Location**	**Top of Pile Elevation (ft)**	**Bottom of Pile Elevation (ft)**
FDOT GRIP Demo	Gainesville, FL	13.40	-80.63
Station	**Offset (ft)**	**Depth Increment Analyzed (cm)**	**MWD Assessment**
100+00.01	10.00	1.00	FDOT Quality Class 1

Specific Energy, e (psi) - All Data	
Mean	1,728
Median	1,327
Standard Deviation	1,932
Coefficient of Variation (CV)	1.12
Maximum	59,253
Minimum	235
Number of Data Points	2,866

Specific Energy, e_{above} (psi) - Above Threshold	
Mean	2,418
Median	1,951
Standard Deviation	2,425
Coefficient of Variation (CV)	1.00
Maximum	59,253
Minimum	1,253
Number of Data Points	1,542

ACIP Pile QA/QC - Rock Socket Length Assessment	
Pile Length (ft)	94.03
Total Rock Socket Length (ft)	50.59
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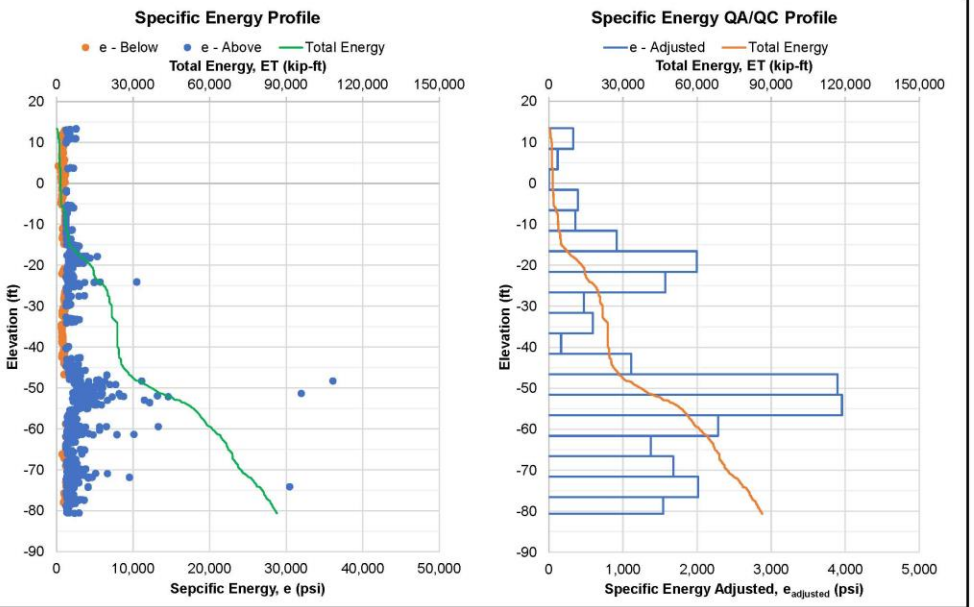
Total Energy, E_T (kip-ft)	86,462



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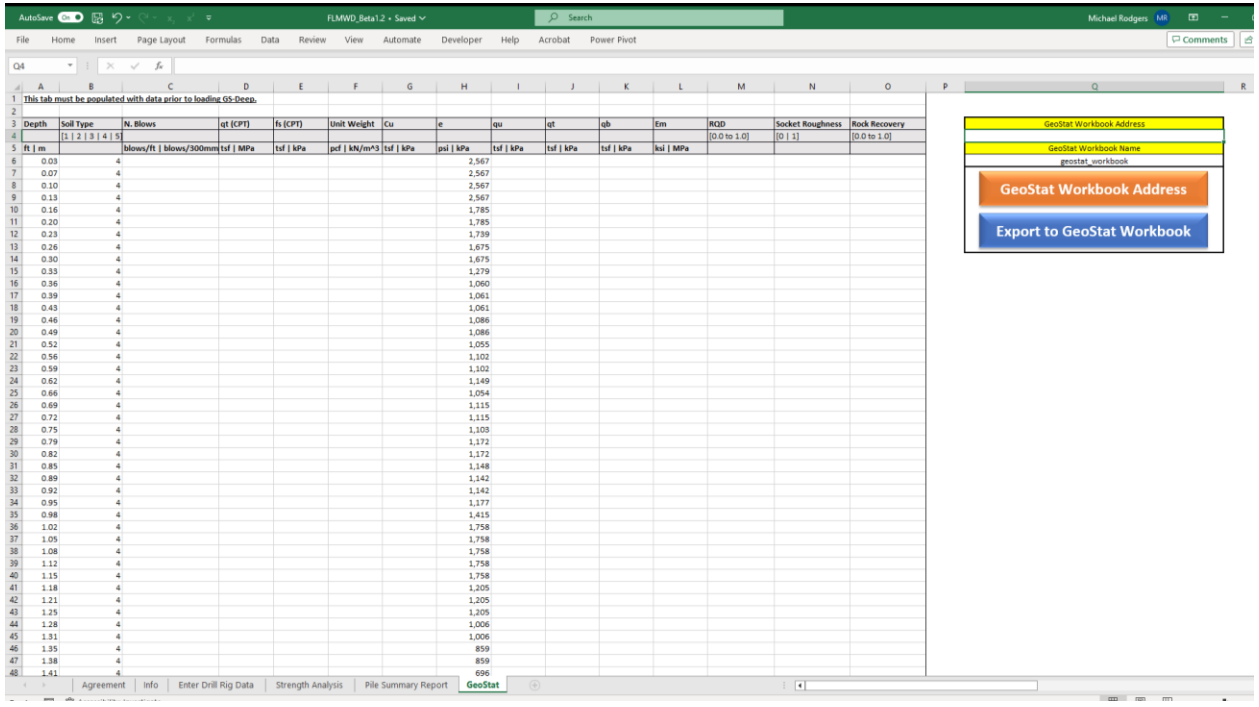
Date of Analysis: 8/14/2023

GeoStat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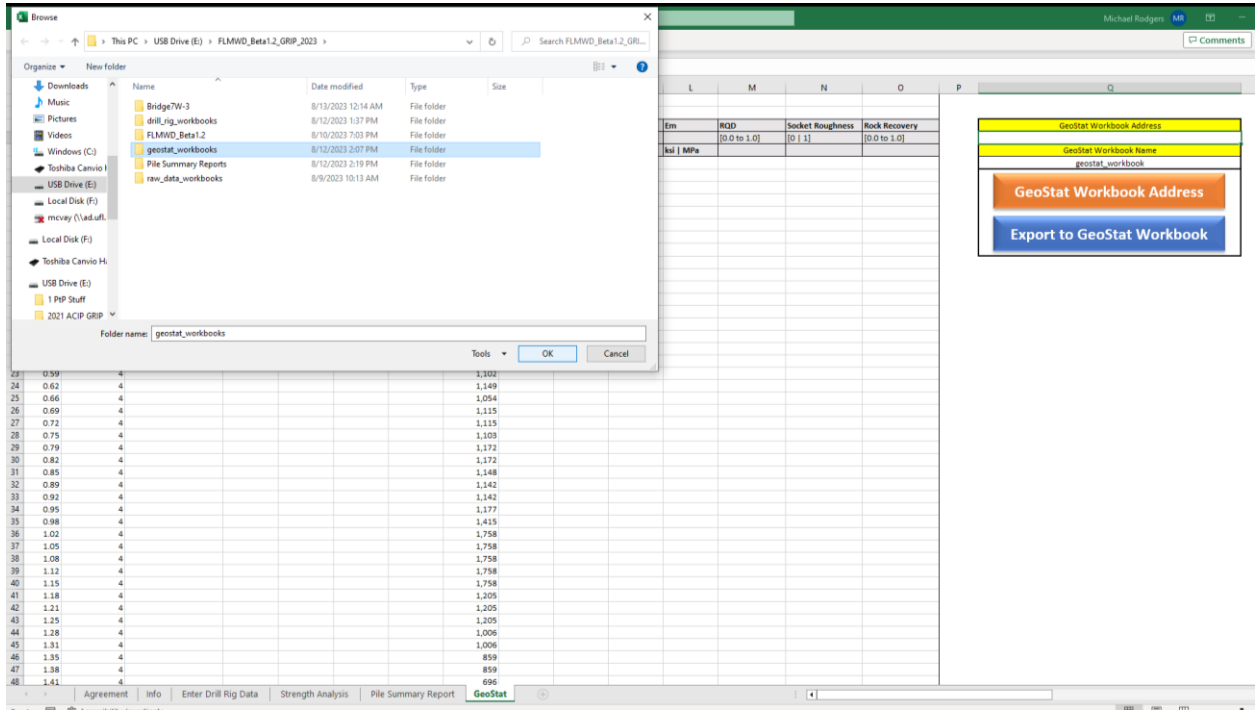
Info
Enter Drill Rig Data
Strength Analysis
Pile Summary Report
GeoStat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This PC
USB Drive (E:)
FLMWD_Beta1.2_GRIP_2023
Organize
New folder
Downloads
Music
Pictures
Videos
Windows (C:)
USB Drive (E:)
Local Disk (F:)
Name
Date modified
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Size
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FLMWD_Beta1.2
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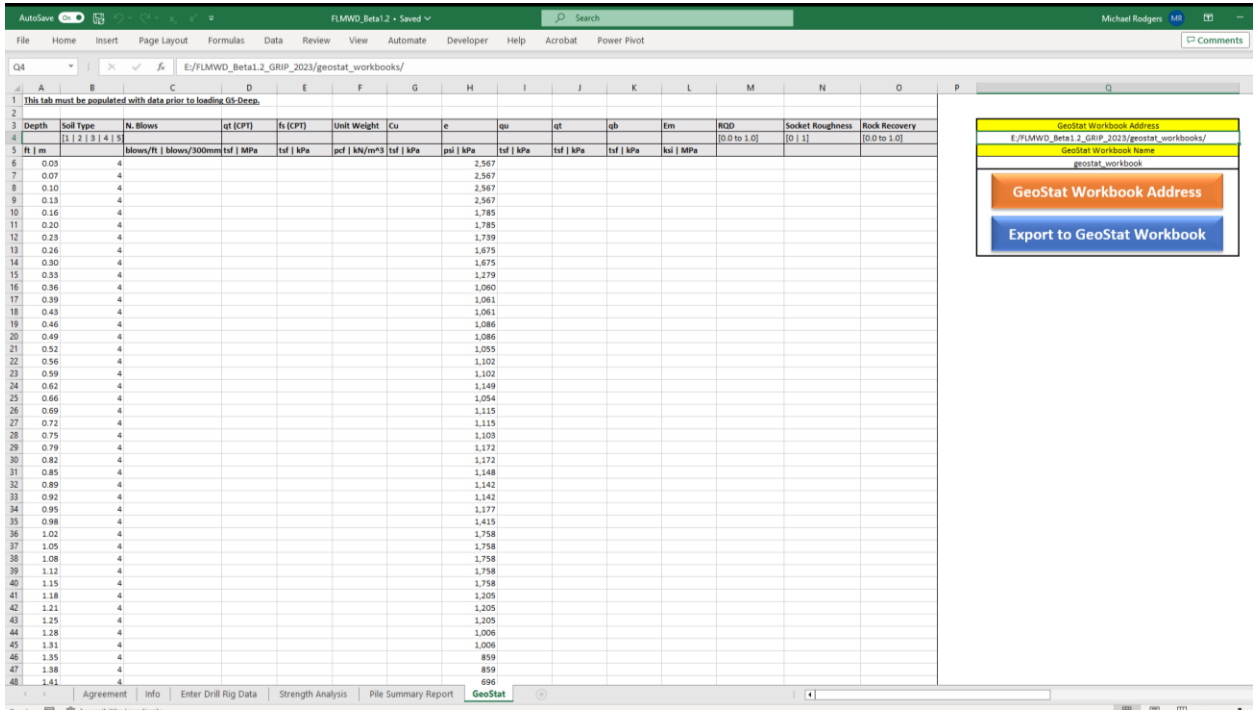
GeoStat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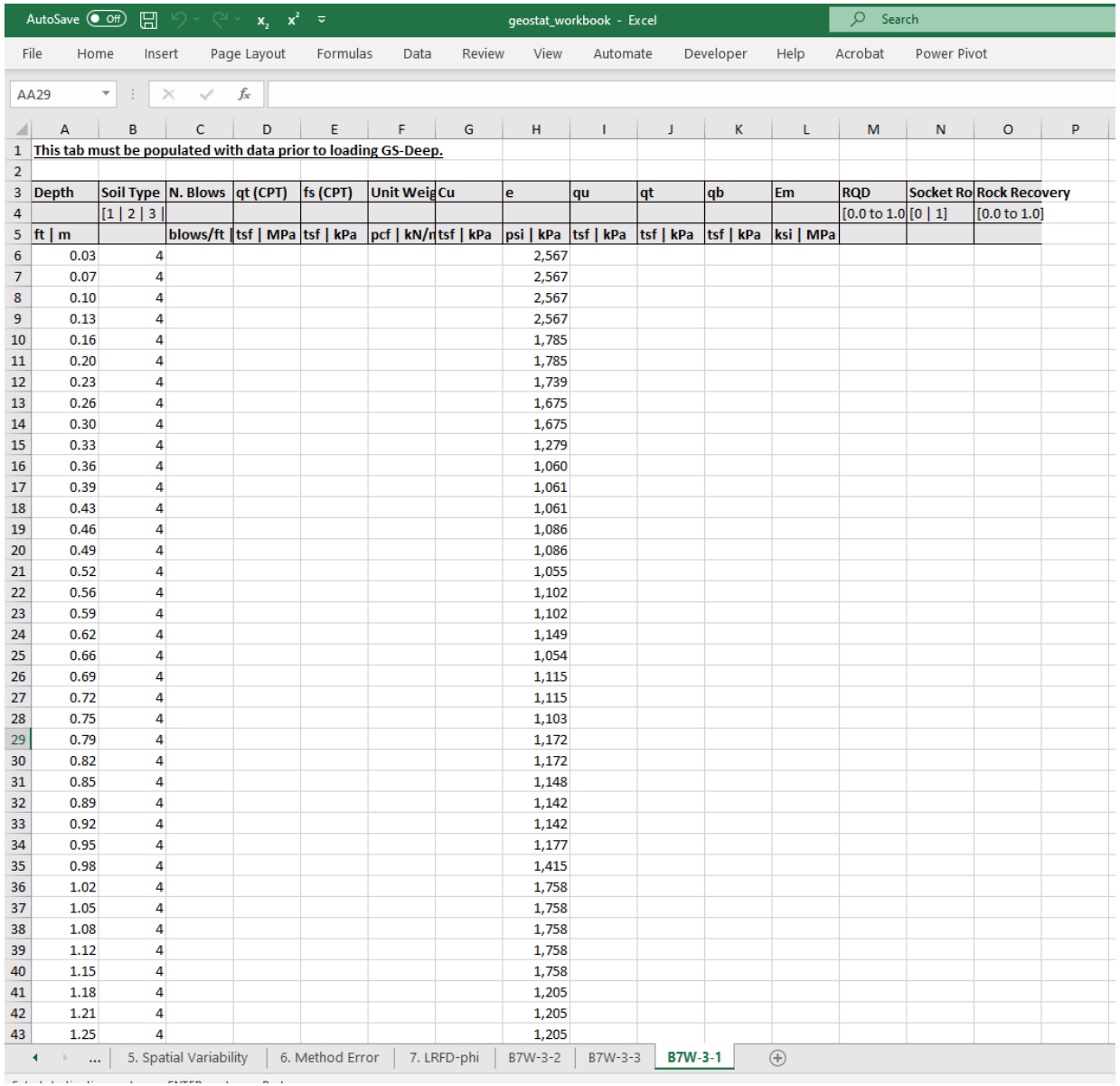
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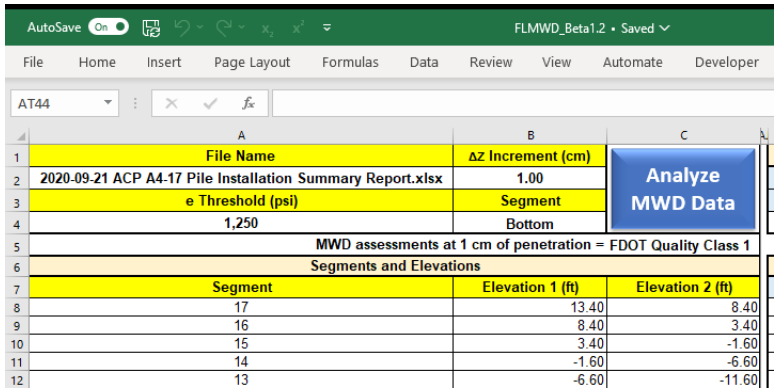
6. Method Error
7. LRFD-phi
B7W-3-2
B7W-3-3
B7W-3-1

GeoStat



	A	B	C
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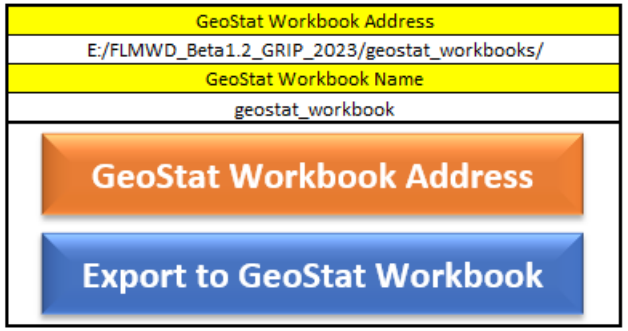
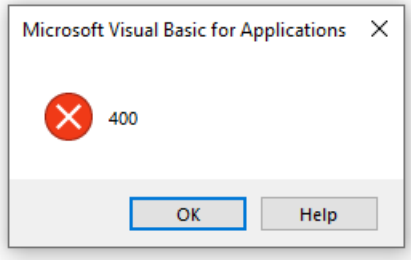
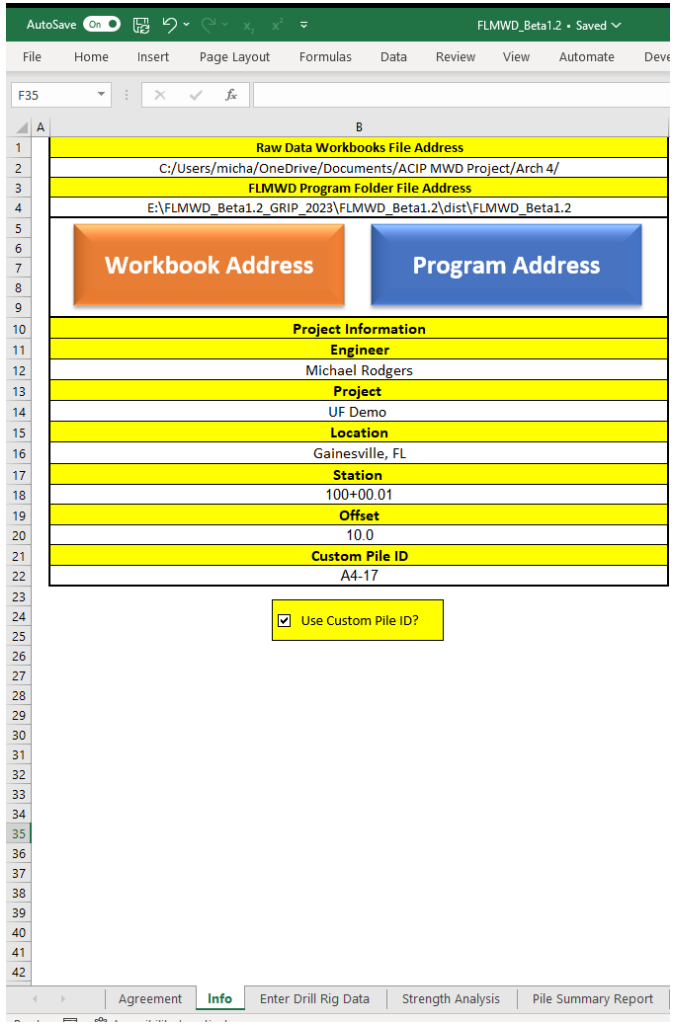
2	2020-09-21 ACP A4-17 Pile Installation Summary Report.xlsx	1.00	
3	e Threshold (psi)	Segment	
4	1,250	Bottom	
5	MWD assessments at 1 cm of penetration = FDOT Quality Class 1		
6	Segments and Elevations		
7	Segment	Elevation 1 (ft)	Elevation 2 (ft)
8	17	13.40	8.40
9	16	8.40	3.40
10	15	3.40	-1.60
11	14	-1.60	-6.60
12	13	-6.60	-11.60







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1	Raw Data Workbooks File Address
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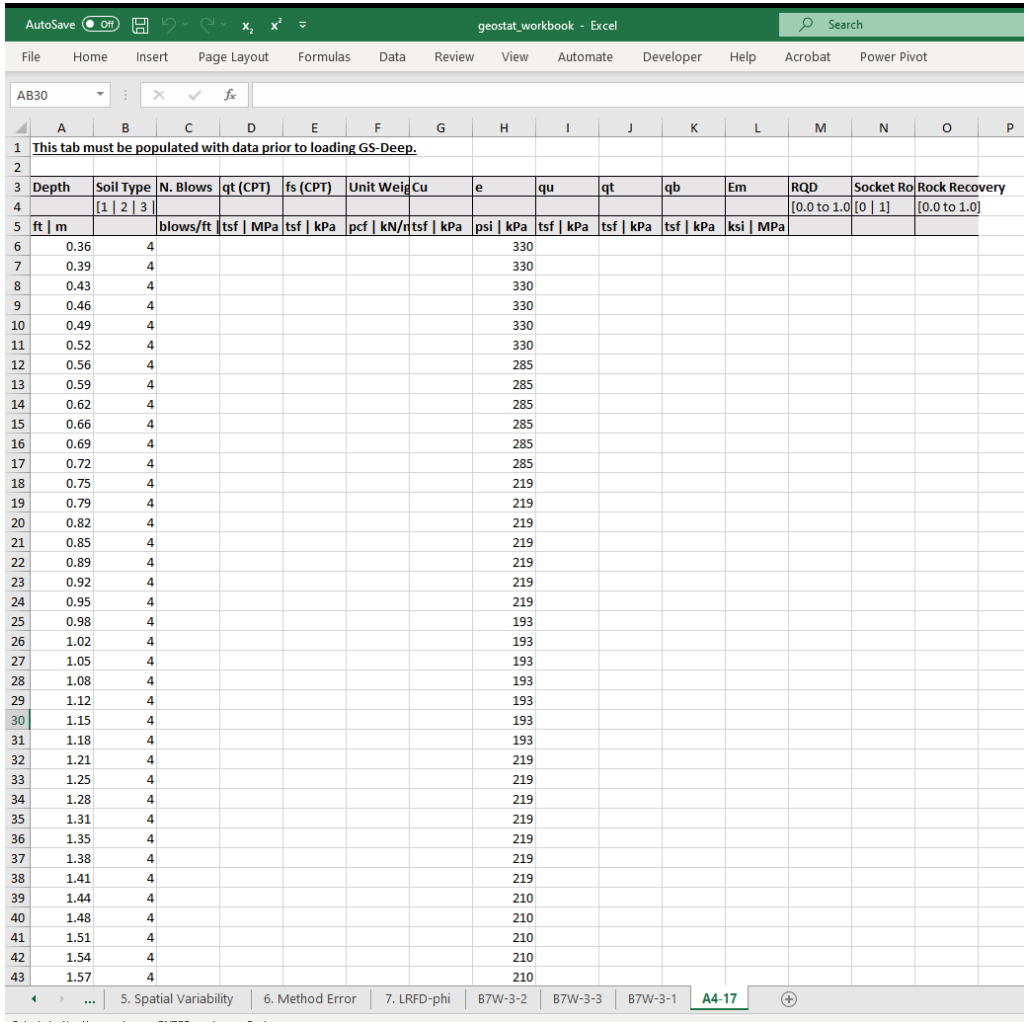
3	FLMWD Program Folder File Address
4	E:\FLMWD_Beta1.2_GRIP_2023\FLMWD_Beta1.2\dist\FLMWD_Beta1.2
5	Workbook Address / Program Address
6	Project Information
7	Engineer
8	Michael Rodgers
9	Project
10	UF Demo
11	Location
12	Gainesville, FL
13	Station
14	100+00.01
15	Offset
16	10.0
17	Custom Pile ID
18	A4-17
19	Use Custom Pile ID?



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
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2															
3	Depth	Soil Type	N. Blows	qt (CPT)	fs (CPT)	Unit Weig	Cu	e	qu	qt	qb	Em	RQD	Socket Ro	Rock Recovery
4		[1 | 2 | 3											[0.0 to 1.0	[0 | 1]	[0.0 to 1.0]
5	ft | m		blows/ft	tsf | MPa	tsf | kPa	pcf | kN/r	tsf | kPa	psi | kPa	tsf | kPa	tsf | kPa	tsf | kPa	ksi | MPa			
6	0.36	4						330							
7	0.39	4						330							
8	0.43	4						330							
9	0.46	4						330							
10	0.49	4						330							
11	0.52	4						330							
12	0.56	4						285							
13	0.59	4						285							
14	0.62	4						285							
15	0.66	4						285							
16	0.69	4						285							
17	0.72	4						285							
18	0.75	4						219							
19	0.79	4						219							
20	0.82	4						219							
21	0.85	4						219							
22	0.89	4						219							
23	0.92	4						219							
24	0.95	4						219							
25	0.98	4						193							
26	1.02	4						193							
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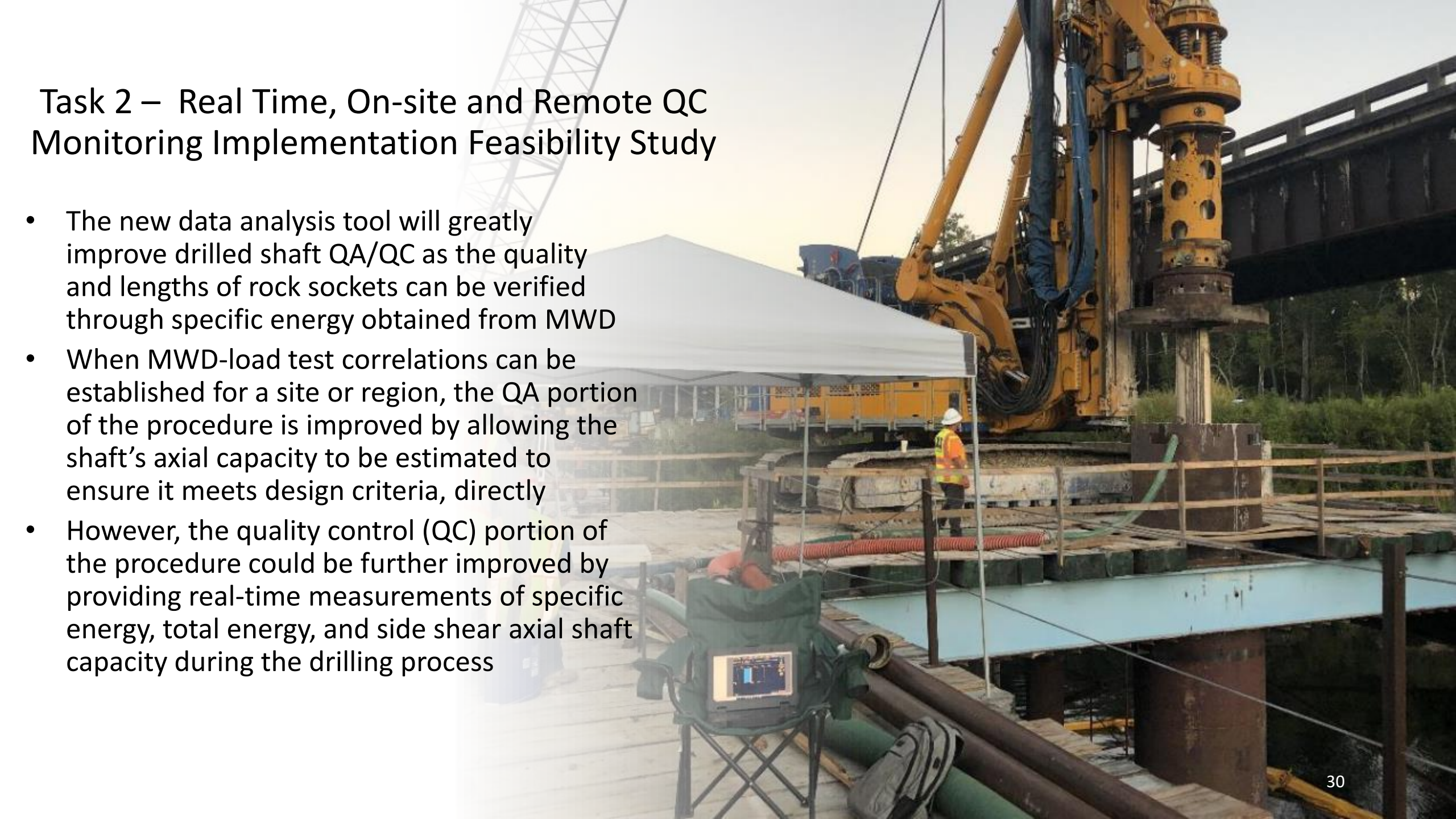
37	1.38	4						219							
38	1.41	4						219							
39	1.44	4						210							
40	1.48	4						210							
41	1.51	4						210							
42	1.54	4						210							
43	1.57	4						210							

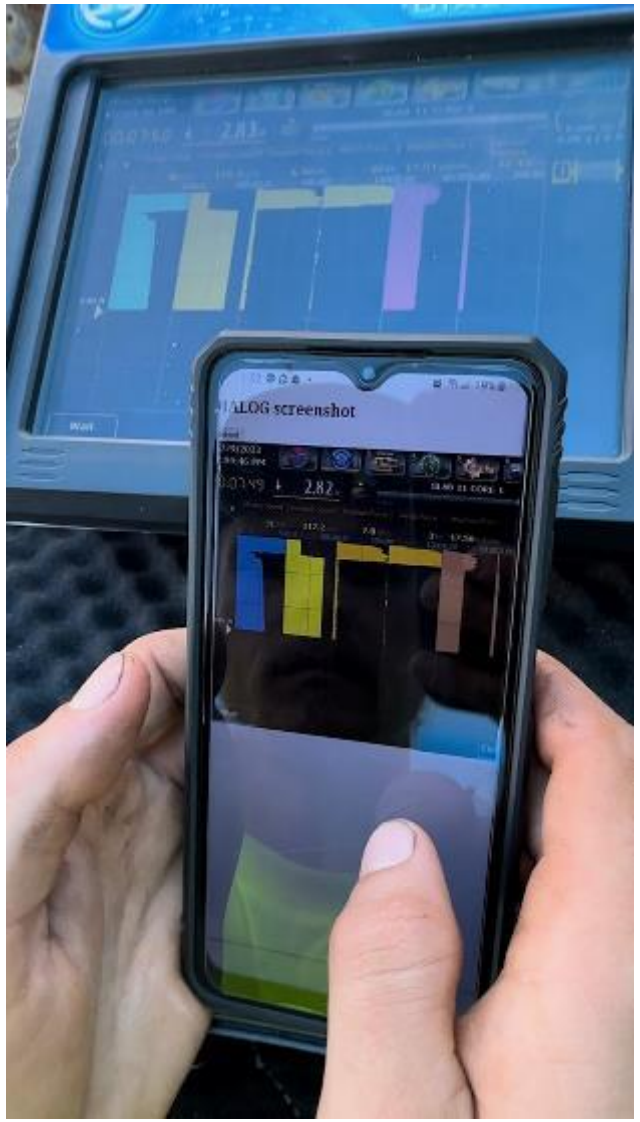
Task 2 – Real Time, On-site and Remote QC Monitoring Implementation Feasibility Study

- The new data analysis tool will greatly improve drilled shaft QA/QC as the quality and lengths of rock sockets can be verified through specific energy obtained from MWD
- When MWD-load test correlations can be established for a site or region, the QA portion of the procedure is improved by allowing the shaft's axial capacity to be estimated to ensure it meets design criteria, directly
- However, the quality control (QC) portion of the procedure could be further improved by providing real-time measurements of specific energy, total energy, and side shear axial shaft capacity during the drilling process



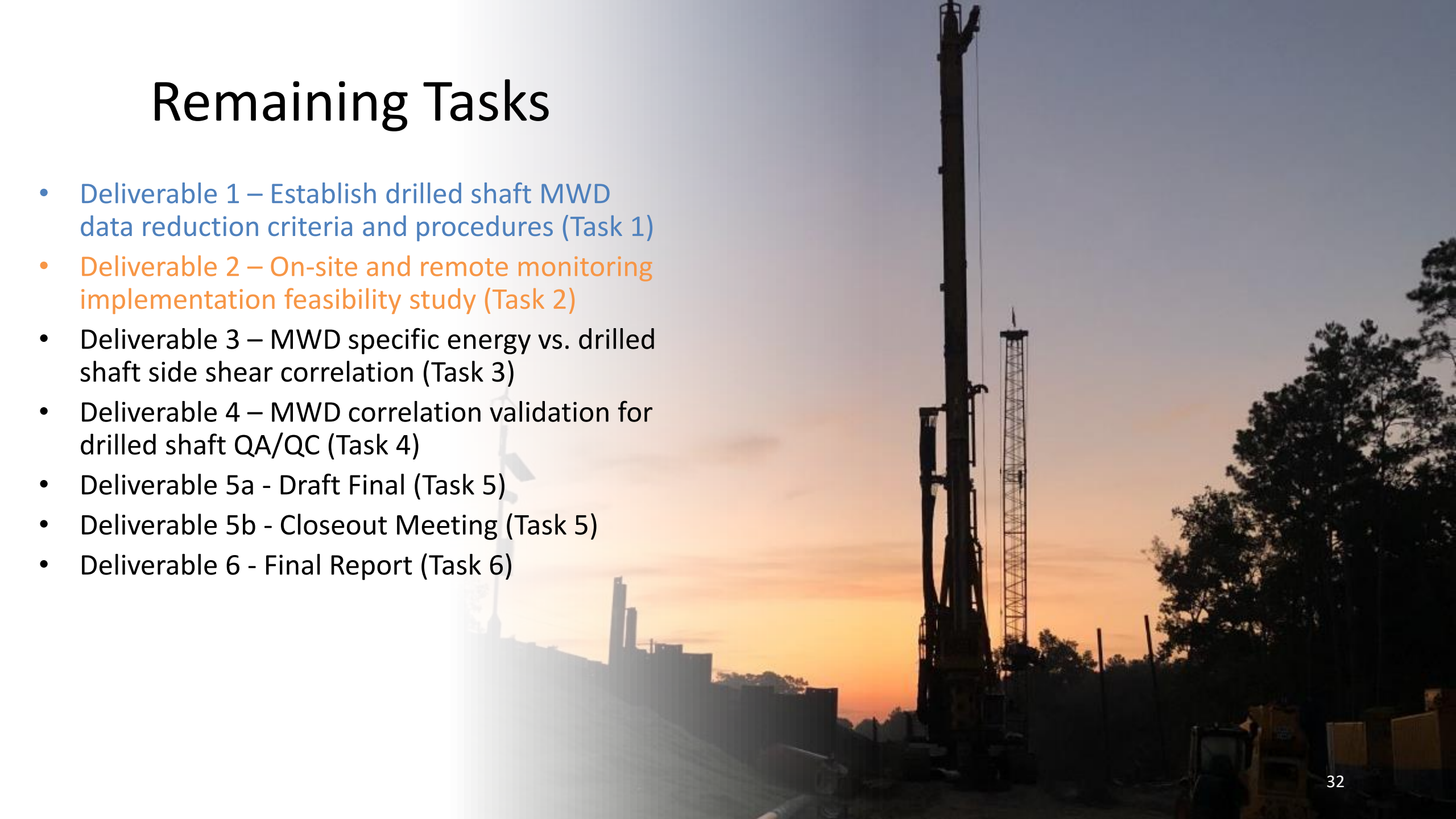
Task 2 – Real Time, On-site and Remote QC Monitoring Implementation Feasibility Study

- Can currently view drilling parameters live
- Need to develop a robust method that can transmit compound parameters that is applicable to all monitoring systems
  - Likely through CAN bus integration
  - Will be tested during BED31-977-03 in a controlled setting
  - SBC module can transmit actual data on-site and to remote locations via CAN and Modem hats added in
- Moving in the direction of remote monitoring using Python and MQTT
  - Live data is sent to a satellite server that can be accessed via the FLMWD Excel UI, filtered, cleaned, and analyzed in the office
    - MQTT -> MQ Telemetry Transport
    - Machine to machine network protocol
    - Ideal for connections with remote locations that have devices with resource constraints or have limited network bandwidth such as the Internet of Things (IoT) which will be used
    - Creates a viable path forward for remote monitoring and live analysis in the office



Remaining Tasks

- Deliverable 1 – Establish drilled shaft MWD data reduction criteria and procedures (Task 1)
- Deliverable 2 – On-site and remote monitoring implementation feasibility study (Task 2)
- Deliverable 3 – MWD specific energy vs. drilled shaft side shear correlation (Task 3)
- Deliverable 4 – MWD correlation validation for drilled shaft QA/QC (Task 4)
- Deliverable 5a - Draft Final (Task 5)
- Deliverable 5b - Closeout Meeting (Task 5)
- Deliverable 6 - Final Report (Task 6)



Questions?