Geothermal Borefield Quality Assurance

Moderator: Geoff Hoffer / *Aztech Geothermal, LLC*

Panel: Kate Cheng / *Geosource Energy*

Geoff Ellison / *Envirohire Ltd.*

Garen Ewbank / *Ewbank Testing*

Kortney Lull / *Midwest Geothermal, LLC*

Borefield Quality Assurance

The Importance of Proper Looping and Grouting

Geosource Geoexchange Solutions

Process Overview

1. Controlled insertion of loop
2. How to get the tremie line and loop down together
3. Grouting in rock
4. Grouting while pulling casing in the overburden
5. Complete loops during construction
6. Grout testing during installation

1. Controlled insertion of Loop

- There must be water in the loop and the borehole when inserting
- Water in the loop: prevents floating and potential loop collapse
- Water in the borehole: reduces differential pressure
  - Prevents loop from “taking off” down borehole
- Use a pusher to “push” instead of having the loop “pull” down
  - Only way to do small diameter boreholes

Water in loop, no water in borehole: a lot of weight on the loop

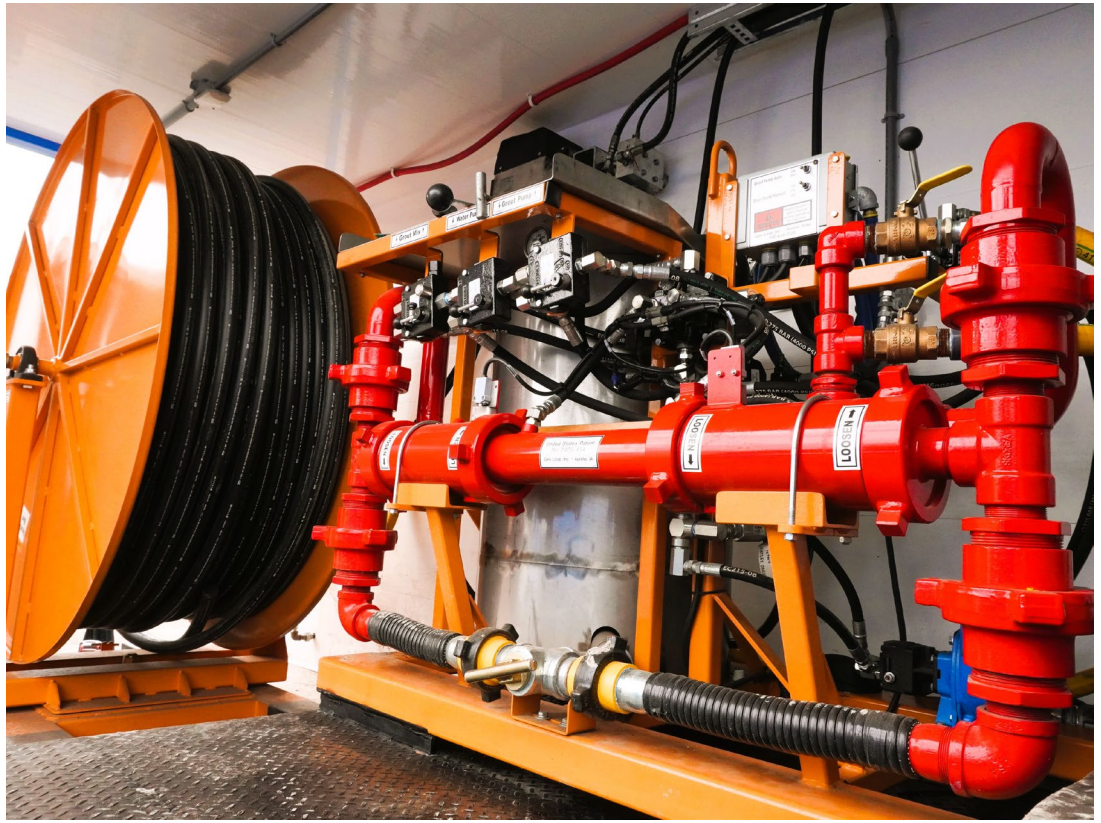
Water in borehole, no water in loop: risk collapsing loop

Don’t do this!!!

Geosource Geoexchange Solutions

2. How to get the tremie line in

- Only way to grout small diameter boreholes is to push the loop and tremie line together
- Tremie line must attach to the loop but must also be retrievable
- Plastic floats – loop and tremie line will want to float, must be managed by weight or other technique



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3. Proper grouting in rock

- Tremie line should be just shy of the bottom
- Important to have first “grout stack” start from the bottom of the borehole to ensure connectivity between the loop and the ground
- Pull tremie line back, pump another batch of grout
- Bottom of tremie line must be inside the grout at all times

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4. Grouting while pulling casing

- Let grout in rock set before grouting and pulling casing in overburden
- Ensure casing does not have grout in it
  - Grout in casing can “pull” the loop
- When ready to pull casing, grout from the bottom of the casing
- Pull casing prior to grout setting up
- Top off grout as you pull casing sections

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5. Complete loops during construction

- Typically see loops sticking out of ground, risky during construction

- Solution is to plug the loops below grade and cut them off
- Stops debris from getting in the loop
- Allows machines to work on top of the loops with no issues

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6. Grout testing during installation

- Testing frequency is set by engineer's specification
- Increased testing = increased costs and time
- Variability within samples – not a solution, it's a mixture
- Start testing in first few boreholes, ensures any problems are caught early
- 2nd test within first 10 boreholes
- 50+ boreholes, 3 tests per 50 boreholes

Geosource Geoexchange Solutions

NY-GEO 2025 – Saratoga Springs

Automated Testing of Ground Source Heating Loops

22-24 April 2025

Presented by Geoff Ellison

LOOP TESTING - What Do We Need to Prove?

1. Does it Leak ?
2. Does the Fluid Flow as Designed ?
3. Where is it ?

Can we trust the results?

Ground Source Heat Loop Test Regime

Must be:

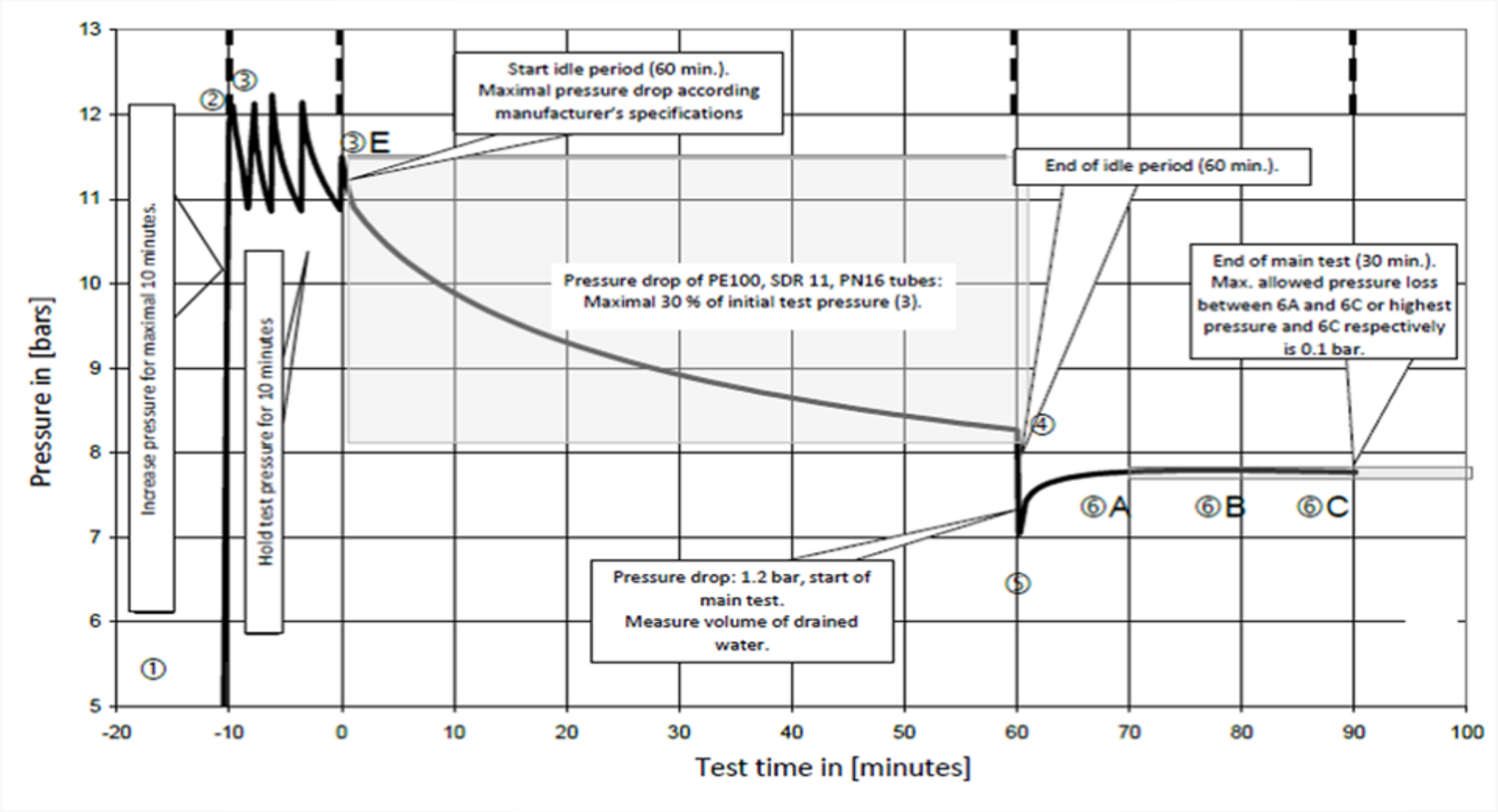
1. Relevant
2. Accurate
3. Consistent
4. Repeatable
5. Safe

Leak Test

Pressure Test

	USA **ASTM F2164**	**UK** **BS EN 805**
Flush and de-gas	Not specified	15 minutes
Raise and hold at test pressure	4 hours	10 minutes
Relax phase	-	1 hour
Pressure drop	10psi	10%
Monitor	60 minutes	30 minutes (90 minutes)
Pass criteria for pressure loss	< 5% of test pressure	< 1.47psi (< 3.7psi)
Test duration	5 hours	1 hour 55 minutes (2 hours 55 minutes)

BS EN 805:2000



Flow Test

Need to identify:-

1. Any obstructions - Debris
2. Any restrictions - Kinks

Compare the flow rate in feed & return pipework, in both directions, without disconnecting the pipework.

Require test apparatus for use at the point of installation.

Loop Test Apparatus

Fully automated test system for pressure & flow testing.

Features:-

De-gassing tanks to remove air.

Filters test fluid and sterilises using ultra-violet light.

Undertakes pressure test in line with ASTM F2164 or BS EN 805.

Carries out flow test in both directions without disconnecting.

Records results electronically for storage and export.

Records the loop position by GPS.

Camera supervision, in unit & loop connection point.

Loop Testing System

Loop Testing System

Loop Testing System

Summary

1. Easy to use
2. Robust
3. Accurate results
4. Incorruptible
5. Safe

Coming soon:-

Depth confirmation

Verticality

Thank you!

Geoff Ellison

www.dragondrilling.co.uk

www.dragonrenewableenergy.co.uk

www.envirohireltd.com

The Certified Geothermal Inspector Course and Content Overview

Certified Geothermal Inspector (CGI)

- Garen N. Ewbank (email gewbank@geotctest.com)
- B.S. IE&M, OSU
- NUMEROUS CERTIFICATIONS
  - IGSHPA
    - TRAINER, ALL COURSE
    - CGD, CGI, AND OTHERS
  - AEE
    - FELLOW
    - LIFE MEMBER
  - ASHRAE
    - FULL MEMBER
    - AUTHORED AND CO-AUTHORED NUMEROUS PRESENTIONS AND PAPERS

Certified Geothermal Inspector (CGI)

Certified Geothermal Inspector

Inspecting GSHP systems will keep you competitive in a market forced to deal with rising energy costs. The CGI course is worth 2 CEUs.

Certified Geothermal Inspector Workshops

Learn to inspect ground source heat pump (GSHP) systems for residential and commercial properties to keep you competitive in a market forced to deal with rising energy costs and resource depletion. Inspector accreditation enables you to anticipate important critical elements of installation and offers customers more assurance of a low-maintenance, economical, and environmentally friendly alternative for their geo comfort needs. With more than 35 years of experience teaching these workshops, accrediting thousands of installers, drillers, engineers and setting the industry standard, IGSHPA pioneered training in GSHP installation.

Certified Geothermal Inspector (CGI)

The IGSHPA Certified Geothermal Inspectors course was developed with two types of inspectors in mind. First, there are "code" officials, whose primary roles are protection of public health, safety, and the environment. A second type has been identified as a "quality" inspector. Quality inspectors are also concerned with the health and environmental issues, but they need to know much more. In addition to the environmental issues of concern to code officials, a quality inspector protects the integrity of the design, and ultimate performance of the system. A quality inspector might work as a field inspector for the owner or a construction manager, or maybe as an engineer's quality control person, etc.

Certified Geothermal Inspector (CGI)

The class is taught in a classroom environment in 12 sections over a two and one-half day period for a total of 20 contact hours. The first day the minimum body of knowledge necessary for an inspector to have in order to perform his/her duties is presented. There is a heavy emphasis on the ground heat exchanger- including closed loop, open loop, and standing column well. The course is structured around the IGSHPA Design and Installation Standards and to the ANSI/IGSHPA/CSA 448-16 binational standards that were developed by the Canadian Standards Association with the help of IGSHPA, NGWA, and many other industry groups.

Certified Geothermal Inspector (CGI)

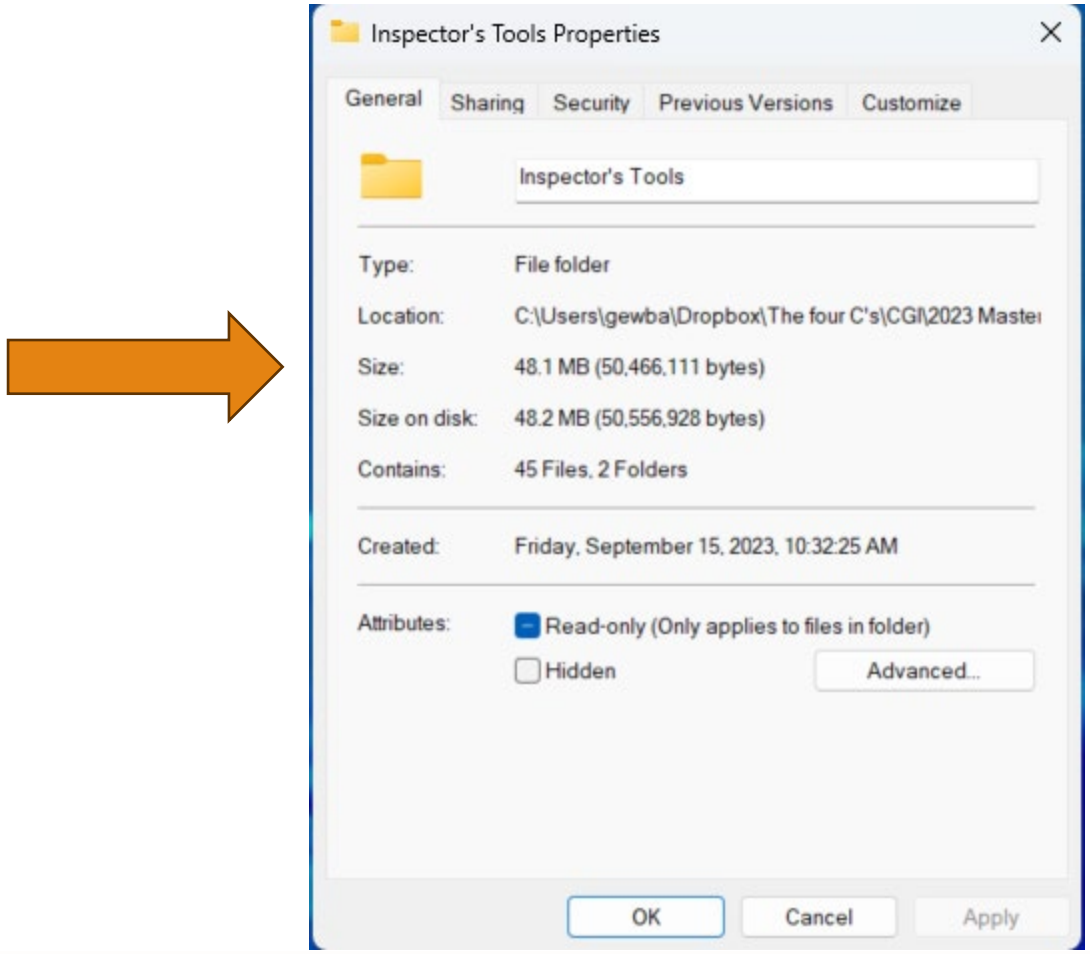
The second day local codes for the geographic area the course is being taught are reviewed. In addition, appropriate sections of the current International Mechanical Code (IMC) and the International Association of Plumbing and Mechanical Officials (IAPMO)- Uniform Solar Energy and Hydronic Code (USEHC) and Uniform Mechanical Code (UMC) are reviewed in the context of the ground source system. Finally, the concepts taught to that point are brought together in the context of a case study of a GSHP project from the Feasibility phase all the way through Project Closeout. The students are given a set of tools, comprised of excel spreadsheets, checklists, and reference materials that they will be able to use in the future to develop their own inspection programs.

Certified Geothermal Inspector (CGI)

After completing the classroom portion of the Inspectors Course, the student will have the opportunity to take the online exam. After passing the exam, and completing the registration process, students with the required experience in the industry will be credentialed as an IGSHPA Certified Geothermal Inspector. Students who pass the exam but do not yet have the required experience will become Inspectors in Training and will have an opportunity to be mentored by the review Board toward achieving full Inspector status.

Learning Units:	20
Credit Designations:	HSW

Certified Geothermal Inspector (CGI)



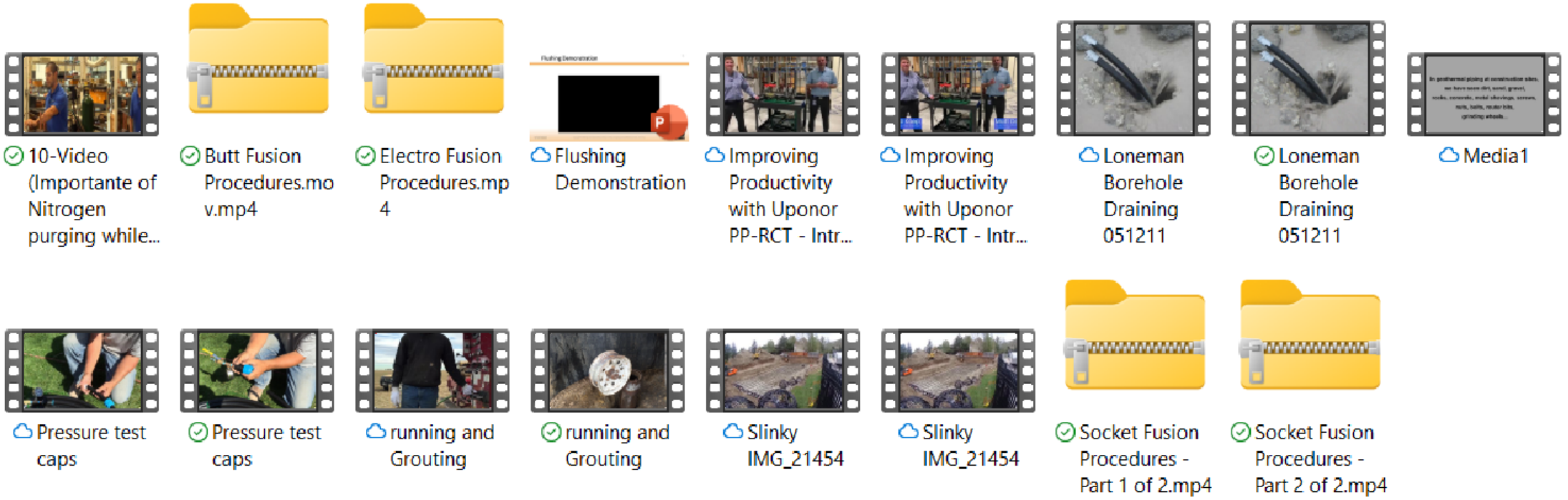
Certified Geothermal Inspector (CGI)

Support Material - Fusion

- Published Material
  - http://www.performancepipe.com/en-us/Documents/PP750FusionProcedures.pdf
  - http://www.performancepipe.com/en-us/Documents/PP750-TN-05But%20Fusio%20JoiningProcedures.pdf
  - http://www.performancepipe.com/en-us/Documents/PP750-TN-07SocketFusionJoiningProcedures.pdf
  - http://www.performancepipe.com/en-us/Documents/PP750-TN-06SaddleFusionJoiningProcedures.pdf

- Videos
  - Butt fusion – https://youtu.be/YN_LWZEhuIs
  - Socket fusion – https://youtu.be/PmE6ryKvOGw
  - Saddle fusion – https://youtu.be/1GJZ5oViBwE
  - Electro Fusion – https://www.youtube.com/watch?v=3GruX__jVSc

Certified Geothermal Inspector (CGI)



Certified Geothermal Inspector (CGI)

- (Precourse) 01 GX Basics
- 01 Introduction and Overview
- 02a Commercial Design
- 02b Residential Design
- 03 Fusion
- 04 Flushing, Purging, and Pressure Testing
- 05 Vertical Heat Exchanger - Section 1
- 05 Vertical Heat Exchanger - Section 2
- 05 Vertical Heat Exchanger - Section 3 [Autosaved]
- 06 Horizontal Heat Exchanger
- 07 Surface Water Heat Pump Systems

Certified Geothermal Inspector (CGI)

- 08 Open Loop Ground Water Systems
- 09 Standing Column Well Heat Exchangers
- 10 Direct Expansion Heat Pump Systems
- 11 Hybrid Systems R1 [Autosaved]
- 12 State Resources and Unique State Modifications...
- 12 State Resources and Unique State Modifications...
- 13 Commissioning
- 14 CGI Central Loop

Certified Geothermal Inspector (CGI)

- THANKS FOR LISTENING; DOCUMENTATION RULES!

IGSHPA®

Kortney Lull

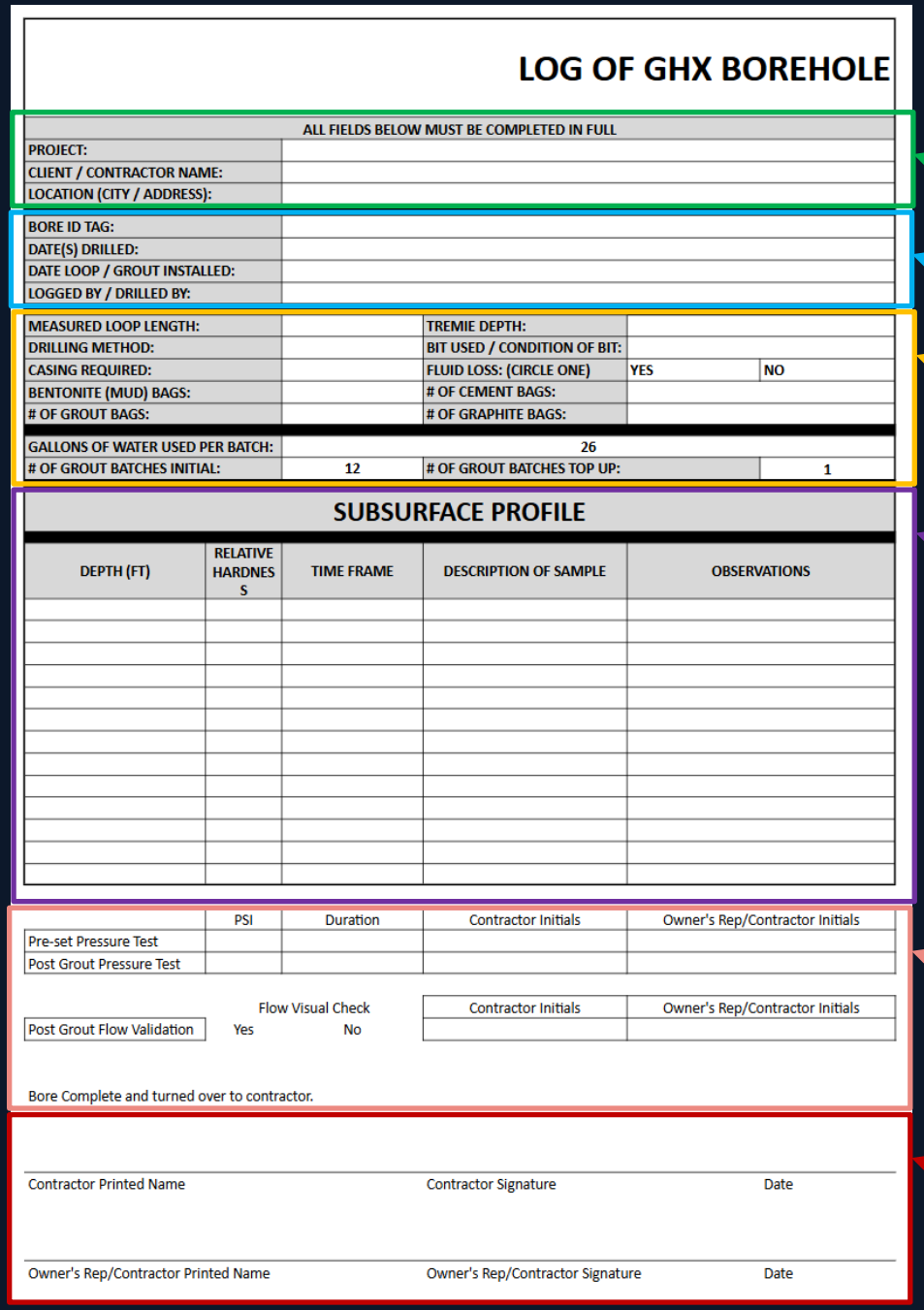
Midwest Geothermal, LLC

Document, document, document

By documenting the quality control procedures during the installation process, we are providing written proof of completion of these processes. Not only does this provide proof of work complete, but allows sign-off and acceptance of what has been installed.

Let’s go through some of the examples of documentation that can be provided throughout the installation of any geothermal field.

Drill Log Example



LOG OF GHX BOREHOLE

ALL FIELDS BELOW MUST BE COMPLETED IN FULL	
PROJECT:	
CLIENT / CONTRACTOR NAME:	
LOCATION (CITY / ADDRESS):	

BORE ID TAG:	
DATE(S) DRILLED:	
DATE LOOP / GROUT INSTALLED:	
LOGGED BY / DRILLED BY:	

MEASURED LOOP LENGTH:		TREMIE DEPTH:		
DRILLING METHOD:		BIT USED / CONDITION OF BIT:		
CASING REQUIRED:		FLUID LOSS: (CIRCLE ONE)	YES	NO
BENTONITE (MUD) BAGS:		# OF CEMENT BAGS:		
# OF GROUT BAGS:		# OF GRAPHITE BAGS:		
GALLONS OF WATER USED PER BATCH:	26			
# OF GROUT BATCHES INITIAL:	12	# OF GROUT BATCHES TOP UP:		1

SUBSURFACE PROFILE

DEPTH (FT)	RELATIVE HARDNESS	TIME FRAME	DESCRIPTION OF SAMPLE	OBSERVATIONS

	PSI	Duration	Contractor Initials	Owner's Rep/Contractor Initials
Pre-set Pressure Test				
Post Grout Pressure Test				

	Flow Visual Check		Contractor Initials	Owner's Rep/Contractor Initials
Post Grout Flow Validation	Yes	No		

Bore Complete and turned over to contractor.

Contractor Printed Name	Contractor Signature	Date
Owner's Rep/Contractor Printed Name	Owner's Rep/Contractor Signature	Date

Installing contractor & project information

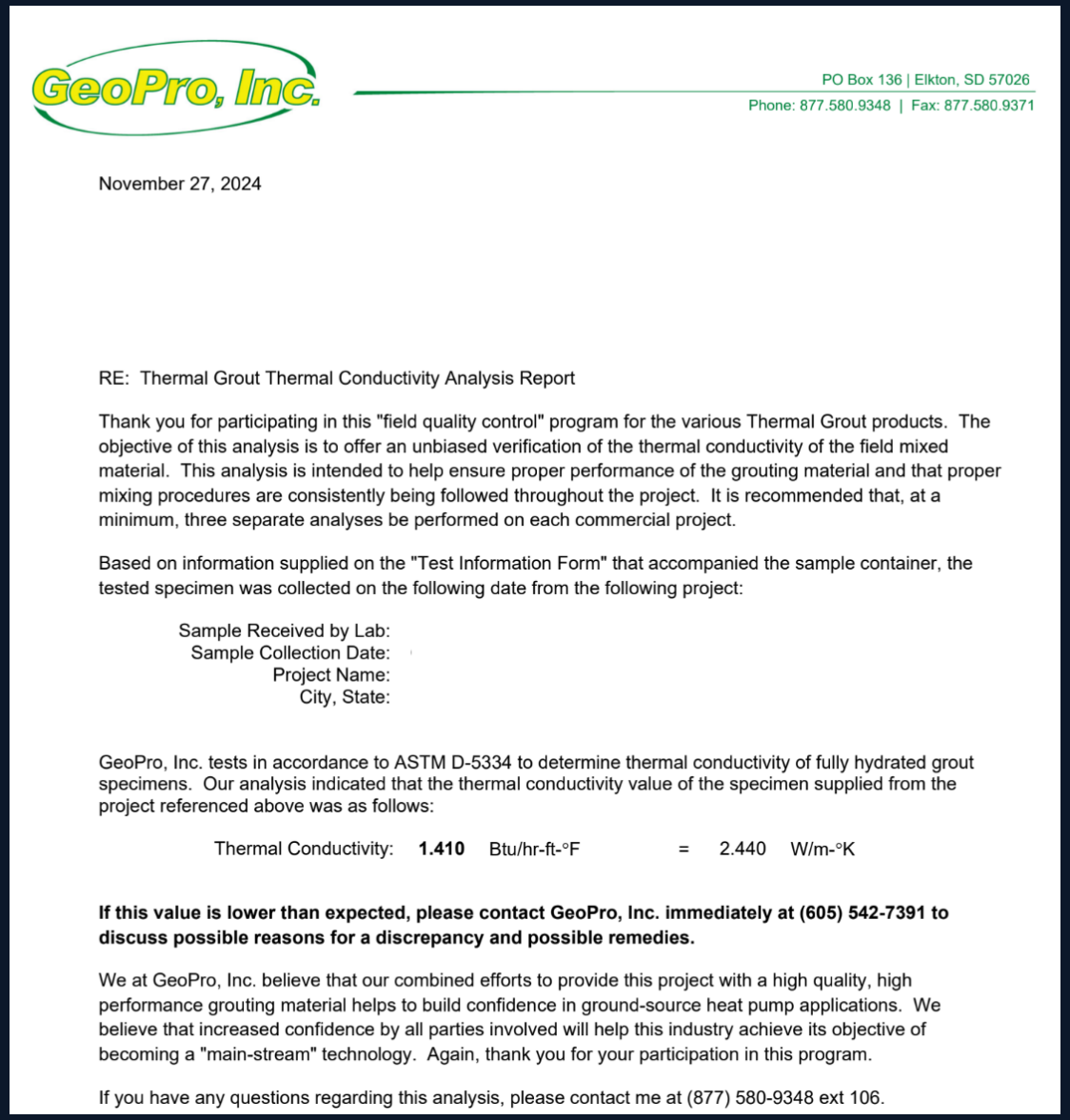
Borehole specific information (ID)

Borehole installation details

Drill log

Pressure test & flow check

Sign-off and acceptance



GeoPro, Inc.

PO Box 136 | Elkton, SD 57026
Phone: 877.580.9348 | Fax: 877.580.9371

November 27, 2024

RE: Thermal Grout Thermal Conductivity Analysis Report

Thank you for participating in this "field quality control" program for the various Thermal Grout products. The objective of this analysis is to offer an unbiased verification of the thermal conductivity of the field mixed material. This analysis is intended to help ensure proper performance of the grouting material and that proper mixing procedures are consistently being followed throughout the project. It is recommended that, at a minimum, three separate analyses be performed on each commercial project.

Based on information supplied on the "Test Information Form" that accompanied the sample container, the tested specimen was collected on the following date from the following project:

Sample Received by Lab:
Sample Collection Date:
Project Name:
City, State:

GeoPro, Inc. tests in accordance to ASTM D-5334 to determine thermal conductivity of fully hydrated grout specimens. Our analysis indicated that the thermal conductivity value of the specimen supplied from the project referenced above was as follows:

Thermal Conductivity: **1.410** Btu/hr-ft-°F = 2.440 W/m-°K

If this value is lower than expected, please contact GeoPro, Inc. immediately at (605) 542-7391 to discuss possible reasons for a discrepancy and possible remedies.

We at GeoPro, Inc. believe that our combined efforts to provide this project with a high quality, high performance grouting material helps to build confidence in ground-source heat pump applications. We believe that increased confidence by all parties involved will help this industry achieve its objective of becoming a "main-stream" technology. Again, thank you for your participation in this program.

If you have any questions regarding this analysis, please contact me at (877) 580-9348 ext 106.

Grout Sampling

Grout sampling is critical to ensuring that the grout placed in the borehole meets or exceeds the design specifications.

Following proper grout sampling procedures from the manufacturer to ensure that samples are truly representative of what is being mixed.

Pressure Testing

A document to show the pressure testing of each circuit individually is critical to show the integrity of each circuit.

If you have multiple vaults on a site, separate each vault into the circuits assigned to that vault.

Match the labeling to the drawings.

Circuit Pressure Test

Project:

Date: _____

Completed By: _____

Vault #	Start Date	Finish Date	Start Time	Finish Time	Starting Pressure	Ending Pressure	Pressure Drop	Performed By	Witnessed By
Circuit X									
Circuit X									
Circuit X									

Site Specific Flushing Procedure

Every commercial project should have a site specific flushing procedure that spells out specifically the requirements to properly meet or exceed the flushing needs of the project.

Be specific on the:

- Loop volume
- Flushing rates
- Duration of time to turn the fluid

Site Specific Flushing Procedure

Project: _____ Date: _____

Completed By: _____

Forward - Flushing Documentation	Loop Volume	Qty Bores	GPM Flush Rate @ 2	Time (10) Turns (minutes)	Start Time	End Time	RPM Start	GPM start	RPM Finish	GPM finish	Owner's Agent Initials (if required)
Circuit 1	567	5	110	52							
Circuit 2	561	5	110	52							
Circuit 3	538	5	110	49							
	1666	Total System Volume									

Project: _____ Date: _____

Completed By: _____

Reverse - Flushing Documentation	Loop Volume	Qty Bores	GPM Flush Rate @ 2 ft/sec	Time (10) Turns (minutes)	Start Time	End Time	RPM Start	GPM start	RPM Finish	GPM finish	Owner's Agent Initials (if required)
Circuit 1	567	5	110	52							
Circuit 2	561	5	110	52							
Circuit 3	538	5	110	49							
	1666	Total System Volume	*This is to be completed after the air has been removed from the system								

Final Hydronics Testing Report

After the entire system has been flushed, purged and each circuit has been pressure tested, the final step is to have a full system final hydrostatic test.

This final test is the most critical pressure test to have witnessed and signed off on.

Final Hydronics Testing Report

Project: Date: _____

Completed By: _____

	Start Date	Finish Date	Start Time	Finish Time	Starting Pressure	Ending Pressure	Pressure Drop
Entire System							

Performed By _____
Signature Date

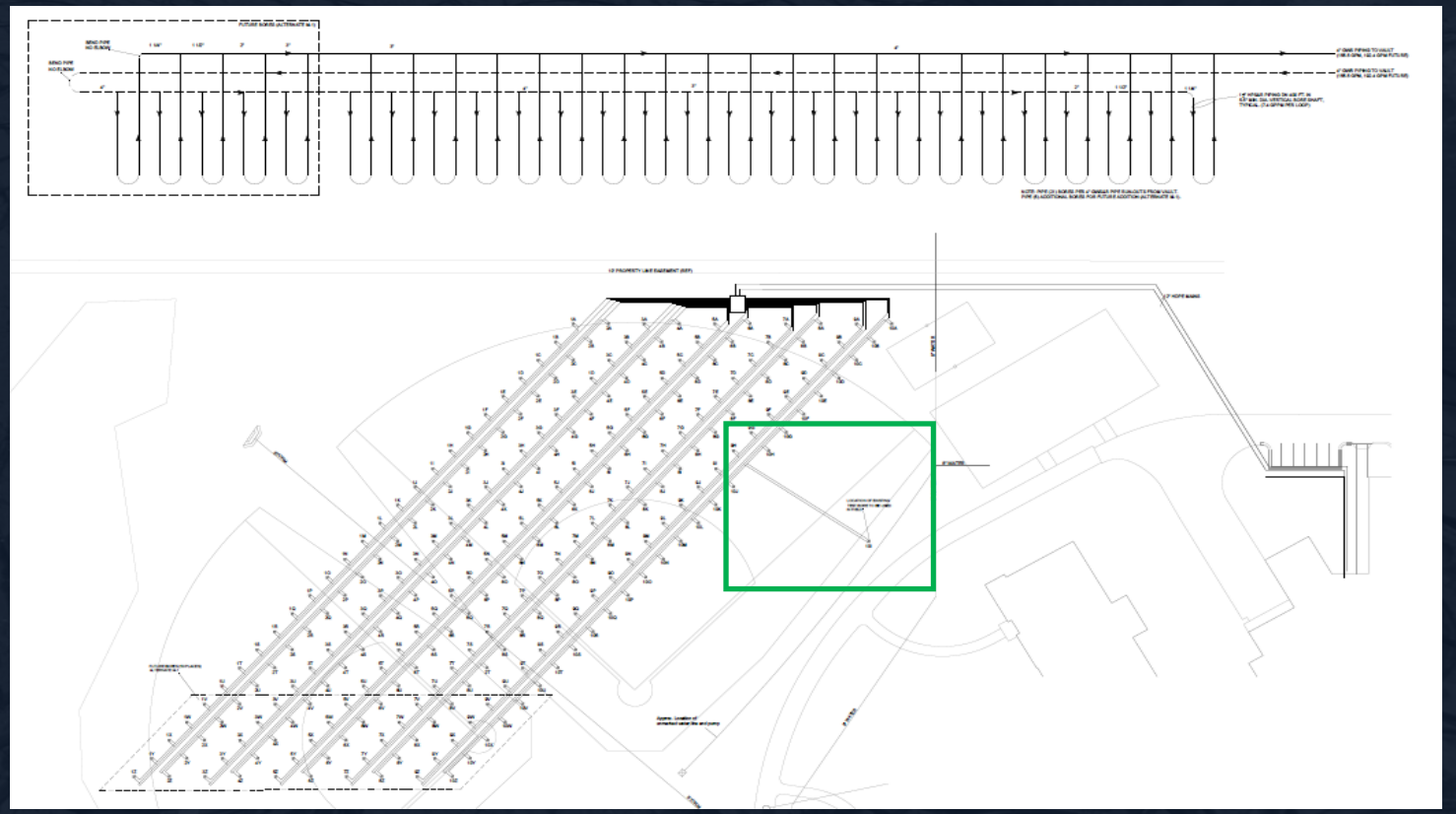
Witnessed By _____
Signature Date

As-builts

To ensure long term love of the geothermal system, the owner needs to know where it is.

Having an accurate and detailed as built, including the use of accurate GPS data, is REQUIRED.

Include not only a drawing with the GPS data, but also provide them a CSV so that future contractors can use it in their GPS hardware.



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