Specifications that Make Sense

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Objectives

- Specifications designed to protect the ownership and contractors of the project
- Meaningful specifications
- Risk management for ownership and contractors
- High-cost adders that can impact project costs
- Design Engineer education resources

Communication is critical

- Documentation of project scope and related work – clear deliverables
- Engineer(s) of record primary contact identified?
- Owner construction manager primary contact identified?
- Any third-party reviewers, inspectors, local government involved?
- Any site-specific working access, working hours identified?

Geothermal Ground-Source Heat Exchanger Spec's

SECTION 230220 – GEOTHERMAL GROUND-SOURCE HEAT EXCHANGER

PART 1 - GENERAL

1.1 SUMMARY

A. Section includes:

1. General Provisions.
2. Scope of Work.
3. Related Work.
4. Submittals.
5. Standards and References.
6. System Description.
7. Quality Assurance.
8. Delivery, Storage and Handling.
9. Warranty.
10. Ground-Sourced Heat Exchanger Piping.
11. Manifolds.
12. Butterfly Valves for Geothermal Piping.
13. Balancing Valves for Geothermal Piping.
14. Meters and Gages for Geothermal Piping.
15. Penetration Sleeves.
16. Mechanical Seals.
17. Pressure/Temperature Taps.
18. Grouting Material.
19. Heat Transfer Fluid.
20. Hydraulic Cement
21. Dielectric Fittings.
22. Drilling Equipment.
23. Detectable Warning Tape and Tracer Wire for Non-
24. Bedding and Backfill Sand around Piping
25. Buried Ground-Source Heat Exchanger Piping Insu
26. Site Survey.
27. Runoff.
28. Drilling.
29. Grout Thermal Conductivity Testing.
30. Ground-Sourced Heat Exchanger System Installatic
31. Flushing, Purging, Testing, and System Charging.
32. Testing, Adjusting, and Balancing for Geothermal
33. Operator Training
34. Trench Excavation.
35. Backfilling and Compaction.
36. Material Disposal.

Example Data Recording Forms (at end of Section)

B. Related Requirements.

1. Division 31 of Project Specifications on Dewaterin
2. Division 31 of Project Specifications on Excavatior
3. Division 31 of Project Specifications on Soil Erosion and Sediment Control.
4. Division 23 of Project Specifications on Heating, Ventilating and Air Conditioning

1.2 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and a DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part the Specifications.

B. All work must be in accordance with ANSI/CSA/IGSHPA C448 Standards NYS Mechanical Code, and NYS Clean Heat Rebate Program Manual, or other the Engineer.

1.3 SCOPE OF WORK

A. The Contractor shall furnish all equipment, materials, labor, transportation, coordination with other Contractors, whether enumerated herein, for a comple geothermal, or "ground-source," heat exchanger system in a neat workmanlike work include, but are not limited to:

1. All excavation, trenching, drilling, casing, pumping, drainage, backfillir spoils and excess water and disposal, high-density polyethylene geothermal manifolds, pipe and manifold supports, test equipment, insula of as-built drawings, and all work related to the installation of horizontal ar heat exchanger piping, as indicated on the drawings, and specified herein
2. Advising the local municipality and all underground utilities of the propo the start of borehole drilling and trench excavation. It is the Contractor's coordinate all interferences (i.e., storm drains, sanitary piping, water mai communication conduits, yard piping, irrigation lines, foundations, b proposed, any other improvements proposed to be installed as a part of tl electrical feeders and conduits) with the Construction Manager, other Co Engineer.
3. Pipe identification: Mark all buried pipe with detectable warning tape specified herein.
4. Maintain marked up drawings in the field during the work of any chang borehole/loop locations, circuit layout or other horizontal piping to manifolds.
5. Provide as-built documentation after the completion of the project.
6. If any boreholes/loops must be moved from their design locations a drawings, Contractor shall re-survey the new locations and document san record drawings.
7. It shall be the responsibility of the Contractor to procure any permits and l for the work from all Local, State and Federal agencies prior to the comm work. Preparation of any drawings and documentation to procure the requ payment of the required fees shall be the responsibility of the Cont mobilization, the Contractor shall provide to the Engineer an original cop or licenses.
8. It is the responsibility of the Contractor to coordinate with the Owner's Construction Manager or Environmental Consultant regarding the management, treatment (if required), and disposal of drill spoils/cuttings and management of groundwater and drilling fluids including details of runoff containment to be used during drilling, method for settling and filtering fluids, and excess water disposal methods and disc in accordance with applicable Local, State and Federal regulations.
9. The work includes installation of subsurface piping in drilled boreholes and installation of manifolds, sleeves, and link seal type fittings at all pene indicated on the drawings.
10. Provide, set in place, and be held responsible for the location of all sleev anchor bolts required for the Work, and in sufficient time to be installed di concrete pours. Where job schedules make this impossible, coordina acceptance from the Structural Engineer for alternate installation methods. so requires cutting and patching of finished work, it shall be done so at tl sole expense.
11. Furnish and install HDPE pipe stubs for the supply and return piping of ea connected to the manifolds. Pipe stubs shall be fitted with temporary caps p of the manifold to the work site.
12. All HDPE connections shall be with socket or butt fusion weld connection
13. Provide erosion control measures during the work and control surface Contractor's work area.
14. The Contractor shall estimate the installation of any casing in their bid that for satisfactory drilling and loop installation. Casing installation shall tak variation in subsurface conditions, top of bedrock, facture and weathered z rock formation and means and method for drilling and groundwater inflov Steel casing may be left in place.
15. Drilling for installation of the geothermal loops includes advanceme subsurface materials including obstructions, at the specified locations a drilling, pre-excavation, or other methods, if required to overcome obstru performed using techniques proposed by the Contractor and approved by tl
16. Flushing, purging, flow and pressure testing, and charging of the installed heat exchanger system including all U-bend loops, circuit piping, and all and including the manifolds, as specified herein, and reporting of results to
17. Preservation and protection of existing and new site features and improven work. Provide dimensioned "as-built" drawing showing surveyed lo geothermal loop.

B. Site Conditions and Available Subsurface Information

1. Before submitting bids, the Contractor shall visit the site and inform them location, nature of the work, equipment and facilities needed, general and l prevailing at the site, and all matters which may affect the work of this Sec
2. Before submitting bids, the Contractor shall examine all sources of informa subsurface soil, bedrock, and groundwater conditions. Each bidder shall conclusions concerning how these conditions may affect their work. Contra to the attention of the Owner any conditions that would not permit the Con the intent of the contract before submitting a bid.
3. Existing Subsurface Information: A geothermal test loop installation and g thermal conductivity testing report are available as part of the project dc request of Contractor. The Owner assumes no responsibility for the accuracy of the existing test borings, geologic logs, and geothermal test loop installation results. Thermal conductivity test results in the bid documents are included only as a general indication of the materials to be found at the site. The Contractor shall examine this data and conduct their own investigations to collect additional data as deemed necessary. The Contractor shall base their bid solely on their understanding of the conditions likely to be encountered at the site.
4. The bidder's submission of their proposal shall be considered "prima facie" evidence that they have made their examination as described in this Section.
5. All piping and equipment shown on the drawings is intended to be approximately correct to scale but dimensions and detailed drawings of the actual equipment furnished shall be followed in every case. The drawings shall be taken in a sense as diagrammatic. Sizes of piping are shown, but it is not the intent to show every offset or fitting, nor every hanger or support, or structural difficulty that may be encountered. The absence of pipe supports and details on the drawings shall not relieve the Contractor of the responsibility for providing them. To carry out the intent and purpose of the drawings, all necessary parts to make a complete working system ready for use shall be furnished without extra charge. The Contractor shall be responsible for coordinating the system installation and routing with the work of all trades.

C. Tolerances:

1. The boreholes shall be drilled within two (2) feet of the plan location as indicated on the drawings. A minimum 25-foot center-to-center spacing of the loops shall always be maintained unless specified otherwise on the drawings and approved by the Engineer. The Contractor shall survey the locations of the completed loops and provide an as-built record drawing.
2. Should the Contractor encounter difficulty drilling and installing a loop to the design depth of 499 feet below grade surface, as measured at the drill site, Contractor shall inform the Engineer immediately and the following shall apply:
   a. Any loops that cannot be installed deeper than 95% of design depth (450 ft) shall be rejected and the Contractor shall abandon the borehole/loop per governing regulations and re-drill the hole at an alternate location as determined by the Engineer. In this case, Contractor shall submit a revised circuit layout showing the new location tied into the circuit piping.
   b. Any loops that cannot be installed to design depth but deeper than 95% of design depth may be accepted with approval by the Engineer. In this case, Contractor shall submit a location for an additional loop to makeup the lost footage along with a revised circuit layout showing the new loop tied into the circuit piping.
   c. In all cases, the total design footage of boreholes/loops is still required, and the Contractor is responsible for all remediation measures, work, and costs for not achieving the design footage, including redesign of circuit piping routing, pipe diameters and fittings, and costs for other trade elements to accommodate the new geothermal system layout.

Documentation of project scope and related work

- General Provisions – Contract and General Conditions
  - Details the project general requirements - details matter here.
  - All work in accordance with ANSI/CSA/IGSHPA and C448 Standards
  - NYS Mechanical Code, and NYS Clean Heat Rebate Program Manual or as approved by Engineer or local city codes
    - Scope of work
      - Section describes in detail all equipment, materials, labor, transportation, supervision and coordination between contractors for a complete and functional ground –source heat exchanger system
      - Proposed work sequencing, phasing, completion schedule conforming to project schedule

Scope of Work - continued

- Advising local municipalities and all underground utilities of proposed work
- Borehole and Pipe identification with tracer wire or detectable tape
- Management of drawings and as-built documentation
  - These will be the post installation resource for information
    - Geothermal heat exchanger boreholes/loops design locations
      - Should include subsurface piping in trenches, manifolds, valves if required
      - Any deviations to system design borehole location must be approved and documented

Scope of Work - continued

- **Details of heat exchanger HDPE pipe installation**
  - Borehole spacing and depth
  - Grouting materials
  - Pipe sizes, pipe and fitting connection method
    - Socket or butt fusion only
- **Excavation and disposal of drill spoils/cuttings**
  - Erosion, water and fluids run off control
- **Excavation backfill material and compaction details**
  - Removal and proper disposal of site excavation materials
  - Heat exchanger bedding and backfill material
  - Site restoration elevation and description details

Quality Assurance

- **Equipment and materials manufacturer Qualifications** – minimum 5 years documented industry experience
- **Installer Qualifications** – minimum 5 years documented industry experience with similar size project references available
- **Owners Representative** – designated field staff for quality assurance to observe and report to the engineer specific activities of the project

Pre-Bid Information

- **Site Survey**
  - Before submitting bids, the contractor should visit site and inform themselves as to the location, nature of work, equipment and facilities needed to perform the scope of work
  - Before submitting bids, the contractor should examine all available sources of information regarding subsurface soil, bedrock and groundwater conditions.
  - Subsurface information should be made available to all bidding contractors
- **GSHP GX well field**
  - Clear and detailed information
    - **Geothermal Thermal Conductivity Testing**
      - Provides subsurface information of drilling conditions
      - Provides design Engineer soil thermal conductivity and diffusivity information

        Helps determines borehole backfill grout selection

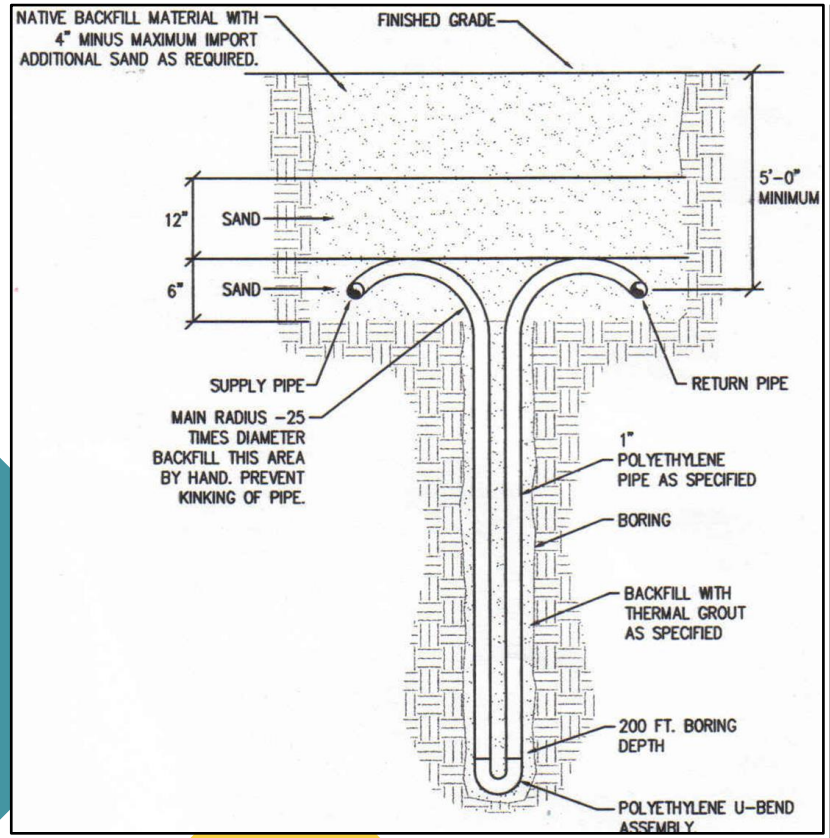
Pre-bid site survey

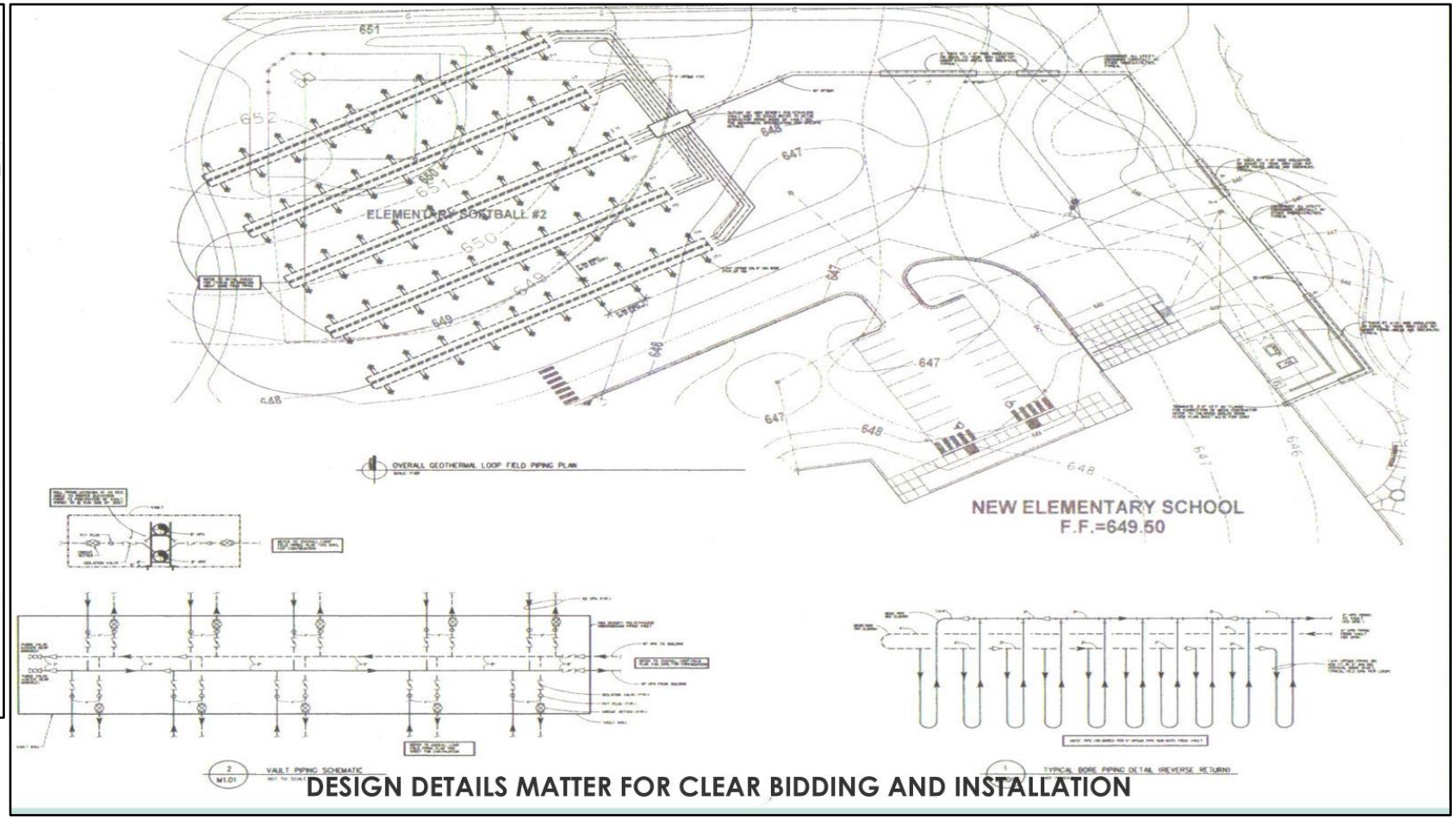
- Provides bidders site access information and material laydown area availability, equipment parking

GSHP HX materials

Factory U Bend fusion and pressurized

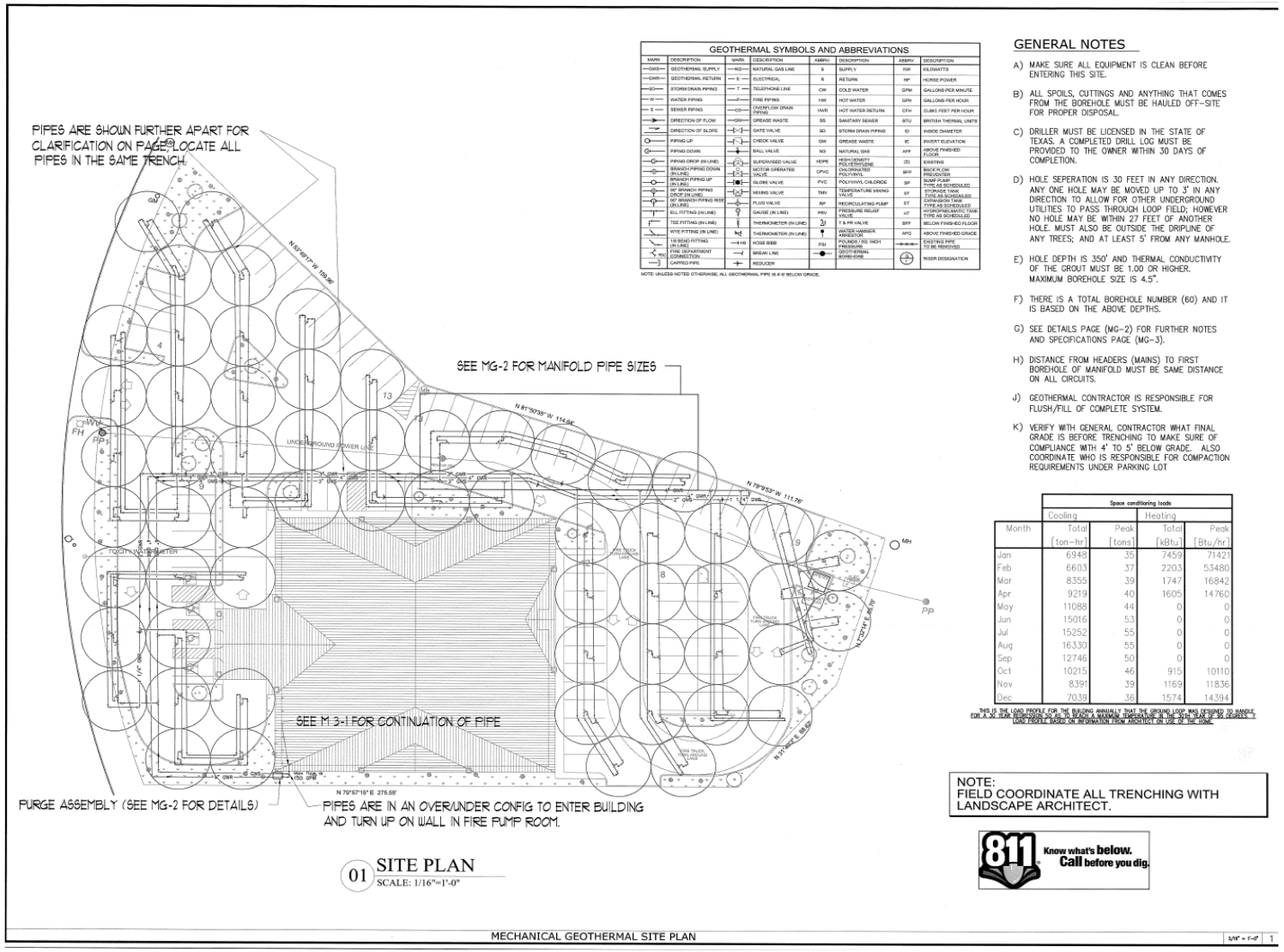
GSHP GX borehole and borefield details





GSHP GX borehole and borefield details

Site space availability will determine the borefield design/borehole spacing



Manifold Vaults

A vault is a buried structure that holds an external manifold for a geothermal loop-field. This is a buried mechanical room.

- Concrete or HDPE construction
- Frees up valuable space inside Mechanical room
- Reduces building penetrations
- Stopping point between loop-field and building
- Prefabricated vault saves field time
- Accommodates larger distance from building
- Easy access for flushing and purging

Thermal Conductivity Testing

- ✓ **Identifies the actual ground loop performance** given a specific location and heat exchanger design
- ✓ **Testing** is conducted several days after the ground loop's installation and data is recorded over a 24–48 hour period
- ✓ **Reported data includes:**
  - ❑ Undisturbed soil temperature
  - ❑ Thermal Conductivity (TC)
  - ❑ Thermal Diffusivity (TD)
  - ❑ Drill log and time

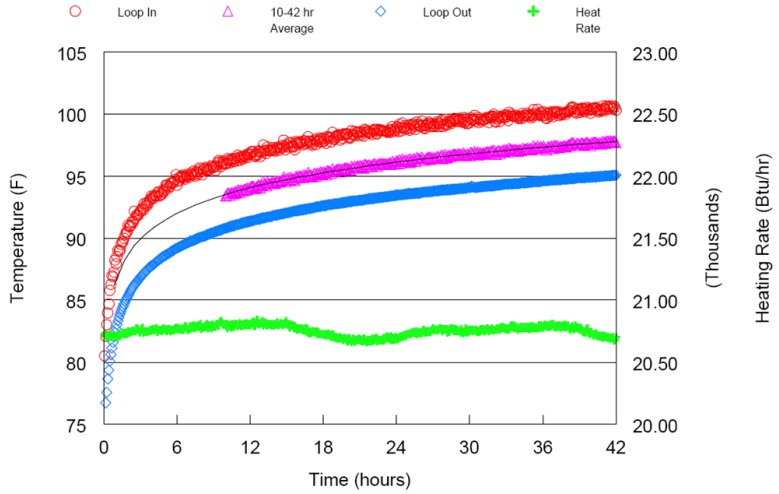


Figure 1: Temperature versus Time Data

Formation Thermal Conductivity Test Report

Date	March 7-9, 2005
Location	Mesquite, NV

Borehole Data

Undisturbed Soil Temperature	Approx. 73-76°F
Borehole Diameter	5 inches

Drill Log

S gravel, trace sandy clay	0'-50'
S-M gravel, trace clay, some cobbles	50'-60'
S-L gravel, trace sandy clay	60'-80'
M-L gravel, trace sandy clay, cobbles	80'-120'
S-L gravel, trace sandy clay	120'-130'
60% coarse sand, 35% L chips, 5% sand	130'-140'
50% coarse sand, 40% fine sand, 10% S-M gravel	140'-150'
70% S-M gravel, 20% sandy clay, 10% sand	150'-160'
60% sandy clay, 40% S-M gravel	160'-200'
70% loose sand, 30% S gravel and coarse sand, trace clay	200'-210'
60% sandy clay, 40% S-M gravel	210'-240'
50% loose sand, 40% coarse sand, 10% S-M gravel	240'-250'
70% S-M gravel, 30% sandy clay	250'-280'
80% S-M gravel, 20% sandy clay	280'-300'
60% sand, 40% S-M gravel	300'-310'
S gravel, coarse sand	310'-320'
70% S-M gravel, 30% sandy clay, trace clay	320'-340'
80% S-M gravel, 20% sandy clay	340'-360'
70% sand, 30% S-M gravel	360'-370'
80% S-M gravel, 20% sandy clay	370'-380'
50% coarse sand and S gravel, 50% sandy clay	380'-415'

U-bend Size	1 1/4 inch HDPE
U-Bend Length	404 ft
Grout Type	GeoPro TGL88
Grout Solids	63%
Grouted Portion	0 – 250 ft

Test Data

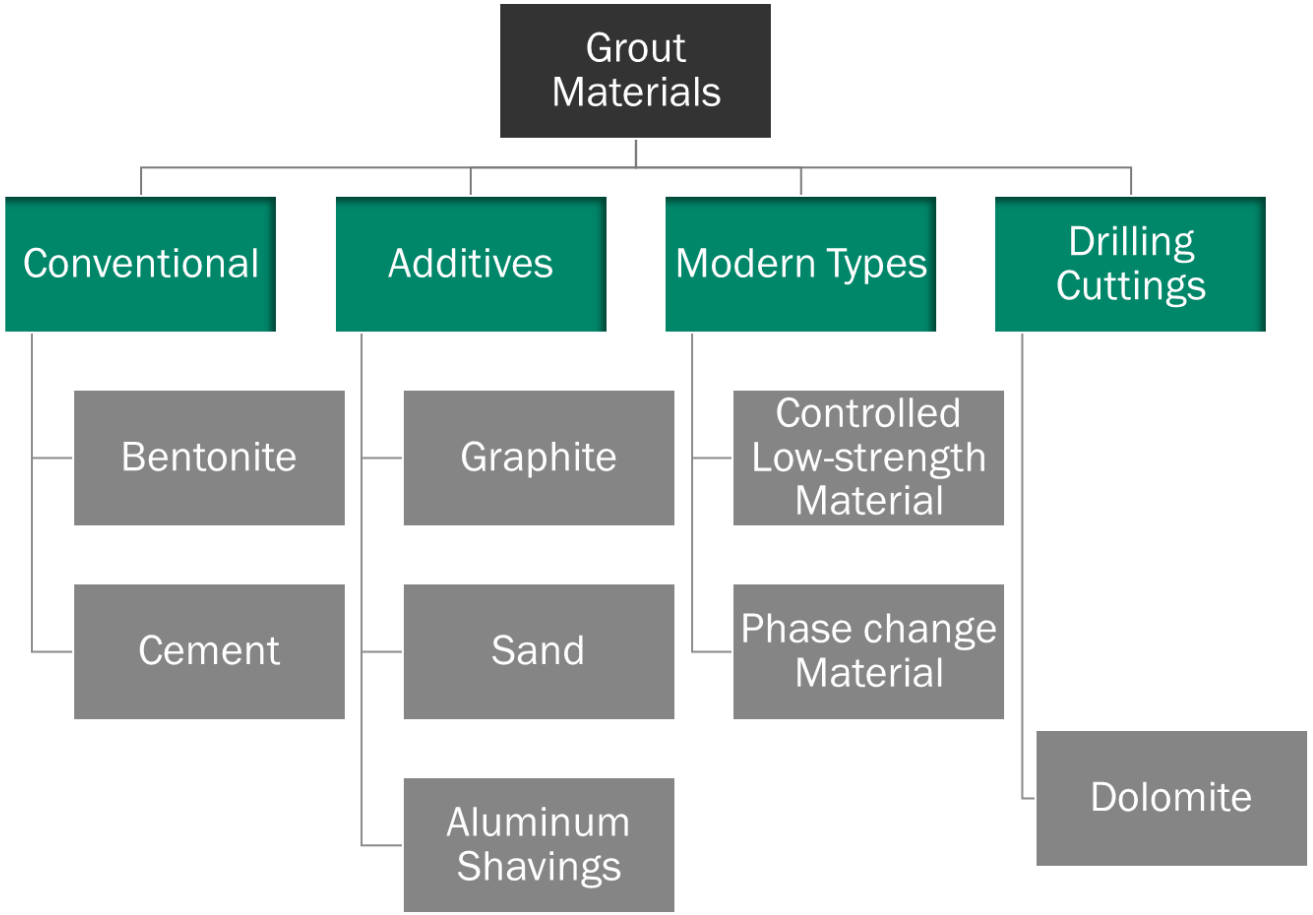
Test Duration	42.0 hrs.
Average Voltage	239.8 V
Average Power	6,081 W
Total Heat Input Rate	20,753 Btu/hr
Calculated Circulator Flow Rate	7.7 gpm

The thermal conductivity test can provide bidders with actual site borehole information

Quality Assurance

- U – Bend piping/loops
  - Delivered to site under pressure
  - Hydrostatic testing prior to borehole insertion
  - Retested after full borehole insertion, capped off to keep contaminants out of pipe
- Borehole grout backfill
  - Grout selection based on thermal conductivity (TC) test results
  - Grout material selection will determine Borefield performance
    - Higher solids grout costs can be justified when TC is higher
    - Grout samples testing to ensure proper mixing
    - Grout samples should be provided to Engineer/Owner’s representative

Grout selection



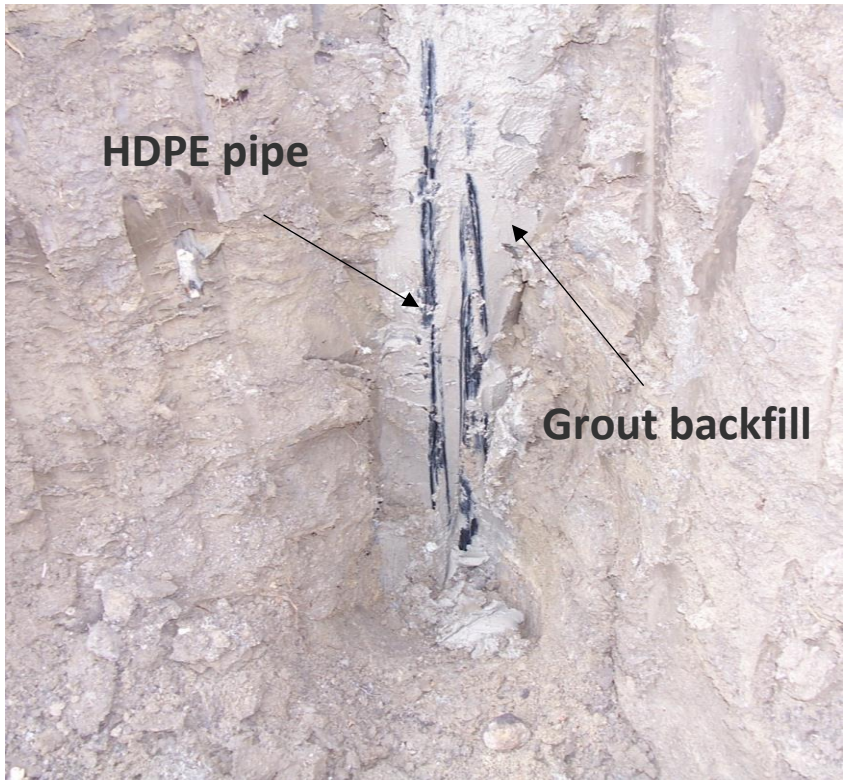
- Grout selection can help borefield performance
- Higher solids = Higher TC = higher costs for materials and labor

Grout borehole backfill

Proper borehole backfill/grouting is critical for system design performance.

Grout provides thermal transfer between the soil – borehole – HDPE pipe

Additionally, it protects aquifer contamination



Quality Assurance - continued

- **Lateral pipe – manifolding**
  - Supply and return branch circuits connecting boreholes
  - Prior to backfill hydrostatic pressure testing
  - Supply and return piping should be buried minimum of 4 feet of clean backfill
  - Install tracer wire or detectable warning tape
  - Retest after borehole, supply and return manifold connection
- **System flushing/purging**
  - All flushing/purging should be performed in presence of Engineer or designated Owner's representative
  - Flush/purge with clean water at rate of no less than 130+% of system design flow and in no case less than 4lf feet per second

Quality Assurance - continued

- Antifreeze and charging
  - To be completed after successful completion of flushing/purging and witnessed testing
  - Antifreeze injection
    - Inhibited glycol solutions, most common but others are available (Methanol, Ethanol)
    - Water should be PH neutral
  - Final solution sample should be provided to Engineer/Owner's representative
  - Retest after borehole, supply and return manifold connection

High-cost adders

- Oversized geothermal borefield
  - Additional boreholes add substantial costs
    - Unequal balance of loads - Hybrid system application can reduce total borehole. Reduces total boreholes required for cooling/heating load imbalance without efficiency reduction.
    - Enhanced grouts in low TC/TD soil – remember the actual geology is the limiting factor
- Excessive scope on the GSHP HX installer
  - Glycol injection by loop contractor – third party contractor can reduce overall risk and improve quality
  - Interior building supply/return manifold by loop contractor – not always done when GXHP is installed and can add additional time, costs for return travel.
- System sensor and data collection
  - These systems are proven so no need to add costs for data collection – not a science experiment

GXHP Design software

- **GLD** – www.groundloopdesign.com
- **Loop Link Pro** – https://looplinkpro.com
- **GSHPCalc** – www.geokiss.com
- **GLHEpro** – www.IGSHPA.okstate.edu
- **EED** – www.buildingphysics.com
- **ECA** – www.elitesoft.com/web/hvacr/ecaw.html
- **Wright-Loop** - www.wrightsoft.com
- **Geofease** - https://geofease.com/home/

Not an endorsement of software. For information purposes only

Audience objectives

- Who can tell me the definition of meaningful specification?
- Name two specifications that will help protect the owners and contractors of the project
- What information can a thermal conductivity test give the bidders?
- How many in the audience have experienced any of the high-cost adders we reviewed?

Thank you

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