



Thermal Dynamics, Inc.
Maple Plain, MN 55359

Notes for MN Veterans Home in Montevideo

Geothermal Drilling Contractor:

Contacts:

Manager – Dave Needham (612) 369-3649 dave.needham@bergersoncaswell.com

Office – Stacey Henrich stacey@bergersoncaswell.com 952-255-7052

A/P – Kimberly Brown kimberly@bergersoncaswell.com

Driller / Site Supervisor – Matt Schwartz 612-250-5632

Grout Locating – Chase Staber 612-618-6646

Headering work for the vault – Bruns Headering, Eric Bruns 507-530-4551 ericgbruns@gmail.com

Phone: 763-479-3121

Address: Bergerson Caswell
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Job Site: MINNESOTA VETERAN'S HOME – MONTEVIDEO
2190 WILLIAM AVENUE
MONTEVIDEO, MINNESOTA 56265

Reed Paitich – PE - Wold Architects and Engineers - rpaitich@woldae.com

Payne Quick – Wold Architects and Engineers - pquick@woldae.com

Bill Mason – Knutson – 612-919-5053 – bmason@knutsonconstruction.com

Mike Holznagel – RJ Mechanical – 320-390-0210 mike.holznagel@rjmechanical.biz

6/12/2022 First meeting regarding project. Timing moved up with work to begin 6/15.

6/17/2022 Met with Dave Needham – Bergerson Caswell, to discuss project. Sent Commissioning Proposal for signature and asked for contacts and material submittals for the geothermal portion of the job. Will make first visit 6/21.

6/17/2022 The driller is concerned that the site does not have sufficient space to properly install and stage the drilling. Also, there is a deep pond over top of the drilling area. Will observe on 6/21/22.

6/21/2022 Received IGSPHA Certificate for Matt Schwartz – Horizontal Drill Operator
Received copies of MDH permits for the job
Received copy of the MDH registration for the Horizontal Drill Machine

Thermal Dynamics, Inc. Maple Plain, MN 55359 USA

Ph: 952.255.7080 e-mail: info@groundloopdesign.com

06/21/2022 Onsite Visit for Geothermal Commissioning - Montevideo VA Home

- Arrived onsite ~1:15 PM.

Viewed Materials staged for immediate use: (Photographed)

- Centennial CenFuse 4710 - 1.25" diameter SDR-11 factory loops – 510 feet length with capped ends. Note: all reels were wound with the loop to the outside. Typical for vertical borehole use. Will need to be unwound to pull through borehole. Noted footage markings appeared to be continuous from 0' – 1020'.
- Pallets of Baroid Barotherm Gold Grout.
- Pallets of GeoPro Powertech Graphite Grout additive
- Baroid Quickbore drilling mix for drilling fluid
- Blue stranded Tracer wire for each borehole

Status: Drilling in process for the sixth borehole – 16-foot depth. Hole about 300 feet progressed and moving fairly quickly. Drilling has encountered primarily clay. This was the second borehole of the day. Observed that there were already five loop pipe sets exposed. Two from the first group were capped. One loop from the first set was not capped but had water in it – in preparation for pressurizing. Photos taken.

Site Conditions: The loopfield area was completely graded and free from any obstacles. There is a pond that covers much of the area of the loopfield. It was mostly drained but had some water from rain the prior evening. The depth of the pond seems to be possibly too deep in comparison to the contour lines on the drawing. That indicates 10-foot max bottom depth. Suggest that the actual depth be checked before the drilling progresses beneath the deepest areas. The 16-foot depth boreholes will only have a small amount of cover if the pond is dug correctly.

The overall available space for the drilling is 560-feet, which does not leave much area on either end to stage the equipment and properly pull the loops. In order to get the required 500-foot heat exchanger in each bore, the drilling angles to start and finish each borehole are very steep to avoid running into construction fences on both ends and still get enough pipe into the ground for performance as designed. The design needs to allow at least 50-feet extra on each end to allow the drillers to setup without damaging their equipment or damaging the installed pipe. Site photos taken.

Initial Boreholes: The first group of three boreholes only had one of three boreholes grouted due to issues with extracting the Tremie lines. The two deeper boreholes could not extract the Tremie lines due to the sharp drilling angle between the entry hole and the flat areas, which caused one tremie line to be broken off deep in the hole and the second tremie line was abandoned after pulling reduced the diameter of the pipe to less than $\frac{3}{4}$ inch due to being stretched and ultimately stuck. At this point, the tremie lines in those two holes are not removable due to the grout being set up. There is simply inadequate space available to properly approach drilling the boreholes. ***Engineering will need to decide whether the two un-grouted lines need to be abandoned or replaced, as they do not meet the spec requirements.***

Observed Borehole: The installation and grouting of the sixth borehole (16 ft) drilled easily, taking about 3 hours to exit for pulling the loops back. The shallow boreholes can

both be completed in a long day, if no complications occur. It took roughly 1 hour, 10 minutes to pull the loops through the completed borehole. I did observe an issue with the factory loop that was pulled into this hole where the ends were pulled in at the same time with the tremie but at the U-Bend, about 15 feet before the U-Bend entry, the pipe lengths did not match up and the process needed to be stopped so that an extra 2-3 feet of length needed to be removed from one side of the U-Bend so that the U-Bend could be pulled into the hole. Observed the pip cut on one side of the U-Bend and re-fused using a butt fusion to make the pipe on both sides of the loop the same length. This adds about 30 minutes extra to each borehole and introduces a fusion to each loop. Loops that are correctly wound should not have different lengths of pipe on each side of the U-Bend. A sample of the butt fusion was collected for destructive testing.

The pipes are being pulled back with an attachment to an 8-inch reamer that precedes the pipe and opens the hole for easier pulling. Photos taken.

Grouting: Observed mixing of three bags of grout to each bag of graphite. Total batch size for the observed loop was five batches for the 16-foot borehole. Three samples were collected at the beginning, middle and end of the grouting process.

Test with KD-2 (Samples also shipped to Halliburton for third party testing)

#1	0.860	6/21/22 5:00 PM Sample Taken
#2	0.865	6/21/22 5:15 PM Sample Taken
#3	0.882	6/21/22 5:24 PM Sample Taken

Observed the tremie was pulled back an estimated 100-150 feet before commencing with the grout pumping. Once the operator observed the graphite/grout exiting the hole and displacing the drilling fluid and cuttings, the tremie line was pulled back about 50 feet at a time and holding until grout resumed exiting the hole. After pulling 300-350 feet, grout began to flow on both ends of the hole until it was coming out near the grout pump only. The amount of grout used seems low but was consistent for the four boreholes grouted to date.

Left the site at 6:10 PM

06/24/2022 Shipped three grout samples to Baroid/Halliburton for testing

07/01/2022 Grout testing results from Halliburton/Baroid for borehole #6 taken 6/21:

- Sample #1 from borehole 6 taken at 5:00PM: TC value 0.71
- Sample #2 from borehole 6 taken at 5:15PM: TC value 0.77
- Sample #3 from borehole 6 taken at 5:24PM: TC value 0.82

07/05/2022 Email received from Reid Paitich regarding the early boreholes with stuck tremie lines. Reid wants them abandoned and replaced with two additional boreholes and has advised the drilling contractor.

07/12/2022 Onsite Visit for Geothermal Commissioning - Montevideo VA Home

Status: Arrived onsite ~3:45 PM. Drilling in process for the borehole #21 – 16-foot depth. Hole just completed and pipes being drawn back through the borehole. On the far end of the borehole, noted that the U-bend length and supply/return alignment were very close, so no need to adjust the lengths before pulling the U-bend into the borehole as discussed in the previous report. Took photos of the seven groups of loops that were installed and observed that there were two loops with pressure gauges showing 80PSI on loops where the supply return lengths needed to be adjusted at the U-bend end of the loop. Loop ends were all protected and looked good. The spacing for ends of each group of three boreholes are fairly close together due to lack of space to allow the drill to move back away from the previous holes in each set. Appears that the deep boreholes are installed first for each group, followed by the middle and shallow boreholes.

Retention Pond: Walked the path of the current borehole (where walkable) through the pond bottom and noted two, maybe three “blowouts” where the shallow borehole hydraulic pressure had forced its way to the surface. There was evidence of drilling mud that appeared to also be exiting above the adjacent grouping, indicating that the disturbed soil at the bottom of the pond did not have enough strength to sustain a hydraulic barrier as the drilling passed close to the surface for the shallow boreholes. There appeared to be little to no seepage from the previously drilled sets of shallow boreholes to the surface. With this current borehole, the work has moved horizontally down the side of the pond down to the base area where the cover is the thinnest. Also noted that channels had been dug to allow the pumps to drain the bottom and those channels will further reduce the available cover between the bottom of the pond and the shallow borehole in each set. Photos taken.

Grouting: Observed mixing of three bags of grout to each bag of graphite. Total batch size for the observed loop was five batches for the 16-foot borehole. Three samples were collected at the beginning, middle and end of the grouting process.

Tremie line pullback began 4:10PM and the operator used the same procedure as with earlier holes where the tremie was pulled about 200 feet before pumping was started. This will be a problem for the shallow boreholes as blowouts on the pond bottom will not allow the grout to follow the borehole all the way to the opening by the drilling machine. The procedure will need to be changed to provide for grout pumping as soon as the tremie pull starts. Took first grout sample at 4:17PM. As the tremie line was being pulled, it was evident that there was grout and graphite bubbling up from the path along the bottom of the pond where the blowouts from drilling mud had occurred. While there was grout injected into the borehole, a lot of it was forced to the surface of the pond bottom.

Test with KD-2 (Samples also shipped to Halliburton for third party testing)

#1	0.778	7/12/22 4:17 PM Sample Taken
#2	0.837	7/12/22 4:25 PM Sample Taken
#3	0.868	7/12/22 4:40 PM Sample Taken

Will advise grout test results in a separate email after testing.

Site Conditions: Noted that there are no stakes in the borefield area to mark the rows or where the header connections are supposed to be. Not certain of actual final finish grade and would need the project crew to provide markings. Driller advises that they have

requested markings from the site manager but have been declined. There are also no markings to confirm the pond depth. This omission should be corrected.

Manual measurements of the seven sets of loops shows that the spacing is 8 feet from group to group but no way to check the starting location. Each group is measured from the first boreholes as the starting point. Driller and drill locator are making best estimates possible given the lack of staking of the area.

The rest of the site around the borefield area remains clear and accessible with only material storage for the loopfield pipes and grout in the vicinity.

Overall Observations: Boreholes are being installed at the rate of ~two completed /day. Drilling taking about 3-3.5 hours per borehole. Pulling the loop and grouting adds another couple hours for each hole. Things appear to have progressed smoothly since the first couple holes with delays being primarily weather related. Driller has an additional water tank to aid with water supply from a 1.25" waterline that looks to be about 1500 feet from the source.

Driller will need to modify grouting procedure for remaining shallow bores as the site conditions are interfering grouting integrity of the shallow boreholes. The soil disturbance of the pond bottom and shallow coverage are posing issues for the driller. Drilling and excavation should have been coordinated before the pond was installed. As the driller moves across the pond bottom horizontally with each new group, the stability of the pond bottom will be an issue and drainage channels for pumping will likely cause additional blowouts along the drilling path for the shallow boreholes in each loop.

Left the site at ~5:40 PM

07/15/22 Grout Samples shipped to Halliburton for testing

07/22/22 Test reports received from Baroid on the 7/12/22 test samples

07/26/22 Copies of grout sample test reports submitted to the project manager and others on the email list for reports.

08/08/22 Site received significant rain (3+ inches?) and all water from the site was pumped into the pond, which resulted in cancellation of the drilling. The project managers clearly place the needs for the geothermal drilling portion of the project low on their list of priorities. Will try to visit on 8/10 if drilling can continue.

08/10/2022 Onsite Visit for Geothermal Commissioning - Montevideo VA Home

Status: Arrived on site ~9:30 AM. Working on bore #43 - 32' depth - finishing the last 75-100 feet. Completed at 10:10AM. Observed that the loop to be installed is completely extended on the east side of the pond in preparation for pulling into the borehole. Pullback of the loop and tremie pipe began at noon and was completed about 2:30PM.

Observed that the grading work on the site now includes a culvert into the retainage pond and a second culvert being added in front of where the drilling is taking place. The pond is holding water and the locator that needs to take measurements is up to his knees in water at the south end of the pond. It is unfortunate that drilling was not allowed to complete before adding the extra complication of the pond, drainage and subsequent difficulties working in the area. Overall photos taken of the site and pond work.

Checked the condition of the previously installed loops and earlier loops were sealed. Took photos of the exposed loop-ends, including loop under pressure test. Each loop is filled with water and pressurized to 80 pounds. No leaks reported or observed. Noted that there was one loop that had 1" tails exposed instead of 1.25" and was advised that these were just markers that were inserted and sealed into the ends of the actual loop that were just below the surface for location purposes. Groups of pipes were measured to confirm 8 feet of separation for each group. No project provided marking stakes were observed. So far, 14 groups of three pipes have been installed with two more groups of three to complete the loopfield.

Retention Pond: As noted above, the pond has made the work difficult for drilling. Due to the water present, I was not able to walk the bottom to inspect for any additional blowouts of grout and drilling fluid for lines installed since the last site visit. The driller advised that they had modified their grouting procedure per the previous report. Noted that the project managers for the site were not maintaining the pump that was in place for draining the pond and the drilling crew was providing the gas and effort to try to keep the pond drained.

Grouting: Grouting of borehole #43 began about 2:45PM. Tremie line pulled back 50-100 feet and grout pumped until it was observed exiting the hole on the far end. First grout sample taken at 2:50PM. Observed mix of one bag graphite to three bags of Baroid Gold grout per batch. The operator has reduced the water content for a thicker mix compared to earlier boreholes. Second sample taken at 3:05PM. Last sample taken at 3:20PM and tremie line was removed from borehole by 3:25. Five batches of grout were mixed for this borehole.

Test with KD-2 at office (Samples also shipped to Halliburton for third party testing):

#1	0.899	8/10/22 2:50 PM Sample Taken
#2	0.910	8/10/22 3:05 PM Sample Taken
#3	0.961	8/10/22 3:20 PM Sample Taken

Will advise third party grout test results in a separate email after testing.

Site Conditions: The area around the pond has "grown up" a lot since the last visit. Weather and the handling of the pond have resulted in some lost drilling days. There is currently no way to get a wheeled vehicle to the drilling area due to ongoing excavation work. The crew continues to have difficulties with the lack of space on each end of the loopfield.

Overall Observations: Work on drilling portion of the project should wrap up in 1-2 weeks. Crew advises that the holes that need to be redrilled (due to the stuck tremie pipe

issues) will need to be drilled a couple feet above the stuck lines in order to get them into the same approximate location. Is there a change order for this?

The shallow holes have taken about a half day each to complete. The deeper borehole takes most of a day to complete. Progress on the borehole installation has been steady with no real problems with rocks, etc. Weather and pond related issues have been the only delays that were noted.

Left the site at ~3:45 PM.

08/18/22 Advised that a change order had been approved to add the additional loops to replace the loops where the tremie pipes were stuck. Final drilling to be completed the week of 8/22/22.

08/19/22 Test reports received from Baroid on the 8/10/22 test samples. All results within expected range and reports forwarded by email to all involved parties.

09/21/22 Dave Needham advises that Bruns Headering will do the vault installation and connections. Eight-inch lines from vault back to building are already installed and needed to be extended to go past the parking lot. Bruns may want to start the week of Sept 26th.

10/03/22 Spoke with Eric Bruns – Bruns Headering. Eric's company will be performing the loopfield tie-in work and connection to the geothermal vault. Will be working on-site for the early 10/5. Eric estimates that the vault work for connection to the 8" lines will be completed this week and the loopfield headers and connection to the vault will be another 1-2 weeks. They plan to do all of the connections before any system pressure testing and will likely be doing the pressurizing about the week of 10/24 or sooner. Requested fusion cards for Bruns from Dave Needham at Bergerson Caswell.

10/05/22 Onsite Visit for Geothermal Commissioning - Montevideo VA Home

Visited the site to see the final loopfield conditions and the progress to tie the loops into the building. Arrived ~12:15PM on site.

Status: The pond area and pond bottom in the vicinity of the loopfield have been re-graded since the last visit. Note that there are some 1.25" HDPE lines exposed on the SE corner of the pond that appear to have been snagged by a bulldozer and are partially buried into the bottom and side of the pond. Consulted with Dave Needham at Bergerson Caswell and he advises that they are probably the water supply lines which were being used for the grouting equipment. They were apparently run over and buried by a bulldozer before the crew had a chance to recover them from the site. Suggest that the site manager may want to have these remnants pulled to avoid any future confusion with the loopfield, which uses similar piping. Photos were taken. There are also additional culverts feeding into the retaining pond since my last visit. Note that the bottom of the pond sits about 4 feet above the shallowest loops. Care needs to be taken working in and around the pond so as to not disturb the loopfield piping.

There are a pair of HDPE eight-inch lines that go between the loopfield and the building and were installed prior to the loopfield in January 2022. These lines run under the driveway and parking lots which have now been paved and curbed. Bruns Headering has exposed these

8" lines for connection. There is a Geothermal Vault that is being installed in the vicinity of the 8" lines and I observed the installed vault and fusion of these lines to the vault. The fusions were timed as performed and the temps used were ~475 degrees F, which is in the recommended range from ISCO. Photos taken.

All of the HDPE lines to connect the 54 loops to the vault have been constructed in advance and are awaiting onsite for installation to the Geothermal Vault within the next week. Photos taken. Looked at the 8" butt fusions and elbow fusions and all looked good. Requested a sample for destructive inspection of a butt fusion.

Estimate that the excavations and connection of the loops will be completed (weather permitting) within the next week and the system will be pressure tested at that time. Will visit again to look at the loop connections to the vault and observe the pressure test after 24 hours on ~10/12.

The vault will be getting cement poured on 10/5 to provide an anchor for the base of the vault. All of the area beneath the vault has been hand bedded and is awaiting backfill after the pressure test is complete. I did not wait for the cement as it would have been a couple more hours before the materials were delivered.

Bruns Headering is waiting for the Project Site Management to move an existing dirt pile which is blocking where the excavator needs to work to expose the loops for connection. All of the loops are staked to show the estimated location of 10 feet of cover so that the excavation can open the needed area for doing the connections. I walked the area with Eric Bruns and advised that there are two abandoned loops with tremie lines which remain buried in the first two rows. Replacements were installed for the two loops that had the stuck tremie lines. Bergerson Caswell advises that the abandoned loops were filled with grout and cut off. The headering crew needs to make sure that they connect to the two replacement loops and do not use the abandoned loops.

All 54 loop tails are exposed and the site is marked for the approximate 8-10 foot depth locations for excavation.

Left the site about 3:15PM

10/11/22 The dirt piles were not relocated to allow Bruns to complete excavation for the connection of the loops. They are doing the work with an excavator instead of a dozer and Eric estimates a delay of at least two days due to the unforeseen issue with dirt stockpiled right where the loops tie-ins needed to be done. Estimate that the system will not be ready to check before 10/14 or 10/17.

10/19/22 Onsite Visit for Geothermal Commissioning - Montevideo VA Home

Visited the site to see the final loopfield conditions and the loop tie-ins to the geothermal vault. Arrived ~3:15 PM on site.

Status: None of the dirt piles that were left in the way of the tie-in work were relocated and the Bruns was forced to clear a space to work using the excavator, which caused our planned visit timetable to be delayed a couple days. All of the 54 loops are now connected to the supply/return lines to the geothermal vault. Since the last visit, roughly 4 yards of

concrete were used to secure the base of the vault into the ground. All of the loops and connections were exposed for inspection in a trench ~12 feet deep. The trench is roughly 90 feet long and 30 feet wide. Photos were taken of all of the supply/return runouts along the length of the trench and individual photos were taken of the groups of 16', 24' and 32' loops as they exited the side and bottom of the trench. Two of the original loops and grout lines were abandoned and marked. The replacement loops were connected. Also observed two additional grout lines that appear to have broken off and were still showing next to connected loops. There was grout present in the open tremie pipe stubs. Requested Bruns to clip off and mark the pipes that were abandoned so as not to be confused with the good plumbing in the event that there is ever a need to access anything for modification or repair. Noted a few couplings in the loop connections where it was necessary to make a good mechanical connection to the supply/return lines. All of the loop pipe looked good and undamaged after excavation work. The north end of the trench appeared to be right at the water table and there was water present at the bottom of the north end. The south end was muddy but did not have as much water present. Observed some sloughing of material from the sides of the trench.

Bruns needed to request hydrants near their locations to be turned on to get water for the pressure testing of the system. The loopfield side of the vault was pressurized to 100 PSI for testing all of the supply/return connections. Gauge photos were taken and time noted. Overnight, the temperatures dropped and there was ice present in the bottom of the trench. Inside the vault, a plug/gasket on the 8" side of the vault deformed and allowed the pressure to be released prior to the completion of 24 hours. ISCO was notified of the need to repair the valve gasket and the vault was repressurized by isolating each supply/return circuit. Another 24-hour test was completed on 10/21/22 with no loss of pressure and Bruns was given the go-ahead to begin to bed the pipes for filling in the trench.

All of the observed connections looked good and I received samples of butt fusions of 1.25" and 3.0" pipe for destructive analysis. Socket fusions looked good and the saddle fusions in the supply return lines were factory supplied. The work looked good and as expected.

The 8" supply/return connections to the building were not tested at this time. All of the pipes are covered by paved and curbed parking lot and the building is not yet ready for any interior connections. Final testing of the building side of the vault will be completed when the system is flushed and purged. Time is TBD by weather and building status.

The area excavated for the vault and loopfield connections should be ready for final grading work 10/24/22.

Took overall site photos noted that there are still a bunch of HDPE waterlines that are abandoned along the NE side of the pond and need to be removed.

Left the site at ~5:45 PM

02/24/23 Discussed system purging with Eric Bruns. Project manager wanting it done by March 15th. With the amount of snow and frost in the ground, that is not likely. Also discussed that there is a blank in the spec where the flow rate for the 3" runouts to the loops from the vault should be. Will contact the engineer for clarification.

02/27/23 The engineer reviewed the spec with the field designer and the recommendation is 100 gpm at about 35' of head for the Montevideo VA Home.

03/21/23 Eric Bruns called to ask about purging the 8" lines from the vault to the building. There is a 3" bypass installed in the building and it needs to be larger to get the needed flows. The inside contractor is not interested in making the change to a larger size. Contacted the engineer for his thoughts on the pump and bypass.

03/27/23 The engineer, Reed Paitich, responded that the inside bypass would need to be increased to 6" in order to successfully purge the 8" lines from the vault and he will contact RJ to get the bypass redone to 6". Discussed that Eric Bruns was doing all of the pumping for the 8" lines and the 3" lines to the loopfield from at the vault and did not plan to do any work from inside the building.

05/02/23 In checking on the schedule for the flushing, I was advised that things are on hold until some change order issues are resolved. I will push this back into June until I hear differently from the drilling contractor.

05/08/23 The engineer has given the OK for Bruns Headering to begin the flushing process without Commissioning presence with the understanding that Eric Bruns provides details and photos of work.

05/09/23 Narrative from Eric Bruns regarding the flush/purge process:

- There are no eight-inch isolation valves separating the geothermal piping from the interior piping.
- There are also no purge ports in the interior.

The process is a little different than usual to make sure to get the cleaning additive through all of the interior steel pipes.

Below is the sequence to follow for flushing:

#1 Flush/purge each circuit individually. Both directions of flow.

#2 Flush/purge eight-inch mains using the three-inch bypass in the mechanical room for both directions of flow.

#3 After completing step #1 and #2, R.J. Mechanical will fill and circulate water through the interior pipes with the cleaning additive. For complete coverage of the steel pipes with the cleaner additive, they will need to use the geothermal eight-inch mains and bypass their water through the eight-inch bypass located in the vault. The rest of the geothermal field (all circuits) will be isolated at that time. There should be no issues with the cleaning additive and the HDPE pipe.

NOTE: R.J. Mechanical will need to advise when they want our glycol tanker trucks on site. As soon as they have finished circulating the cleaner additive, flushing and

filling with clean water, the glycol must be installed to prevent rusting of the interior of the steel pipes.

Follow up: The 8-inch mains were flushed in both directions of flow for one hour in each direction using the 3-inch bypass in the building. Flow rate of 250 gpm achieved in each direction with supply pressure of 48 psi.

After the flush, water was cycled through 5-micron filtration bags for 30 minutes each direction. The filtration bags reduced the flow rate to about 205 gpm. Photos of gauges and pump setup were provided. The system, including the 8-inch mains, was charged to 100 PSI and allowed to stand overnight. (~12 hrs.) Photos provided.

06/01/2023 Filling the Geothermal System with Glycol Solution

On site ~8:30 AM to observe the filling of the geo system circuits with the Glycol solution.

- Noted construction of a new cement block building in the vicinity of the vault and loopfield that was not on the original drawings. There was also excavating for a monument in the corner of the property which was very close to the area of the geothermal loop tie-in. Care needs to be taken not to disturb the installed piping in the vicinity of the tie-ins and also the pond bottom, which only sits a few feet above the top layer of the loopfield.

Met with Eric Bruns to watch the process filling. A 4,000-gallon tanker truck was parked at the site to dispense a reported pre-mixed solution of 25% Glycol to meet the 23-21-13 requirements.

Prior to introduction of the glycol solution, the loop circuits were checked and found to still have ~100PSI remaining pressure from the flushing operation on 5/9/23.

2-1/2" hose lines were used from the tanker truck to the vault for the purpose of filling the system and the lines were flushed with glycol prior to connection the vault. The 8" Supply / Return lines were filled first. Noted in the mechanical room that the 3" bypass was closed and the flow appeared to be through the pumps for the purpose of filling. The tanker was a little less than half-full (by weight) when the discharge of the flushing fluid showed that glycol was fully introduced and circulated in the 8" lines.

The vault valves were then switched to fill the loop circuits, one set of 3" circuit lines at a time. Roughly two and a half circuit groups were filled when the tanker was emptied. The next tanker estimate was to arrive on Friday, 6/2/23, late in the day.

A sample of the glycol which was filled in the 8" lines from the vault to the mechanical room was collected, in the mechanical room, from the 8" supply line at one of the pumps and photos were taken of the connection used. The line was allowed to flow for ~15 seconds before collection into a clean, sealed container. It was noted on inspection later in the day that the fluid was clear and that there seemed to be more sediment (sand) than expected in the collected sample. Suggest that system filters be checked again before full operation. The 3" bypass that was used in the mechanical room may not have allowed as much flow for flushing the 8" supply/return lines as an 8" bypass in the mechanical room would have allowed for.

The Glycol Refractometer showed a protection level of approximately 12 degrees F for the collected solution.

Left the job site at ~11:00 AM.

06/28/2023 Prepared final commissioning report package. Submitted to Bergerson Caswell.