U.S. DEPARTMENT OF ENERGY
FEDERAL ASSISTANCE REPORTING

DISTRICT ENERGY CORPORATION
SW 40TH STREET THERMAL ENERGY PLANT

DOE AWARD #EE0002953

Final Progress Report

Prepared By:

District Energy Corporation

This material is based upon work supported by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy's (EERE) Building Technologies Program under Award Number EE-0002953.

Index

Executive Summary ..... Page 3

DEC and Project Background ..... Page 4

Geothermal Well Field Construction Overview ..... Page 5

Thermal Plant Construction Overview ..... Page 6

Heat Pump Technology Overview ..... Page 6

Domestic Hot Water System Analysis ..... Page 7

Environmental Permitting ..... Page 8

Project Milestones Schedule ..... Page 8

Project Cost Detail ..... Page 8

Plant Operations Review ..... Page 9

Awards, Publications and Conference Presentations ..... Page 10

Appendix

- Monitoring Plan ..... Page 11
- Site Layout Drawing ..... Page 20
- Geothermal Well Field Drawing ..... Page 21
- Thermal Plant Drawing ..... Page 22
- Well Field Thermal Test Report ..... Page 23
- Construction Photos ..... Page 39

Executive Summary

The overall deliverable from the project is the design, construction and commissioning of a detention facility heating and cooling system that minimizes ownership costs and maximizes efficiency (and therefore minimizes environmental impact). The primary deliverables were the proof of concept for the application of geothermal systems for an institutional facility and the ongoing, quarterly system operating data downloads to the Department of Energy[1].

The primary advantage of geothermal based heat pump systems is the higher efficiency of the system compared to a conventional chiller, boiler, cooling tower based system. The higher efficiency results in a smaller environmental foot print and lower energy costs for the detention facility owner, Lancaster County. The higher efficiency for building cooling is primarily due to a more constant compressor condensing temperature with the geothermal well field acting as a thermal "sink" (in place of the conventional system's cooling tower). In the heating mode, Ground Couple Heat Pump (GCHP) systems benefits from the advantage of a heat pump Coefficient of Performance (COP) of approximately 3.6, significantly better than a conventional gas boiler. The geothermal well field acting as a thermal "source" allows the heat pumps to operate efficiently in the heating mode regardless of ambient temperatures. The well field is partially located in a wetland with a high water table so, over time, the project will be able to identify the thermal loading characteristics of a well field located in a high water table location. The project demonstrated how a large geothermal well field can be installed in a wetland area in an economical and environmentally sound manner. Finally, the SW 40th Street Thermal Energy Plant project demonstrates the benefits of providing domestic hot water energy, as well as space heating, to help balance well filed thermal loading in a cooling dominated application.

During the period of August 2012 thru March 2014, with the detention facility occupied for the final seven months, the well field supply water temperatures to the heat pumps dropped to a minimum of 39°F and reached a maximum temperature of 68 °F while providing 15,819 MMBtu of cooling energy and 27,467 MMBtu of heating energy. During this period the peak recorded system cooling load was 610 tons and the peak heating load was 8.4 MMBtu. The DEC is currently evaluating the most beneficial electric rate for plant operations. Total project cost of $16.9 million was approximately $3.2 million less than the estimate provided in the grant application. The reduction in project costs were primarily due to favorable construction material prices as well as strong competition in the local construction contractor market.

The DEC plant reached the substantial completion milestone in December 2011 and began providing thermal service to the detention facility in January 2012 when the building's HVAC system was ready to accept heating service. The plant reached commercial operating status on August 1, 2012. However, due to construction delays, the detention facility was not occupied until September of 2013. The detention facility construction delays also impacted the installation and commissioning of the project's dedicated domestic hot water heat pump. Final coordination with the detention facility's building management system vendor to establish network links for the exchange of date is currently being completed. This will allow the development of control sequences for the optimal operation of the domestic hot water system.

[1] The project's Monitoring and Analysis Plan and operating data can be found on the DOE contractor website (see below link) referencing project: ARRA GSHP Site 15 – District Energy – Monitoring Plan. http://cdhenrgy.user.openhosting.com/ORNL_GHP/Site%2015%20District%20Energy%20SW%2040th%20St/

DEC and Project Background

The District Energy Corporation (DEC) is a nonprofit inter-local corporation created by the City of Lincoln and Lancaster County to provide space heating and cooling needs for County, City and State buildings in Lincoln, Nebraska. The DEC has its origins in studies initiated in 1984 by the City of Lincoln and the Lincoln Electric System. The DEC was formed December 15, 1989. It is governed by a five member Board of Directors appointed by the Lancaster County Board, Lincoln City Council, Mayor of Lincoln, and Lincoln Electric System Administrative Board. The DEC contracted with the Lincoln Electric System (LES) to provide management, technical, accounting and administrative functions as well as operate and maintain the DEC facilities. The first facility, serving the 595,500 sq. ft. of County/City government buildings, began providing service in 1991. An additional facility was constructed in 1999 to serve the State Capitol, State Office Building and State Administrative Office building (827,000 sq. ft. of office space). The County Adult Detention Facility (CADF) geothermal system was constructed in 2011. Finally, the DEC developed a district energy system that currently serves 845,500 sq. ft. of space including a 15,000-seat arena as well as office, retail and residential space in the newly developed West Haymarket District. The system has been designed to expand to serve an additional 500,000 sq. ft. of mixed use space.

In 2008 the Lancaster County Board approved the construction of a 786 bed county adult detention facility, for occupancy in 2012. During the decision process the County Board requested the District Energy Corporation to identify the optimal heating and cooling system for the new facility. The Lancaster County Board was familiar with the DEC since it has provided heating and cooling services to county facilities since its incorporation in 1991. As part of the evaluation, the DEC commissioned an engineering and economic analysis which evaluated ten different heating and cooling system designs. The analysis identified a geothermal based heat pump system to have the lowest life cycle costs. Even though the installed "first cost" of the ground coupled heat pump system (GCHP) was estimated to be $2.5 million more than the conventional boiler/chiller/cooling tower based system; the GCHP system's higher efficiency and projected energy savings of 29%, more than recovered the additional capital costs over the 50 year life of the facility. The analysis forecasted first year energy and O&M savings of $166,500 and the 50 year net present value "all in cost" savings of $8 million for the GCHP system compared to a conventional system. Therefore, the Lancaster County Board approved the District Energy Corporation's recommendation to proceed with the installation of a geothermal, ground coupled heat pump system for the new detention facility. In 2009 the District Energy Corporation applied for and was awarded a $5 million DOE Energy Efficiency and Renewable Energy grant, as part of the American Recovery and Reinvestment Act, to assist with the development of the geothermal based energy production system.

The thermal system's primary components are:

- the geothermal well field comprised of 667 - 300 foot deep wells,
- five 350 ton heat pump banks with each bank containing 10 heat pump compressors,
- six circulating pumps (2 each for both well field loop and hot and chilled water loops)and
- 4 pipe distribution piping for the hot and chilled water distribution.

The SW 40th DEC Thermal Plant project included not only the geothermal thermal system but also three 1200 kW emergency generators which provide emergency electrical service for both the DEC plant and the correctional facility.

The project was managed by the Lincoln Electric System with Farris Engineering acting as the Owner's Engineer. Separate contracts were issued for major pieces of equipment (heat pumps, large pumps, emergency generators, etc.) and construction activities (well field and thermal plant). In all, the project required over 20 equipment and construction contracts, which were competitively bid.

Geothermal Well Field Construction Overview

Geothermal wells are used with heat pumps to provide efficient, environmentally beneficial heating and cooling. The well field provides a heat sink/source for the heat pumps allowing them to operate a maximum efficiency. Lancaster County selected to use a geothermal system at the new Lancaster County Adult Detention Facility, located at W. O Street and SW 40th Street, Lincoln, Nebraska since it had the lowest life cycle costs of nine different HVAC systems evaluated by Farris Engineering. The project also received a $5 million ARRA grant due to the use of the geothermal system.

As part of the design process test boreholes were drilled to perform well field thermal properties testing. The tests indicated the proposed well field site had good thermal characteristics with a calculated thermal conductivity (Kg) of 1.56 Btu/hr.-ft.-°F and an estimated thermal diffusivity of 1.34 ft^2/day. The thermal test report is included in the Appendix.

During the development of the eight acre, 667 borehole well field, a subcontractor to the primary well field contractor used a 5.5" drill bit instead of a 6" drill bit to bore 145 of the 300 foot deep wells. On October 12, 2010 the Nebraska Department of Health and Human Services (HHS) notified the well field contractor the 145 wells must be abandoned and re-drilled. After multiple meetings with HHS, the DEC and Lancaster County it was decided to file a petition with the HHS challenging the determination that the bore holes needed to be abandoned. The petition identified the following points:

- The 145 bore holes substantially conform to the requirements, purpose, and function of the design,
- The dimensions for all or some of 145 bore holes are within reasonable tolerances of regulatory requirements,
- Abandoning and re-drilling the boreholes may increase, rather than reduce, the likelihood of groundwater contamination,
- The requisite volume of sealing grout used was comparable to the volume for a 6" diameter hole,
- All boreholes have been inspected for proper grout column integrity
- Numerous thermal conductivity tests demonstrated the suspect bore holes exceed minimum rates of conductivity,
- The bore hole diameter would meet regulatory requirements in the states of Colorado, Kansas and Missouri,
- Reduced bore hole sizes increase the thermal performance of a well field,
- Reduced bore hole sizes reduce the potential for aquifer contamination by water movement through the borehole,
- Re-drilling 145 boreholes constitutes unreasonable economic waste.

HSS declined the petition and the existing 145 boreholes loops were removed and new boreholes were drilled. All costs for removing the non-compliant loops and re-drilling compliant boreholes were born by the well field contractor and there were no additional cost to the DEC. While, the well field rework

impacted well field completion schedule it did not impact the ability to provide thermal service on schedule.

Thermal Plant Construction Overview

The 16,500 sq. ft. CADF Thermal Plant includes areas for both the thermal energy production facility and the emergency electrical generator systems. The emergency generators are located in a separate room from the thermal energy equipment. In addition to the three 1600 kW emergency generators the plant houses:

- Redundant circulating pumps for both the well field and hot and cold water loops,
- Five heat pump banks totaling 1750 tons of cooling capacity
- Well field header system
- Loop strainers and de-aeration equipment
- Control Room
- Electrical switchgear and motor control centers

The ground loop system is circulated by two 75 hp pumps providing 3350 gpm; the cooling water loop can circulate 2553 gpm using two 50 hp pumps and the heating water loop is circulated using two 25 hp pumps that provide 1360 gpm. All circulating pumps have 100% redundancy. Well field headers are located in the basement of the plant and balancing valves are installed for each thermal loop segment. The system includes air/dirt separators for both the well field loops and the thermal distribution loops. Removing excess air from the piping systems reduces pumping energy. The electrical switchgear equipment allows the plant and detention facility to transfer from utility service to isolated operation in an emergency situation. The plant can be remotely monitored from any of the three other DEC thermal plants and LES' Rokeby Generating Station (where the DEC operating staff are located).

Heat Pump Technology

The CADF thermal system consists of 26 (five banks of five units plus one additional used to supplement domestic hot water production), 70-ton Multistack water-to-water heat pump units (WWHPs). The nominal combined capacity of the system is 1,820-tons. Each heat pump bank contains ten Copeland screw compressors that operate in 5 stages. The 25 WWHPs located in the thermal plant serve the four-pipe distribution system, allowing for high diversity mixed heating and cooling loads to be met efficiently. Typical peak summer operation is anticipated to utilize three banks of WWHPs (up to 1,050 tons) for cooling, one bank (350 tons) for space heating or re-heat, and one bank as a backup. As the heating load increases, some of the heat pump banks switch from cooling operation to heating operation, but the four-pipe system always allow for simultaneous heating and cooling service to be provided.

The final WWHP, located in the detention facility, is dedicated solely for domestic hot water (DHW), serving an independent DHW loop separate from the thermal plant heat pumps. The DHW heat pump was not part of the grant scope; however the energy used from the geothermal loop for the DHW system, supply and return loop water temperatures and flow will be provided in the monitoring data.

Domestic Hot Water Heat Pump System Study

The energy modeling completed by the detention facility's architectural engineer estimated domestic hot water peak energy consumption of 5.7 MMBtu/hour, with an annual usage of 14,241 MMBtu/year (based on 1000 bed occupancy). This energy use is equivalent to 123% the estimated space heating requirements of 11,550 MMBTU/year. The building energy modeling also indicated the overall space conditioning requirements will be cooling load dominated, on an annual basis. With the system being cooling load dominated the geothermal well field temperature will trend up over time. One approach to address the temperature issue is improving the system's thermal balance by adding heating load. Therefore, the District Energy Corporation (DEC) working with Farris Engineering and Clark Enersen Partners evaluated the economics and operational benefits of integrating the domestic hot water system with the DEC's geothermal system.

The evaluated domestic hot water system (HWS) consisted of three stages. The first two stages would use heat exchangers connected to the DEC hot water supply and return loops. This arrangement would bring the city water service from 55 °F to approximately 115 °F. The final temperature rise to 140-145 °F would be accomplished with a water source heat pump. The heat pump operates on the chilled water loop when the jail requires space cooling (approximately 4600 hr./yr.) and ties directly to the DEC geothermal loop field during the remainder of the time. Energy savings of at least 35% are projected by using the geothermal system for domestic hot water production. The domestic hot water system will remove heat energy from the geothermal system, significantly improving the geothermal system's energy balance. This will improve overall thermal system efficiency and reduce the electrical demand of the DEC Central Plant system. The central plant benefits have not been quantified for this analysis.

A dedicated heat recovery heat pump heats the domestic hot water from approximately 115 °F to 140 °F. While operating on the chilled water return loop (with an entering loop water temperature of 52 °F and a leaving water temperature of 42 °F) the heat pump would have a COP of approximately 5.7. Assuming the heat pump had a monthly 33% capacity factor. The demand component of the electric costs would be determined by dividing the demand charge, $16.20/kW, by 240 hours, which is approximately one-third of the month. The electrical demand charge would add approximately $0.0675/ kWh to the energy cost ($16.20/240 hours). The total domestic hot water heating cost for the DEC based system would be $0.0975/kWh ($28.04/MMBtu) for a summer month. Using a COP of 5.7 and an 80% efficient gas water heater this would be equivalent to $3.94/MMBtu for natural gas. Obviously, the heat pump needs to be controlled by the detention facility's building management system so that heat pump operation does not increase the detention facilities monthly electrical demand charge. And it is only operated when the unit would have a monthly capacity factor of 33% or greater. When operated without increasing the jail's monthly electrical demand charge the equivalent price for heating the water with the geothermal heat pump is less than $2.35/MMBtu. The current DEC estimate for "burner tip" delivery of natural gas in 2013 is between $6 and $7/MMBtu.

The additional capital cost for the system was approximately $200,000. The estimated energy savings from the DEC connected domestic hot water system is $65,000 per year. The system is expected to save the County $1.7 million in energy costs over the first twenty years of operation. It has a simple payback of 3 years and a net present value of $798,000 in the first twenty years[2]. There would also be energy savings incurred by the DEC due to the central plant equipment operating more efficiently with the

[2] Study assumed 2011 natural gas price of $8.00/MMBtu, 14,241 MMBtu/yr. domestic hot water requirements and 80% efficient natural gas boiler.

lower well field loop temperature. Ultimately these savings would also be realized by the County in the form of lower space conditioning energy costs. A better balanced system would also delay and reduce the need for future well field conditioning due to the energy imbalance. The jail facilities installed natural gas water heaters for back up and peak shaving operation.

The DEC is currently coordinating domestic hot water system operation with the detention facility building automation control system vendor. Since the domestic hot water system equipment is located with-in the detention facility it was decided the jail maintenance staff take responsibility for the system's maintenance.

Environmental Permitting

Since the project disturbed more than 1 acre of land a Storm Water Pollution Prevention Plan was required. In addition, since the geothermal well field is constructed in wetlands a 404 Wetlands Permit was required. Due to rigorous erosion control and good general site management procedures there were no violations of either permit during construction of the well field or thermal plant facilities. The emergency generators require an air permit and since the site was one contiguous property under the control of one entity, the County, the DEC air permit needed to include the emissions of the detention facility's backup, domestic hot water natural gas boilers.

Project Schedule

The DEC plant reached the substantial completion milestone in December 2011 and began providing thermal service to the detention facility in January 2012 when the building's HVAC system was ready to accept heating service. The project was substantially complete and providing thermal services ahead of the schedule provided in the grant application. The plant reached commercial operating status on August 1, 2012. However, due to construction delays, the detention facility was not occupied until September of 2013.

Key Milestone Dates:
Detention Facility Project Approved by Lancaster County Board: July 2007
Feasibility Study for HVAC system completed: October 2008
Thermal Conductivity Testing Completed: December 2008
Begin Engineering Design Activities: April 2009
Thermal Service Agreement Signed with County: October 2009
Begin Construction Well Field: May 2010
Began Construction of Thermal Plant: May 2010
Began Providing Construction Heating to detention facility: January 2012
Completed Construction of Well Field: January 2012
Completed Construction of Thermal Plant: March 2012
Plant Reached Commercial Operations Status: July 2012

Project Cost Breakdown

Total project costs of $16.9 million were approximately $3.2 million less than the estimate provided in the grant application. The original project cost estimates were based on engineering estimates developed by Farris Engineering in consultation with the DEC. The DEC did not have any of the work bid

at the time of the grant application. The reduction in project costs were primarily due to favorable construction material prices as well as strong competition in the local construction contractor market. The County also experienced the same beneficial construction market for the detention facility. The engineering estimate for the detention facility was $84.5 million but the actual bid was for $65 million. Costs associated with the emergency electrical generating system were tracked separately since those costs were not eligible for grant matching funds. Tax free municipal bonds were issued by the DEC to fund the project.

Table 1: DEC County Adult Detention Facility Project Expense Detail

Description	Cost
Preliminary Design Costs	$52,644.68
Design Backup Power System	$551,515.73
Design Geothermal System	$144,412.87
Purchase and Construction Backup Power System	$5,220,855.07
Capital Purchases Heat Pumps	$1,224,120.90
Construction Geothermal Plant	$6,252,667.05
Construction Geothermal Well Field	$1,800,900.00
External Consultant Geothermal System	$1,018,006.61
Construction Management Geothermal System	$569,312.75
Project Finance Geothermal System	$23,299.29
Project Finance Backup Power System	$22,739.75
Total Cost Project Direct Costs	$16,880,474.71
Thermal System Costs Eligible for Reimbursements:	$11,691,133

Plant Operations to Date

Even though the DEC facility began providing construction heating and cooling service in January 2012, due to construction delays the detention facility wasn't "occupied" until September 2013. The DEC began providing operational data to DOE contractor on 1/1/13 and will continue providing data until 1/1/16. Since the facility has been occupied 43,286 MMBtu of thermal energy has been supplied by the DEC geothermal heat pump system. Thermal heating energy consumption by the detention facility is trending noticeable higher than building modeling predicted. The DEC is working with the Department of Corrections staff to identify potential causes and evaluate solutions. One item that certainly contributed to the higher usage is the CADF is still in the process of commissioning air exhaust energy recovery systems. Higher than anticipated use of geothermal based snow melt systems may also be a contributing factor to the higher usage. DEC staff is working with detention facility staff and vendors to optimize the operation of the domestic hot water system.

Currently he plant operates under a "heating rate" tariff that has a lower energy rate during the October thru May period but a higher energy rate during the June thru September period and no peak demand charge. After additional operating data is available, the DEC will evaluate if changing to a "large light & power" tariff, which has lower energy rates all year but includes an electrical demand component (with a ratchet), provides an economic benefit.

Finally, the distribution piping system was extended in the fall of 2013 to provide service a new 18,000 square foot building located on the site which will house inmate work training programs and warehouse facilities.

Awards, Publications and Conference Presentations

Quarterly presentations were made the DEC Board during the design and construction phases of the project. The project's design firm, Farris Engineering, received the American Council of Engineering Companies 2013 Merit Award for the design of the SW 40th Street Thermal Plant.

APPENDIX

MONITORING AND ANALYSIS PLAN

A MONITORING PLAN FOR
AMERICAN RECOVERY AND REINVESTMENT ACT OF 2009 (ARRA)
GROUND SOURCE HEAT PUMP TECHNOLOGY
DEMONSTRATION PROJECTS

GSHP SITE 15
DISTRICT ENERGY CORP.
SW 40TH STREET
THERMAL ENERGY PLANT

January 2012

Submitted to:

Oak Ridge National Laboratory
Subcontract 4000101053

Submitted by:

Adam Walburger
Sue Perriello
CDH Energy Corp
PO Box 641
2695 Bingley Rd
Cazenovia, NY 13035
315-655-1063

Project Team:

Principal Investigator:

Tom Davlin
LES
tdavlin@les.com

Project Manager:

Tom Davlin, P.E.
Manager Project Engineering
LES
tdavlin@les.com
402-473-3399

Controls:

Tanner Rousselle
LES
trousselle@les.com
402-473-3375

Scott Koehler
LES
skoehler@les.com
402-473-3379

Monitoring and Analysis Plan ARRA GSHP Site 15 – District Energy

Introduction

This document describes the heat pump system configuration, and monitoring and data collection used to characterize the ground source heat pump (GSHP) system installed at District Energy Corporation's thermal energy plant at the Lancaster Co. Adult Detention Facility (CADF) in Lincoln, NE. The detention facility is a 270,000 square foot, 750-800 bed, secured facility. The GSHP system is located in a separate thermal energy plant that provides hot and chilled water for the detention facility's space heating air handling system, radiant flooring heating systems, and space heating for the thermal energy plant. The geothermal well field and dedicated heat pump is also used for the detention facility domestic hot water pre-heating system. The GSHP system operates to displace a conventional boiler/chiller HVAC system at the facility.

System Description

The GSHP system at this facility consists of 25 - 70-ton Multistack water-to-water heat pump units (WWHPs) plus on bank of 3, 50 ton Multistack water-to water heat pumps used for domestic hot water preheating. The nominal combined capacity of the system is 1,900-tons. The 25 WWHPs (five banks with five units per bank) for space conditioning serve a four-pipe system, allowing for high diversity mixed heating and cooling loads to be met efficiently. Typical peak summer operation is anticipated to utilize three banks of WWHPs (up to 1,050 tons) for cooling, one bank (350 tons) for space heating or re-heat, and one bank as a spare. As the heating load increases, WWHP capacity switches from cooling operation to heating operation, but the four-pipe system will always allow for cooling capacity to be provided.

The 150 ton WWHP is dedicated to domestic hot water (DHW) production, serving an independent DHW loop from the space conditioning heat pumps. The domestic hot water system is also configured to allow the detention facility to use either the geothermal loop field or the chilled water return loop as the heat source for the DHW WWHP. The DHW heat pump was not part of the grant scope; however the energy used from the geothermal loop for the DHW system, supply and return loop water temperatures and flow will be provided in the monitoring data.

On the ground loop side of the WWHPs, the heat pumps are piped in parallel to a vertical bore geothermal well field consisting of 667 bores each approximately 300-feet deep, for a total of 200,100 bore-feet and a normalized bore depth of 105 bore-feet/ton. Based on the anticipated operation of the system for the design cooling load of 1,050 tons, the normalized bore depth increases to 228 bore-feet/ton. Continuous heat extraction for DHW production and space heating operation are expected to moderate the ground loop temperatures during peak heat rejection (cooling) periods.

The ground loop system is circulated by two 75 hp pumps (one primary and one backup) each providing 3350 gpm; the cooling water loop can circulate 2550 gpm using two 50 hp pumps (one primary and one backup) and the heating water loop is circulated using two 25 hp pumps that provide 1350 gpm. All circulating pumps have 100% redundancy and are controlled by variable frequency drives (VFD).

Figure 1 displays a basic schematic of the GSHP system, along with the location of the data points to be monitored for ongoing performance monitoring.

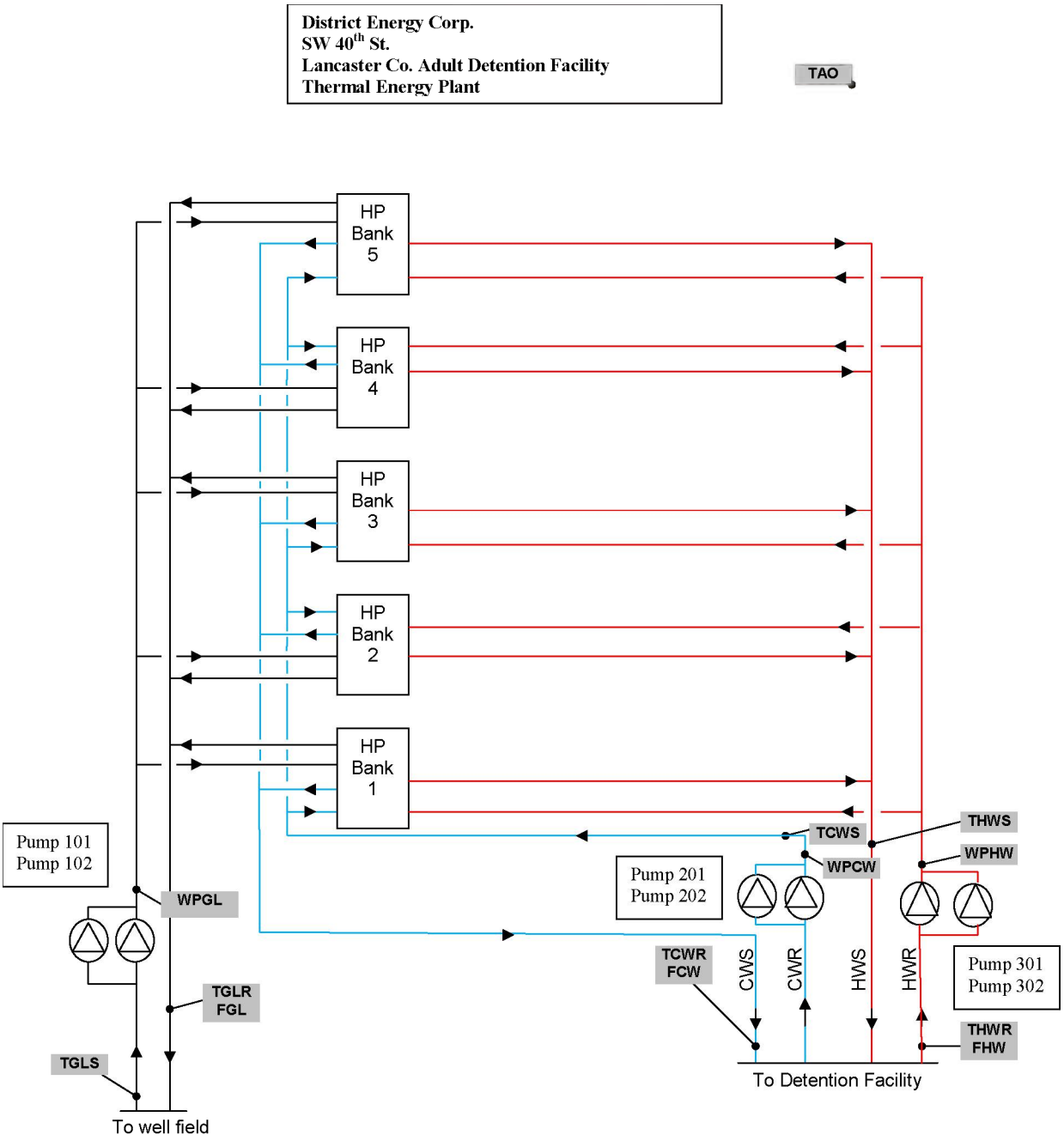


Figure 1. District Energy GSHP System Schematic with Monitoring Points

Figure 12 displays a basic schematic of the DHW part of the GSHP system, along with the location of the data points to be monitored for ongoing performance monitoring.

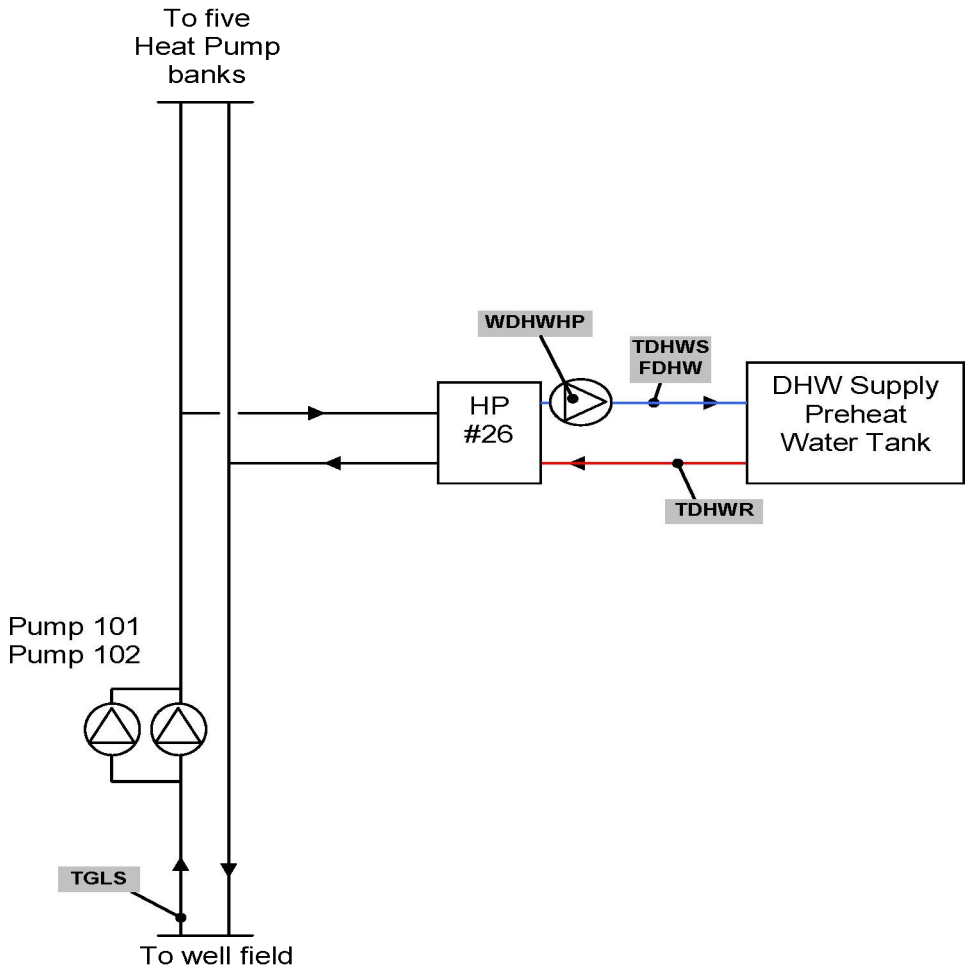


Figure 2. District Energy DHW GSHP System Schematic with Monitoring Points

Data Collection

Performance monitoring and data collection for the WWHPs system will be provided by the District Energy Corporation using the on-site Wonderware SCADA system. The SCADA system will poll the sensors once per 10 seconds and provide 15-minute totals or averages of each sensor depending on the sensor type. The data records will be recorded in a column oriented, comma delimited file (CSV format) along with a corresponding date/time stamp for the data record. The data file will be transmitted to the FTP site quarterly.

Table 1. District Energy Monitored GSHP Data Points we are investigating how we can get heat pump electrical usage data

District Energy GSHP Monitoring Points				
No.	**Data Point**	**Description**	**Units**	**Sensor**
1	TGLS	Ground Loop Supply Temperature	deg F	RTD[1]
2	TGLR	Ground Loop Return Temperature	deg F	RTD
3	FGL	Ground Loop Flow	GPM	Impeller[2]
4	THWS	Supply Temperature Hot Water	deg F	RTD
5	THWR	Return Temperature Hot Water	deg F	RTD
6	FHW	Flow Hot Water	GPM	Impeller
7	TCWS	Supply Temperature Chilled Water	deg F	RTD
8	TCWR	Return Temperature Chilled Water	deg F	RTD
9	FCW	Flow Chilled Water	GPM	Impeller
10	TDHWS	Supply Temperature Domestic Hot Water	deg F	RTD
11	TDHWR	Return Temperature Domestic Hot Water	deg F	RTD
12	FDHW	Flow Domestic Hot Water	GPM	Impeller
13	WPGL	Ground Loop Pump 101 Power	kWh	VFD[3]
14	WPGL	Ground Loop Pump 102 Power	kWh	VFD
15	WPHW	Hot Water Loop Pump 301 Power	kWh	VFD
16	WPHW	Hot Water Loop Pump 302 Power	kWh	VFD
17	WPCW	Chilled Water Loop Pump 201 Power	kWh	VFD
18	WPCW	Chilled Water Loop Pump 202 Power	kWh	VFD
19	WDHWHP	Domestic Hot Water Pump Power	kWh	VFD
20	TAO	Ambient Temperature	deg F	RTD
21	WT	Total Power District Energy Thermal Energy Facility	kWh	Meter[4]
22	WP	Total Power Generated	kWh	Switchgear[5]

1. Pyromation 100 ohm RTDs connected to an AB SLC500 RTD Input Module
2. Data Industrial Flow meters (Impeller flow sensors)
3. Variable Frequency Drive output
4. Plant electrical service utility meter
5. Emergency generators' switchgear panel meters

Calculations from Monitored Data

Using the data collected, the following quantities of system performance can be determined.

Heat extracted (cooling operation) by WWHPs:

$Q_C = 500 \times FCW \times (TCWS-TCWR) /1000\times 15 \text{ min} \div 60 \text{ min/h}$

Where:

Q_C	= Heat extracted from chilled water loop (MBtu)
FCW	= Chilled water loop flow rate (GPM)
TCWS	= Chilled water supply temperature to facility (°F)
TCWR	= Chilled water return temperature from facility (°F)

Heat supplied (heating operation) by WWHPs:

$Q_H = 500 \times FHW \times (THWS-THWR) /1000 \times 15 \text{ min} \div 60 \text{ min/h}$

Where:

Q_H	= Heat supplied to hot water loop (MBtu)
FHW	= Hot water loop flow rate (GPM)
THWS	= Hot water supply temperature to facility (°F)
THWR	= Hot water return temperature from facility (°F)

Heat supplied (heating operation) by WWHPs to the DHW loop:

$Q_{DHW} = 500 \times FDHW \times (TDHWS-TDHWR) /1000 \times 15 \text{ min} \div 60 \text{ min/h}$

Where:

Q_{DHW}	= Heat supplied to DHW loop (MBtu)
FDHW	= DHW flow rate (GPM)
TDHWS	= DHW supply temperature to building (°F)
TDHWR	= DHW return temperature to building (°F)

Net heat transfer to the earth through the ground loop:

$Q_{GL} = 500 \times FGL \times (TGLS-TGLR) /1000 \times 15 \text{ min} \div 60 \text{ min/h}$

Where:

Q_{GL}	= Heat Transfer through Ground Loop (MBtu) (Heat rejected MBtu < 0, Heat extracted MBtu >0)
FGL	= Ground Loop (Well Field) Flow (GPM)
TGLS	= Ground Loop (Well Field) Return Temperature (°F)
TGLR	= Ground Loop (Well Field) Supply Temperature (°F)

Heat pump energy in heating mode:

$WHP_{Heat} = (Q_H + Q_{DHW} - QGL_{Extracted})/ 3.413$

Where

Q_H	= Heat supplied to hot water loop (MBtu)
Q_{DHW}	= Heat supplied to domestic hot water loop (MBtu)
$QGL_{Extracted}$	= Heat extracted from the ground loop (MBtu)

Heat pump energy in cooling mode:

$WHP_{cool} = (QGL_{Rejected} - Q_C)/ 3.413$

Where

Q_C = Heat extracted from chilled water loop (MBtu)

$QGL_{Extracted}$ = Heat extracted from the ground loop (MBtu)

WWHP Heating Efficiency:

$COP_H = Q_H / ((WHP_{Heat}+WPHW+ WPDHW +WPGL_{\%Heat}) \times 3.413)$

Where:

WHP_{Heat} = Calculated heat pump energy in heating mode (kWh)

WPHW = Measured hot water circulating pump energy (kWh)

WDHWHP =Domestic hot water circulating pump energy (kWh)

$WPGL_{\%Heat}$ = Ground loop pump energy allocated to heating operation (kWh)

$WPGL_{\%Heat} = WPGL \times (WHP_{Heat} \div WHP_{tot})$

WWHP Cooling Efficiency:

$EER_C = Q_C / (WHP_{Cool}+WPCW+WPGL_{\%Cool})$

Where:

Q_c = Heat extracted from chilled water loop (MBtu)

WHP_{Cool} = Calculated heat pump energy in cooling mode (kWh)

WPCW = Measured hot water circulating pump energy (kWh)

$WPGL_{\%Cool}$ = Ground loop pump energy allocated to heating operation (kWh)

$WPGL_{\%Cool} = WPGL \times (WHP_{Cool} \div WHP_{tot})$

Proposed Savings Calculation Methodology

To calculate the savings from this GSHP demonstration project, the measured delivered heating, cooling and DHW loads provided by the WWHP units will be used to drive a performance map based model of a conventional system relating input power required to delivered capacity. The performance map model should incorporate variations in performance from changes in ambient conditions. Depending on the completeness of the dataset collected, it may be necessary to relate the measured loads to an independent variable, (such as ambient temperature) to project the load for periods of missing or incomplete data collection.

The conventional system for comparison in cooling operation is a water cooled centrifugal chiller, using a generic performance map of a water-cooled chiller from DOE2.

For heating and DHW operation, the conventional system for comparison is a natural gas fired boiler system, with the comparison made using a generic forced-draft boiler performance map from DOE2. As the GSHP system represents a premium system, comparisons could also be made to a high efficiency condensing boiler system.

DRAFT

The resulting calculation of the baseline system energy consumption should be performed at either an hour-by-hour basis, or simplified using a bin calculation. Energy savings are derived by the difference in measured energy for the GSHP system, and the projected energy consumption of the baseline system from the performance map model. The savings calculation does not evaluate any difference in the primary/secondary pumping energy, as the distribution components are assumed to operate equally in both the GSHP system and baseline systems.

To account for the ground loop pumping energy contribution to the GSHP system, it is necessary to separate the loop pumping energy into periods corresponding to WWHP heating and WWHP/Chiller cooling operation. In the baseline heating system comparison, the boiler will have no energy consumption that corresponds to the WWHP ground loop pump energy when heating operation occurs. In the baseline cooling system comparison, a cooling tower performance model will be used to relate input power to heat rejection load on a BTU/Wh basis. The cooling tower performance model can utilize relations from DOE2 and be evaluated on an hour-by-hour basis, or a simplified kW/ton heat rejection number can be assigned to the baseline system. The annualized heat rejection energy of the two systems (GSHP rejected to ground loop, baseline chiller system rejected to ambient) will be compared as a further component of GSHP energy savings.

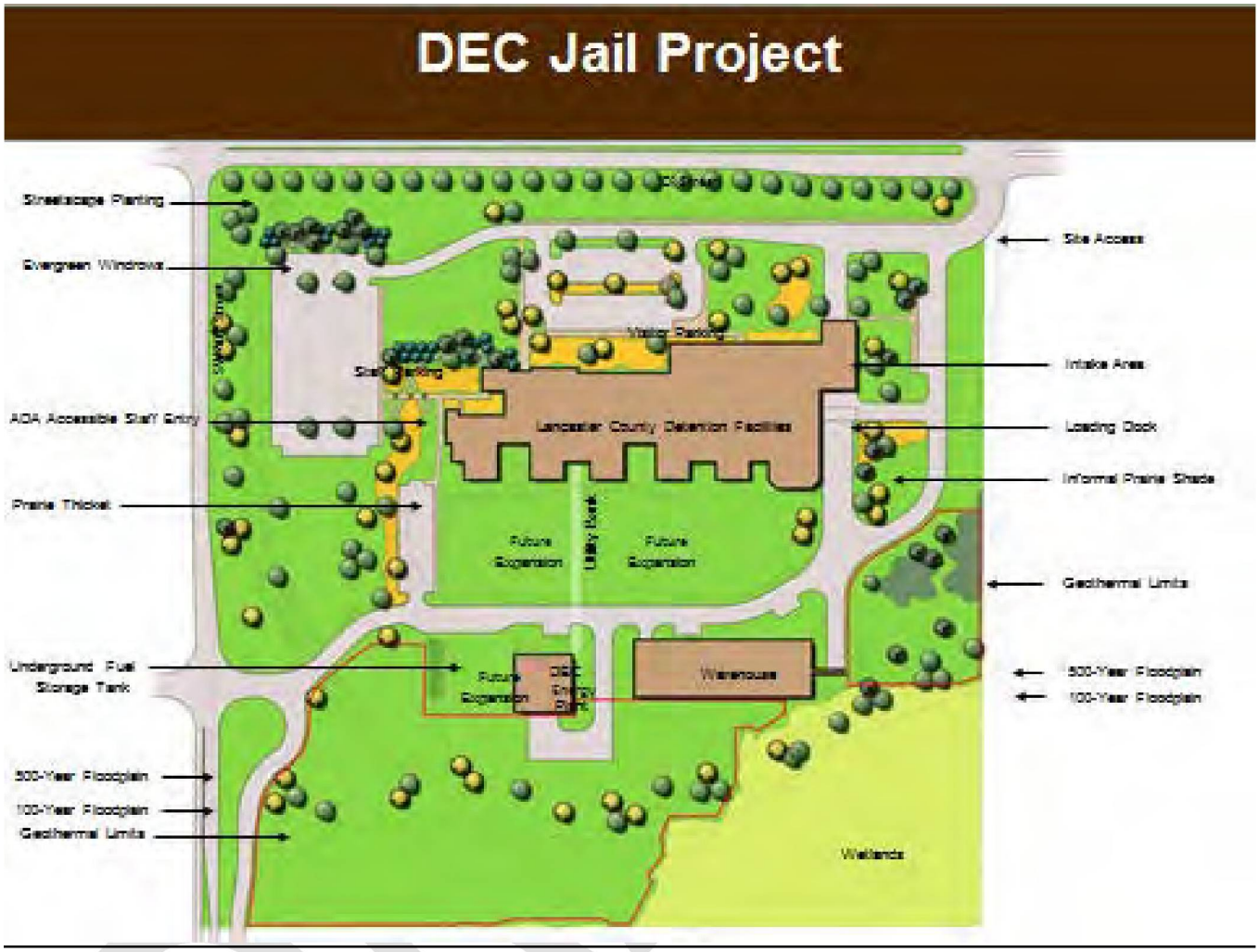
Finally, because the baseline heating system requires fuel switching to natural gas, cost savings using a standardized utility rate (such as either the actual site average utility rate, or the EIA average rate for Nebraska) can be used to convert energy savings to energy cost savings for comparison.

System Operation

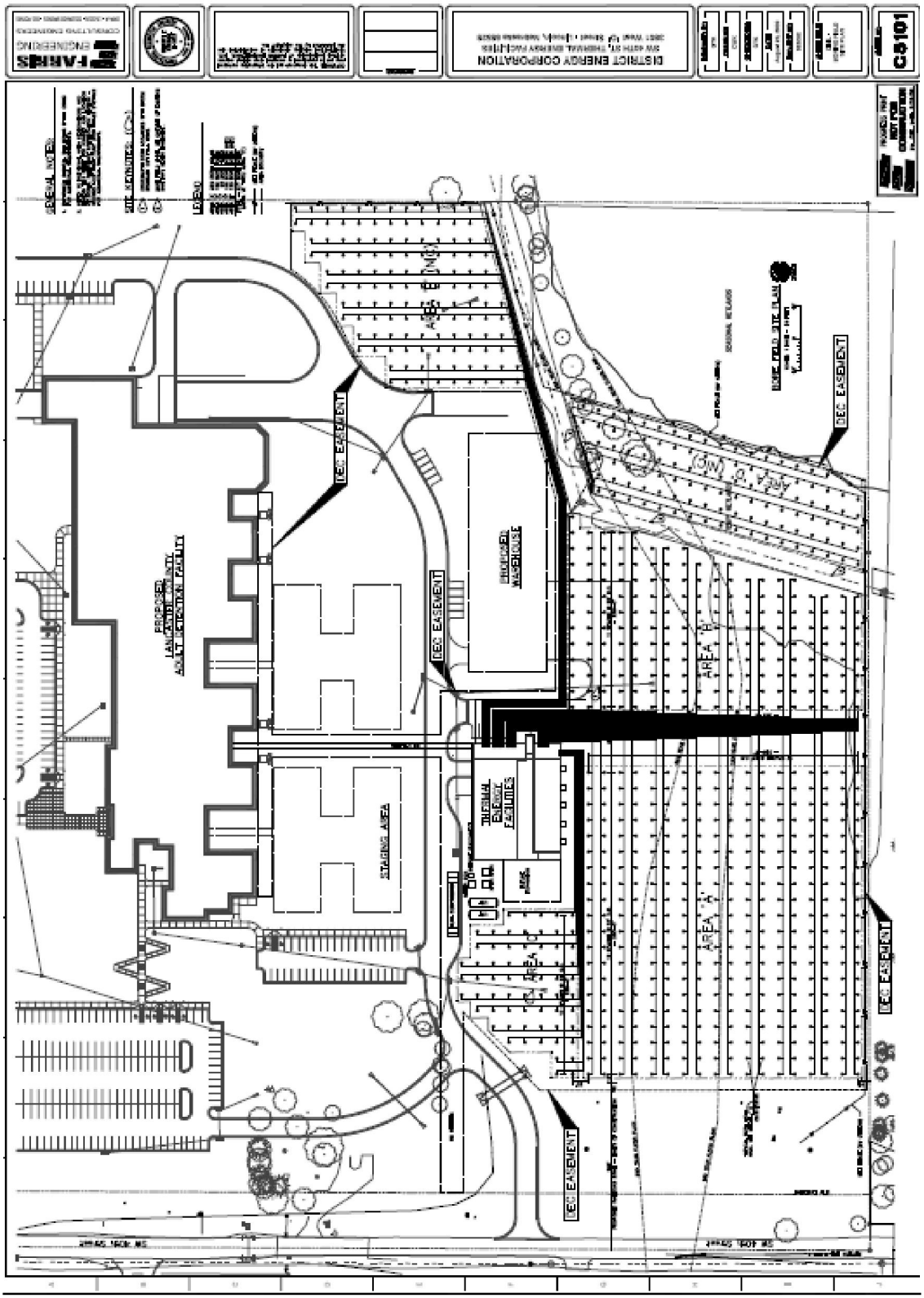
During the period of August 2012 thru March 2014, with the detention facility occupied for the final seven months, the well field supply water temperatures to the heat pumps dropped to a minimum of 39°F and reached a maximum temperature of 68 °F while providing 15,819 MMBtu of cooling energy and 27,467 MMBtu of heating energy. During this period the peak recorded system cooling load was 700 tons and the peak heating load was 8.4 MMBtu. Total project cost of $16.9 million was approximately $3.2 million less than the original budget estimate. The reduction in project costs were primarily due to favorable construction material prices as well as strong competition in the local construction contractor market.

DRAFT

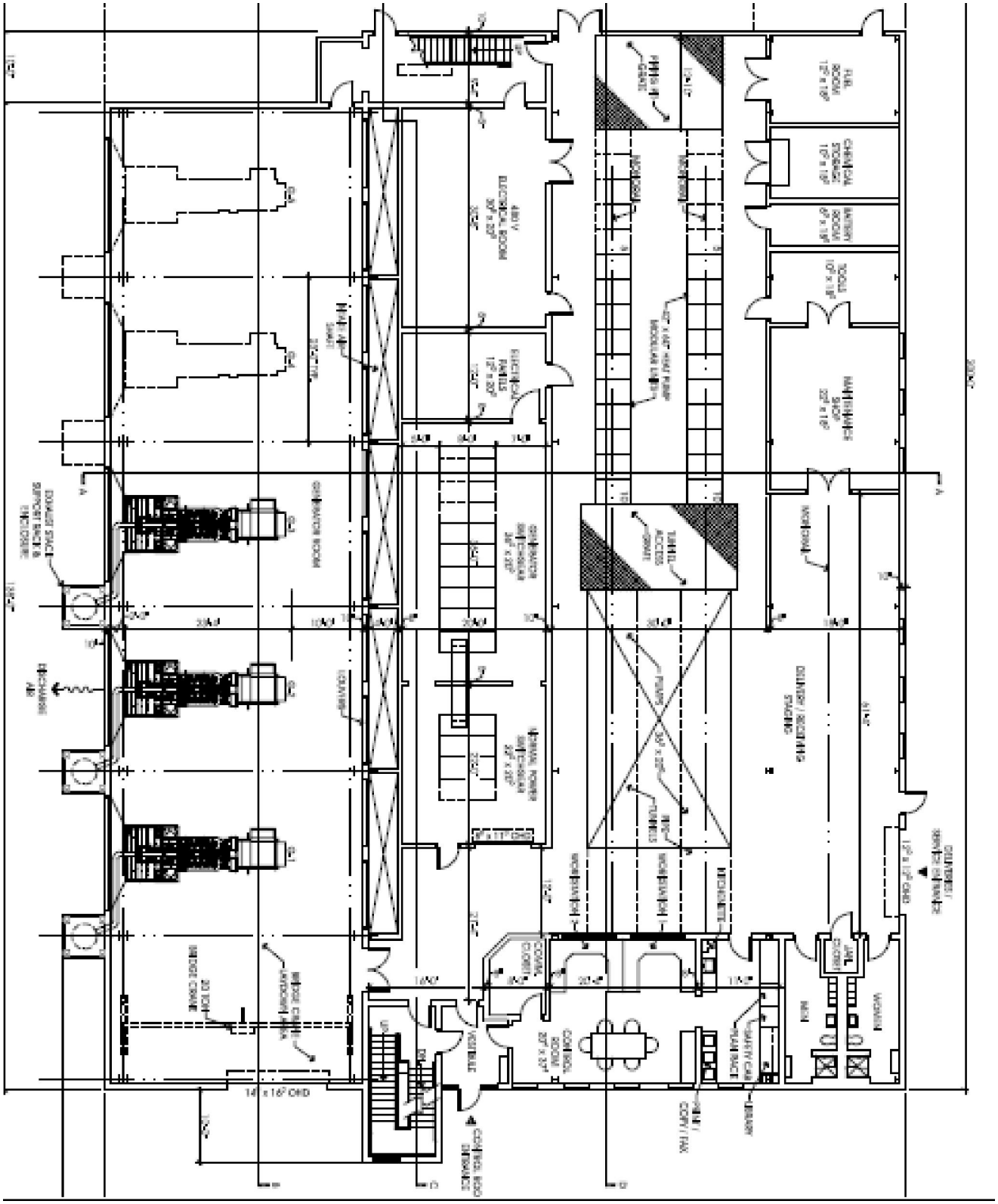
Figure 1 Site Layout for SW 40th Street Thermal Energy Plant S



Drawing 1: Site Layout with Well Field loop configuration



Drawing 2: Thermal Plant General Arrangement



your energy partner
OPPD
Omaha Public Power District

444 South 16th Street Mall
Omaha NE 68102-2247

December 22, 2008

District Energy Corporation
Mr. Byron Bakenhus
1040 O Street
Lincoln, NE 68508

Dear Mr. Bakenhus:

SUBJECT: Thermal Conductivity Test for the Lancaster County Correctional Facility

The Commercial and Industrial Energy Solutions Department has completed the ground thermal conductivity test for the Lancaster County Correctional Facility project located near Southwest 40th and West M Street in Lincoln, NE. The test results are essential design input to size the geothermal loop heat exchanger (GLHE) properly for this project. OPPD performed the test on a 305-feet deep test loop installed by LoopTech International. The attached well drilling log indicates the soil formations encountered. The on-site testing was performed for 72.0 hours from 12/16/08 until 12/19/08.

The calculated thermal conductivity of the ground (Kg) at this test bore location is 1.56 Btu/hr-ft-°F.

The ground thermal diffusivity can be estimated from published data and the actual test well log report. For this test well, the thermal diffusivity is estimated to be 1.34 ft^2/day.

The best approximation for an undisturbed soil temperature is 53-57° F based upon published annual earth temperatures near the site. The initial loop water temperature was approximately 55.0° F during our test. I recommend consideration of a higher ground temperature for cooling design and a lower ground temperature for heating design due to potential ground water movement, which can create variations in deep-earth temperature throughout the year.

Attached is the raw data gathered from the 72.0-hour test. The data is provided in tabular and graphical formats for your review. Approximately 6,002 watts (20,499 Btu per hour) of heat was continuously added to the test loop during the 72.0-hour test. At the end of the test, the water temperature was approximately 92.1°F going into the ground and 83.9°F coming out of the ground.

The results of this test must be properly used to size the GLHE. The following cautions should be read before applying this data.

Design Cautions:

1. When designing the GLHE, the borehole backfill material becomes very important and affects the overall thermal conductivity, thus loop performance. The thermal conductivity determined by this test is for the **ground only** and does not include the effect of the borehole construction.

2. Bore hole construction (e.g. the diameter of the bore hole, diameter of the pipe loop, pipe loop material, and the type of backfill material) may impact the overall thermal conductivity of the heat exchanger and must be incorporated into the GLHE sizing calculations.

3. The calculated ground thermal conductivity is the average conductivity over the entire length of the single borehole tested. Significant changes between the depth of the borehole tested herein and any upcoming actual GLHE installation may result in change in thermal conductivity. Reference the attached test well log.

4. Changes in soil conditions may influence the overall thermal conductivity. Changes in soil conditions may be the result of variations in subsurface moisture content, change in pipe loop length from that used in the test loop, and/or changes in geological materials.

If you have any questions or need further information, please call me at (402) 636-3507.

Sincerely,

Timothy S. Rauscher, P.E., C.E.M.
Supervisor - Commercial & Industrial Energy Solutions

Encl.

cc: OPPD Project Files

DOWNEY DRILLING INC

402 NORTH GRANT, LEXINGTON, NE 68850
308-324-2303

TEST HOLE LOG & WELL DESIGN

DEC JAIL FACILITY
NWNW 29-10-6E
LANCASTER CO.
GPS: N 40 48 38.665
W 96 46 36.025

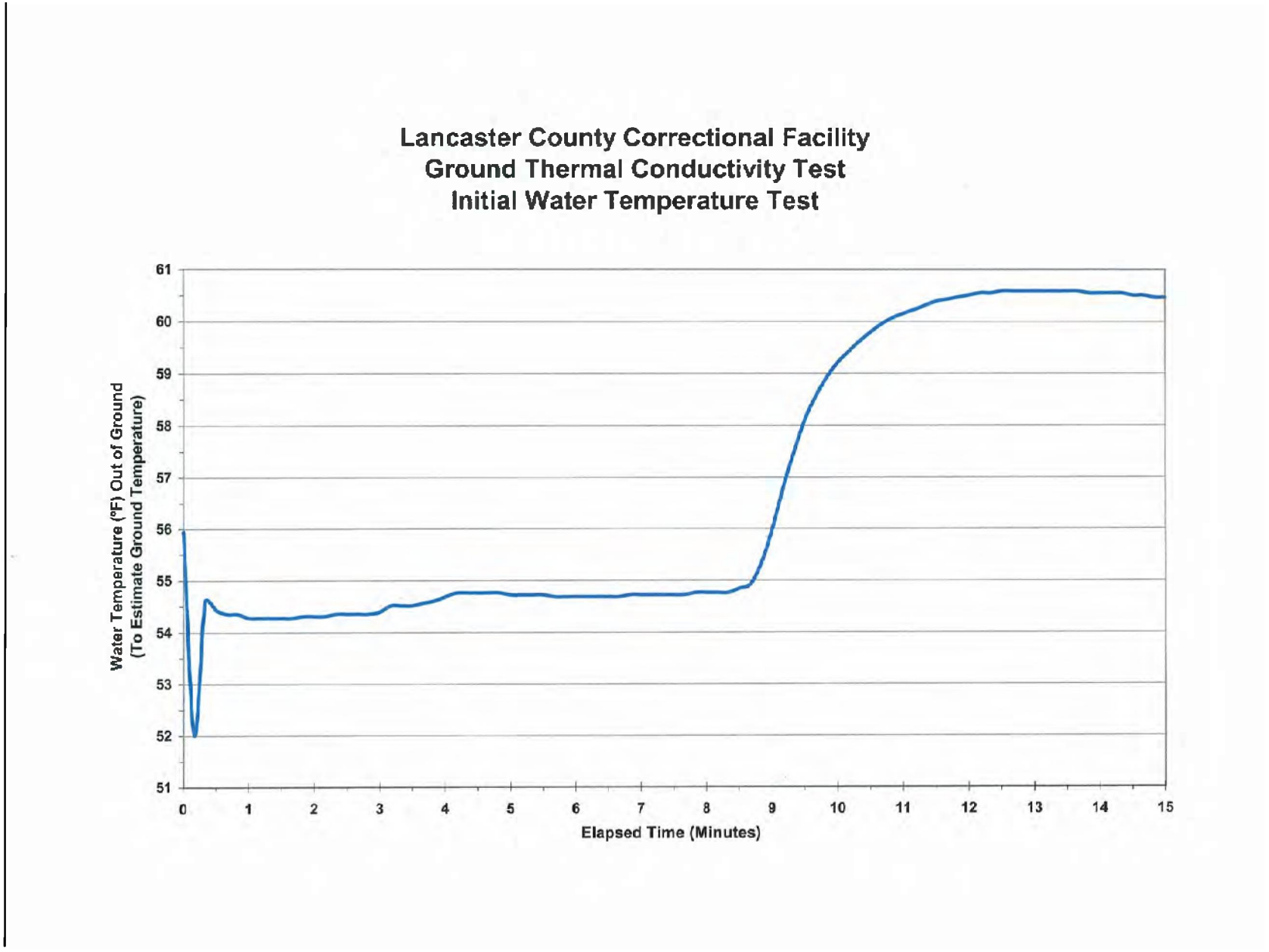
FT	DESCRIPTION
0-6	TOPSOIL
6-14	BROWN CLAY
14-47	GRAY CLAY (SHALE)
47-54	FINE GRAVEL
54-60	SANDY BROWN CLAY, SANDY SILT
60-80	FINE SAND, SANDY CLAY
80-100	FINE SAND, SANDY BROWN CLAY
100-121	GRAY CLAY (SHALE)
121-140	FINE SAND
140-148	FINE SAND, TRACE CLAY
148-160	WHITE FINE SAND
160-180	FINE SAND
180-196	MEDIUM-COARSE SAND, TRACE FINE GRAVEL
196-220	WHITE SANDY SILT
220-246	WHITE SANDY SILT, FINE SAND
246-260	GRAY CLAY (SHALE)
260-276	HARD RED CLAY
276-305	SEMI HARD GRAY CLAY (SHALE)

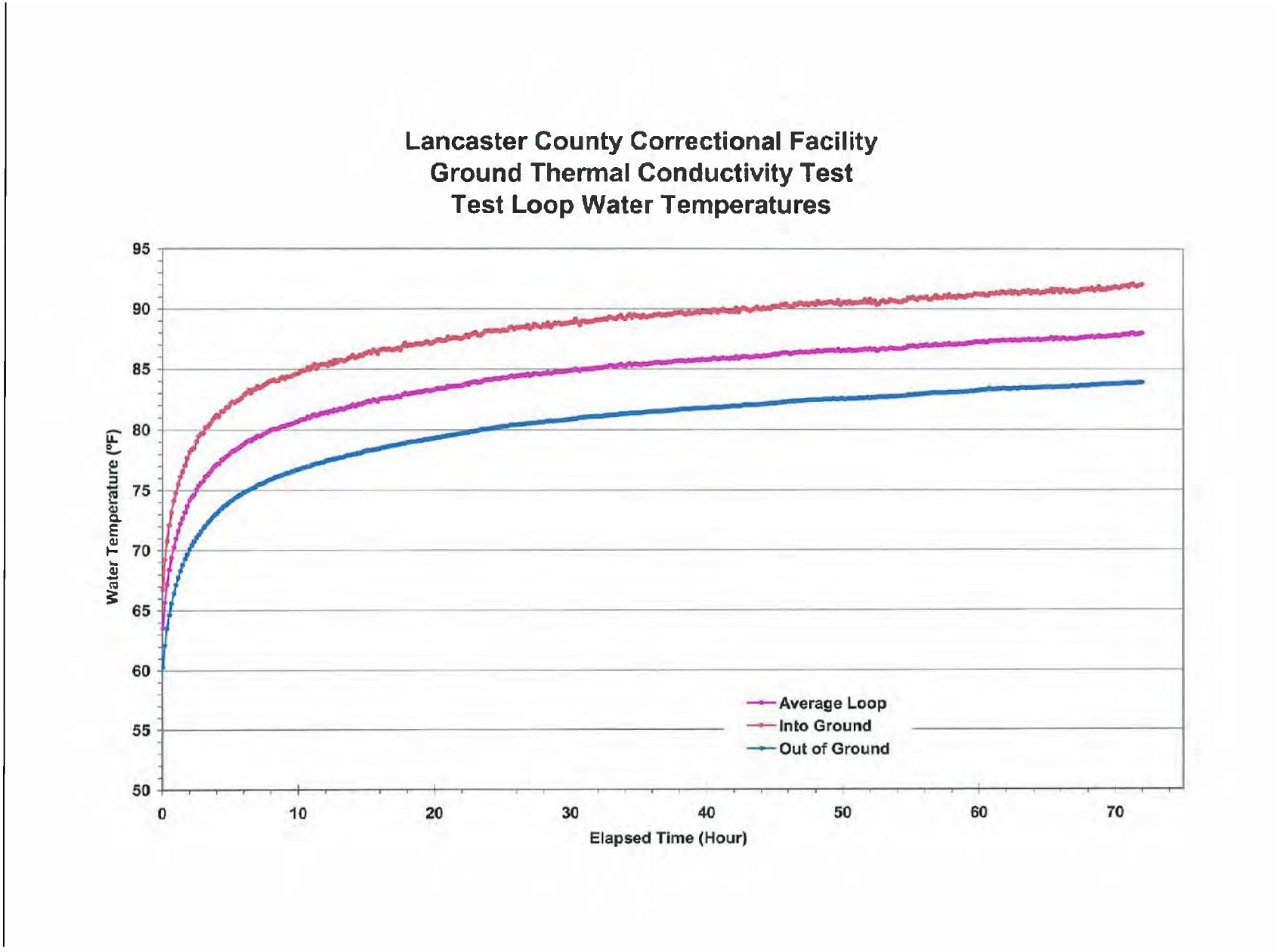
WELL DESIGN

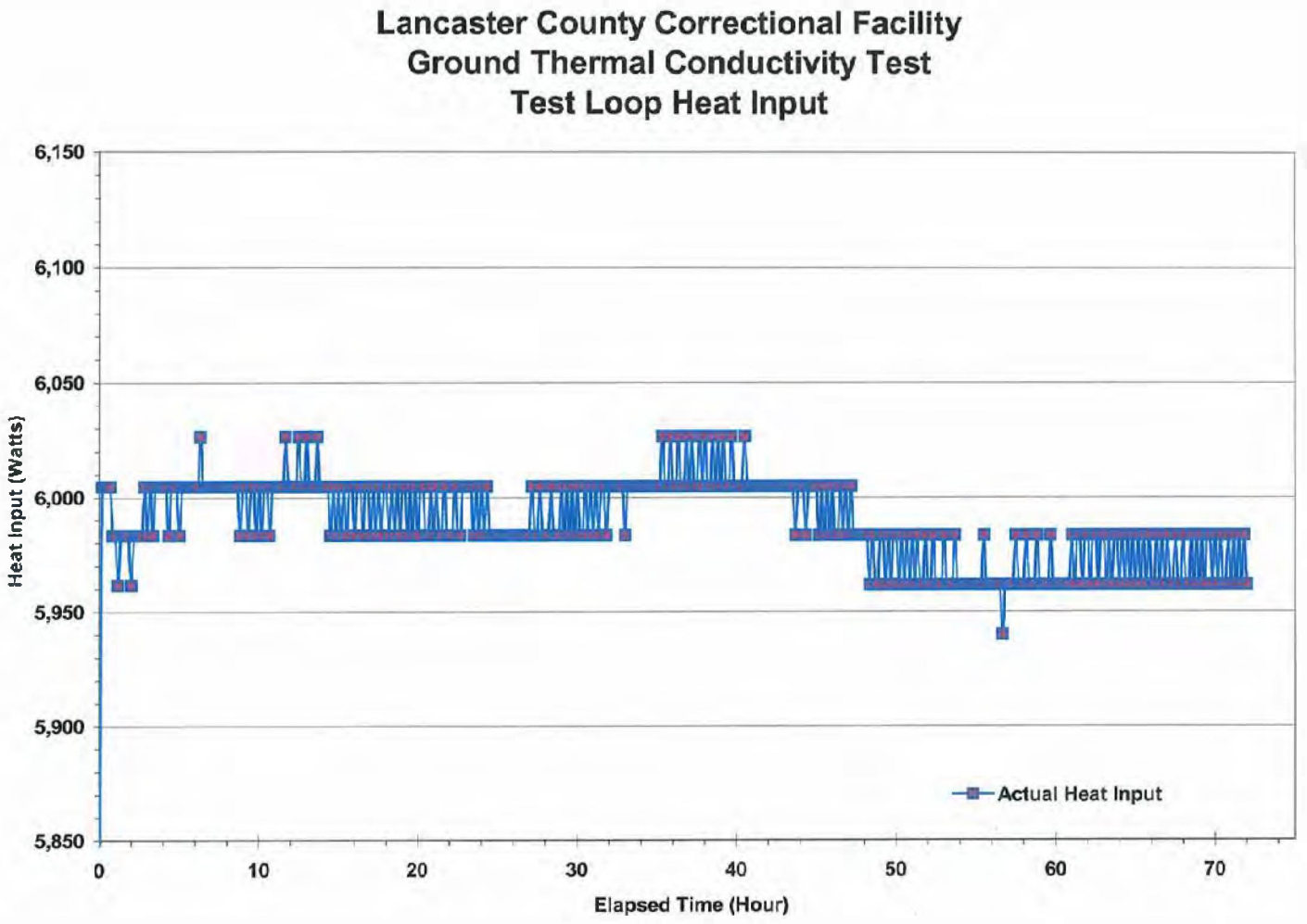
DATE: 11-21-08 DRILLER: TOM, JAKE, AARON
DRILLING METHOD: _____ DEPTH: 305'

CASING TYPE: CENFUSE DIA: 1" LENGTH: 305' SDR: 11
INTERVALS: 0-30 TRADE NAME: _____

GROUT SEAL USED: 40/30 SAND - 4 PARTS INTERVALS: _____
TGL - 1 PART
SWL: _____ PWL: _____ GPM: _____


Lancaster County Correctional Facility
Ground Thermal Conductivity Test
Initial Water Temperature Test
Water Temperature (°F) Out of Ground
(To Estimate Ground Temperature)
61
60
59
58
57
56
55
54
53
52
51
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Elapsed Time (Minutes)


Lancaster County Correctional Facility
Ground Thermal Conductivity Test
Test Loop Water Temperatures
Water Temperature (°F)
95
90
85
80
75
70
65
60
55
50
0
10
20
30
40
50
60
70
Elapsed Time (Hour)
Average Loop
Into Ground
Out of Ground


Lancaster County Correctional Facility
Ground Thermal Conductivity Test
Test Loop Heat Input
6,150
6,100
6,050
6,000
5,950
5,900
5,850
Heat Input (Watts)
0
10
20
30
40
50
60
70
Elapsed Time (Hour)
Actual Heat Input

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
					LOGGED DATA INITIALLY TO DETERMINE UNDISTURBED SOIL TEMPERATURE					
	Min.	Approximate Flow Rate			3.0 gpm		Frequency of Samples:		10.0 sec.	
0	0.0	12/16/08	12:28:42 PM	55.95	86.42	0	0	9.5	12.4	71.19
1	0.2	12/16/08	12:28:52 PM	52.02	88.70	1	22	9.5	12.5	70.36
2	0.3	12/16/08	12:29:02 PM	54.60	86.77	0	0	9.6	12.7	70.69
3	0.5	12/16/08	12:29:12 PM	54.43	85.24	0	0	9.7	12.7	69.84
4	0.7	12/16/08	12:29:22 PM	54.35	84.47	0	0	9.8	12.8	69.41
5	0.8	12/16/08	12:29:32 PM	54.35	84.17	0	0	9.7	12.9	69.26
6	1.0	12/16/08	12:29:42 PM	54.27	83.51	0	0	9.8	12.9	68.89
7	1.2	12/16/08	12:29:52 PM	54.27	83.30	0	0	9.7	12.9	68.79
8	1.3	12/16/08	12:30:02 PM	54.27	83.00	1	22	9.7	12.9	68.64
9	1.5	12/16/08	12:30:12 PM	54.27	82.41	0	0	9.7	12.8	68.34
10	1.7	12/16/08	12:30:22 PM	54.27	82.08	0	0	9.8	12.9	68.18
11	1.8	12/16/08	12:30:32 PM	54.31	81.08	0	0	9.8	12.9	67.70
12	2.0	12/16/08	12:30:42 PM	54.31	81.08	0	0	9.8	12.8	67.70
13	2.2	12/16/08	12:30:52 PM	54.31	80.37	0	0	9.8	12.8	67.34
14	2.3	12/16/08	12:31:02 PM	54.35	79.92	0	0	9.8	12.8	67.14
15	2.5	12/16/08	12:31:12 PM	54.35	79.72	0	0	9.8	12.8	67.04
16	2.7	12/16/08	12:31:22 PM	54.35	78.84	1	22	9.8	12.7	66.60
17	2.8	12/16/08	12:31:32 PM	54.35	78.84	0	0	9.7	12.8	66.60
18	3.0	12/16/08	12:31:42 PM	54.39	78.24	0	0	9.8	12.6	66.32
19	3.2	12/16/08	12:31:52 PM	54.51	77.54	0	0	9.8	12.7	66.03
20	3.3	12/16/08	12:32:02 PM	54.51	77.21	0	0	9.8	12.8	65.86
21	3.5	12/16/08	12:32:12 PM	54.51	76.84	0	0	9.9	12.7	65.68
22	3.7	12/16/08	12:32:22 PM	54.56	76.39	0	0	9.9	12.6	65.48
23	3.8	12/16/08	12:32:32 PM	54.60	76.27	0	0	10.1	12.7	65.44
24	4.0	12/16/08	12:32:42 PM	54.68	75.74	1	22	10.1	12.7	65.21
25	4.2	12/16/08	12:32:52 PM	54.76	75.37	0	0	10.1	12.7	65.07
26	4.3	12/16/08	12:33:02 PM	54.76	74.84	0	0	10.1	12.5	64.80
27	4.5	12/16/08	12:33:12 PM	54.76	74.68	0	0	10.1	12.4	64.72
28	4.7	12/16/08	12:33:22 PM	54.76	74.28	0	0	10.1	12.4	64.52
29	4.8	12/16/08	12:33:32 PM	54.76	73.95	0	0	10.2	12.6	64.36
30	5.0	12/16/08	12:33:42 PM	54.72	73.83	0	0	10.2	12.7	64.28
31	5.2	12/16/08	12:33:52 PM	54.72	73.42	0	0	10.3	12.7	64.07
32	5.3	12/16/08	12:34:02 PM	54.72	73.02	1	22	10.3	12.7	63.87
33	5.5	12/16/08	12:34:12 PM	54.72	72.86	0	0	10.3	12.7	63.79
34	5.7	12/16/08	12:34:22 PM	54.68	72.66	0	0	10.3	12.7	63.67
35	5.8	12/16/08	12:34:32 PM	54.68	72.38	0	0	10.4	12.7	63.53
36	6.0	12/16/08	12:34:42 PM	54.68	71.85	0	0	10.4	12.8	63.27
37	6.2	12/16/08	12:34:52 PM	54.68	71.48	0	0	10.3	12.7	63.08
38	6.3	12/16/08	12:35:02 PM	54.68	71.40	0	0	10.2	12.7	63.04
39	6.5	12/16/08	12:35:12 PM	54.68	71.16	1	22	10.1	12.7	62.92
40	6.7	12/16/08	12:35:22 PM	54.68	70.72	0	0	10.1	12.7	62.70
41	6.8	12/16/08	12:35:32 PM	54.72	70.40	0	0	10.1	12.7	62.56
42	7.0	12/16/08	12:35:42 PM	54.72	70.15	0	0	10.2	12.7	62.44
43	7.2	12/16/08	12:35:52 PM	54.72	69.99	0	0	10.2	12.6	62.36
44	7.3	12/16/08	12:36:02 PM	54.72	69.66	0	0	10.3	12.7	62.19
45	7.5	12/16/08	12:36:12 PM	54.72	69.31	0	0	10.3	12.7	62.02
46	7.7	12/16/08	12:36:22 PM	54.72	69.19	0	0	10.3	12.7	61.96
47	7.8	12/16/08	12:36:32 PM	54.76	69.11	1	22	10.3	12.6	61.94
48	8.0	12/16/08	12:36:42 PM	54.76	68.62	0	0	10.3	12.6	61.69
49	8.2	12/16/08	12:36:52 PM	54.76	68.54	0	0	10.3	12.6	61.65
50	8.3	12/16/08	12:37:02 PM	54.76	68.29	0	0	10.3	12.6	61.53
51	8.5	12/16/08	12:37:12 PM	54.84	68.13	0	0	10.3	12.6	61.49
52	8.7	12/16/08	12:37:22 PM	54.92	67.73	0	0	10.3	12.6	61.33
53	8.8	12/16/08	12:37:32 PM	55.33	67.53	0	0	10.2	12.5	61.43
54	9.0	12/16/08	12:37:42 PM	55.99	67.33	0	0	10.2	12.6	61.66
55	9.2	12/16/08	12:37:52 PM	56.81	67.17	1	22	10.2	12.6	61.99
56	9.3	12/16/08	12:38:02 PM	57.50	67.25	0	0	10.2	12.5	62.38

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy Into the Loop System Pulses Read	Energy Into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
57	9.5	12/16/08	12:38:12 PM	58.12	67.09	0	0	10.1	12.4	62.61
58	9.7	12/16/08	12:38:22 PM	58.57	66.84	0	0	10.1	12.4	62.71
59	9.8	12/16/08	12:38:32 PM	58.93	66.80	0	0	10.0	12.5	62.87
60	10.0	12/16/08	12:38:42 PM	59.21	66.72	0	0	9.9	12.6	62.97
61	10.2	12/16/08	12:38:52 PM	59.42	66.56	0	0	9.9	12.5	62.99
62	10.3	12/16/08	12:39:02 PM	59.62	66.52	0	0	9.9	12.5	63.07
63	10.5	12/16/08	12:39:12 PM	59.79	66.52	1	22	9.9	12.6	63.16
64	10.7	12/16/08	12:39:22 PM	59.95	66.44	0	0	9.9	12.5	63.20
65	10.8	12/16/08	12:39:32 PM	60.07	66.27	0	0	9.9	12.4	63.17
66	11.0	12/16/08	12:39:42 PM	60.15	66.11	0	0	9.8	12.5	63.13
67	11.2	12/16/08	12:39:52 PM	60.23	65.92	0	0	9.8	12.6	63.08
68	11.3	12/16/08	12:40:02 PM	60.31	65.88	0	0	9.7	12.5	63.10
69	11.5	12/16/08	12:40:12 PM	60.39	65.80	0	0	9.7	12.4	63.10
70	11.7	12/16/08	12:40:22 PM	60.43	65.60	1	22	9.6	12.6	63.02
71	11.8	12/16/08	12:40:32 PM	60.47	65.60	0	0	9.6	12.5	63.04
72	12.0	12/16/08	12:40:42 PM	60.51	65.48	0	0	9.7	12.5	63.00
73	12.2	12/16/08	12:40:52 PM	60.55	65.40	0	0	9.8	12.5	62.98
74	12.3	12/16/08	12:41:02 PM	60.55	65.32	0	0	9.9	12.5	62.94
75	12.5	12/16/08	12:41:12 PM	60.59	65.32	0	0	10.1	12.6	62.96
76	12.7	12/16/08	12:41:22 PM	60.59	65.20	0	0	10.1	12.6	62.90
77	12.8	12/16/08	12:41:32 PM	60.59	65.24	0	0	10.1	12.7	62.92
78	13.0	12/16/08	12:41:42 PM	60.59	65.12	1	22	10.1	12.7	62.86
79	13.2	12/16/08	12:41:52 PM	60.59	64.99	0	0	10.1	12.7	62.79
80	13.3	12/16/08	12:42:02 PM	60.59	64.91	0	0	10.1	12.7	62.75
81	13.5	12/16/08	12:42:12 PM	60.59	64.79	0	0	10.2	12.7	62.69
82	13.7	12/16/08	12:42:22 PM	60.59	64.75	0	0	10.1	12.7	62.67
83	13.8	12/16/08	12:42:32 PM	60.55	64.63	0	0	10.1	12.8	62.59
84	14.0	12/16/08	12:42:42 PM	60.55	64.63	0	0	10.1	12.7	62.59
85	14.2	12/16/08	12:42:52 PM	60.55	64.59	0	0	10.1	12.8	62.57
86	14.3	12/16/08	12:43:02 PM	60.55	64.42	1	22	10.2	12.8	62.49
87	14.5	12/16/08	12:43:12 PM	60.51	64.38	0	0	10.2	12.8	62.45
88	14.7	12/16/08	12:43:22 PM	60.51	64.26	0	0	10.2	12.7	62.39
89	14.8	12/16/08	12:43:32 PM	60.47	64.19	0	0	10.2	12.7	62.33
90	15.0	12/16/08	12:43:42 PM	60.47	64.19	0	0	10.3	12.7	62.33

Water Volume of Loop in Ground = 3.84 ft^3, or = 28.76 gallons

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twl) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp, Amb (°F)
0	0.00	12/16/08	12:58:07 PM	60.27	66.76	268	5,789	9.3	18.2	63.52
1	0.17	12/16/08	1:08:07 PM	62.09	69.23	278	6,005	9.5	17.6	65.66
2	0.33	12/16/08	1:18:07 PM	63.51	70.76	278	6,005	9.9	18.5	67.14
3	0.50	12/16/08	1:28:07 PM	64.63	72.09	278	6,005	10.3	18.4	68.36
4	0.67	12/16/08	1:38:07 PM	65.60	73.14	278	6,005	10.4	18.8	69.37
5	0.83	12/16/08	1:48:07 PM	66.40	74.12	277	5,983	11.3	19.9	70.26
6	1.00	12/16/08	1:58:07 PM	67.13	74.76	277	5,983	11.1	20.3	70.95
7	1.17	12/16/08	2:08:07 PM	67.73	75.49	276	5,962	10.4	19.1	71.61
8	1.33	12/16/08	2:18:07 PM	68.29	76.11	277	5,983	10.4	19.0	72.20
9	1.50	12/16/08	2:28:07 PM	68.78	76.52	277	5,983	10.3	18.6	72.65
10	1.67	12/16/08	2:38:07 PM	69.27	77.04	277	5,983	10.2	18.9	73.16
11	1.83	12/16/08	2:48:07 PM	69.66	77.66	277	5,983	10.5	19.1	73.66
12	2.00	12/16/08	2:58:07 PM	70.07	78.15	276	5,962	10.5	19.3	74.11
13	2.17	12/16/08	3:08:07 PM	70.40	78.36	277	5,983	10.7	19.4	74.38
14	2.33	12/16/08	3:18:07 PM	70.72	78.48	277	5,983	10.7	19.8	74.60
15	2.50	12/16/08	3:28:07 PM	71.04	79.01	277	5,983	10.1	19.0	75.03
16	2.67	12/16/08	3:38:07 PM	71.28	79.43	277	5,983	10.2	18.3	75.36
17	2.83	12/16/08	3:48:07 PM	71.56	79.64	278	6,005	10.1	19.0	75.60
18	3.00	12/16/08	3:58:07 PM	71.85	79.68	277	5,983	9.9	18.8	75.77
19	3.17	12/16/08	4:08:07 PM	72.05	80.17	278	6,005	9.9	18.7	76.11
20	3.33	12/16/08	4:18:07 PM	72.30	80.25	277	5,983	10.1	19.0	76.28
21	3.50	12/16/08	4:28:07 PM	72.50	80.45	278	6,005	10.1	19.1	76.48
22	3.67	12/16/08	4:38:07 PM	72.70	80.74	278	6,005	9.7	19.0	76.72
23	3.83	12/16/08	4:48:07 PM	72.90	81.00	278	6,005	9.9	18.8	76.95
24	4.00	12/16/08	4:58:07 PM	73.06	81.21	278	6,005	9.6	18.7	77.14
25	4.17	12/16/08	5:08:07 PM	73.26	81.08	278	6,005	9.5	18.6	77.17
26	4.33	12/16/08	5:18:07 PM	73.46	81.50	277	5,983	9.8	18.6	77.48
27	4.50	12/16/08	5:28:07 PM	73.62	81.50	278	6,005	9.8	18.6	77.56
28	4.67	12/16/08	5:38:07 PM	73.75	81.79	278	6,005	9.5	18.2	77.77
29	4.83	12/16/08	5:48:07 PM	73.91	81.83	278	6,005	9.7	18.2	77.87
30	5.00	12/16/08	5:58:07 PM	74.03	82.12	277	5,983	9.8	18.4	78.08
31	5.17	12/16/08	6:08:07 PM	74.20	82.29	278	6,005	9.3	18.3	78.25
32	5.33	12/16/08	6:18:07 PM	74.32	82.21	278	6,005	8.3	17.8	78.27
33	5.50	12/16/08	6:28:07 PM	74.44	82.37	278	6,005	7.5	17.2	78.41
34	5.67	12/16/08	6:38:07 PM	74.60	82.45	278	6,005	7.7	16.9	78.53
35	5.83	12/16/08	6:48:07 PM	74.68	82.62	278	6,005	3.7	15.7	78.65
36	6.00	12/16/08	6:58:07 PM	74.80	82.84	278	6,005	2.3	14.7	78.82
37	6.17	12/16/08	7:08:07 PM	74.92	83.00	278	6,005	0.5	13.8	78.96
38	6.33	12/16/08	7:18:07 PM	75.00	83.22	279	6,026	-0.8	12.6	79.11
39	6.50	12/16/08	7:28:07 PM	75.08	83.00	278	6,005	-1.4	11.7	79.04
40	6.67	12/16/08	7:38:07 PM	75.16	83.26	278	6,005	-2.8	10.9	79.21
41	6.83	12/16/08	7:48:07 PM	75.28	83.34	278	6,005	-2.6	10.6	79.31
42	7.00	12/16/08	7:58:07 PM	75.41	83.55	278	6,005	-4.0	9.4	79.48
43	7.17	12/16/08	8:08:07 PM	75.49	83.43	278	6,005	-1.6	8.8	79.46
44	7.33	12/16/08	8:18:07 PM	75.53	83.51	278	6,005	-5.4	8.4	79.52
45	7.50	12/16/08	8:28:07 PM	75.62	83.68	278	6,005	-5.0	8.2	79.66
46	7.67	12/16/08	8:38:07 PM	75.74	83.80	278	6,005	-3.6	7.9	79.77
47	7.83	12/16/08	8:48:07 PM	75.82	83.92	278	6,005	-7.2	7.6	79.87
48	8.00	12/16/08	8:58:07 PM	75.90	84.01	278	6,005	6.9	6.5	79.96
49	8.17	12/16/08	9:08:07 PM	75.99	84.09	278	6,005	-5.8	6.4	80.04
50	8.33	12/16/08	9:18:07 PM	76.07	83.97	278	6,005	-7.1	5.6	80.02
51	8.50	12/16/08	9:28:07 PM	76.11	84.01	278	6,005	-6.8	5.2	80.06
52	8.67	12/16/08	9:38:07 PM	76.19	84.17	278	6,005	6.9	5.1	80.18

LOGGED DATA TO CALCULATE SOIL THERMAL CONDUCTIVITY

Number of Hours:	72.00	hours	
Calculated Meter Reading:	432.169	Watt*hrs	
Multiplier:	3.6	Watt*hrs/pulse	
Approximate Flow Rate	4.6	gpm	
Total Accumulative Pulses Read:	120,047	Pulses	
Average Pulses/Hour:	1,667	Pulses/hr	
Average Heat Input:	6,002	Watts	
Frequency of Samples:	10.0	minutes	

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
53	8.83	12/16/08	9:48:07 PM	76.23	84.30	277	5,983	-5.4	4.9	80.27
54	9.00	12/16/08	9:58:07 PM	76.35	84.17	278	6,005	-4.9	4.7	80.26
55	9.17	12/16/08	10:08:07 PM	76.39	84.34	278	6,005	-6.0	4.7	80.37
56	9.33	12/16/08	10:18:07 PM	76.43	84.34	277	5,983	-6.0	4.3	80.39
57	9.50	12/16/08	10:28:07 PM	76.52	84.39	278	6,005	-6.5	4.3	80.46
58	9.67	12/16/08	10:38:07 PM	76.56	84.51	278	6,005	-6.5	4.0	80.54
59	9.83	12/16/08	10:48:07 PM	76.88	84.56	277	5,983	-6.8	4.0	80.62
60	10.00	12/16/08	10:58:07 PM	76.72	84.60	278	6,005	-6.9	3.7	80.66
61	10.17	12/16/08	11:08:07 PM	76.76	84.81	277	5,983	-6.9	3.4	80.78
62	10.33	12/16/08	11:18:07 PM	76.84	84.86	278	6,005	-6.5	3.4	80.85
63	10.50	12/16/08	11:28:07 PM	76.88	84.86	278	6,005	-7.3	3.5	80.87
64	10.67	12/16/08	11:38:07 PM	76.96	85.11	277	5,983	-7.3	3.2	81.04
65	10.83	12/16/08	11:48:07 PM	76.96	84.94	278	6,005	-8.4	2.9	80.95
66	11.00	12/16/08	11:58:07 PM	77.08	85.19	278	6,005	-8.0	2.4	81.14
67	11.17	12/17/08	12:08:07 AM	77.12	85.36	278	6,005	-8.1	2.6	81.24
68	11.33	12/17/08	12:18:07 AM	77.21	85.02	278	6,005	-8.7	2.1	81.12
69	11.50	12/17/08	12:28:07 AM	77.21	85.24	278	6,005	-9.5	2.3	81.23
70	11.67	12/17/08	12:38:07 AM	77.29	85.36	279	6,026	-8.6	2.1	81.33
71	11.83	12/17/08	12:48:07 AM	77.29	85.36	278	6,005	-8.0	2.0	81.33
72	12.00	12/17/08	12:58:07 AM	77.41	85.36	278	6,005	-8.2	1.8	81.39
73	12.17	12/17/08	1:08:07 AM	77.46	85.24	278	6,005	-8.6	1.8	81.35
74	12.33	12/17/08	1:18:07 AM	77.50	85.53	278	6,005	-9.2	1.5	81.52
75	12.50	12/17/08	1:28:07 AM	77.54	85.40	279	6,026	-9.8	1.5	81.47
76	12.67	12/17/08	1:38:07 AM	77.54	85.70	278	6,005	-9.1	1.4	81.62
77	12.83	12/17/08	1:48:07 AM	77.62	85.53	278	6,005	-9.0	1.1	81.58
78	13.00	12/17/08	1:58:07 AM	77.70	85.70	279	6,026	-9.0	1.2	81.70
79	13.17	12/17/08	2:08:07 AM	77.70	85.70	278	6,005	-8.8	1.8	81.70
80	13.33	12/17/08	2:18:07 AM	77.74	85.61	278	6,005	-9.2	1.4	81.68
81	13.50	12/17/08	2:28:07 AM	77.83	85.70	278	6,005	-9.0	1.4	81.77
82	13.67	12/17/08	2:38:07 AM	77.87	85.86	279	6,026	-8.6	1.2	81.87
83	13.83	12/17/08	2:48:07 AM	77.87	85.95	278	6,005	-8.0	1.8	81.91
84	14.00	12/17/08	2:58:07 AM	77.95	86.12	278	6,005	-5.8	2.6	82.04
85	14.17	12/17/08	3:08:07 AM	77.95	85.91	278	6,005	-4.7	3.1	81.93
86	14.33	12/17/08	3:18:07 AM	78.07	85.99	278	6,005	-4.9	3.8	82.03
87	14.50	12/17/08	3:28:07 AM	78.03	86.12	277	5,983	-4.0	4.3	82.08
88	14.67	12/17/08	3:38:07 AM	78.11	86.03	278	6,005	-3.2	4.7	82.07
89	14.83	12/17/08	3:48:07 AM	78.19	86.21	277	5,983	-2.3	5.5	82.20
90	15.00	12/17/08	3:58:07 AM	78.24	86.29	278	6,005	-1.6	6.2	82.27
91	15.17	12/17/08	4:08:07 AM	78.28	86.38	277	5,983	-0.7	6.6	82.33
92	15.33	12/17/08	4:18:07 AM	78.28	86.29	278	6,005	0.6	7.1	82.29
93	15.50	12/17/08	4:28:07 AM	78.32	86.55	277	5,983	0.8	7.5	82.44
94	15.67	12/17/08	4:38:07 AM	78.36	86.42	278	6,005	0.4	7.2	82.39
95	15.83	12/17/08	4:48:07 AM	78.40	86.25	278	6,005	0.6	7.0	82.33
96	16.00	12/17/08	4:58:07 AM	78.44	86.55	277	5,983	0.5	7.0	82.50
97	16.17	12/17/08	5:08:07 AM	78.52	86.60	278	6,005	-0.5	7.0	82.56
98	16.33	12/17/08	5:18:07 AM	78.52	86.64	278	6,005	-0.9	6.8	82.58
99	16.50	12/17/08	5:28:07 AM	78.56	86.55	277	5,983	-1.2	6.8	82.56
100	16.67	12/17/08	5:38:07 AM	78.60	86.64	278	6,005	-0.2	6.8	82.62
101	16.83	12/17/08	5:48:07 AM	78.68	86.55	278	6,005	0.7	7.0	82.62
102	17.00	12/17/08	5:58:07 AM	78.68	86.55	277	5,983	1.0	7.3	82.62
103	17.17	12/17/08	6:08:07 AM	78.72	86.64	278	6,005	1.4	7.7	82.68
104	17.33	12/17/08	6:18:07 AM	78.76	86.72	277	5,983	1.0	7.7	82.74
105	17.50	12/17/08	6:28:07 AM	78.80	86.55	278	6,005	1.7	8.2	82.68
106	17.67	12/17/08	6:38:07 AM	78.84	86.90	277	5,983	2.3	8.4	82.87
107	17.83	12/17/08	6:48:07 AM	78.84	87.15	278	6,005	2.68	8.84	83.00
108	18.00	12/17/08	6:58:07 AM	78.93	86.90	278	6,005	3.21	9.12	82.92
109	18.17	12/17/08	7:08:07 AM	78.93	86.98	277	5,983	3.52	9.66	82.96
110	18.33	12/17/08	7:18:07 AM	79.01	86.94	278	6,005	3.67	10.19	82.98
111	18.50	12/17/08	7:28:07 AM	79.01	86.98	277	5,983	3.52	10.06	83.00
112	18.67	12/17/08	7:38:07 AM	79.01	87.07	278	6,005	3.83	10.06	83.04
113	18.83	12/17/08	7:48:07 AM	79.09	87.07	277	5,983	4.28	10.32	83.08
114	19.00	12/17/08	7:58:07 AM	79.09	87.02	278	6,005	4.79	10.59	83.06

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
115	19.17	12/17/08	8:08:07 AM	79.14	87.07	278	6,005	4.72	11.19	83.11
116	19.33	12/17/08	8:18:07 AM	79.18	87.19	277	5,983	5.01	11.46	83.19
117	19.50	12/17/08	8:28:07 AM	79.18	87.24	278	6,005	5.61	11.65	83.21
118	19.67	12/17/08	8:38:07 AM	79.22	87.07	277	5,983	6.61	12.04	83.15
119	19.83	12/17/08	8:48:07 AM	79.26	87.15	278	6,005	6.75	12.75	83.21
120	20.00	12/17/08	8:58:07 AM	79.26	87.24	277	5,983	7.74	13.19	83.25
121	20.17	12/17/08	9:08:07 AM	79.34	87.36	278	6,005	8.56	14.05	83.35
122	20.33	12/17/08	9:18:07 AM	79.34	87.41	278	6,005	9.12	14.69	83.38
123	20.50	12/17/08	9:28:07 AM	79.39	87.32	277	5,983	9.79	15.06	83.36
124	20.67	12/17/08	9:38:07 AM	79.43	87.32	277	5,983	10.38	15.67	83.38
125	20.83	12/17/08	9:48:07 AM	79.43	87.36	278	6,005	10.86	16.34	83.40
126	21.00	12/17/08	9:58:07 AM	79.51	87.62	277	5,983	11.52	17.12	83.57
127	21.17	12/17/08	10:08:07 AM	79.51	87.49	278	6,005	12.94	18.12	83.50
128	21.33	12/17/08	10:18:07 AM	79.55	87.58	277	5,983	13.69	19.21	83.57
129	21.50	12/17/08	10:28:07 AM	79.55	87.58	277	5,983	13.75	19.56	83.57
130	21.67	12/17/08	10:38:07 AM	79.59	87.58	278	6,005	14.56	19.79	83.59
131	21.83	12/17/08	10:48:07 AM	79.64	87.49	277	5,983	14.50	20.60	83.57
132	22.00	12/17/08	10:58:07 AM	79.68	87.53	277	5,983	14.88	20.94	83.61
133	22.17	12/17/08	11:08:07 AM	79.72	87.62	277	5,983	15.12	21.44	83.67
134	22.33	12/17/08	11:18:07 AM	79.72	87.79	278	6,005	16.40	21.95	83.76
135	22.50	12/17/08	11:28:07 AM	79.76	87.62	277	5,983	17.58	24.17	83.69
136	22.67	12/17/08	11:38:07 AM	79.84	87.83	277	5,983	16.94	24.33	83.84
137	22.83	12/17/08	11:48:07 AM	79.84	87.92	278	6,005	17.64	24.64	83.88
138	23.00	12/17/08	11:58:07 AM	79.88	88.00	278	6,005	19.62	25.50	83.94
139	23.17	12/17/08	12:08:07 PM	79.88	87.79	278	6,005	19.79	28.09	83.84
140	23.33	12/17/08	12:18:07 PM	79.96	87.74	278	6,005	20.94	30.00	83.85
141	23.50	12/17/08	12:28:07 PM	80.01	87.87	277	5,983	21.50	29.56	83.94
142	23.67	12/17/08	12:38:07 PM	80.01	88.09	278	6,005	21.05	29.71	84.05
143	23.83	12/17/08	12:48:07 PM	80.05	88.13	277	5,983	22.23	30.35	84.09
144	24.00	12/17/08	12:58:07 PM	80.05	88.13	278	6,005	21.89	30.90	84.09
145	24.17	12/17/08	1:08:07 PM	80.09	88.09	277	5,983	23.91	31.78	84.09
146	24.33	12/17/08	1:18:07 PM	80.13	88.13	278	6,005	20.43	29.51	84.13
147	24.50	12/17/08	1:28:07 PM	80.17	88.18	277	5,983	23.75	30.00	84.18
148	24.67	12/17/08	1:38:07 PM	80.17	88.13	277	5,983	21.05	31.20	84.15
149	24.83	12/17/08	1:48:07 PM	80.21	88.09	277	5,983	23.96	31.49	84.15
150	25.00	12/17/08	1:58:07 PM	80.25	88.22	277	5,983	23.75	31.59	84.24
151	25.17	12/17/08	2:08:07 PM	80.25	88.18	277	5,983	23.58	31.88	84.22
152	25.33	12/17/08	2:18:07 PM	80.25	88.18	277	5,983	24.59	32.56	84.22
153	25.50	12/17/08	2:28:07 PM	80.33	88.40	277	5,983	23.85	32.17	84.37
154	25.67	12/17/08	2:38:07 PM	80.37	88.44	277	5,983	23.91	31.15	84.41
155	25.83	12/17/08	2:48:07 PM	80.37	88.27	277	5,983	24.01	31.00	84.32
156	26.00	12/17/08	2:58:07 PM	80.37	88.40	277	5,983	24.64	30.20	84.39
157	26.17	12/17/08	3:08:07 PM	80.41	88.40	277	5,983	24.59	29.81	84.41
158	26.33	12/17/08	3:18:07 PM	80.41	88.44	277	5,983	23.80	29.90	84.43
159	26.50	12/17/08	3:28:07 PM	80.45	88.48	277	5,983	23.26	29.26	84.47
160	26.67	12/17/08	3:38:07 PM	80.45	88.44	277	5,983	22.82	28.54	84.45
161	26.83	12/17/08	3:48:07 PM	80.50	88.61	277	5,983	22.50	27.53	84.56
162	27.00	12/17/08	3:58:07 PM	80.50	88.31	277	5,983	21.84	26.90	84.41
163	27.17	12/17/08	4:08:07 PM	80.50	88.44	278	6,005	21.61	26.33	84.47
164	27.33	12/17/08	4:18:07 PM	80.54	88.70	277	5,983	21.27	25.87	84.62
165	27.50	12/17/08	4:28:07 PM	80.54	88.61	277	5,983	21.05	25.66	84.58
166	27.67	12/17/08	4:38:07 PM	80.58	88.48	278	6,005	20.60	25.23	84.53
167	27.83	12/17/08	4:48:07 PM	80.58	88.44	277	5,983	20.43	24.96	84.51
168	28.00	12/17/08	4:58:07 PM	80.58	88.65	277	5,983	20.14	24.90	84.62
169	28.17	12/17/08	5:08:07 PM	80.66	88.52	277	5,983	20.14	24.74	84.59
170	28.33	12/17/08	5:18:07 PM	80.66	88.78	278	6,005	19.91	24.54	84.72
171	28.50	12/17/08	5:28:07 PM	80.70	88.44	277	5,983	19.74	24.43	84.57
172	28.67	12/17/08	5:38:07 PM	80.66	88.65	277	5,983	19.56	24.28	84.66
173	28.83	12/17/08	5:48:07 PM	80.70	88.78	277	5,983	19.44	24.12	84.74
174	29.00	12/17/08	5:58:07 PM	80.70	88.74	278	6,005	19.10	23.91	84.72
175	29.17	12/17/08	6:08:07 PM	80.74	88.78	277	5,983	18.99	23.58	84.76
176	29.33	12/17/08	6:18:07 PM	80.74	88.70	278	6,005	18.99	23.37	84.72

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
177	29.50	12/17/08	6:28:07 PM	80.79	88.74	277	5,983	18.88	23.53	84.77
178	29.67	12/17/08	6:38:07 PM	80.79	88.74	278	6,005	18.82	23.31	84.77
179	29.83	12/17/08	6:48:07 PM	80.83	88.78	277	5,983	18.76	23.20	84.81
180	30.00	12/17/08	6:58:07 PM	80.83	88.83	278	6,005	18.59	23.26	84.83
181	30.17	12/17/08	7:08:07 PM	80.87	88.83	277	5,983	18.70	23.37	84.85
182	30.33	12/17/08	7:18:07 PM	80.87	89.13	277	5,983	18.53	23.04	85.00
183	30.50	12/17/08	7:28:07 PM	80.91	88.87	278	6,005	18.36	23.15	84.89
184	30.67	12/17/08	7:38:07 PM	80.96	88.65	277	5,983	18.18	23.20	84.81
185	30.83	12/17/08	7:48:07 PM	80.96	88.95	278	6,005	17.94	22.66	84.96
186	31.00	12/17/08	7:58:07 PM	81.00	88.95	277	5,983	17.35	22.12	84.98
187	31.17	12/17/08	8:08:07 PM	81.00	88.87	278	6,005	17.47	22.17	84.94
188	31.33	12/17/08	8:18:07 PM	81.04	88.91	277	5,983	16.64	21.95	84.98
189	31.50	12/17/08	8:28:07 PM	81.04	88.91	278	6,005	16.16	21.16	84.98
190	31.67	12/17/08	8:38:07 PM	81.04	88.95	278	6,005	16.16	20.83	85.00
191	31.83	12/17/08	8:48:07 PM	81.08	89.04	277	5,983	15.73	20.83	85.06
192	32.00	12/17/08	8:58:07 PM	81.08	89.04	278	6,005	15.43	20.14	85.06
193	32.17	12/17/08	9:08:07 PM	81.08	89.04	278	6,005	15.06	19.91	85.06
194	32.33	12/17/08	9:18:07 PM	81.08	89.08	278	6,005	15.00	20.03	85.08
195	32.50	12/17/08	9:28:07 PM	81.12	89.13	278	6,005	14.18	19.44	85.13
196	32.67	12/17/08	9:38:07 PM	81.17	89.08	278	6,005	14.50	19.27	85.13
197	32.83	12/17/08	9:48:07 PM	81.17	89.30	278	6,005	14.50	19.21	85.24
198	33.00	12/17/08	9:58:07 PM	81.21	89.25	277	5,983	13.44	18.88	85.23
199	33.17	12/17/08	10:08:07 PM	81.17	89.17	278	6,005	14.31	19.21	85.17
200	33.33	12/17/08	10:18:07 PM	81.21	89.13	278	6,005	13.50	18.76	85.17
201	33.50	12/17/08	10:28:07 PM	81.21	89.30	278	6,005	13.19	18.76	85.26
202	33.67	12/17/08	10:38:07 PM	81.29	89.42	278	6,005	11.72	17.94	85.36
203	33.83	12/17/08	10:48:07 PM	81.25	89.21	278	6,005	10.99	17.58	85.23
204	34.00	12/17/08	10:58:07 PM	81.29	89.13	278	6,005	12.16	17.76	85.21
205	34.17	12/17/08	11:08:07 PM	81.29	89.38	278	6,005	13.19	17.82	85.34
206	34.33	12/17/08	11:18:07 PM	81.33	89.51	278	6,005	12.75	17.94	85.42
207	34.50	12/17/08	11:28:07 PM	81.33	89.25	278	6,005	12.94	17.88	85.29
208	34.67	12/17/08	11:38:07 PM	81.33	89.47	278	6,005	12.75	17.58	85.40
209	34.83	12/17/08	11:48:07 PM	81.33	89.38	278	6,005	12.29	17.35	85.36
210	35.00	12/17/08	11:58:07 PM	81.33	89.38	278	6,005	11.97	17.12	85.36
211	35.17	12/18/08	12:08:07 AM	81.33	89.25	278	6,005	11.39	16.94	85.29
212	35.33	12/18/08	12:18:07 AM	81.38	89.42	279	6,026	10.79	16.64	85.40
213	35.50	12/18/08	12:28:07 AM	81.42	89.30	278	6,005	8.84	16.04	85.36
214	35.67	12/18/08	12:38:07 AM	81.46	89.30	278	6,005	9.25	15.67	85.38
215	35.83	12/18/08	12:48:07 AM	81.46	89.38	279	6,026	7.88	15.31	85.42
216	36.00	12/18/08	12:58:07 AM	81.50	89.38	278	6,005	8.98	15.31	85.44
217	36.17	12/18/08	1:08:07 AM	81.50	89.47	278	6,005	9.39	15.25	85.49
218	36.33	12/18/08	1:18:07 AM	81.50	89.47	279	6,026	10.06	15.19	85.49
219	36.50	12/18/08	1:28:07 AM	81.50	89.55	278	6,005	9.99	15.43	85.53
220	36.67	12/18/08	1:38:07 AM	81.50	89.42	278	6,005	10.06	15.43	85.46
221	36.83	12/18/08	1:48:07 AM	81.50	89.47	279	6,026	10.12	15.43	85.49
222	37.00	12/18/08	1:58:07 AM	81.54	89.42	278	6,005	9.39	15.31	85.48
223	37.17	12/18/08	2:08:07 AM	81.54	89.55	279	6,026	8.29	15.00	85.55
224	37.33	12/18/08	2:18:07 AM	81.54	89.47	278	6,005	9.12	15.12	85.51
225	37.50	12/18/08	2:28:07 AM	81.58	89.55	278	6,005	7.32	14.56	85.57
226	37.67	12/18/08	2:38:07 AM	81.58	89.68	279	6,026	8.56	14.44	85.63
227	37.83	12/18/08	2:48:07 AM	81.58	89.64	278	6,005	4.72	13.44	85.61
228	38.00	12/18/08	2:58:07 AM	81.63	89.68	279	6,026	7.11	13.63	85.66
229	38.17	12/18/08	3:08:07 AM	81.67	89.68	278	6,005	4.43	12.42	85.68
230	38.33	12/18/08	3:18:07 AM	81.67	89.55	278	6,005	4.50	12.49	85.61
231	38.50	12/18/08	3:28:07 AM	81.67	89.51	279	6,026	3.28	11.72	85.59
232	38.67	12/18/08	3:38:07 AM	81.67	89.72	278	6,005	2.91	11.65	85.70
233	38.83	12/18/08	3:48:07 AM	81.67	89.59	279	6,026	3.52	11.33	85.63
234	39.00	12/18/08	3:58:07 AM	81.71	89.64	278	6,005	3.67	11.26	85.68
235	39.17	12/18/08	4:08:07 AM	81.71	89.68	279	6,026	3.06	11.39	85.70
236	39.33	12/18/08	4:18:07 AM	81.75	89.72	278	6,005	3.28	10.86	85.74
237	39.50	12/18/08	4:28:07 AM	81.75	89.64	278	6,005	2.61	10.66	85.70
238	39.67	12/18/08	4:38:07 AM	81.75	89.77	279	6,026	2.76	10.45	85.76

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
239	39.83	12/18/08	4:48:07 AM	81.75	89.72	278	6,005	1.20	9.99	85.74
240	40.00	12/18/08	4:58:07 AM	81.75	89.72	278	6,005	2.38	9.93	85.74
241	40.17	12/18/08	5:08:07 AM	81.79	89.72	278	6,005	2.30	9.93	85.76
242	40.33	12/18/08	5:18:07 AM	81.83	89.68	278	6,005	2.45	10.12	85.76
243	40.50	12/18/08	5:28:07 AM	81.83	89.90	279	6,026	2.30	9.93	85.87
244	40.67	12/18/08	5:38:07 AM	81.79	89.86	278	6,005	2.30	9.93	85.83
245	40.83	12/18/08	5:48:07 AM	81.83	89.68	278	6,005	2.30	9.66	85.76
246	41.00	12/18/08	5:58:07 AM	81.83	89.81	278	6,005	1.67	9.53	85.82
247	41.17	12/18/08	6:08:07 AM	81.83	89.95	278	6,005	2.14	9.39	85.89
248	41.33	12/18/08	6:18:07 AM	81.88	89.81	278	6,005	1.51	9.05	85.85
249	41.50	12/18/08	6:28:07 AM	81.88	89.81	278	6,005	1.59	8.98	85.85
250	41.67	12/18/08	6:38:07 AM	81.88	89.72	278	6,005	0.57	8.84	85.80
251	41.83	12/18/08	6:48:07 AM	81.92	89.81	278	6,005	1.83	8.77	85.87
252	42.00	12/18/08	6:58:07 AM	81.92	89.72	278	6,005	1.43	8.70	85.82
253	42.17	12/18/08	7:08:07 AM	81.92	90.04	278	6,005	1.35	8.98	85.98
254	42.33	12/18/08	7:18:07 AM	81.92	89.72	278	6,005	1.35	8.70	85.82
255	42.50	12/18/08	7:28:07 AM	81.92	89.95	278	6,005	1.04	8.43	85.94
256	42.67	12/18/08	7:38:07 AM	82.00	90.04	278	6,005	1.35	8.70	86.02
257	42.83	12/18/08	7:48:07 AM	82.00	89.99	278	6,005	2.14	8.91	86.00
258	43.00	12/18/08	7:58:07 AM	82.00	89.90	278	6,005	1.83	8.77	85.95
259	43.17	12/18/08	8:08:07 AM	82.00	89.81	278	6,005	2.45	9.12	85.91
260	43.33	12/18/08	8:18:07 AM	82.00	89.90	278	6,005	2.30	9.32	85.95
261	43.50	12/18/08	8:28:07 AM	82.00	89.99	278	6,005	3.13	9.79	86.00
262	43.67	12/18/08	8:38:07 AM	82.00	90.12	277	5,983	4.72	10.32	86.08
263	43.83	12/18/08	8:48:07 AM	82.04	89.99	278	6,005	6.19	11.39	86.02
264	44.00	12/18/08	8:58:07 AM	82.04	89.95	278	6,005	8.49	12.42	86.00
265	44.17	12/18/08	9:08:07 AM	82.08	90.08	278	6,005	12.23	14.44	86.08
266	44.33	12/18/08	9:18:07 AM	82.12	89.99	277	5,983	11.91	16.28	86.06
267	44.50	12/18/08	9:28:07 AM	82.12	90.04	278	6,005	13.00	17.94	86.08
268	44.67	12/18/08	9:38:07 AM	82.16	89.99	278	6,005	15.73	20.14	86.08
269	44.83	12/18/08	9:48:07 AM	82.16	90.17	278	6,005	16.22	22.00	86.17
270	45.00	12/18/08	9:58:07 AM	82.16	90.21	278	6,005	16.88	23.53	86.19
271	45.17	12/18/08	10:08:07 AM	82.16	90.17	277	5,983	18.70	24.12	86.17
272	45.33	12/18/08	10:18:07 AM	82.21	90.17	278	6,005	19.44	25.50	86.19
273	45.50	12/18/08	10:28:07 AM	82.21	90.34	277	5,983	20.66	27.11	86.28
274	45.67	12/18/08	10:38:07 AM	82.25	90.34	278	6,005	20.03	28.59	86.30
275	45.83	12/18/08	10:48:07 AM	82.25	90.39	277	5,983	21.73	28.29	86.32
276	46.00	12/18/08	10:58:07 AM	82.29	90.26	278	6,005	21.73	29.21	86.28
277	46.17	12/18/08	11:08:07 AM	82.29	90.12	277	5,983	22.71	29.21	86.21
278	46.33	12/18/08	11:18:07 AM	82.33	90.17	277	5,983	23.04	29.36	86.25
279	46.50	12/18/08	11:28:07 AM	82.29	90.39	278	6,005	21.27	29.31	86.34
280	46.67	12/18/08	11:38:07 AM	82.33	90.34	277	5,983	20.49	28.19	86.34
281	46.83	12/18/08	11:48:07 AM	82.33	90.48	278	6,005	22.17	27.94	86.41
282	47.00	12/18/08	11:58:07 AM	82.33	90.43	277	5,983	22.82	28.29	86.38
283	47.17	12/18/08	12:08:07 PM	82.37	90.34	278	6,005	22.71	27.68	86.36
284	47.33	12/18/08	12:18:07 PM	82.37	90.43	277	5,983	23.09	29.51	86.40
285	47.50	12/18/08	12:28:07 PM	82.41	90.30	277	5,983	23.31	29.21	86.36
286	47.67	12/18/08	12:38:07 PM	82.41	90.43	277	5,983	23.96	28.80	86.42
287	47.83	12/18/08	12:48:07 PM	82.41	90.43	277	5,983	24.49	28.29	86.42
288	48.00	12/18/08	12:58:07 PM	82.45	90.34	277	5,983	23.58	27.73	86.40
289	48.17	12/18/08	1:08:07 PM	82.45	90.61	277	5,983	23.91	27.43	86.53
290	48.33	12/18/08	1:18:07 PM	82.45	90.43	276	5,962	22.87	26.85	86.44
291	48.50	12/18/08	1:28:07 PM	82.45	90.39	277	5,983	23.31	27.06	86.42
292	48.67	12/18/08	1:38:07 PM	82.50	90.48	276	5,962	23.69	27.37	86.49
293	48.83	12/18/08	1:48:07 PM	82.50	90.48	276	5,962	23.80	27.53	86.49
294	49.00	12/18/08	1:58:07 PM	82.50	90.52	277	5,983	23.47	27.48	86.51
295	49.17	12/18/08	2:08:07 PM	82.50	90.56	277	5,983	23.47	27.37	86.53
296	49.33	12/18/08	2:18:07 PM	82.54	90.48	276	5,962	22.82	27.01	86.51
297	49.50	12/18/08	2:28:07 PM	82.50	90.43	277	5,983	23.09	26.85	86.47
298	49.67	12/18/08	2:38:07 PM	82.50	90.69	276	5,962	22.82	26.64	86.60
299	49.83	12/18/08	2:48:07 PM	82.54	90.34	277	5,983	22.39	26.48	86.44
300	50.00	12/18/08	2:58:07 PM	82.54	90.48	277	5,983	21.73	26.02	86.51

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or twi) (°F)	Water Temp. Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp Amb (°F)
301	50.17	12/18/08	3:08:07 PM	82.50	90.52	276	5,962	21.16	25.60	86.51
302	50.33	12/18/08	3:18:07 PM	82.54	90.43	277	5,983	21.05	25.23	86.49
303	50.50	12/18/08	3:28:07 PM	82.54	90.61	276	5,962	20.65	24.90	86.58
304	50.67	12/18/08	3:38:07 PM	82.54	90.43	277	5,983	20.60	24.64	86.49
305	50.83	12/18/08	3:48:07 PM	82.54	90.48	276	5,962	20.54	24.43	86.51
306	51.00	12/18/08	3:58:07 PM	82.54	90.48	277	5,983	20.43	23.96	86.51
307	51.17	12/18/08	4:08:07 PM	82.58	90.48	276	5,962	20.54	24.17	86.53
308	51.33	12/18/08	4:18:07 PM	82.58	90.52	277	5,983	20.49	24.38	86.55
309	51.50	12/18/08	4:28:07 PM	82.58	90.52	276	5,962	20.37	24.01	86.55
310	51.67	12/18/08	4:38:07 PM	82.58	90.74	276	5,962	20.37	23.91	86.66
311	51.83	12/18/08	4:48:07 PM	82.62	90.52	277	5,983	20.37	24.12	86.57
312	52.00	12/18/08	4:58:07 PM	82.58	90.78	276	5,962	20.37	23.80	86.68
313	52.17	12/18/08	5:08:07 PM	82.62	90.48	276	5,962	20.37	23.58	86.55
314	52.33	12/18/08	5:18:07 PM	82.62	90.65	277	5,983	20.49	23.58	86.64
315	52.50	12/18/08	5:28:07 PM	82.62	90.34	276	5,962	20.66	23.75	86.48
316	52.67	12/18/08	5:38:07 PM	82.67	90.39	276	5,962	20.37	23.47	86.53
317	52.83	12/18/08	5:48:07 PM	82.67	90.61	276	5,962	20.86	24.12	86.64
318	53.00	12/18/08	5:58:07 PM	82.67	90.69	277	5,983	20.83	24.12	86.68
319	53.17	12/18/08	6:08:07 PM	82.67	90.52	276	5,962	21.05	24.12	86.60
320	53.33	12/18/08	6:18:07 PM	82.67	90.56	276	5,962	21.10	24.49	86.62
321	53.50	12/18/08	6:28:07 PM	82.71	90.74	276	5,962	21.73	25.07	86.73
322	53.67	12/18/08	6:38:07 PM	82.71	90.69	277	5,983	22.00	25.39	86.70
323	53.83	12/18/08	6:48:07 PM	82.71	90.65	276	5,962	22.28	25.17	86.68
324	54.00	12/18/08	6:58:07 PM	82.71	90.61	276	5,962	22.93	25.50	86.66
325	54.17	12/18/08	7:08:07 PM	82.75	90.56	276	5,962	23.04	25.92	86.65
326	54.33	12/18/08	7:18:07 PM	82.75	90.52	276	5,962	23.31	26.23	86.64
327	54.50	12/18/08	7:28:07 PM	82.75	90.69	276	5,962	23.26	26.02	86.72
328	54.67	12/18/08	7:38:07 PM	82.79	90.69	276	5,962	23.58	26.64	86.74
329	54.83	12/18/08	7:48:07 PM	82.84	90.87	276	5,962	24.12	27.06	86.86
330	55.00	12/18/08	7:58:07 PM	82.84	90.87	276	5,962	24.08	28.09	86.85
331	55.17	12/18/08	8:08:07 PM	82.84	90.96	276	5,962	24.96	28.59	86.90
332	55.33	12/18/08	8:18:07 PM	82.88	90.83	276	5,962	25.50	29.00	86.86
333	55.50	12/18/08	8:28:07 PM	82.88	90.74	277	5,983	24.96	29.05	86.81
334	55.67	12/18/08	8:38:07 PM	82.92	90.91	276	5,962	25.50	29.31	86.92
335	55.83	12/18/08	8:48:07 PM	82.92	90.91	276	5,962	25.81	29.00	86.92
336	56.00	12/18/08	8:58:07 PM	82.92	90.91	276	5,962	26.23	29.36	86.92
337	56.17	12/18/08	9:08:07 PM	82.96	91.00	276	5,962	26.85	29.56	86.98
338	56.33	12/18/08	9:18:07 PM	82.96	90.78	276	5,962	26.96	29.76	86.87
339	56.50	12/18/08	9:28:07 PM	83.00	90.78	276	5,962	27.06	29.90	86.89
340	56.67	12/18/08	9:38:07 PM	83.00	90.91	275	5,940	27.37	30.35	86.96
341	56.83	12/18/08	9:48:07 PM	83.00	91.09	276	5,962	27.68	30.50	87.05
342	57.00	12/18/08	9:58:07 PM	83.00	90.87	276	5,962	27.78	30.50	86.94
343	57.17	12/18/08	10:08:07 PM	83.00	90.91	276	5,962	27.94	30.30	86.96
344	57.33	12/18/08	10:18:07 PM	83.00	90.87	276	5,962	27.88	30.35	86.94
345	57.50	12/18/08	10:28:07 PM	83.00	91.09	277	5,983	28.09	30.40	87.05
346	57.67	12/18/08	10:38:07 PM	83.00	90.96	276	5,962	28.38	30.80	86.98
347	57.83	12/18/08	10:48:07 PM	83.05	91.17	276	5,962	27.99	30.70	87.11
348	58.00	12/18/08	10:58:07 PM	83.05	90.96	276	5,962	27.88	30.20	87.01
349	58.17	12/18/08	11:08:07 PM	83.05	91.04	277	5,983	27.48	30.10	87.05
350	58.33	12/18/08	11:18:07 PM	83.05	90.91	276	5,962	27.48	29.80	86.98
351	58.50	12/18/08	11:28:07 PM	83.09	91.09	276	5,962	27.53	30.10	87.09
352	58.67	12/18/08	11:38:07 PM	83.09	91.04	276	5,962	27.48	30.35	87.07
353	58.83	12/18/08	11:48:07 PM	83.09	91.04	277	5,983	28.09	30.95	87.07
354	59.00	12/18/08	11:58:07 PM	83.13	90.96	276	5,962	27.94	31.35	87.05
355	59.17	12/19/08	12:08:07 AM	83.13	91.09	276	5,962	27.94	31.59	87.11
356	59.33	12/19/08	12:18:07 AM	83.17	91.13	276	5,962	28.09	31.83	87.15
357	59.50	12/19/08	12:28:07 AM	83.17	91.09	276	5,962	28.29	32.27	87.13
358	59.67	12/19/08	12:38:07 AM	83.17	91.26	277	5,983	28.19	32.37	87.22
359	59.83	12/19/08	12:48:07 AM	83.22	91.22	276	5,962	28.29	32.27	87.22
360	60.00	12/19/08	12:58:07 AM	83.22	91.22	276	5,962	28.14	32.47	87.22
361	60.17	12/19/08	1:08:07 AM	83.26	91.17	276	5,962	28.09	32.47	87.22
362	60.33	12/19/08	1:18:07 AM	83.26	91.26	276	5,962	28.09	32.47	87.26

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp. Out of Grnd Tgo (or Twi) (°F)	Water Temp. Into Ground Tgi (or Two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System We (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp. Amb (°F)
363	60.50	12/19/08	1:28:07 AM	83.26	91.13	276	5,962	28.19	32.47	87.20
364	60.67	12/19/08	1:38:07 AM	83.34	91.09	276	5,962	24.85	31.39	87.22
365	60.83	12/19/08	1:48:07 AM	83.34	91.30	276	5,962	22.50	29.61	87.32
366	61.00	12/19/08	1:58:07 AM	83.30	91.30	277	5,983	22.00	28.69	87.30
367	61.17	12/19/08	2:08:07 AM	83.30	91.26	276	5,962	21.73	27.99	87.28
368	61.33	12/19/08	2:18:07 AM	83.34	91.35	277	5,983	21.27	27.58	87.35
369	61.50	12/19/08	2:28:07 AM	83.34	91.26	277	5,983	20.83	27.17	87.30
370	61.67	12/19/08	2:38:07 AM	83.34	91.43	276	5,962	20.43	26.64	87.39
371	61.83	12/19/08	2:48:07 AM	83.38	91.39	277	5,983	20.37	26.48	87.39
372	62.00	12/19/08	2:58:07 AM	83.34	91.30	277	5,983	20.03	26.23	87.32
373	62.17	12/19/08	3:08:07 AM	83.34	91.39	276	5,962	19.79	25.87	87.37
374	62.33	12/19/08	3:18:07 AM	83.34	91.48	277	5,983	19.56	25.60	87.41
375	62.50	12/19/08	3:28:07 AM	83.30	91.26	277	5,983	19.33	25.17	87.32
376	62.67	12/19/08	3:38:07 AM	83.38	91.43	276	5,962	19.21	24.96	87.41
377	62.83	12/19/08	3:48:07 AM	83.34	91.39	277	5,983	18.88	24.64	87.37
378	63.00	12/19/08	3:58:07 AM	83.30	91.26	277	5,983	18.59	24.28	87.32
379	63.17	12/19/08	4:08:07 AM	83.43	91.39	276	5,962	18.53	24.01	87.41
380	63.33	12/19/08	4:18:07 AM	83.43	91.48	277	5,983	18.76	23.96	87.46
381	63.50	12/19/08	4:28:07 AM	83.38	91.43	276	5,962	19.05	24.12	87.41
382	63.67	12/19/08	4:38:07 AM	83.43	91.52	277	5,983	18.82	24.12	87.48
383	63.83	12/19/08	4:48:07 AM	83.43	91.30	277	5,983	17.82	23.53	87.37
384	64.00	12/19/08	4:58:07 AM	83.43	91.43	276	5,962	17.58	23.09	87.43
385	64.17	12/19/08	5:08:07 AM	83.43	91.39	277	5,983	17.12	22.82	87.41
386	64.33	12/19/08	5:18:07 AM	83.47	91.48	276	5,962	16.88	22.50	87.48
387	64.50	12/19/08	5:28:07 AM	83.47	91.30	277	5,983	16.76	22.23	87.39
388	64.67	12/19/08	5:38:07 AM	83.47	91.39	276	5,962	16.40	22.06	87.43
389	64.83	12/19/08	5:48:07 AM	83.51	91.39	277	5,983	16.28	21.78	87.45
390	65.00	12/19/08	5:58:07 AM	83.47	91.48	276	5,962	16.16	21.67	87.48
391	65.17	12/19/08	6:08:07 AM	83.51	91.48	277	5,983	15.67	21.44	87.50
392	65.33	12/19/08	6:18:07 AM	83.51	91.66	276	5,962	15.43	21.18	87.59
393	65.50	12/19/08	6:28:07 AM	83.47	91.39	277	5,983	15.00	21.05	87.43
394	65.67	12/19/08	6:38:07 AM	83.51	91.61	276	5,962	15.37	21.05	87.56
395	65.83	12/19/08	6:48:07 AM	83.51	91.57	277	5,983	15.49	21.27	87.54
396	66.00	12/19/08	6:58:07 AM	83.51	91.39	276	5,962	15.00	20.94	87.45
397	66.17	12/19/08	7:08:07 AM	83.51	91.61	276	5,962	14.69	20.60	87.56
398	66.33	12/19/08	7:18:07 AM	83.56	91.52	277	5,983	14.56	20.37	87.54
399	66.50	12/19/08	7:28:07 AM	83.51	91.43	276	5,962	14.56	20.37	87.47
400	66.67	12/19/08	7:38:07 AM	83.56	91.52	277	5,983	15.06	20.60	87.54
401	66.83	12/19/08	7:48:07 AM	83.59	91.48	276	5,962	15.43	20.94	87.54
402	67.00	12/19/08	7:58:07 AM	83.59	91.39	277	5,983	15.73	21.39	87.49
403	67.17	12/19/08	8:08:07 AM	83.55	91.48	276	5,962	15.97	21.56	87.52
404	67.33	12/19/08	8:18:07 AM	83.59	91.43	276	5,962	16.22	21.84	87.51
405	67.50	12/19/08	8:28:07 AM	83.63	91.57	277	5,983	16.64	22.23	87.60
406	67.67	12/19/08	8:38:07 AM	83.59	91.57	276	5,962	17.12	22.61	87.58
407	67.83	12/19/08	8:48:07 AM	83.63	91.66	276	5,962	17.64	22.93	87.65
408	68.00	12/19/08	8:58:07 AM	83.63	91.66	277	5,983	18.53	23.96	87.65
409	68.17	12/19/08	9:08:07 AM	83.63	91.61	276	5,962	18.82	24.12	87.62
410	68.33	12/19/08	9:18:07 AM	83.68	91.75	276	5,962	19.10	24.33	87.72
411	68.50	12/19/08	9:28:07 AM	83.68	91.52	277	5,983	19.50	24.74	87.60
412	68.67	12/19/08	9:38:07 AM	83.68	91.66	276	5,962	20.03	25.26	87.67
413	68.83	12/19/08	9:48:07 AM	83.68	91.84	277	5,983	21.16	25.81	87.76
414	69.00	12/19/08	9:58:07 AM	83.72	91.57	276	5,962	22.39	26.54	87.65
415	69.17	12/19/08	10:08:07 AM	83.72	91.66	277	5,983	21.95	27.32	87.69
416	69.33	12/19/08	10:18:07 AM	83.72	91.57	276	5,962	21.95	26.96	87.65
417	69.50	12/19/08	10:28:07 AM	83.72	91.75	277	5,983	23.80	27.58	87.74
418	69.67	12/19/08	10:38:07 AM	83.76	91.70	277	5,983	24.54	28.19	87.73
419	69.83	12/19/08	10:48:07 AM	83.76	91.79	276	5,962	24.17	29.00	87.78
420	70.00	12/19/08	10:58:07 AM	83.76	91.84	277	5,983	25.50	29.76	87.80
421	70.17	12/19/08	11:08:07 AM	83.76	91.79	276	5,962	23.26	29.10	87.78
422	70.33	12/19/08	11:18:07 AM	83.76	91.75	277	5,983	23.37	28.80	87.76
423	70.50	12/19/08	11:28:07 AM	83.80	91.84	276	5,962	23.31	28.90	87.82
424	70.67	12/19/08	11:38:07 AM	83.84	91.93	276	5,962	23.42	28.80	87.89

Lancaster County Correctional Facility

GROUND THERMAL CONDUCTIVITY TEST - LOGGED DATA

Rdg. No.	Hour	Date	Time	Water Temp Out of Grnd Tgo (or twi) (°F)	Water Temp Into Ground Tgi (or two) (°F)	Energy into the Loop System Pulses Read	Energy into the Loop System Wc (Watts)	Outside Ambient Temp Tavg (°F)	Trailer Ambient Temp Amb (°F)	Average Loop Temp Amb (°F)
425	70.83	12/19/08	11:48:07 AM	83.84	91.93	277	5,983	23.69	29.05	87.89
426	71.00	12/19/08	11:58:07 AM	83.84	91.84	276	5,962	23.15	29.10	87.84
427	71.17	12/19/08	12:08:07 PM	83.84	92.06	277	5,983	22.93	29.00	87.95
428	71.33	12/19/08	12:18:07 PM	83.84	92.10	276	5,962	23.15	28.90	87.97
429	71.50	12/19/08	12:28:07 PM	83.84	91.93	277	5,983	24.07	29.31	87.89
430	71.67	12/19/08	12:38:07 PM	83.88	91.88	276	5,962	23.47	29.36	87.88
431	71.83	12/19/08	12:48:07 PM	83.88	91.97	277	5,983	24.54	29.56	87.93
432	72.00	12/19/08	12:58:07 PM	83.88	92.06	276	5,962	24.85	29.95	87.97
433	72.17									
434	72.33									
435	72.50									
436	72.67									
437	72.83									
438	73.00									
439	73.17									
440	73.33									
441	73.50									
442	73.67									
443	73.83									
444	74.00									
445	74.17									
446	74.33									
447	74.50									
448	74.67									
449	74.83									
450	75.00									
451	75.17									
452	75.33									
453	75.50									
454	75.67									
455	75.83									
456	76.00									
457	76.17									
458	76.33									
459	76.50									
460	76.67									
461	76.83									
462	77.00									
463	77.17									
464	77.33									
465	77.50									
466	77.67									
467	77.83									
468	78.00									
469	78.17									
470	78.33									
471	78.50									
472	78.67									
473	78.83									
474	79.00									
475	79.17									
476	79.33									
477	79.50									
478	79.67									
479	79.83									
480	80.00									
481	80.17									
482	80.33									
483	80.50									
484	80.67									
485	80.83									
486	81.00									

Photo 1: SW 40th Street Thermal Plant (right) and Lancaster County Adult Detention Facility (left)



Photo 2: Well Field Drilling Operations



Photo 3: Well Field Circulation Pumps (foreground), Filter/Air Separator (background)



Photo 4: Well Field Pipe Header system in plant basement.



Photo 5: Thermal Plant Heat Pump Hall



Photo 6: 10 Stage Heat Pump Bank

