AMERICAN ACADEMY OF ENVIRONMENTAL ENGINEERS & SCIENTISTS®

LANDFILL BASED GEOTHERMAL HEATING SYSTEM

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Grand Prize Small Projects Category

2013 Awards Luncheon & Conference

Presented By:

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north country ENVIRONMENTAL SERVICES

CMA ENGINEERS

PE Petersen Engineering

Acknowledgements

- North Country Environmental Services
  - Kevin Roy, General Manager
  - Joe Gay, Engineering Manager
- Petersen Engineering
- NHDES Waste Management Division
- Pike Industries, Inc.

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North Country Environmental Services, Inc. (NCES) is the owner/operator of the landfill facility located in Bethlehem, NH. NCES is a division of Casella Waste Management headquartered in Rutland, VT with operations throughout New England, New York and Pennsylvania. NCES worked with CMA Engineers to develop the concept and supported the efforts to evaluate and design the system. Petersen Engineering is a mechanical consulting engineering company in Portsmouth NH that assisted CMA Engineers with the design for the ground coupled heat exchanger and circulation system, using their experience with conventional geothermal system design. NHDES Waste Management Division, who regulate the solid waste facility worked with the team to incorporate the system into the approved landfill expansion construction. Pike Industries out of Belmont NH was the general contractor for the landfill expansion project and completed the installation of the system.

Project Background

- North Country Environmental Services
- Bethlehem, NH
- 34 Acre Double Lined Facility
- 100,000 tpy
- Stage IV Phase II-A Landfill Expansion
  - 1.2 Million CY
  - 40’ Vertical Berms
  - Piggy Back

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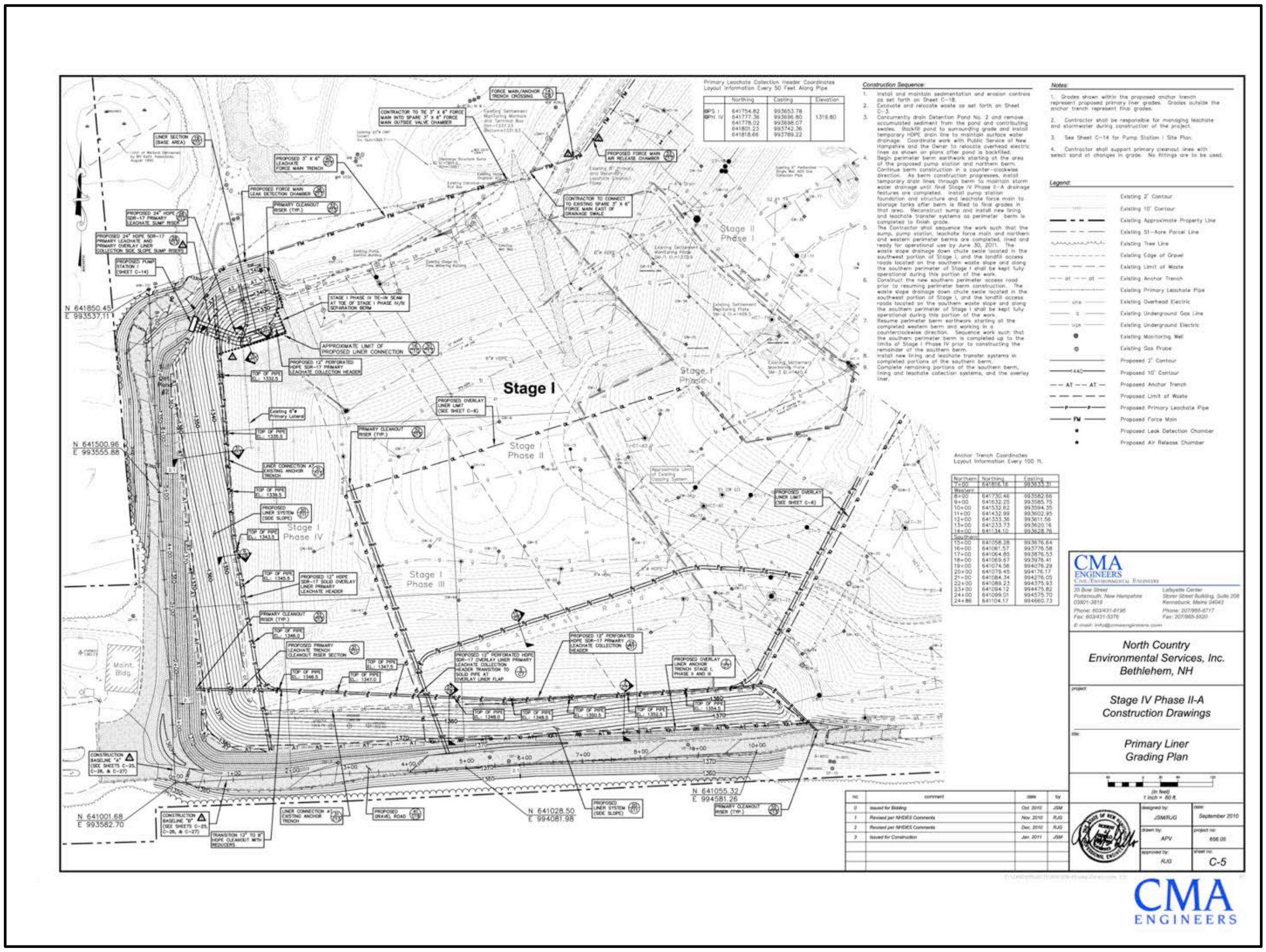
The landfill based geothermal heating system is located at the NCES facility which is a 34 acre double lined landfill facility in Bethlehem, NH. The facility accepts approximately 100,000 tons per year of municipal solid waste. Bethlehem is in the northern part of the state and adjacent to the White Mountain National Forest. Average high temperatures are below 50 °F for five months of the year. In 2011, NCES began construction of the Stage IV Phase II-A Landfill Expansion to provide an additional 1.2 M CY of waste disposal capacity at the site.



This is proposed grading plan for the Phase II-A landfill expansion, which included 40 foot high soil berms and a 3 acre horizontal expansion of the existing footprint. The facility equipment maintenance garage, truck scale, and operations building are located southwest of the landfill.

Project Background

- Construction Meeting Discussion
  - Ownership of LFG Rights and Heating of Maintenance Facility
  - Too Bad Can't Collect Heat Direct From Landfill Waste
    - Why Not?
- Proceed with Feasibility Evaluation
- First of Its Kind

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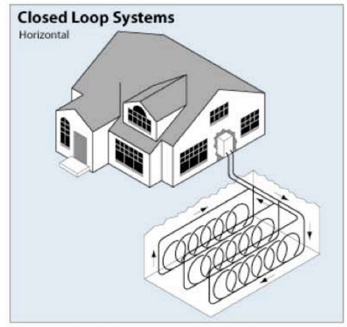
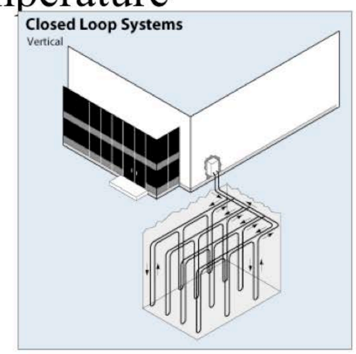
It was during a construction meeting that the concept of collecting the wasted heat from within the landfill was developed. There was a discussion about the third partly landfill gas contractor and the rights to the heat from the combustion of the landfill gas that lead to questioning why we could not collect the heat from the waste directly. Following that meeting, NCES authorized CMA Engineers to proceed with a feasibility study. Through some research we had determined that this would likely be the first of its kind application for beneficial use of the heat generated by the decomposing waste.

Preliminary Evaluation

- Geothermal Heating Systems
  - Ground Source Heat Pump
  - Pipe Loops
    - Horizontal Field
    - Vertical Wells
  - Extracts Heat from 54° F Soil
- Landfill Waste Mass Elevated Temperature
  - 110 to 130°F in Center of Waste
- Efficient System?
- Reasonable Payback?





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Conventional geothermal systems utilize a an array of pipe loops buried in the ground or installed in bore holes to extract heat from the soil or groundwater, which are at 54 °F in NH. A heat pump is then utilized to transfer that energy to a refrigerant, compress the refrigerant to increase its temperature, and then transfer that heat energy to the heating water. Literature, and site information confirmed that landfill waste mass temperatures in the center of the landfill could be expected to be in the range of 110 to 130 °F. The focus of the preliminary evaluation was to determine if this heat could be collected efficiently and would there be a reasonable payback on the investment.

Preliminary Evaluation

- Feasibility Study
  - Highest Temps in Center of Waste Cell (100-120°F)
    - Difficult to Collect Efficiently Due to Settlement
  - Literature - Temperatures 85° to 105°F at Liner
  - Direct Use if Temperatures are >100°F
    - Water to Water Heat Pump Required if <90-100°F
- Temperature at Liner Affected By
  - Temperature of Waste at Placement
  - Proximity to Surface Conditions
  - Soil/Liner System Insulation Properties
  - Rate and Stage of Degradation

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Preliminary evaluation found that typical temperatures at the liner system would support a geothermal heating system. System location would be critical to its success.

Preliminary Evaluation

- Design Basis
  - Garage 180,000 Btu/hr
  - Snow Melt 250,000 Btu/hr
  - Typical Home is 80,000 Btu/hr
  - Ground Coupled Heat Exchanger Above Liner
    - 7.5°F Increase across GCHX at 70 GPM
    - 9,000 SF required for Peak Load
  - Circulating Pump for Glycol GCHX
    - High Flow, Low Pressure for Closed Loop
  - 119 gal Storage Tank to Separate GCHX from Load
- No Separate Regulatory Permitting Required By NHDES

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NCES desired to heat its existing maintenance garage using the system with the potential to construct a snow melt system for the approaches to the facility truck scale. The estimated peak heat demand for the garage and snow melt system were estimated to be 180,000 and 250,000 Btu/hr. A typical home in the northeast could have a demand of 80,000 Btu/hr for comparison. It was determined that the desired location for the ground coupled heat exchanger would be atop the primary liner system near the tie-in to the existing liner system, where it would be protected by the 18-inch select sand layer, and be beneath 40 to 60 feet of waste, and isolated from ambient conditions. It was calculated that with a conservative 7.5 °F transfer to the circulating fluid in the heat exchanges, a 9,000 SF system would be needed for the peak load.

Facility Maintenance Garage

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This is the existing 4500 SF maintenance bay located adjacent to the Stage IB Phase II-A Landfill Expansion. The facility utilizes waste and virgin oil to heat the facility. With improvements to the equipment operation, the facility was generating less waste oil and was purchasing upwards of 3,000 gallons of heating oil per at over $10,000 per year.

Facility Truck Scale

The truck scale and scale house were installed in 2008. NCES desires to install a snow melt system on the paved approaches to the truck scale to reduce snow removal requirements and improve site safety.

Final Design

- GCHX 10 - 500 Foot Loops
- 1.25" SDR 9 HDPE Pipe with 50% Glycol
- Installed Below 18" Select Sand Layer Above Primary Liner, 24" OC
- 3" Return and Supply Line
- Manifold at Anchor Trench
  - Testing and Termination of Loops
- Heat Pump and Unit Heaters Design to Follow

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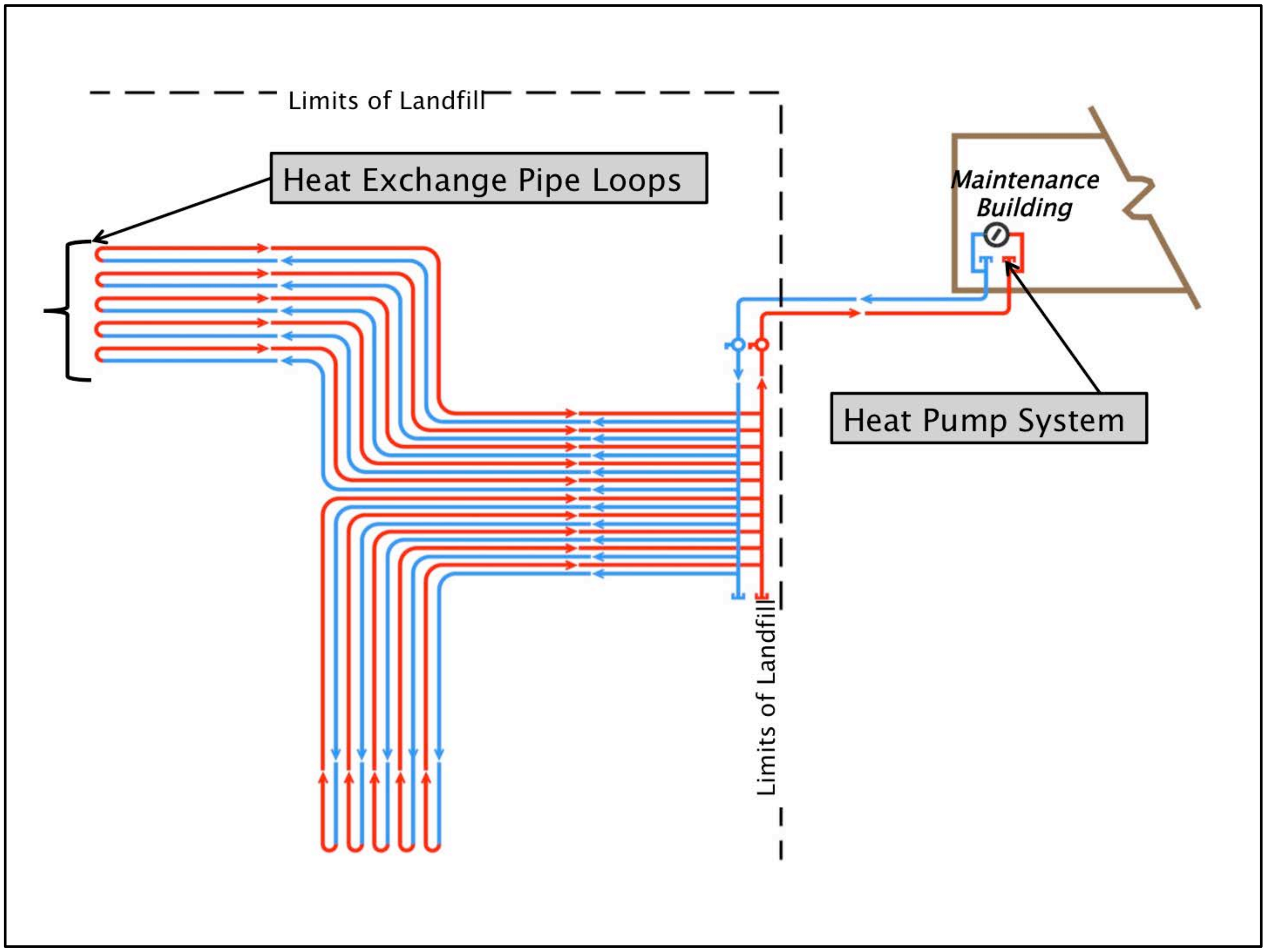
The final design of the geothermal heating system consists of 10, 500 foot long loops of 1.25 inch SDR 9 HDPE piping. The piping system was specified to be installed atop the primary geomembrane and its drainage geocomposite at a 24" spacing. The loops would be connected to 3-inch supply and return lines via a manifold located at the anchor trench of the berm. The supply and return lines would be routed to the maintenance garage for connection to the circulating pump and heat plant. We evaluated installing the system within the waste mass, where the temperatures would be higher, but determined that was settlement could compromise portions of the system. The installation on the liner system was believed to be simple and inexpensive to install. The decomposition of waste would take at least 12 months before it became fully anaerobic and generating landfill gas and heat, so the design of the heating plant will be completed once stable temperatures are achieved. If temperatures are near 100 °F, it is possible that the heated water could be used directly without the assistance of a heat pump.



This is a schematic of the system design, indicating the flow in the ground coupled heat exchanger installed above the landfill liner system.

Simple Payback

	Garage Building w/GCHX without Heat Pumps (100°F)
Annual Heat Required (kBtu/yr)	322,480
Pumping Power (kwh/yr)	1,168
Fan Power (kwh/yr)	480
Heat Pump Power	0
Total Electricity Consumption (kwh/yr)	1,648
Annual Cost of Operation (electricity at $0.1644/kwh)	$271
Annual Savings over Existing Building Condition	$10,314
Approximate Initial Cost	$40,000
Simple Payback (years)	3.9

A simple analysis for the garage heating system without a heat pump determines that the annual savings over the existing heating operational costs provides a payback in just four years.

Simple Payback

	Garage Building w/GCHX with Heat Pumps (85°F)
Annual Heat Required (kBtu/yr)	322,480
Pumping Power (kwh/yr)	1,168
Fan Power (kwh/yr)	480
Heat Pump Power	18,936
Total Electricity Consumption (kwh/yr)	20,584
Annual Cost of Operation (electricity at $0.1644/kwh)	$3,384
Annual Savings over Existing Building Condition	$7,201
Approximate Initial Cost	$50,000
Simple Payback (years)	6.9

A simple analysis for the garage heating system with a 20 ton heat pump determines that the annual savings over the existing heating operational costs provides a payback in just seven years.

This is a photograph of the initial installation of the heat exchanger coils above the landfill liner system. The existing landfill is on the right, with the tie-in seam of the expansion and existing liner system located below the leachate transmission piping on the right. The northern leg of the collection system was installed first so that the landfill liner system construction could be completed and landfill operations commenced before the southern portion of the landfill liner system and heat exchanger were completed.

Pike Industries came up with a concept of using geonet to maintain the desired 24” spacing of the collector loops during placement of the select sand atop the pipe and liner system. The geonet was attached to the drainage geocomposite materials using plastic ties.

Securing Loops to Geonet with Zip Ties

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The collector piping was unrolled from its coil and then attached to the geonet to hold them in place. A two person crew installed the northern leg piping in just a few hours.

Completed Northern GCHX Collector on Western Slope

This is the completed northern leg of the heat exchanger on the western berm. Extensions of the loops to the manifold were completed with a single fusion pipe joint.

Installation of the select sand materials over the heat exchanger piping and primary liner system, using LGP dozer from the bottom of the slope to the top. The geonet attachment was successful in maintaining the collector spacing to optimize heat transfer.

GCHX Pipe Manifold at Return and Supply Lines

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Constructed pipe manifold with supply and return lines and risers for filling and testing the system. Manifold is located at anchor trench of liner system for future access.

Circulating Pump and Tank in Maintenance Facility

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Constructed circulating pump and storage tank within the maintenance facility.

Initial waste placement in October 2011 in Stage IV Phase II-A and over the heat exchanger.

Initial lifts of waste filling completed with 60 feet of waste over the top of the heat exchanger. Intermediate cover installed on the outboard slopes, with start of vegetative stand. Horizontal landfill gas collection trenches installed in waste mid slope. Landfill gas collection commenced in February 2013, heat exchange temperatures are at 85 °F and rising over time.

Applicability

- Nearby Heating Requirement
  - Landfill Maintenance Facility/Offices
  - Pump Stations
  - Commercial/Industrial Building
  - Greenhouse
- Direct Use Provides Quicker Payback
- Install in Base of Landfill Cell
  - Size of GCHX Based on Heating Requirements
  - Simple Installation
- More Efficient Than Conventional Geothermal

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