# Geothermal Heat Pumps in Agricultural Applications

Oregon Geothermal Working Group Meeting
May 17, 2006

*'Alternative Farming Center', Johnson County, Tennessee*

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# Presentation Outline

- Overview of geothermal heat pump (GHP) systems
  - aka: GeoExchange (GX), ground-source, ground-coupled
- Feasibility of agricultural applications
  - Greenhouses
  - Aquaculture
  - Dairy farming
- Example agricultural installations

Detroit, MI


Ice Arena, B.C.

# Overview:
# What do GHP systems provide?

- Heating
- Cooling
- Hot water
- Humidity control
- Ice making


Residential Heat Pump

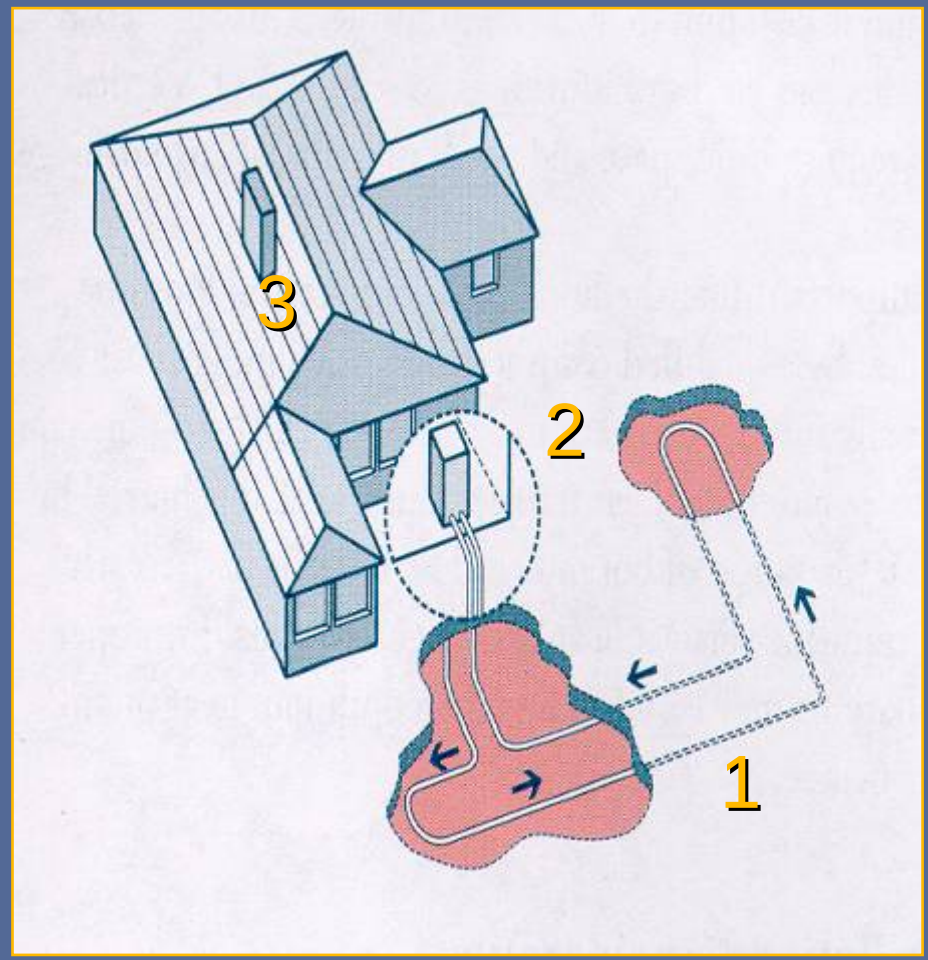

Lowell, MA

*...but also...*

- Energy efficiency
- Decreased maintenance
- Decreased space needs
- Low operating costs
- No outdoor equipment (no noise or outdoor maintenance)
- Comfort & air quality
- Reduced peak electrical loads for air conditioning

# Components of GHP Systems

1. Earth connection
   - Closed-loop
   - Open-loop
2. Water-source heat pump
3. Interior heating/ cooling distribution subsystem
   - Forced air
   - Radiant



# Components: Water-Source Heat Pump

- Water-to-air or water-water heat pump
- ¾ to 10 ton units are most common

# Vertical Closed-Loop


Historic building in downtown Detroit, MI

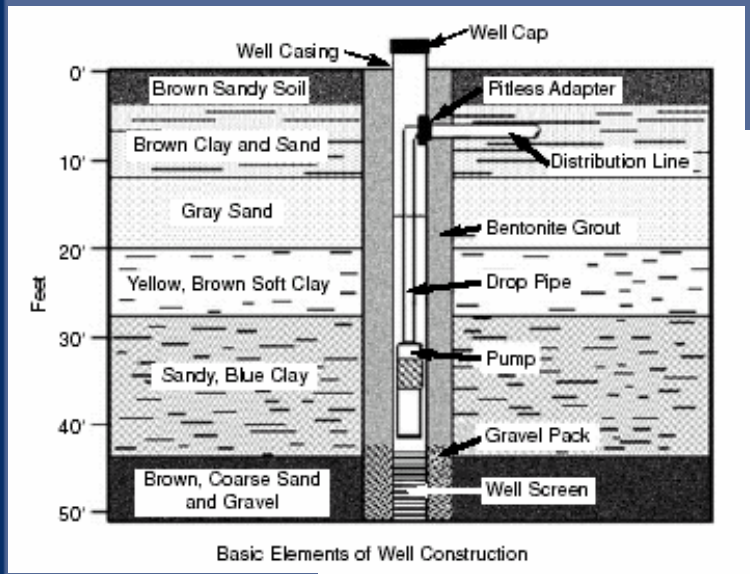
# Horizontal Closed-Loop

Trenching

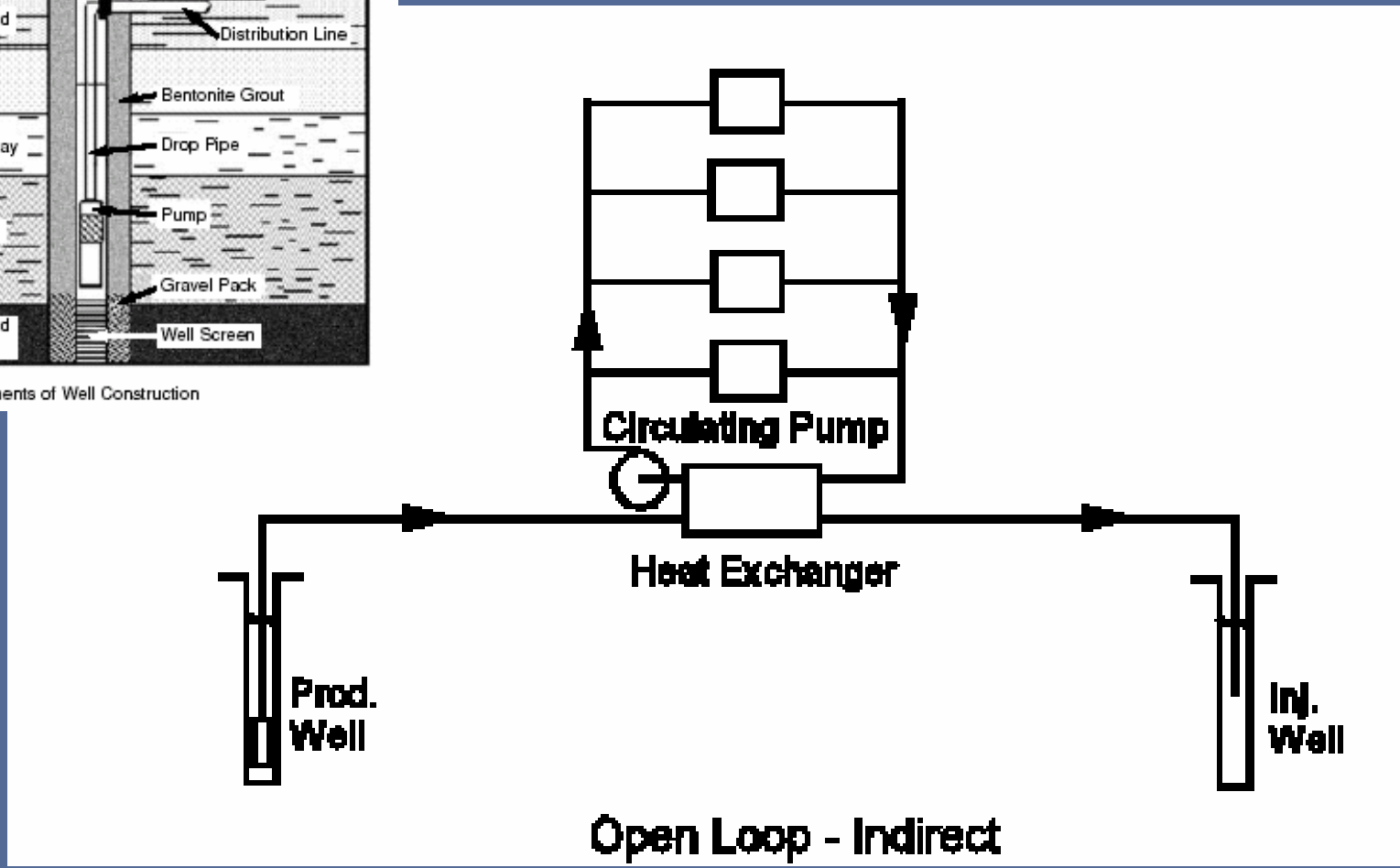
Excavation for a horizontal ground heat exchanger


Spiral slinky,

# Open-Loop



Basic Elements of Well Construction



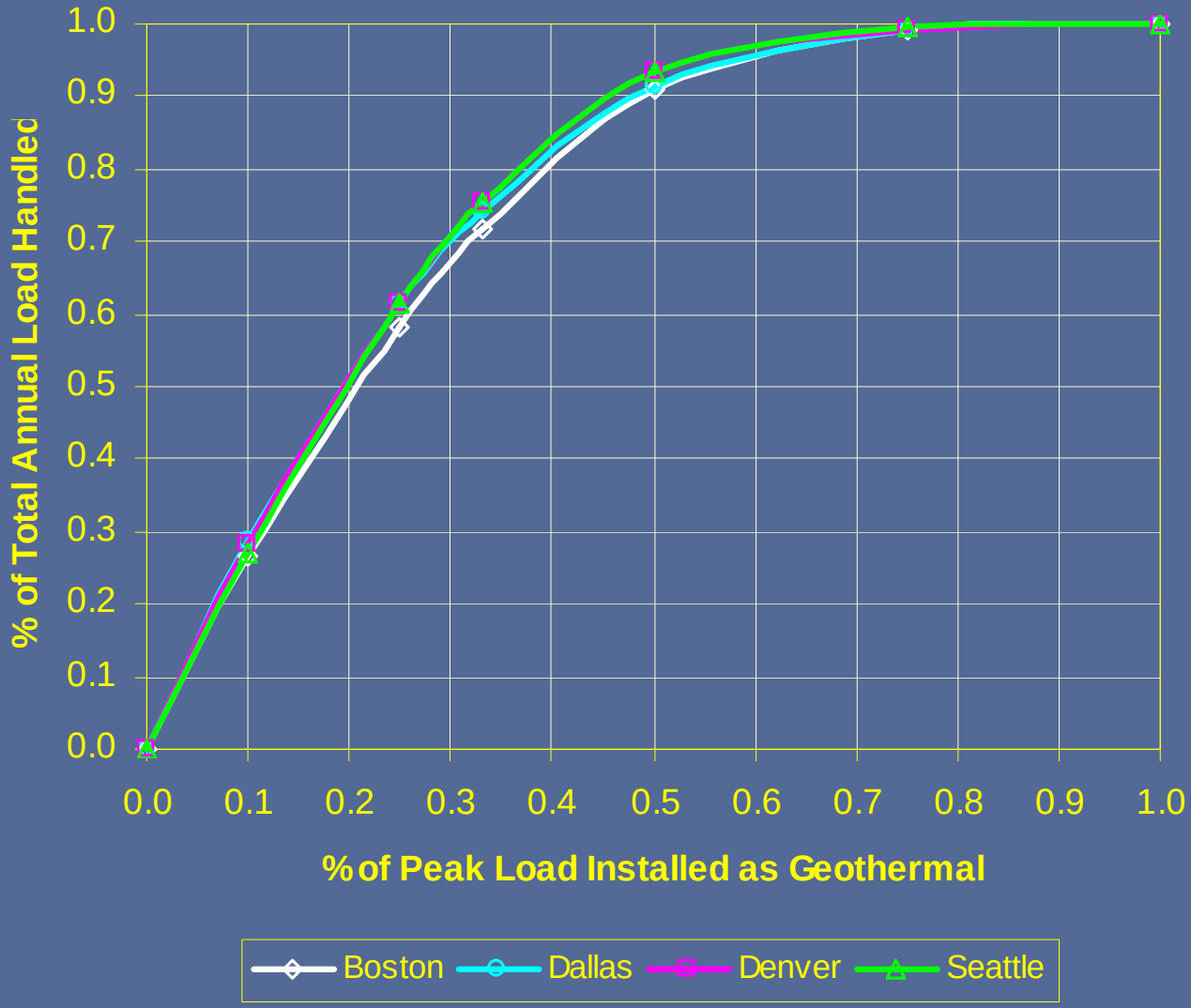
Open Loop - Indirect

# Some GHP Design Considerations: Loop Sizing

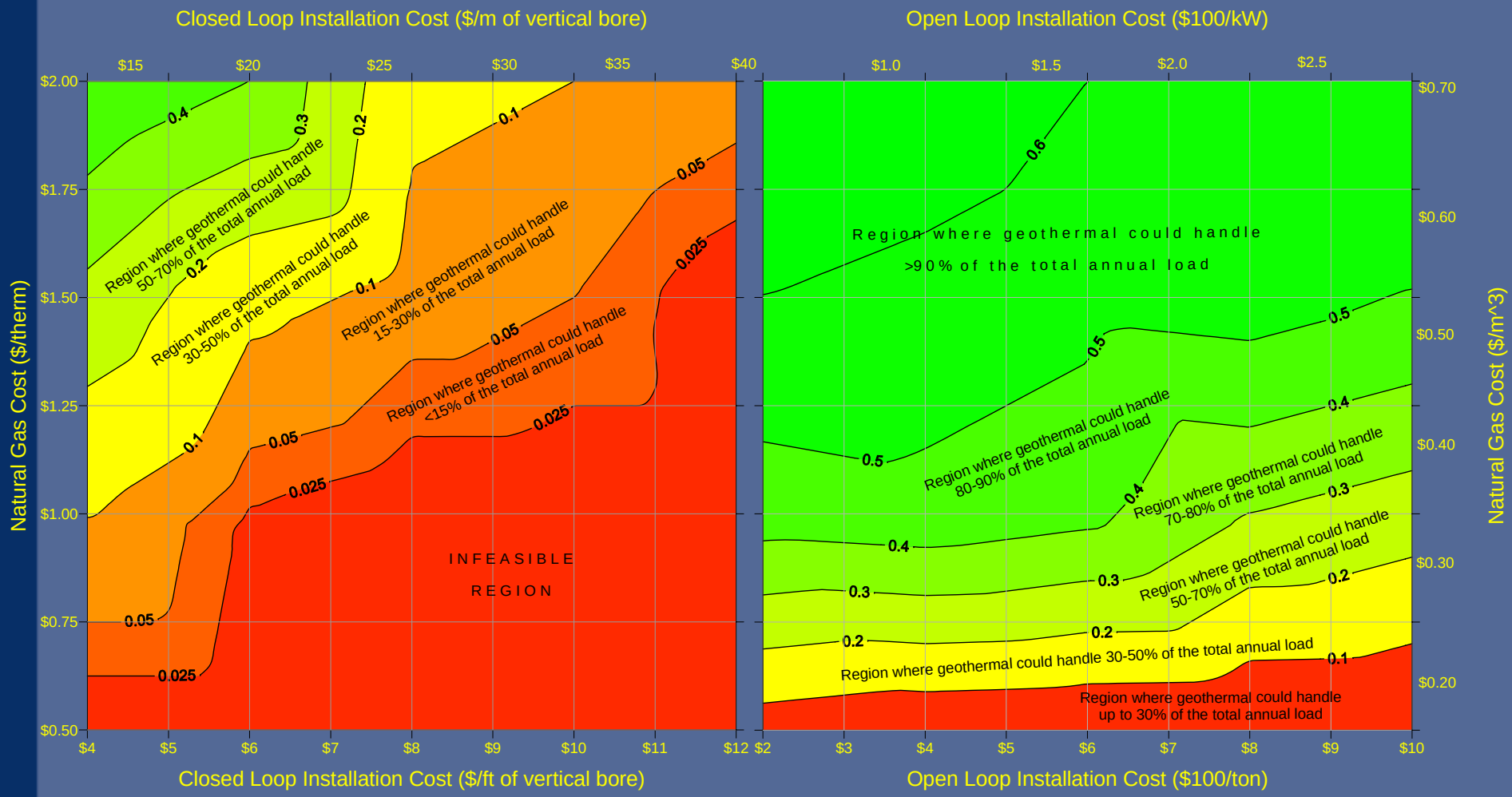
- Closed-loop lengths depend on:
  - Peak hourly load
  - Annual heating loads vs. annual cooling loads
  - Optimum loop lengths occur when annual loads are balanced

- Open-loops:
  - Required groundwater flow rate depends on its temperature (usually about 2 gpm/ton)
  - Groundwater quality and regulations!!

# Some GHP Design Considerations: Peak vs. Annual Loads



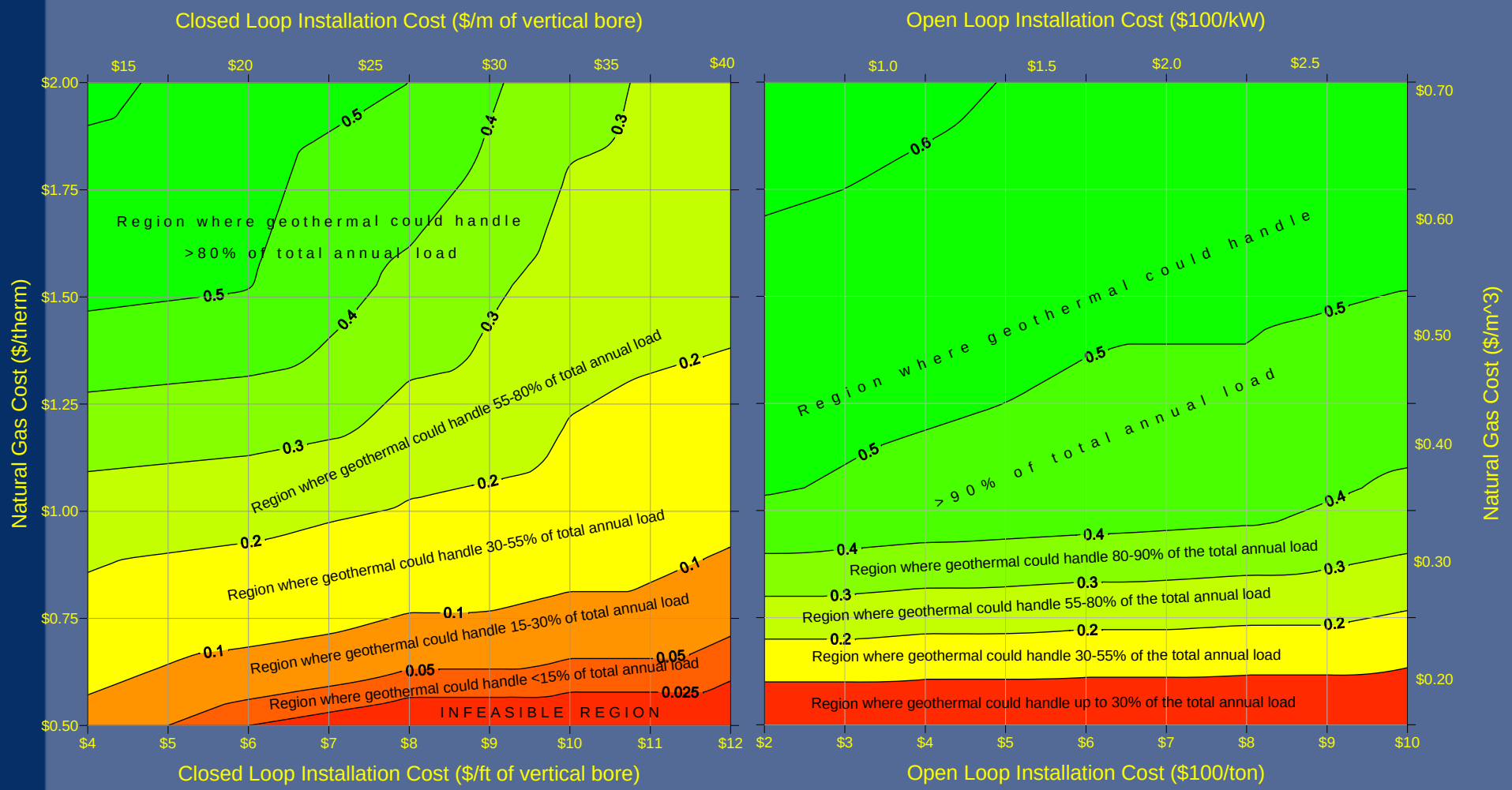
# GHPs and Greenhouses: Feasibility




**Contours represent fraction of geothermal capacity to the peak hourly heating load**

***Full article available at http://geoheat.oit.edu/bulletin/bull26-1/art2.pdf***

# GHPs and Aquaculture: Feasibility

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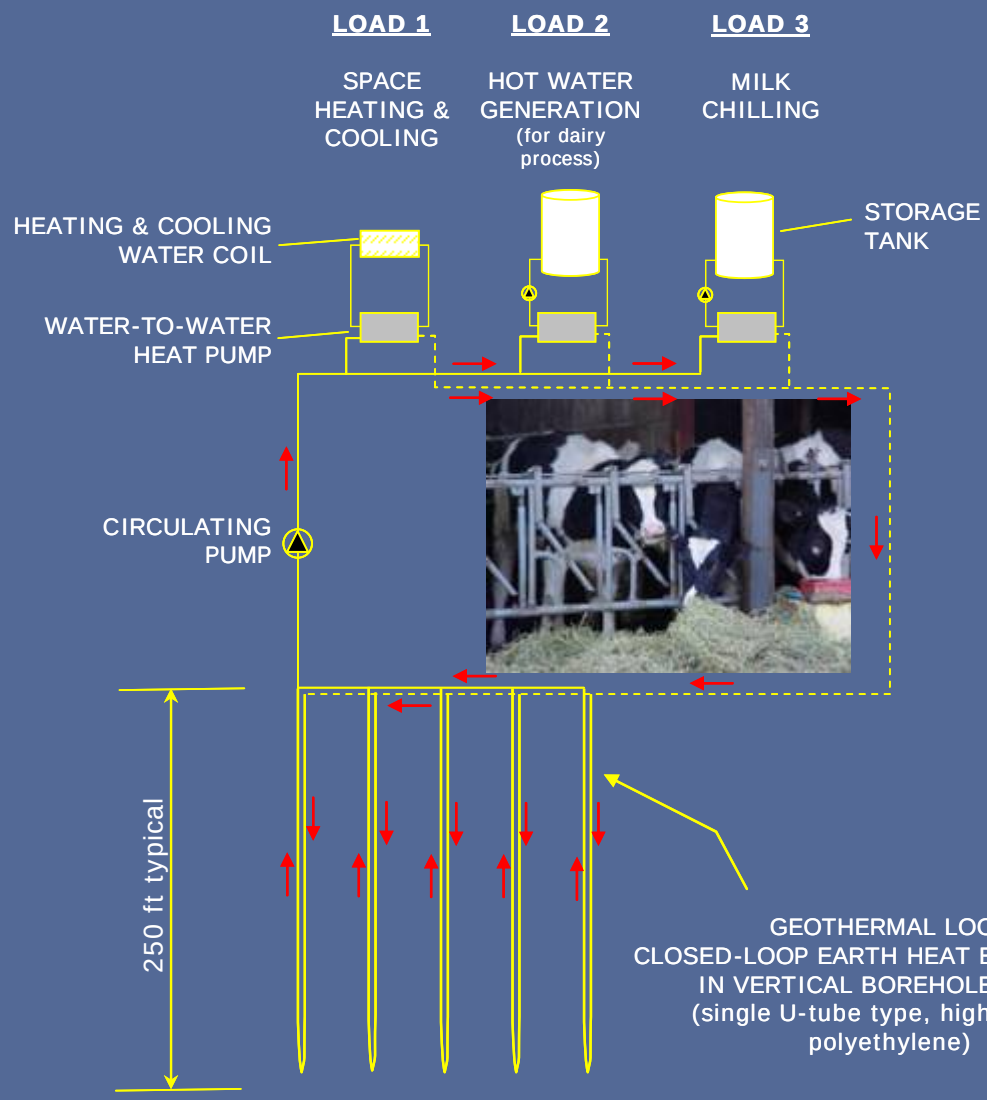
# GHPs Applied to a Dairy Farm




**PROCESS DESCRIPTION**

THE GEOTHERMAL LOOP ACTS AS A HEAT SOURCE AND SINK FOR WATER-SOURCE HEAT PUMPS.

IN ADDITION, THE GEOTHERMAL LOOP WILL ACT AS A THERMAL STORAGE MEDIUM, ALLOWING LOADS 2 AND 3 TO COMPLEMENT EACH OTHER ON BOTH SHORT AND LONG TIME SCALES. FOR EXAMPLE, LOAD 2 (HOT WATER GENERATION) WILL ONLY EXTRACT HEAT FROM THE LOOP WHILE LOAD 3 WILL ONLY REJECT HEAT TO THE LOOP. WHEN THESE TWO LOADS ARE IN DEMAND SIMULTANEOUSLY, THE NET LOAD ON THE EARTH LOOP APPROACHES ZERO. AT OTHER TIMES, THERMAL ENERGY WILL BE TRANSFERRED TO/FROM THE EARTH BY ONE LOAD AT CERTAIN TIMES, AND THEN RECOVERED BY THE OTHER LOAD AT LATER TIMES.

# Example Installations: Alternative Farming Center, TN

- Aquaculture operation in greenhouse structure (60’ x 150’)
- 90,000 gal. of water conditioned by five 5-ton water-water heat pumps for Tilapia production
- Approx. 100,000 lbs. fish/yr
- Air is conditioned by 4 water-air heat pumps (17 tons)
- Closed-loop vertical boreholes: 15 boreholes, 300 ft deep
- Annual operating cost savings exceed $30,000


# Example Installations: Greenhouse, Quebec

- 4+ acres, specializing in cut flowers
- Energy efficient construction; 7.2 million Btu/hr peak load
- Geothermal capacity: 58% (handles 89% of annual load)
- 640 boreholes, 105 ft deep @ **$4/ft**
- Installation cost: $1.2 million
- Incentives: $775,000
- Annual operating cost savings: $115,000
- $CO_2$ emissions: 1274 -> 285 tons

*Credit: P. Lambert, BMA Geo-Energy Inc., Montreal, Que.*

# Concluding Summary

- Geothermal heat pumps are an energy-efficient technology
- Large agricultural applications are few, but potential is large
- More cost effective in some situations than others
  - Simultaneous heating and cooling loads
  - Low closed-loop cost
  - High conventional fuel costs
  - Reduced greenhouse gas emissions