

# Geothermal H.V.A.C. Systems in High Performance Buildings



## An Introduction to Geothermal Systems for Green | Spaces

By: Matt Williams, P.E., LEED AP  
Campbell & Associates, Inc.

# The 3 Major Components to an Energy Efficient Building:

- HVAC
- Lighting
- Building Envelope

# System Strategies:

## 1. HVAC

- Standard Systems: Packaged or Split System DX, Variable Air Volume, Heat Pumps or Gas
- High Performance Systems: Geothermal, Variable Refrigerant Volume (VRV), Ultra High Efficiency DX Equipment
- Energy Recovery Ventilators (ERV's)
- Demand Control Ventilation

## 2. Lighting

## 3. Building Envelope

# System Strategies:

## 1. HVAC

## 2. Lighting

- High Efficiency Fixtures (T5, T5 HO's, LED's)
- Task Lighting
- Occupancy Sensors
- Natural Daylighting (Clerestories, Light Tubes, Light Shelves)
- Daylighting Controls

## 3. Building Envelope

# System Strategies:

1. HVAC
2. Lighting
3. Building Envelope
  - Roof – R-Value, High Albedo
  - Walls – R-Value, Shading
  - Glazing – High Performance, Location, Glare Control

# Considerations:

## 1. Fast Paybacks (1-3 years)

- ERV's, Demand Control Ventilation
- Enhanced Glazing
- Occupancy Sensors for Lighting

## 2. Mid Range Paybacks (4-9 years)

- Geothermal, VRV
- Enhanced Insulation
- High Efficiency Lighting, Daylighting Controls
- Passive Solar Water Heating

## 3. Long Term Paybacks (10+ years)

- Active Solar Photovoltaics (can be quicker with incentives)
- Cisterns
- Geothermal

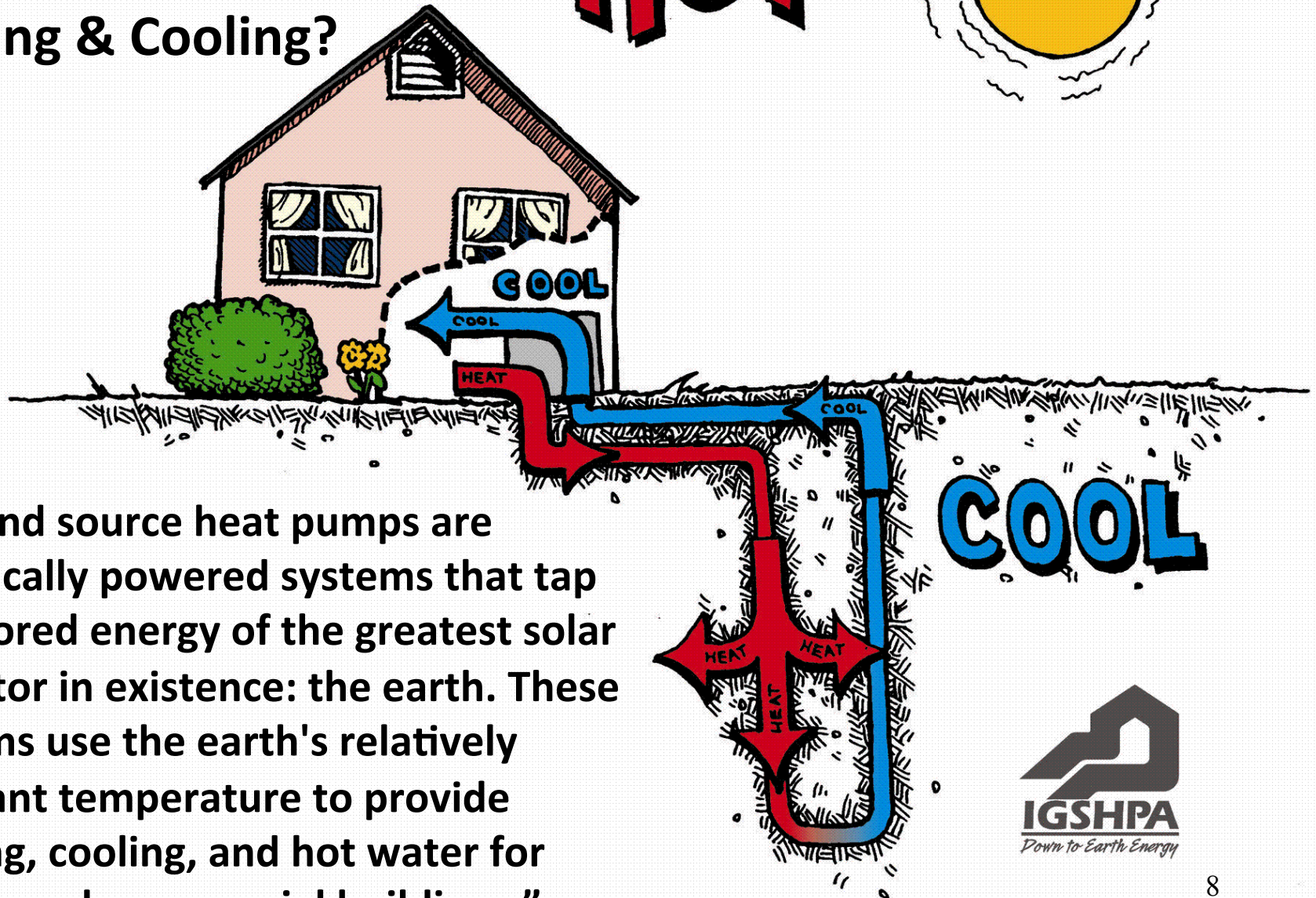
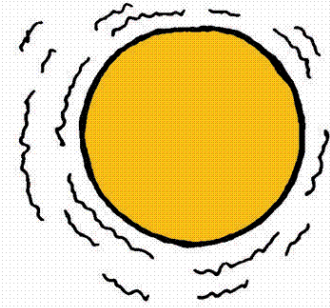
# Geothermal Heat Pump Systems

## Types of Geothermal Systems

- Conventional Closed Loop
  - Vertical
  - Horizontal
  - Reservoir (Radiator or Coils)
- Hybrid
- Open Loop
  - Pump & Dump
  - Reinjection

# What is Geothermal Heating & Cooling?

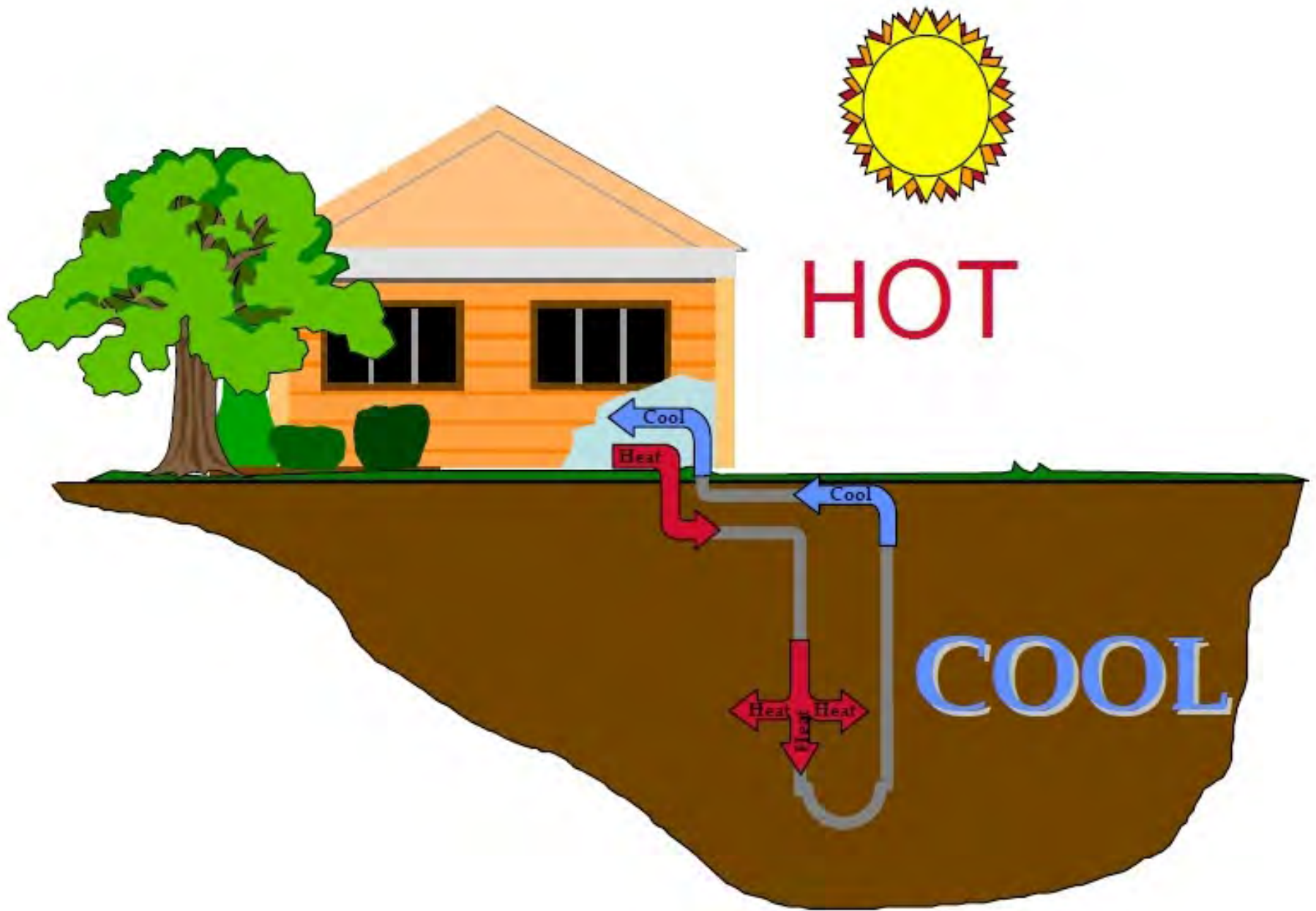
# HOT



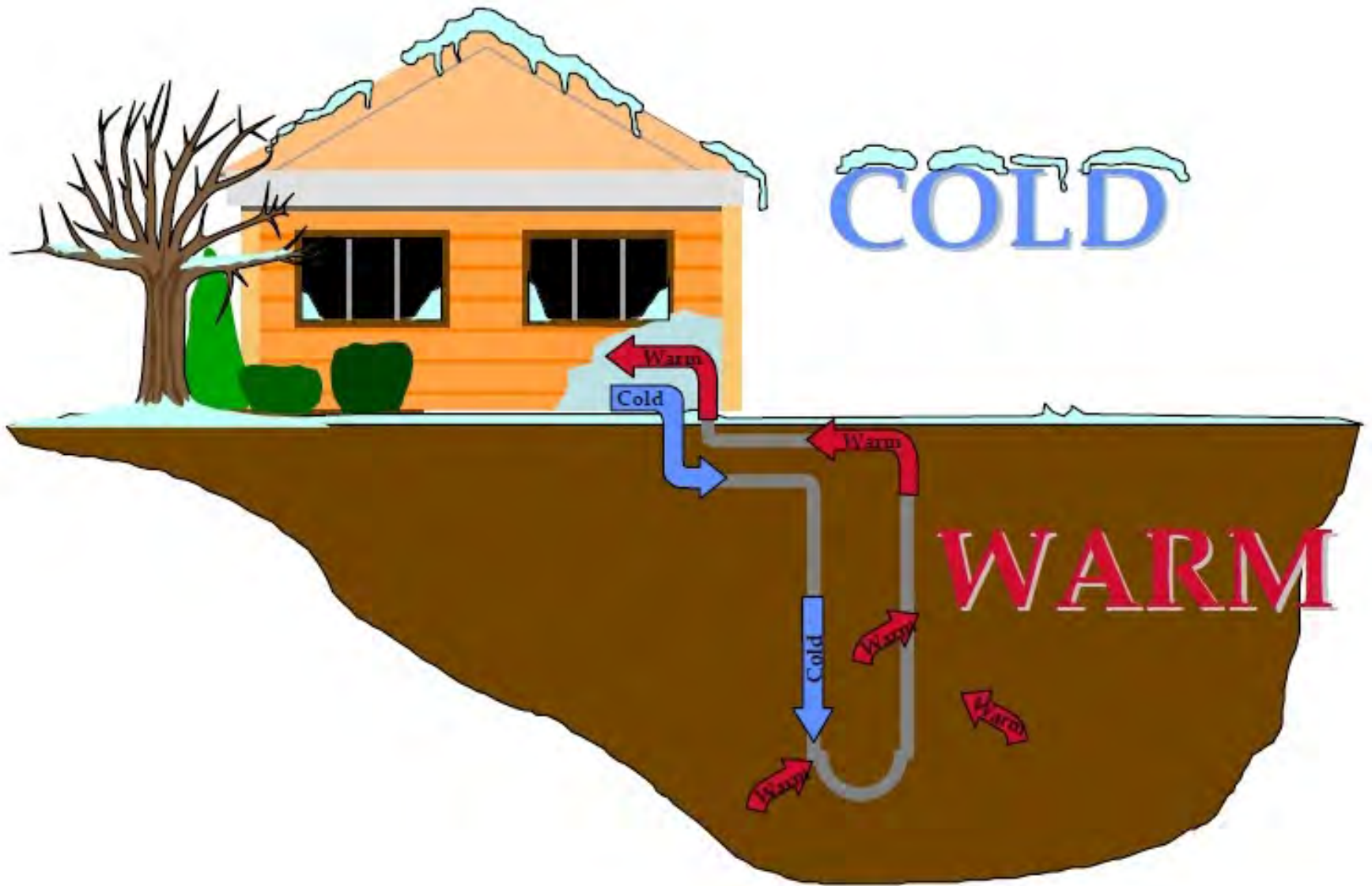
“Ground source heat pumps are electrically powered systems that tap the stored energy of the greatest solar collector in existence: the earth. These systems use the earth's relatively constant temperature to provide heating, cooling, and hot water for homes and commercial buildings.”



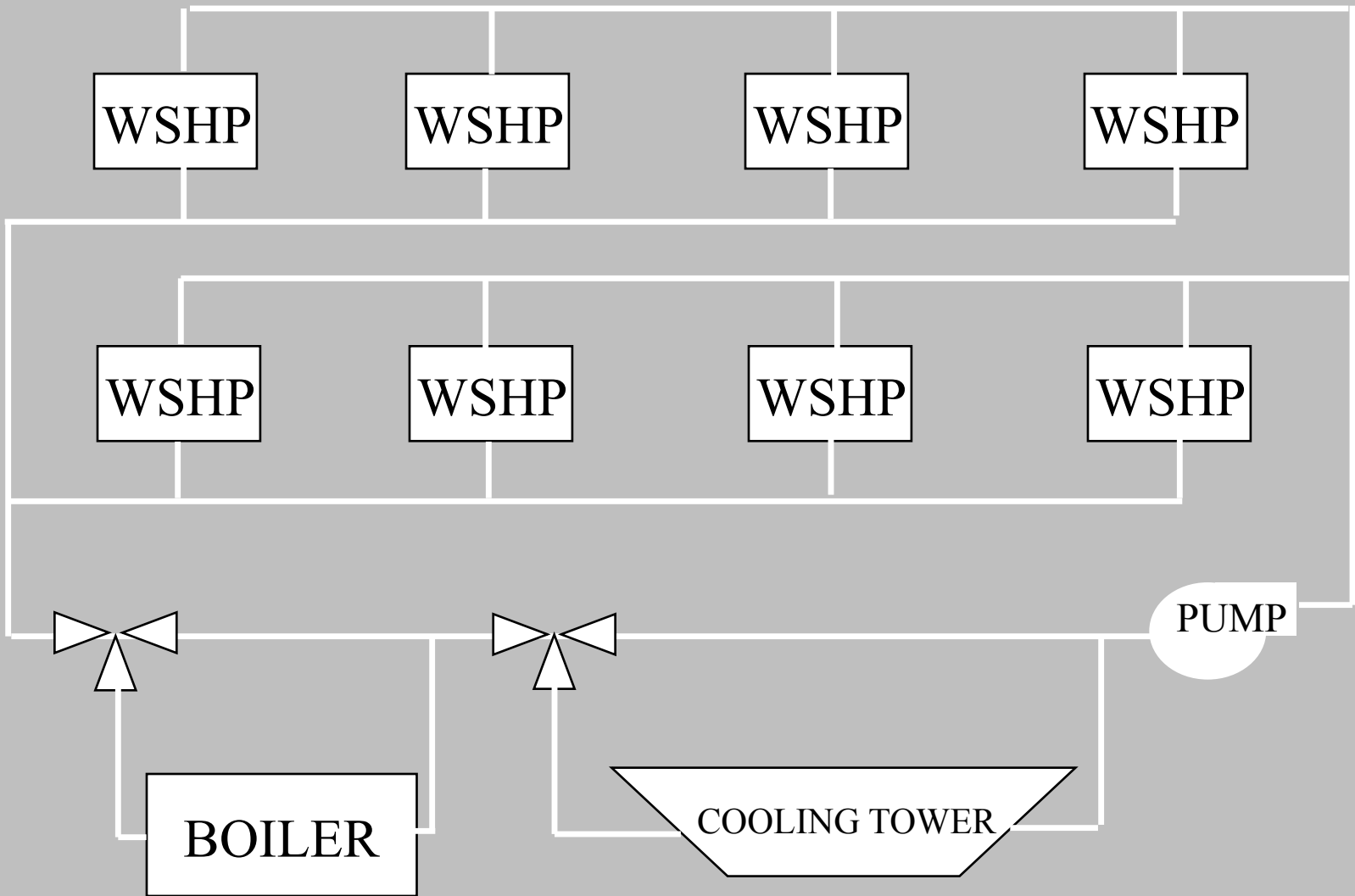




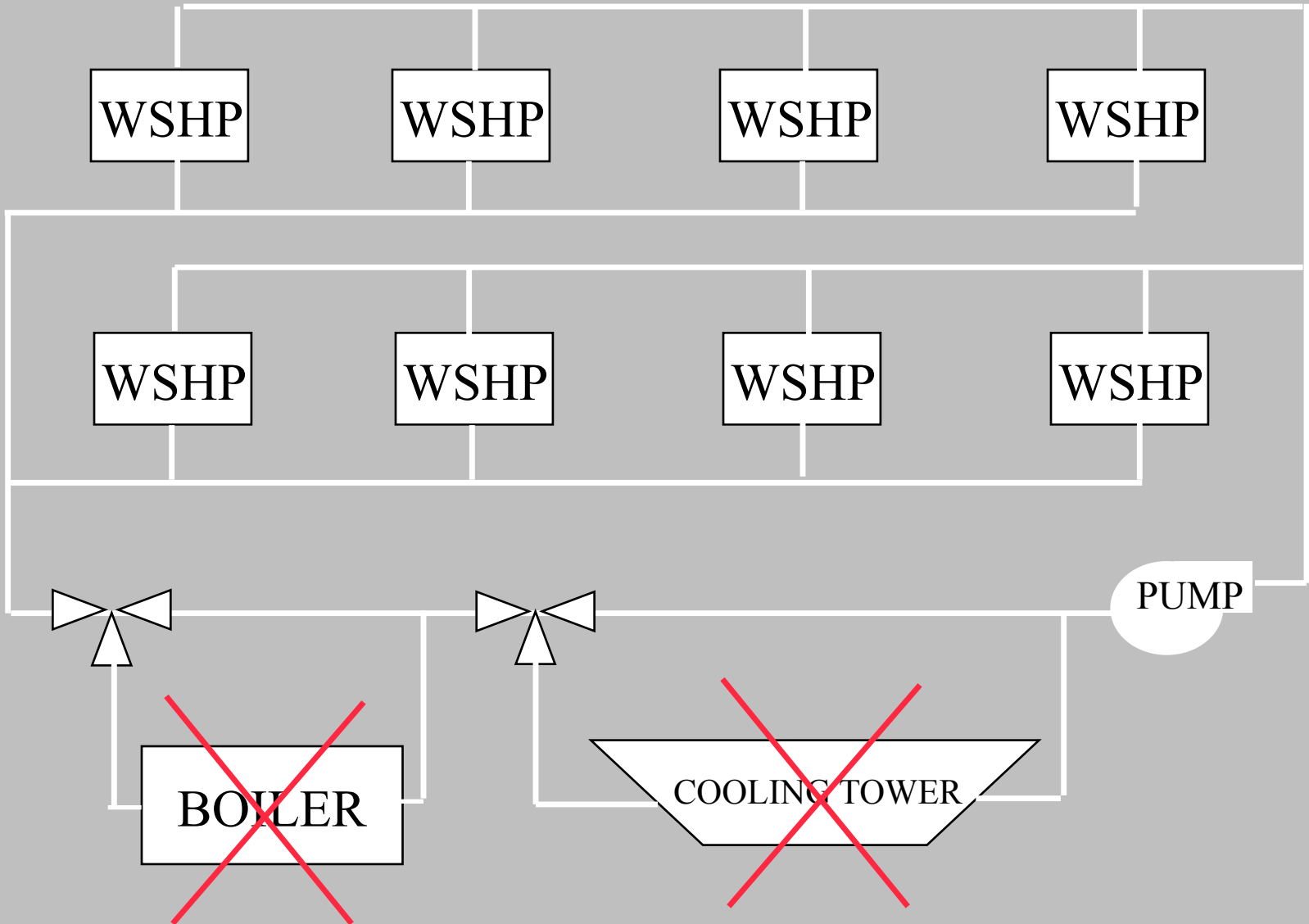
COLD



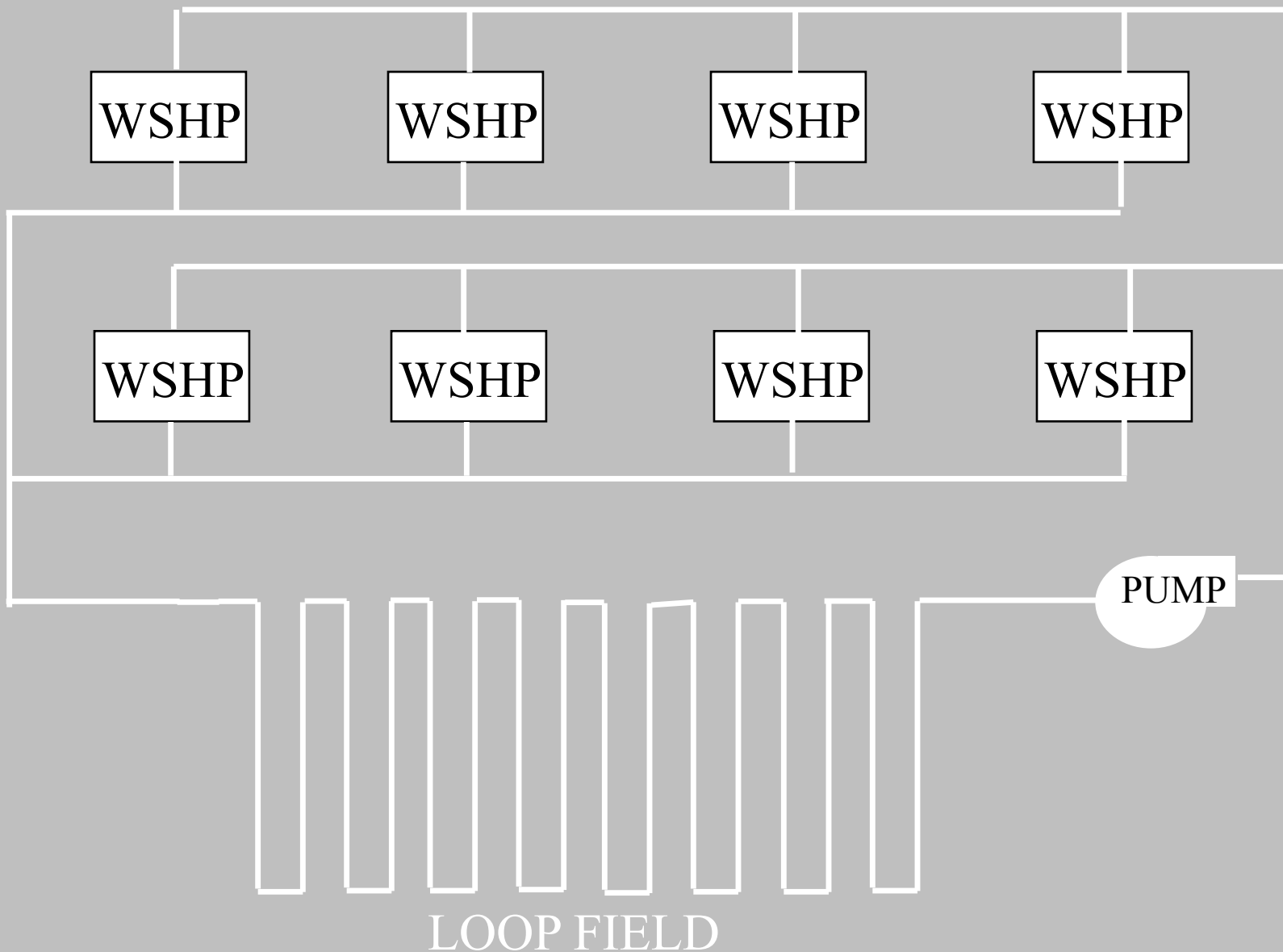
# WATER-LOOP HEAT PUMP SYSTEM

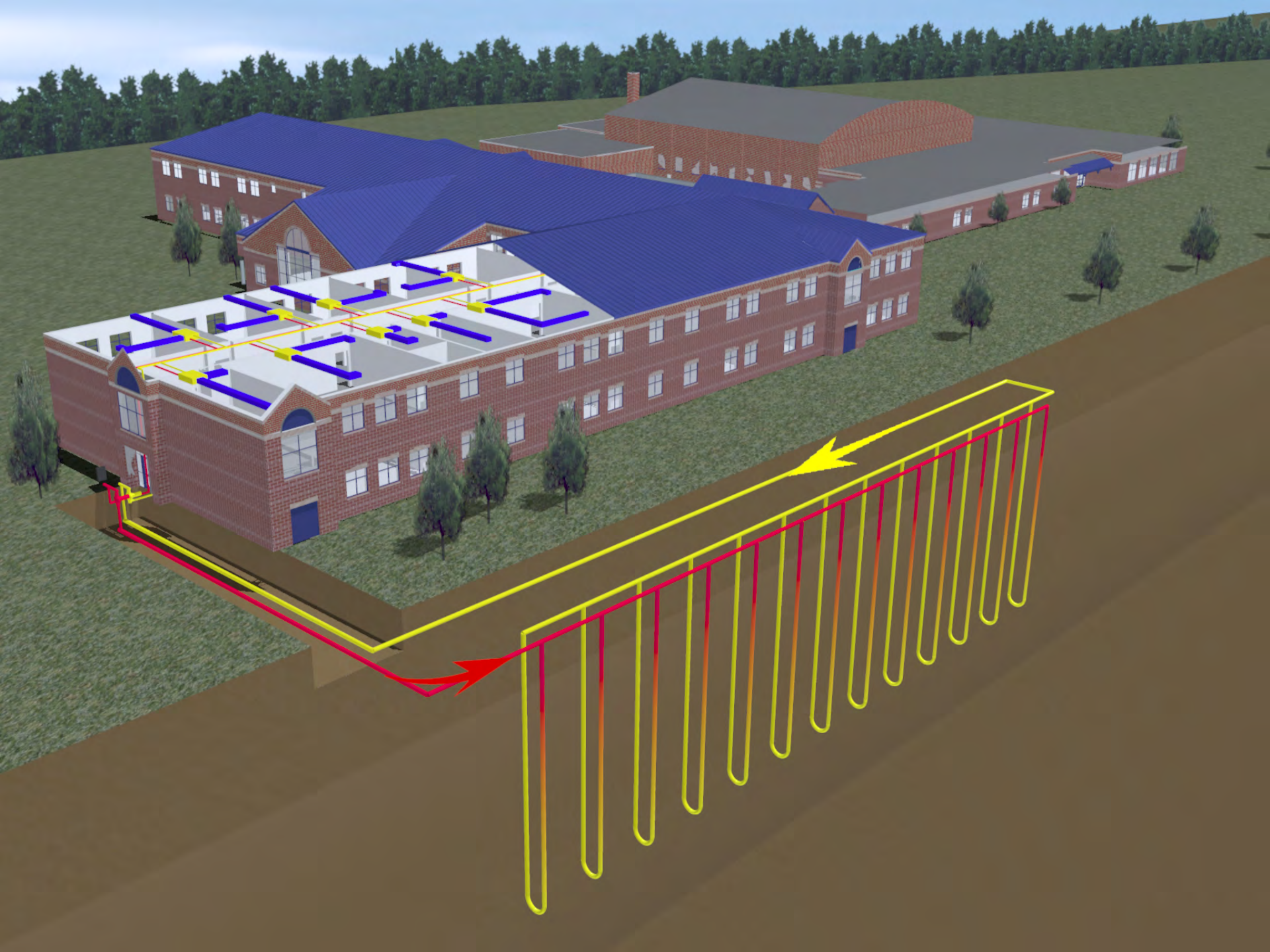


# WATER-LOOP HEAT PUMP SYSTEM



# CONVENTIONAL GEOTHERMAL HEAT PUMP SYSTEM



















**Stub Up  
Supply/Return  
Piping in  
Building**







LED WATER SUP

CHILLED WATER SUPPLY

CHILLED WATER RETURN

CHILLED WATER RETURN  
GEOHERMAL WATER RET

0.0  
0.0

0.0  
0.0

CHILLED WATER RETURN  
CHILLED WATER RETURN  
CHILLED WATER RETURN

CHILLED WATER SUP.  
CHILLED WATER SUP.

GEOHERMAL WATER SUPPLY  
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GEOHERMAL WATER RETURN  
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GEOHERMAL WATER  
GEOHERMAL WATER

CHILLED WATER RETURN  
CHILLED WATER RETURN  
CHILLED WATER RETURN



**Excavate  
Circuit Trench  
~3' Wide X 4-5'  
Deep**

07.25.2011 17:06





**Fabricate Circuit  
Piping Along  
Trench Above  
Ground**



**Bed Ditch, Place Header  
Piping in Ditch and  
Connect Each Loop**

# Hydrostatically Test the Circuit

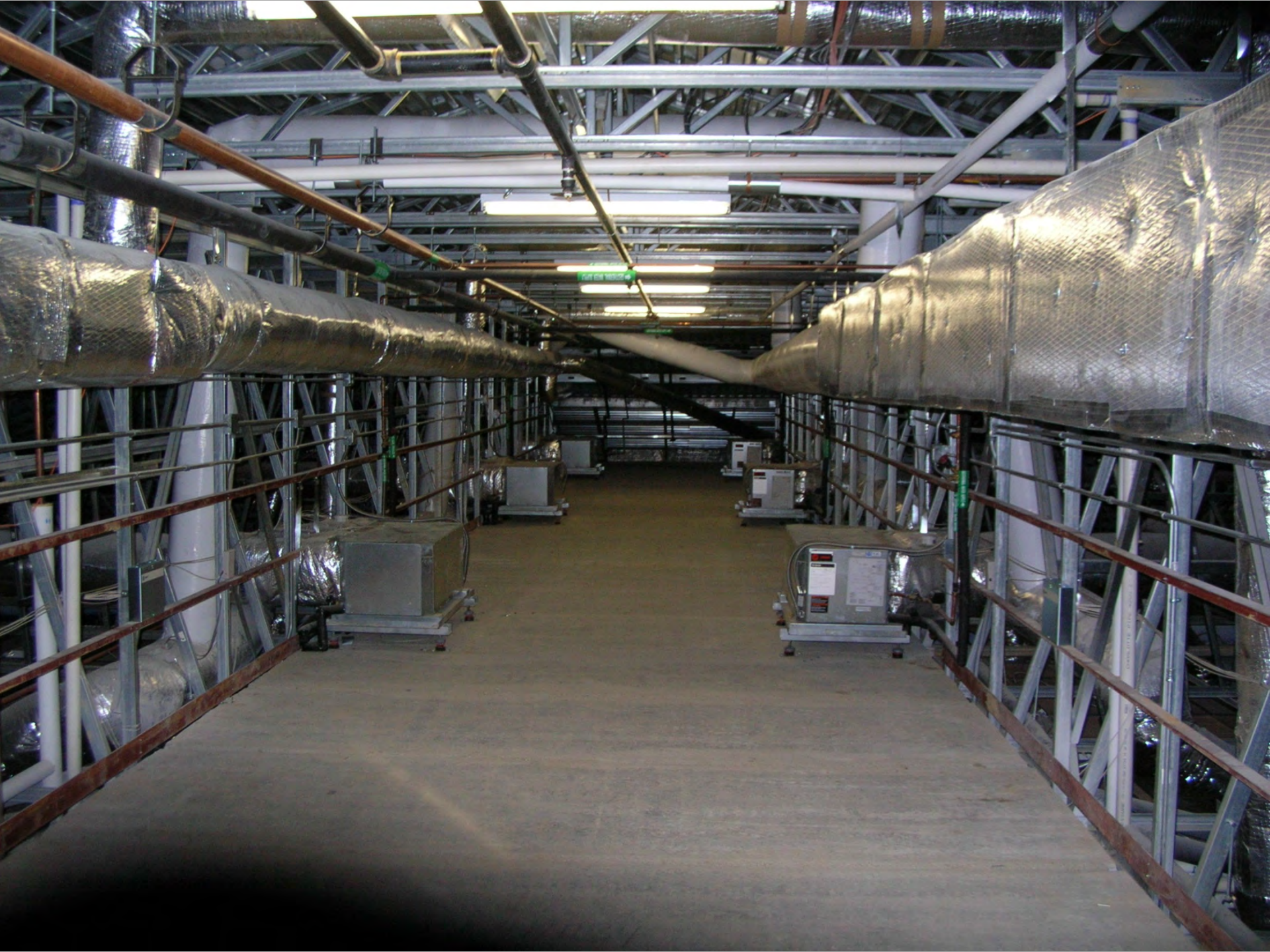


A photograph showing a trench with a pipe and gravel backfill. The trench walls are lined with orange-brown soil. A dark pipe is visible in the foreground, and a layer of light-colored gravel is visible in the background. A text box is overlaid on the right side of the image.

**Install Locater  
Wire and Backfill  
with Screenings**







# Excerpt from “HVAC System Comparative Study for the Signal Mountain High and Middle Schools”

	<b>Variable Air Volume (VAV)</b>	<b>Ground Coupled Heat Pump (GCHP)</b>	
First Cost	\$ 2,821,000	\$ 3,687,400	
Statistical Life	22	19	
Present Value	\$3,451,884	\$4,027,695	
Life Cycle Cost	\$25,058,731	\$20,077,855	
Annual Operating Cost/ sf	\$1.44	\$0.94	
Payback (years)	-	6.4	



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- GCHP provides lower operating, maintenance and life cycle costs.
- Energy savings over the next 20 years of approximately \$2 million. Actual 20 year payback closer to \$3M.
- According to the EPA, geothermal is the most energy-efficient, environmentally clean, and cost-effective space conditioning system available.

# Heritage High School: Ringgold, GA





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aerial innovations  
of Georgia, Inc. 770-986-0333



HERITAGE HIGH SCHOOL  
Ringgold, Georgia

Date: MAY 09 2008

HHS





Signal Mtn. Middle & High School

# Signal Mountain MHS



Signal Mtn. Project  
Looking East  
09/15/07


# Signal Mountain MHS



# Signal Mountain MHS







**262,250 ft<sup>2</sup>**

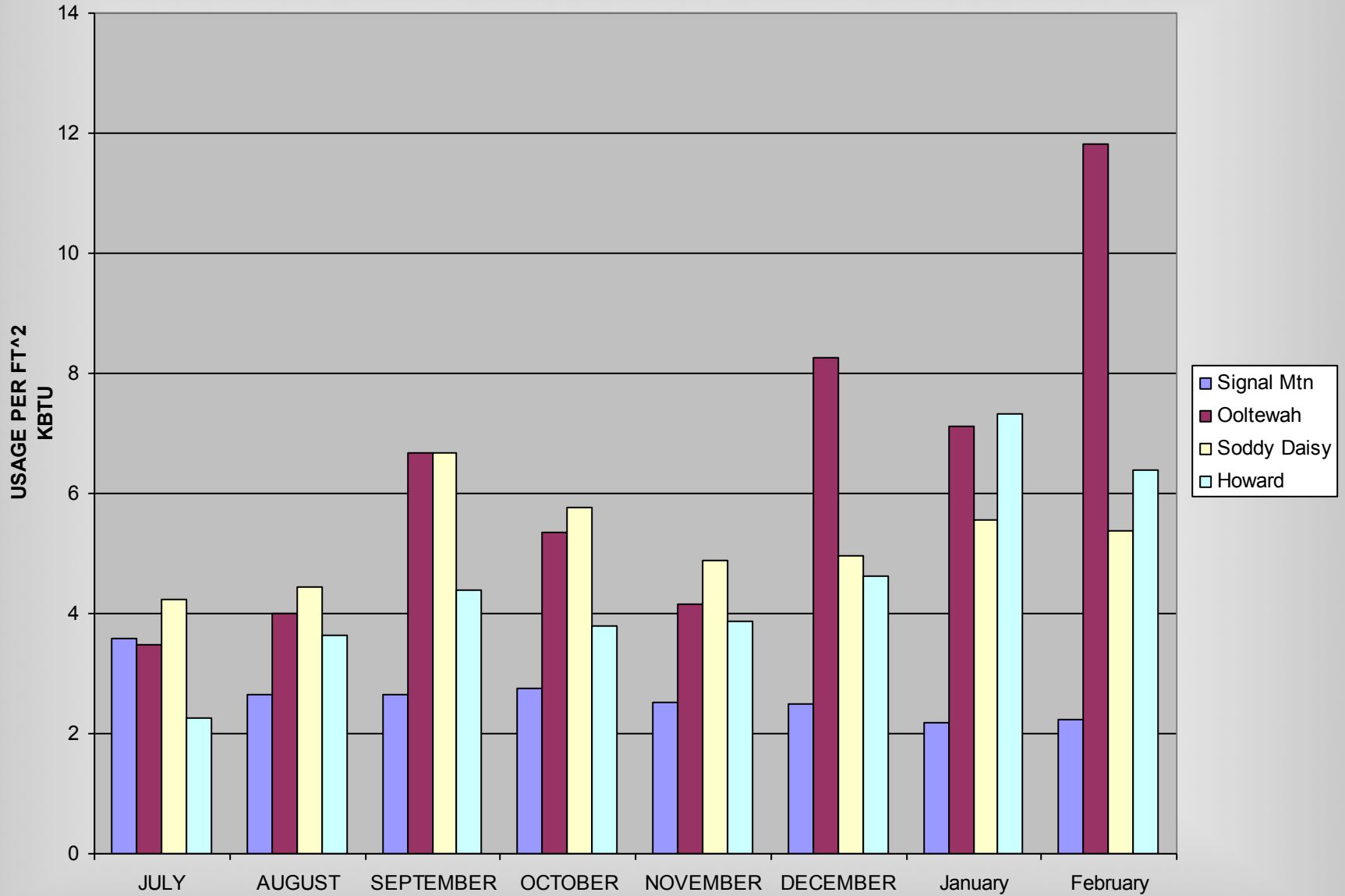
**362 Bores @ 300' Ea**

**Signal Mtn. Middle-  
High School**

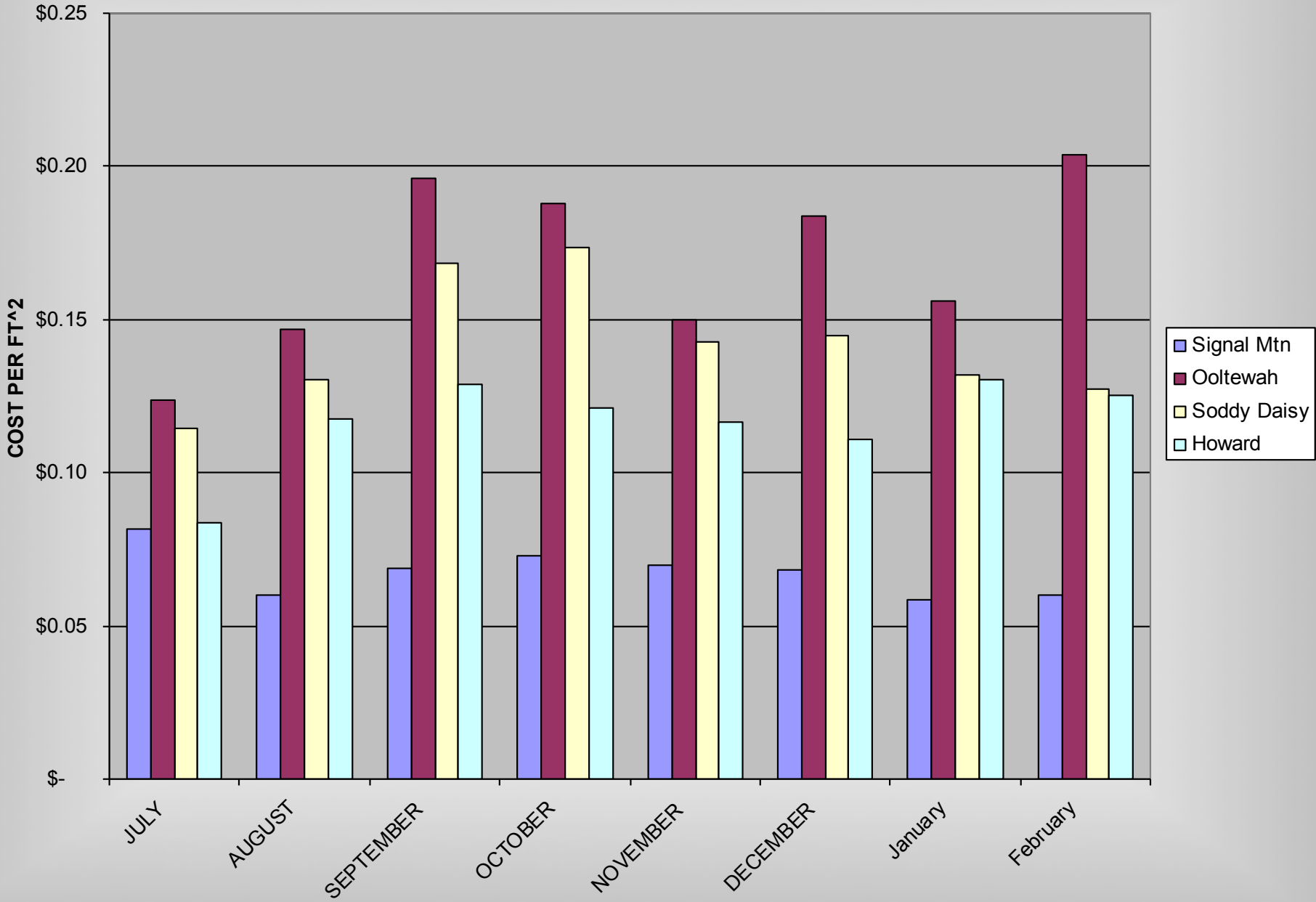
# Signal Mountain MHS



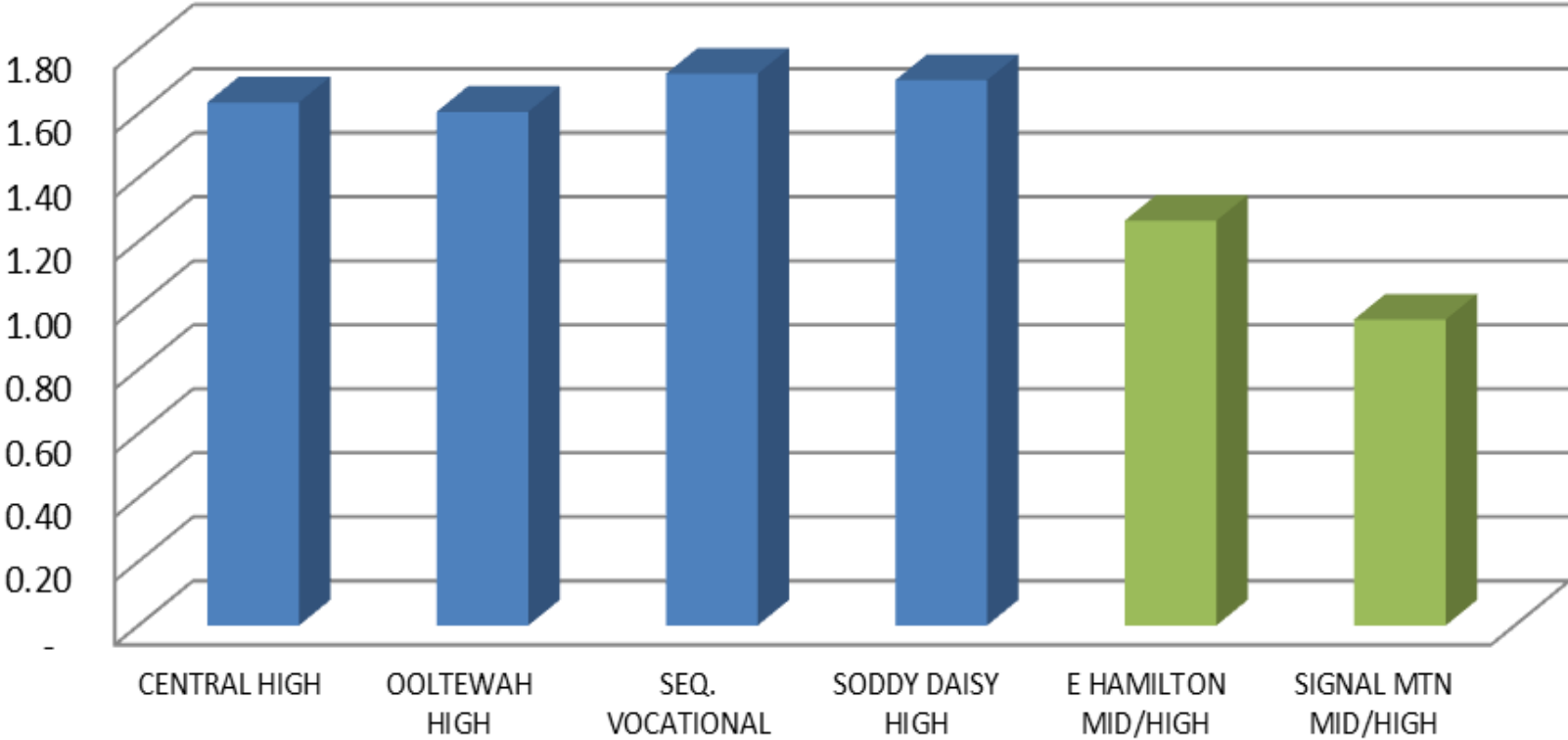
# HIGH SCHOOL COMPARISON



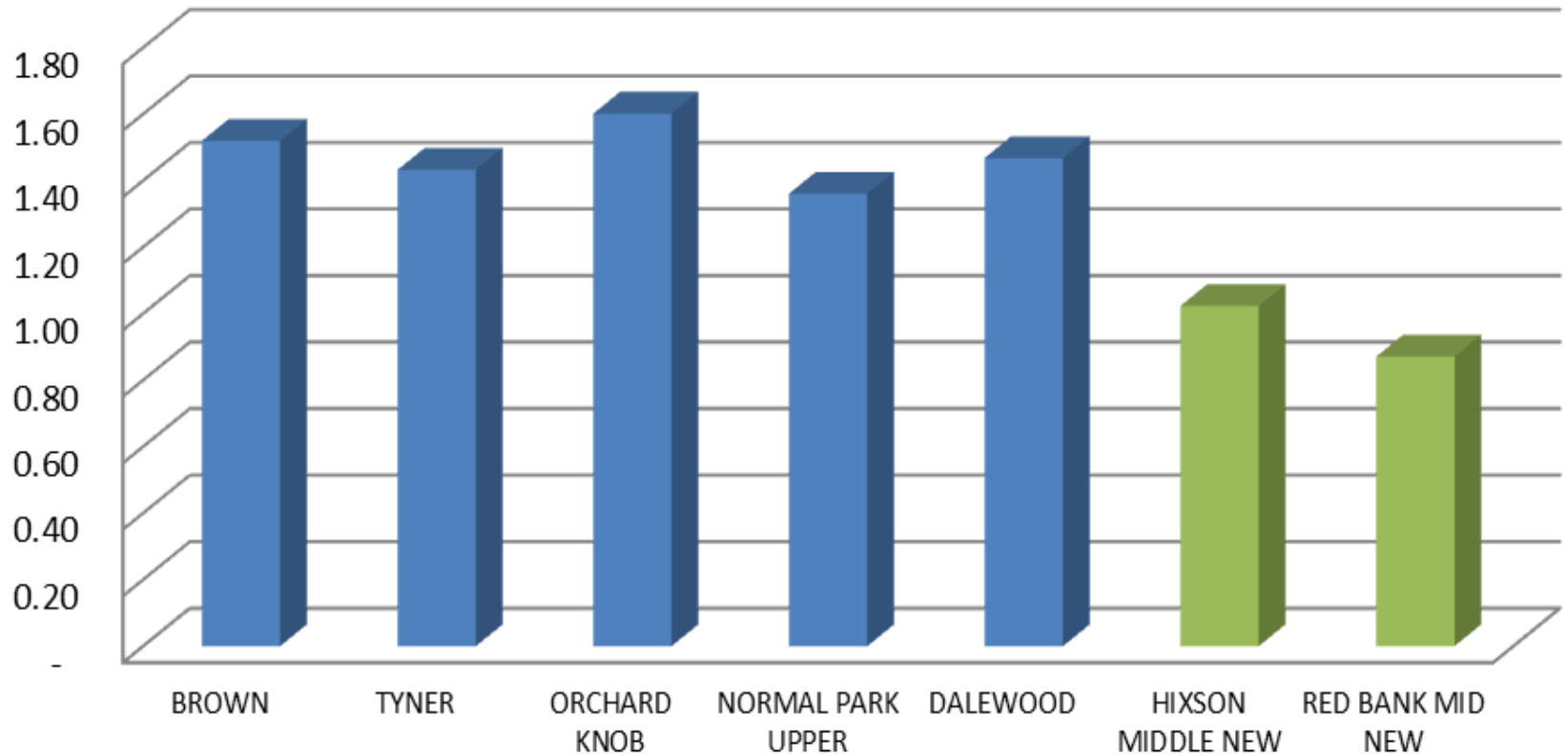
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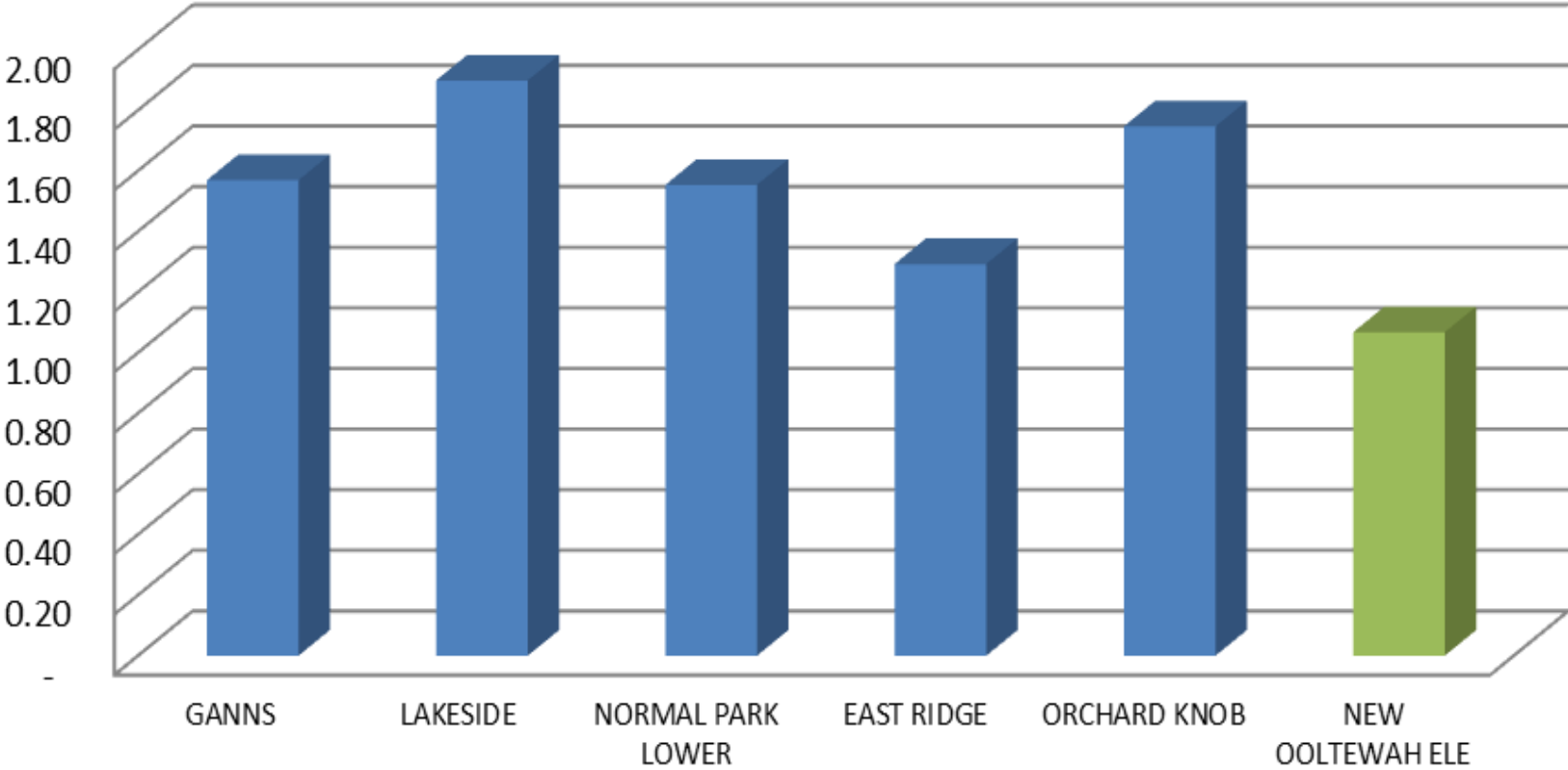
# HIGH SCHOOL ENERGY USE (\$/SF)



## MIDDLE SCHOOL ENERGY USE (\$/SF)



# ELEMENTARY SCHOOL ENERGY USE (\$/SF)



# Charlotte Office Building





# Charlotte Office Building



# Charlotte Office Building



# Horizontal Bore Field Installation



# Horizontal Installation: Section at Trench



# Horizontal Borefield Installation



# Alternate Heat Sink: A Lake



# Lake as a Heat Sink









# Finished product: David Crockett State Park



# Open Systems



# Open Systems



# HVAC System Comparison

**Dade County Courts Facility**

Estimated Square Footage = 28,680

Item	Variable Air Volume Rooftop (VAV)	Conventional Geothermal Heat Pump	Variable Refrigerant Heat Pump
First Cost	483,258	623,790	573,600
Statistical Life	22	19	19
Operating costs	45,314	27,246	33,842
Life Cycle Cost	3,266,747	2,617,422	2,608,741
Annual Operating Cost (\$/SF)	1.58	0.95	1.18
Annual Operating Cost	45,314.40	27,246.00	33,842.40
Simple Payback (years)		7.8	7.9
*note - no incentives available in Dade Co. from Ga. Power		-	-

# Hixson Middle School



# Hixson Middle School



Questions?

Thank you green | spaces!