STANDING COLUMN WELLS
AT VILLANOVA UNIVERSITY

ARB Geowell
A SMARTER GEOTHERMAL WELL

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Agenda

- SCW Geothermal Engineering Project
- Geowell® SCW Design & Hardware
- Fedigan Hall Geothermal Installation
- SCW Thermal Testing & Analysis
- Hybrid Geothermal HVAC System Design
- Geowell Hybrid System Performance
- Summary & Conclusions
Villanova Engineering Team
Experimental Layout & Test Facility
Test Column Layout

- Pump/Casing
- Foam float
- Polypipe entry section
- Concrete guide

Dimensions:
- 20'
- 2'
- 1.5'
- 11'
- 1.3'
Insertion of Pump Assembly into Housing
Well string is divided into two separable sections:
- the bottomhole umbilical, and
- the pump section.

Intended as a faster installation scheme, replacing the use of 20’ PVC well casing sections + joints with continuous deployment of m/HDPE or PP polypipe from reels.

Well string employs a submersible pump housing & flotation assembly to affect a seal, allowing the pump to be retrieved separately for service.

Flat hose return lines mounted at the OD of the housing to insure water is returned below static level and to allow potential retrieval of the umbilical section.
Geowell™ “Hanging” Column Well Design

- 8” Grouted Steel Casing
- 8” Bore
- 6” Bore
- Pump Housing
- Float
- 1½” Twin Polypipe Extensions
- 10’ Perf Section
- Flat Hose Returns
- 60’
- 90’
- 650’
- 650’

Dimensions:
- 60’
- 90’
- 650’
Geowell™ String Components

Perforated Pipe
Bottom-hole Section

Weighted Base & Waste Gate

Submersible Pump
Pump Housing
Flat Hose Returns
Wellhead Test Jig
Suspension Float
VILLANOVA UNIVERSITY
FEDIGAN HALL DORMITORY

Jan 2009
Two 800’ SCW: Drilling & String Installation
Drilling Subcontract
Drilling Subcontract
Drilling Subcontract
Installation of Perforated Bottom Section
800’ Well String Installation
Twin m/HDPE Pipe Installation Jig
Assemblage of pump housing atop float

- Band attachment of flat hose
- Pump housing
- Twin m/HDPE pipe attachment
- Suspension float
Installation of Pump & Housing
Hydrogeologic Investigation

- Rock types: felsic & mafic gneiss with a brittle amphibolite zone
- Largest WBZ at 300’ @ 10-30 gpm (source: Darby Creek to the south)
- Static water level @ 70’
- pH 8.3 with little TDS encountered
- Drawdown testing: sustained operation 3-4 gpm and 10 gpm for well #1 and #2, respectively.
2 Geowells, 800’ deep, delivering 15 tons, but connected to a 60 ton peak bldg. load with campus H/CW backup
Thermal Testing Results

Heat Flux = 46.5 BTUH/ft
K = 1.857 BTUH/ft°F

Slope = 11.3
Thermal Relaxation Testing

\[ T = 82.31 - 7.374 \ln(t) \]

36 min
Simulated 7.5 Ton Load
Duty Cycle Investigation

SCW Response to Duty Cycle Delivering 7.5 Tons

Time of Day

SCW Water Temperature (°F)

- DC=50%
- DC=58%
- DC=67%
- DC=75%
- DC=83%
- DC=100%
Design (fpt) Basis for 7.5 Tons
K-Value Impact on Design

K-factor Affect on Design (ft/ton)

Design (ft/ton)

k (BTUH/ft°F)

1 1.5 2 2.5 3

50 100 150
VU FEDIGAN HALL
HYBRID HVAC SCHEME

Two Geowells (15 ton) Maintaining a 60 ton Heat Pump Loop
Supplemented by Campus Steam & Chilled Water Backup
Hybrid HVAC Schematic

Steam or Chilled Water Supplement

VFD

HP Loop

TL2

TL1

Plate HX

T2

FS1

P1

P2

T4

SCW Wells

T3

FS2

FS
Crawl Space & Mechanical Room

Geo-Supply Lines

Controls

Plate HX
Control Logic

- HP Loop operates [45-85°F]; outside that range, the system will use 15 tons (125,000 BTUH) geothermal to satisfy the load.

- Before activating geothermal, the SCW temperature is checked to verify contribution. If insufficient, the wells are de-activated for a period, “τ”, to achieve recovery.

- If after “x” loops around the circuit, geothermal cannot meet the load alone, the supplemental heating/cooling is added.
Load hours supplied by geothermal
Fedigan Hall Cooling Load

Fedigan Hall Cooling Load

Ton-hrs

Cooling Day
Geowell Performance

Serving 39% of the Load Hours

Geo-Portion of Load

- Load Served (ton-hrs)
- Cooling Day
- Serving 39% of the Load Hours

Legend:
- Load-hrs
- Geo-hrs
Geowell Performance

Impact of Thermal Relaxation in Wells

SCW Temperature Span

Cooling Day

max T
min T
Two SCW installed to 800’ to provide 15 tons (215,000 BTUH) supplemented by campus steam & chilled water to serve a 60 ton connected HP load.

Measurement of key thermal properties (k, α, τ) of the borehole has allowed the design to be specified using modeling & simulation tools to verify performance.

The two Geowells served 39% of the building load-hrs, saving 2000 kWh (net).

This project has enabled VU students to participate in geothermal projects on campus, while fulfilling a vision for a more sustainable campus.