Delineation of Wellhead Protection Areas and Geothermal Ordinance Development Using Surface Geophysical Methods

Presentation by
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Bedrock of the Great Valley Section of the Ridge and Valley Province
Groundwater Exploration – Bedrock Geology

Waynesboro Formation
Cambrian shale, sandstone, conglomerate, dolomite and shale

Tomstown Formation
Cambrian dolomite and shale

Antietam Formation
Cambrian quartzite, schist

Harpers Formation
Cambrian phyllite, schist, quartzite

Mont Alto Member of Harpers Formation
Cambrian quartzite

Weverton and Loudoun Formations, undivided
Cambrian quartzite, conglomerate, slate, sandstone

Formation listing is in stratigraphic order (oldest formation at bottom of list)

Existing High Yield Wells

Earth Resistivity Line

Existing Spring
Earth Resistivity Method

Earth Resistivity Field Data Collection

Showing field data collection equipment and example subsurface resistivity measurement points

Shallow Measurement
(Electrodes used for shallow measurement are spaced close together)

Deep Measurement
(Electrodes used for deep measurement are spaced far apart)
ER Used to Locate High Yield Well

Fractured Bedrock (blue area)
Unfractured Bedrock (red area)

Resistivity Color Scale

Saturated Soil
Fractured Bedrock
Weathered Bedrock
Massive Bedrock

Resistivity (Ohm-m)
Topographic Watershed for Aquifer

> 16,000 acres

Existing High Yield Wells

Existing High Yield Spring
Mud-Rotary Drilling
6-inch Test Well
Final Drilling Discharge Rate ~ 2,440 gpm
Well Total Depth – 702 feet
Cylindrical Borehole with Deeper Void

Asymmetric Borehole with Large Fracture
Submersible Pump
~150 HP – 1,500 gpm
Creek Discharge < 100 NTU
Aquifer Test Pumping Water Level and Turbidity Graph

**Pumping Water Level Graph**
- 800 gpm
- 1,000 gpm

**Turbidity Graph**
- 5 NTUs

Key Points:
- 1,494 gpm (2.15 mgd)
- 1,000 gpm (1.44 mgd)
- 800 gpm (1.15 mgd)

Date/Time:
- 2/23/09
- 2/24/09
- 2/25/09
- 2/26/09
- 2/27/09
- 2/28/09
- 3/1/09
- 3/2/09
Wellhead Protection (WHP)

A strategy designed to protect public drinking water supplies by managing the land surface around a well where activities might affect the quality of the water.
Wellhead Protection

WHP Zone Definitions

**Zone I** is the innermost protective zone around a water supply source which generally ranges from a 100 to 400 foot radius depending on source and aquifer characteristics.

**Zone II** is the capture zone which may be based upon unique local hydrogeological conditions, pumping test data, and surface geophysical survey results.

**Zone III** is the area beyond Zone II that contributes recharge to the aquifer within the capture zone.
Layout of ER Profiles

Existing High Yield Wells

Existing High Yield Spring

1

2

3

4

H1

H2

0.0 mi  0.5 mi  1.0 mi  1.5 mi  2.0 mi
ER Profiles used for WHP Zone 2
WHP Zone 2 – North End Near Wells

Existing High Yield Wells
WHP Zone 2 – South End Near Spring
Geothermal Ordinance Development

A strategy designed to protect public drinking water supplies by providing guidance for geothermal well installations where activities might affect the quality of the water.
Ground Source Geothermal Systems
Closed Loop

Heat is transferred from circulating fluid in the ground loop to the bedrock (cooling cycle).
Heat is transferred to the circulating fluid in the ground loop from the bedrock (heating cycle).

Bedrock Temperature
52-54 degrees F
In southeastern PA

Well Depth
300-400 Feet Each

Closed Loop – Generally OK for WHP Zone 2 and Zone 3
Ground Source Geothermal Systems

Open Loop - Surface Discharge

Bedrock Temperature
52-54 degrees F
In southeastern PA

Well Depth
200-700 Feet
May Require Multiple Wells

Open Loop - Surface Discharge – Generally OK for WHP Zone 2 and Zone 3
Ground Source Geothermal Systems

Open Loop - Bedrock Discharge

Bedrock Temperature
52-54 degrees F
*
In southeastern PA

Well Depth
200-700 Feet
May Require Multiple Wells

Open Loop - Bedrock Discharge – Generally OK for WHP Zone 3 only
Ground Source Geothermal Systems
Standing Column Well

Bedrock Temperature
52-54 degrees F
In southeastern PA

Well Depth
900-1,500 Feet
Requires Multiple Wells

Standing Column Well – Generally OK for WHP Zone 3 only
Relatively Low Risk of Groundwater Contamination

- Closed Loop – Generally OK for WHP Zone 2 and Zone 3
- Open Loop - Surface Discharge – Generally OK for WHP Zone 2 and Zone 3

Somewhat Higher Risk of Groundwater Contamination

- Open Loop - Bedrock Discharge – Generally OK for WHP Zone 3 only
- Standing Column Well – Generally OK for WHP Zone 3 only
Thank You for Attending!

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