PURSUING DEVELOPMENT OF A PUBLIC COMMUNITY WATER SUPPLY UNDER LIMITED ACCESS AND AQUIFER CONDITIONS

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Lower Hudson River Valley Case Study

• Develop a minimum 2 million gallons per day (MGD) supplemental Public Community Water Supply by 2015/2016 for a partial NYC-water interconnect-dependent Town

• Yield potential and groundwater resources accessibility within Town limit the availability for developing the necessary supply

• Several sites already evaluated only exhibited typical yield gain potential of about 0.3 to 0.5 MGD
Possible Solution

• Previous studies of the Hudson River channel deposits previously completed in connection with the New York City water supply, indicated the presence of a laterally and vertically (but possibly thin) extensive glacial deposits aquifer system.

• Town park exists along the shoreline of this stretch of the Hudson River.
What Was Originally Known About The Groundwater Resource

• The aquifer underlying the tidal Hudson River is overlain by a thick sequence of river-bottom sediment and glacial clay and silt, which is believed to protect it from surface-water quality impacts (e.g., brackish water)

• Preliminary testing and analyses by others for NYC indicated that the overall aquifer capacity potential is on the order of about 250 to 300 MGD.
Exploration/Data Collection

- Phase One
  - Exploration program at top of glaciodeltaic terrace
  - Vertical test well at shoreline
  - Hudson River barge borings
  - Conceptual hydrogeologic model favors angle well development near shoreline
- Phase Two
  - Sonic rig setup and sampling at shoreline
  - Angle Boring #1 - to explore near shore aquifer and deltaic deposits
  - Angle Boring #2 - to explore anticipated maximum aquifer thickness perpendicular to shore
  - Angle Boring #3 - to further explore possible deltaic deposits near shore
  - Real-time yield and quality testing
- Phase Three
  - Large Diameter Angled Test Well
Initial Exploration – Phase One

Exploration at Top of Glaciodeltaic Terrace
Initial Exploration Phase

*Vertical Test Well at Shoreline*
Initial Exploration Phase

*Hudson River Barge Borings*
Conceptual Hydrogeologic Model
Atypical Aquifer Configuration Does Not Favor Vertical Well Development From Near Shoreline
Possible Alternative Supply Well Options for “Atypical” Aquifer

• Development of groundwater supplies from hydrogeologically atypical aquifers often require the use of innovative well designs and management techniques.

• Types:
  – Horizontal Wells/Infiltration Galleries (generally depth limited)
  – Collector Wells (laterals are oriented horizontally)
  – Angle Wells
Some Examples of Atypical Groundwater Resources

- wedge/inclined alluvial and coastal plain formations
- thin and lens-shaped formations
- remote alluvial units and extensive fracture zones
- formations influenced by hydraulically connected surface-water bodies/other formations
Horizontal Well/Infiltration Gallery
Collector Well Configuration

[Diagram of well configuration with labels L1, L4, and other geologic layers such as sand and gravel aquifer, river, and bedrock.]

[Plan view of well layout showing connections to Russian River.]
Angle Well
Groundwater Flow Towards A Pumping Screened Well

Ideal

Actual
Inherent Benefits of Angle Well over Vertical Well

• Allows screen to “follow” the slope of the formation

• Extensive screen oriented away from vertical allows for lower entrance velocity potential and better efficiency

• Anticipated contrast between vertical and angle well performance:
  – specific capacity ratio of 1:2.1
  – yield ratio of 1:2.5
Phase Two - Focused Supplemental Exploration of Sub-River Aquifer from Shoreline

• Exploration under topographic constraints of site and lateral distance to sloping aquifer were accommodated by angle well drilling technique.

• Use of “sonic” rig allowed for:
  – high-quality sample collection necessary for refining aquifer configuration and makeup
  – attainment of “test” well design parameters
  – real-time yield and water-quality assessment
Exploration Borings and Well Layout
Angle Boring (Sonic) Rig Setup and Sampling to Maximize Limited Access Shoreline Conditions
Angle Boring Exploration Phase

Angle Boring #1 - 30° angle from horizontal

Chosen to explore aquifer and deltaic deposits
Angle Boring Exploration

Angle Boring #2 - 25° angle from horizontal
Chosen to explore anticipated max aquifer thickness
Angle Boring Exploration

Angle Boring #3 - 25° angle from horizontal
Chosen to explore possible deltaic deposits
Angle Boring Real-Time Yield Testing

Town of New Windsor
New Windsor, New York

Angle Boring #1 - Distance Vs. Drawdown
Angle Boring #1 - Step-Rate Pumping Test, 10/03/12

6-inch slotted pipe set at 316 to 326 angle feet.
Pump setting: 143 ft lbs
## Angle Boring Real-Time Quality Testing

<table>
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<td>1145 hrs</td>
<td>1420 hrs</td>
<td>0945 hrs</td>
<td>0940 hrs</td>
<td>1010 hrs</td>
<td>0945 hrs</td>
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<td>12 C</td>
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<td>7.8</td>
<td>7.9</td>
<td>8</td>
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<td><strong>ORP</strong></td>
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<td>41.5</td>
<td>47</td>
<td>50.1</td>
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<td><strong>DO</strong></td>
<td>4.7 mg/l</td>
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<td>1.7 mg/l</td>
<td>0.6 mg/l</td>
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<td><strong>NTU</strong></td>
<td>5.45</td>
<td>3.3</td>
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<td>P day 6</td>
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<tr>
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<td><strong>Total Iron</strong></td>
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<td>.44 mg/l</td>
<td>.56 mg/l</td>
<td>.50 mg/l</td>
<td>.45 mg/l</td>
<td>.39 mg/l</td>
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<td><strong>Ferrous Iron</strong></td>
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<td>.42 mg/l</td>
<td>.57 mg/l</td>
<td>.52 mg/l</td>
<td>.43 mg/l</td>
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<td><strong>Ferric Iron</strong></td>
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<tr>
<td><strong>Total Manganese</strong></td>
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<td>.277 mg/l</td>
<td>.256 mg/l</td>
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<td>.257 mg/l</td>
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<td><strong>Chloride</strong></td>
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<td><strong>Hardness</strong></td>
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<td>313 mg/l</td>
<td>310 mg/l</td>
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<td><strong>Calcium</strong></td>
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<td>88.5 mg/l</td>
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<td>&lt;1 mg/l</td>
<td>&lt;1 mg/l</td>
<td>&lt;1 mg/l</td>
<td>&lt;1 mg/l</td>
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<tr>
<td><strong>Odor</strong></td>
<td>4 TON</td>
<td>1 TON</td>
<td>1 TON</td>
<td>1 TON</td>
<td>1 TON</td>
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<tr>
<td><strong>Color</strong></td>
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<td>&lt;5 Pt Co</td>
<td>&lt;5 Pt Co</td>
<td>13 Pt Co</td>
<td>11 Pt Co</td>
<td>8 Pt Co</td>
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</table>
Findings to Date

• Targeted aquifer is on the order of tens of feet thick and thickens towards river channel. Best way to access aquifer from shoreline proximal to steep slope is with angle drilling.

• Locally occurs under confined conditions below a thick sequence of clay and silt of at least 100 feet thick.

• Groundwater quality does not appear to be influenced by overlying brackish river water.

• The results of the angle borings/test wells indicate potentially favorable subsurface conditions. The results are currently being used to design a full scale angle/horizontal “test well” installation geared to pump at least 0.5 MGD from the desired aquifer materials under the Hudson River.

• Depending on long-term yield, at least 3 permanent angle/horizontal wells capable of yielding 1 MGD each are proposed for installation from same shoreline area.
Phase Three

• The results of the angle borings/test wells indicate potentially favorable subsurface conditions. The results are currently being used to design a full scale angle/horizontal “test” well installation geared to pump at least 0.5 MGD from the desired aquifer materials under the Hudson River.

• Cost Estimate for installation of 10 to 16-inch diameter angle “test” well between $200,000 and $250,000, with potential for modification to “permanent” well construction.
Summary/Questions

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