How to Fix the Water Pressure for a Subdivision Built Next to a Ground Storage Tank

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Lance Livesay, City of Fairborn
Rona Hills Tank

- Built in 1970; last painted in 1993; last inspected in 2003
- 2 million gallon ground storage tank
- Located at an elevation of approximately 1000’
- Well-suited to serve the city’s average elevation of 837’
- Nearby condominium complex slightly downhill of the tank had historical pressure of about 40 psi

- 80 ft in diameter
- 54 ft SWD
New Growth

• In the late 1990’s/early 2000’s, the area started to experience new residential growth
• Homes were being located closer and closer to the tank
• Upscale homes with two to three levels, multiple bathrooms, and other water using devices
• Pressure at the street met OEPA requirements but not the aesthetic desires of the customers
\[(1060 - 990) \times 0.433 = 30.31 \text{ psi}\]

1000’ + 60’ water level = 1060’
Finding a Solution

• The 2003 Master Plan outlined a recommendation to establish a new high pressure zone
• Project was added to the city’s capital improvement plan
• In 2007, URS was hired to evaluate and later to design the Rona Village Area High Pressure Zone
• The City also needed to replace the Kauffman Ave Sewage Pump Station. URS designed both projects to be bid as one package to reduce construction administration costs.
CHECK VALVE AND PSV

RONA BPS
Legend
- Water Main (Existing)
- Waterline installed by Developer
- Waterline loop needed for fire flow
- Waterline replacement needed for fire flow
- Valve (Existing)
- Valve (Proposed)
- Fire Hydrant
- Fire Hydrant (Failed Fire Flow Model Test)

175 ft. 8" Loop or Replace 6" with 8" (200 ft.)

Failed 1500 gpm Test
Rona Village

Failed 1500 gpm Test

Failed 1500 gpm Test

3" to be installed by Developer

New 150 ft. 8" Loop Installed by Developer

8" to be installed by Developer

Close Valve

Valve Vault with a check valve and isolation valve on original line to allow flow from medium pressure zone upon low pressure.
A backpressure sustaining valve can be added as an option to create a loop back to the medium pressure system.

Install New 8" Valve to Isolate System

Close Valve

Booster Pump Station
New High Pressure Zone
Design Considerations

• Location:
  ▪ Outer edge of distribution system (dead end)
  ▪ Adjacent to existing elevated tank

• Elevating the existing tank or constructing a new elevated tank would obviously not be cost-effective to serve a small subdivision

• Pump Control Options

• Average and peak demand calculations

• Fire flows

• Standby Power

• Building Construction
Closed Sanitary Sewer Overflow
Proposed Site Plan
Calculating Design Flows

- Average demand:
  - 500 EDUs x 400 (gpd)/EDU = 200,000 gpd or 139 gpm

- Peak day factor of 2.0 and an additional peak hour factor of 1.75
  - Peak hour demand is 700,560 gpd or 487 gpm

- Need to consider fire flows
  - State Insurance Services Office and AWWA publications: Single family homes require 1,000 gpm and condominiums require 1,500 gpm
  - WaterGEMS was used to perform the fire flow analysis

<table>
<thead>
<tr>
<th>Area</th>
<th>EDUs</th>
<th>Description</th>
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<tbody>
<tr>
<td>Rona Village</td>
<td>250</td>
<td>Condominiums</td>
</tr>
<tr>
<td>Stoneybrook Trail</td>
<td>8</td>
<td>Single Family Homes</td>
</tr>
<tr>
<td>Stoneybrook Trail</td>
<td>43</td>
<td>Church</td>
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<tr>
<td>Stoneybrook Trail</td>
<td>43</td>
<td>Nursing Home</td>
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<tr>
<td>Ashbury Hill</td>
<td>96</td>
<td>Single Family Homes</td>
</tr>
<tr>
<td>Ashbury Hill 2nd Phase</td>
<td>30</td>
<td>Single Family Homes</td>
</tr>
<tr>
<td>Deercliffe</td>
<td>30</td>
<td>Single Family Homes</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>500</strong></td>
<td><strong>EDUs</strong></td>
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</tbody>
</table>
**Four BPS Design Options Considered**

Option 1: Constant speed pumps/large expansion tank

Option 2: VFDs/smaller expansion tank

Option 3: Constant speed pumps/recirculation loop (separate suction line from tank)

Option 4: VFDs/recirculation loop (suction connected to existing tank inlet piping)
Fire Flow Options Considered

• Problem - dead ends on 6” lines failed fire flow test

• Solutions
  - Option 1: Provide separate pumps for fire flow and peak hour flow
    - Advantages: Simple
    - Disadvantages: More pumps; one large fire pump; more power
  - Option 2: Use Medium Pressure Zone
    - Provide a bypass line with a check valve around the booster pumps
    - Advantages: Reduced building footprint and lower power costs
    - Disadvantages: None
Pipe-Flo Model (Engineered-Software)
Advantages/Disadvantages of Options 1 & 2

Option 1: Constant speed pumps/large expansion tank
- Advantages: Simple controls
- Disadvantages: Expansion tank - TSS requires 10X pump capacity (5,000-gal)
- Only 1,700-gallons with Pressure Sustaining Valve (still quite large)
- Without loop to the medium pressure zone, fire flow pumps are required

Option 2: VFDs/smaller expansion tank
- Advantages: VFDs reduce expansion tank size and lower power costs
- Disadvantages: Requires more controls and still requires a bladder tank (only 200-gallons)
- Fire flow pumps still required
BPS with Expansion Tank & Generator
BPS with Expansion Tank & Generator

PLAN

- URS
- One Water
BPS with VFDs without Generator
Advantages/Disadvantages of Options 3 & 4

Option 3: Constant speed pumps/recirculation loop (separate suction line from tank)
  • Advantages: Simple controls; No expansion tank; Increases tank turnover; Fire flows can be provided by medium pressure zone and no standby power
  • Disadvantages: Higher construction cost as well as power costs

Option 4: VFDs/recirculation loop (suction connected to existing tank inlet piping)
  • Advantages: Same as Option 3 with lower power costs
  • Disadvantages: Reduced tank turnover (however, the amount of recirculation can still be increased by adjusting the PSV and VFDs to increase recirculation, if needed)
Calculating Surge Pressure

$$\Delta H = a \cdot \Delta v / g + H_s$$

where “a” is the speed of sound in water feet per second (ft/s), \(v\) is the velocity (ft/s), “g” is the acceleration of gravity (32.2 ft/s\(^2\)), and “Hs” is the static head on pump discharge or surge relief valve.

<table>
<thead>
<tr>
<th>Static Head, ft</th>
<th>Surge (psig) for Ductile Iron Pipe</th>
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</thead>
<tbody>
<tr>
<td>Flow Rate, gpm</td>
<td>6</td>
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<tr>
<td>300</td>
<td>186</td>
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<td>600</td>
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<tr>
<td>800</td>
<td>453</td>
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<tr>
<td>1200</td>
<td>666</td>
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Startup Issues:

Pressure Relief Valve
• Stayed open all the time
• Plastic from factory (or shop) was stuck in valve

HVAC
• Electrician forgot to power up unit
• City bought portable dehumidifier due to condensation
ENR news:

• 41,000 lb, 125 kW nat. gas generator on top of precast concrete bldg

• Flood-tight doors and hatches

• Forcemain splits into two different directions (tricky hydraulics)
2012 Construction Costs

- Engineer’s Estimate:
  - $700,000 for Rona BPS
  - $860,000 for Kauffman Ave PS
  - Total $1.56M

- Low bid awarded to Danis Construction:
  - $490,000
  - $868,000
  - Total $1.36M (12.8% below estimate)
Public Interface

- Started interaction early with letters to all residents
  - Explained the benefits of the project while reminding them that higher pressure could impact bad plumbing
- Updates were posted weekly on City’s website
- Danis Construction Field Superintendent had great customer service skills so most concerns were handled at his level
Challenges Encountered

• “Not In My Yard” – Right of Way & Easements
  • One resident tried to stop construction by parking vehicles in right of way work area

• Super Dry Weather Impeded Restoration
  • credited a nearby customer’s water bill for watering
Operation

- VFD’s are set to maintain 50 psi at the Booster Station
- Typical pressure following the project – 65 psi
- Verified through hydrant testing
End Result

- Happy Customers
  - Door to door survey conducted
  - Results were overwhelmingly positive
Next Steps

• Perform fire flow tests
• If needed, loop area mains to further improve flow
• More houses can be built and the associated water lines will create more loops
Questions?

Contact:

• Jeremy Cook, P.E. URS Corporation
• Lance Livesay, City of Fairborn Water Plant Manager