Cold Region Considerations in Water Distribution and Collection

Aaron D. Dotson
Department of Civil Engineering
University of Alaska Anchorage
addotson@alaska.edu
Water Treatment Facilities in Alaska
Total Facilities = 222

- 77% of Alaska’s population is served by a large systems
- 97% of the systems in the state are small (<10,000 ppl)

### Served Population

<table>
<thead>
<tr>
<th>Served Population</th>
<th>Groundwater under the influence</th>
<th>Groundwater</th>
<th>Surface Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large (&gt;10,000)</td>
<td>0</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Small (3,300 - 10,000)</td>
<td>0</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Very small (500 – 3,300)</td>
<td>3</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Very very small (&lt;500)</td>
<td>10</td>
<td>76</td>
<td>58</td>
</tr>
</tbody>
</table>

*Community Systems
Living in Remote Alaska (Kipnuk, AK)
Putting Remote into Context (typical):
Transportation

- Propeller Air Cargo / Transport - Gravel Runway: Possibility for C130 Cargo Place (last resort)
- Seasonal Barge Service
- Boat/Snowmachine/4wheeler along River/Trail: many communities do not have large vehicles
Putting Remote into Context (typical):

- **Power**
  - Community Grid Power – Diesel Fuel
  - Home Heating – Diesel Fuel or Wood (where available)
  - Vehicles - Gasoline
Frozen Ground, Permafrost & Subsurface Ice

• Soil borings, depth, number, samples
• Thermal monitoring

Foundation Selection
– AWWA - D103 6 types
– Arctic modifications
The Cold Region + Limited Access
+ Frozen Ground =

An all around challenge to live a modern life

http://ehp.niehs.nih.gov/wp-content/uploads/2012/11/ehp.120-a460.g006.png Sod home in NW Arctic Borough along Selawik River
Observed Water Use in the AK

- Self Haul: 1-5 gpcpd
- Watering Point: 5 gpcpd
- Washateria: 10-20 gpcpd
- Trucked Haul: 5-30 gpcpd
- Piped Arctic: 40-60 gpcpd
  - Minimal seasonal variation unless used for freeze household protection
- US National: 100 – 150 gpcpd
Self Haul

Washeteria/Watering Point

Ice

Rain
Large Vehicle Haul

**Rural Alaska**

Big need for water truck drivers shows itself in Bethel -- when water runs out

Lisa Demer | January 22, 2016

**Photos: Bethel's water delivery trucks keep the town**

Bethel water trucker driver Lisa Paul, 30, works to deliver water to homes and businesses in Bethel, Alaska, on Thursday, Jan. 21, 2016. She displays a Spiderman mask on her truck as a nod to her 8-year-old son, Logan.
Arctic Pipe
Above Ground
Below Ground
Fast Main

END VIEW

Heat Tape

4x12 Arctic Pipe Carrier

1" Service Lines

100 Ft. Maximum

Pitorifices

Water Main

Flow direction

END VIEW

Pumphouse

Circulation Pump

Single Circulating Water Main

Typical House

100 Ft. Maximum

Water Supply

Heat Addition
Slow Main System

- Pumphouse
- Water Supply
- Heat Addition
- Circulation Pump
- Single Circulating Water Main
- Typical House with Individual Circulation Pump
- House Circulation Pump
- 4x12 Arctic Pipe Carrier
- 1" Service Lines
- Water Main
- Standard Corp Stop Connection
- Heat Tape
Utilidors
Freeze Protection versus Wasted Energy

We can now re-estimate the interior temperature by proportioning the resistance and temperature differences; 

\[ R_{\text{total}} = R_{\text{pipe}} + R_{\text{pipe\_conv}} + R_{\text{utilidor\_insulation}} + R_{\text{utilidor\_material}} \]

\[ T_u = \frac{T_w + T_a}{1 + R_c R_u} \]

\[ q = \frac{T_w - T_a}{R_{\text{total}}} \]

Go back to the assumed \( T_u \) and change until these two match.

Total heat loss:

\[ q = 38.6 \text{ BTU/hr ft} \]

\[ \dot{Q} = 38.6 \text{ BTU/hr} \]
System only as good as the connection
Considering Reservoirs

- Water tank 45 F
- MAAT 28 F
- gravel fill
- silt 40% moisture
- permafrost 30 F
- Tank Foundation - gravel fill
- insulation
- nfs fill
Ice Features?
Managing Winter Failures

- Heat tapes/glycol
- Heat exchangers
- Thermal Expansion
Thank you for the opportunity to share!

Photos from Longyearbyen, Svalbard – 78° North – June 2018