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# WIHAH Conference

Adaptation of the Built Environment

To Climate Changes in Alaska

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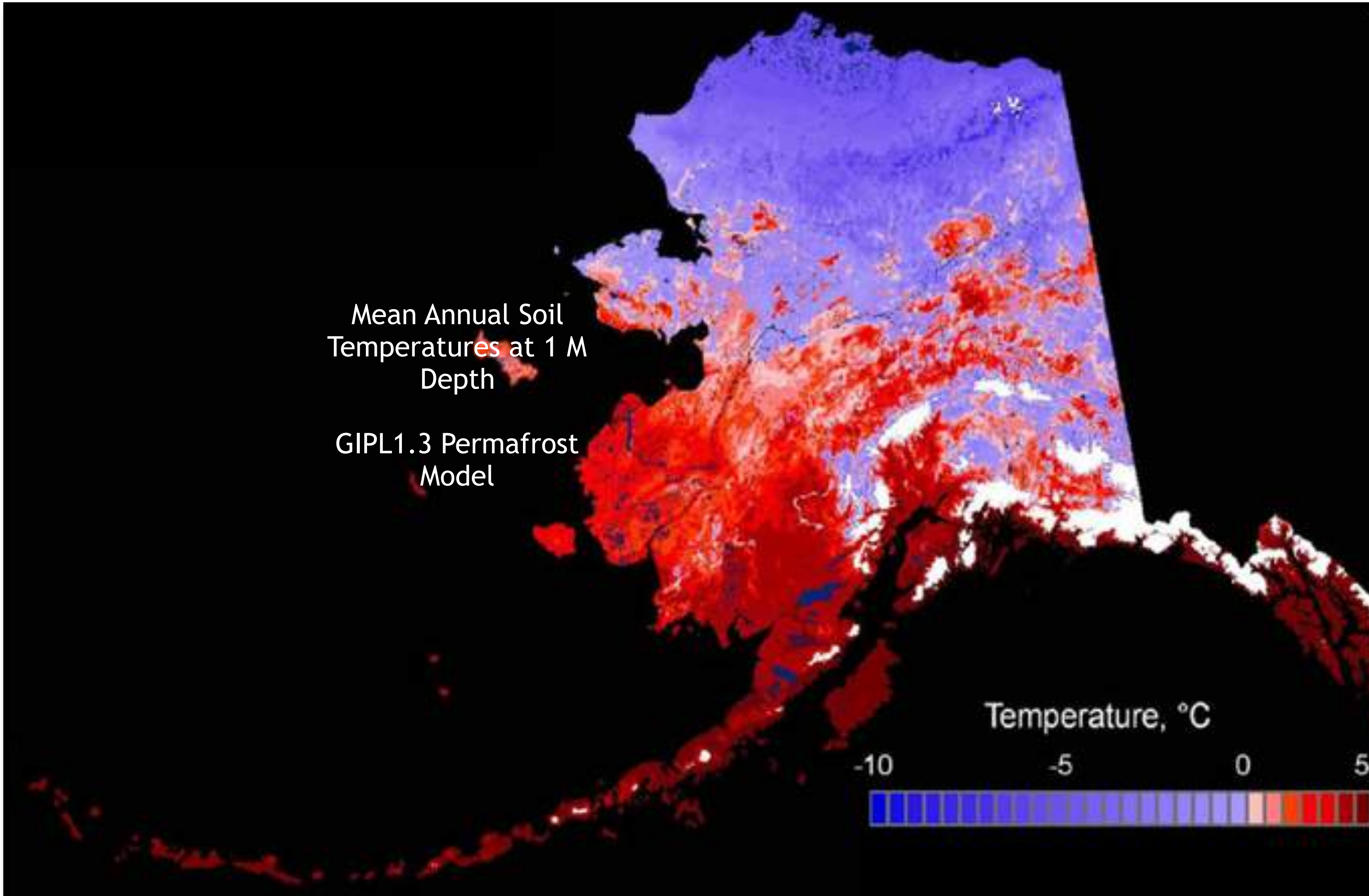
# Utilities in the Changing Arctic: Water and Sewer

Michael Black, Director of Rural Utilities Management Services, ANTHC


Mean Annual Soil Temperatures at 1 M Depth
GIPL1.3 Permafrost Model
Temperature, °C
-10
-5
0
5

*Our current sanitation infrastructure is designed for the conditions of the past, not for the present or the future.*

Average January air temperature in Point Hope, Alaska:

- 1961-1990, -3°F
- 2001-2010, 3°F
- 2031-2040, 6°F

Projected change of +9°F over 89 years.

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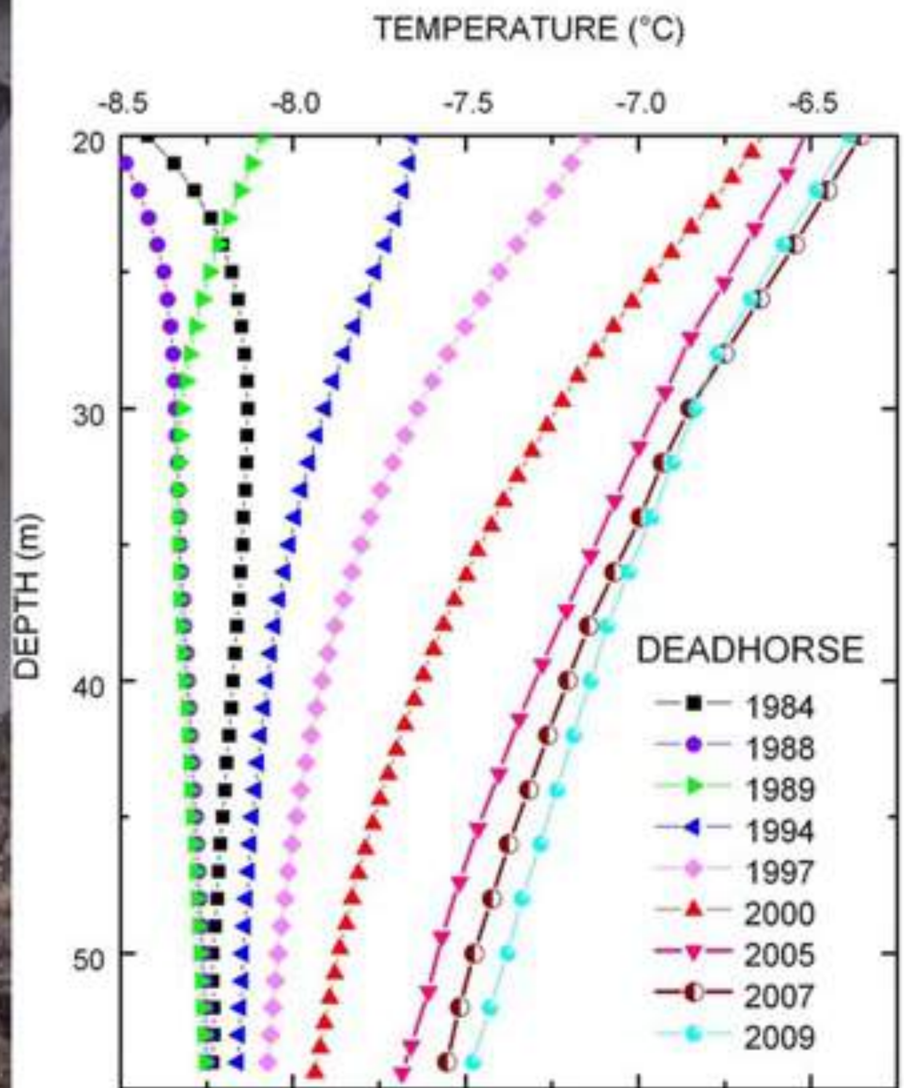
Photo by Guido Grosse


TEMPERATURE (°C)
-8.5
-8.0
-7.5
-7.0
-6.5
20
30
40
50
DEPTH (m)
DEADHORSE
1984
1988
1989
1994
1997
2000
2005
2007
2009

# What is the cost of climate change to water and sewer infrastructure?

- Water and Sewer along with Transportation Infrastructure is estimated to be most vulnerable to climate change.
- Cost of not adapting infrastructure has been estimated in a 2007 study by University of Alaska (ISER) to shorten the useful life of water and sewer infrastructure by 3.5 years (20 year normal design life assumed).
- Compounding this shortened life over decades adds billions of dollars to preserving the sanitation utility. Estimated to add $3-6 B (rebuilding) by 2030 for Alaskan villages.

(Larsen, Goldsmith, Smith, et al. (2007) Estimating Future Costs for Alaska Public Infrastructure At Risk from Climate Change.

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# How does climate change affect transportation in villages?

Damage and the inability to use trails, roads, rivers and boardwalks is caused by:

- Erosion
- Flood damage
- Storm damage
- Melting permafrost
- Sedimentation

# How does changing Arctic affect solid waste?

Collection systems:

- Destruction or loss of access

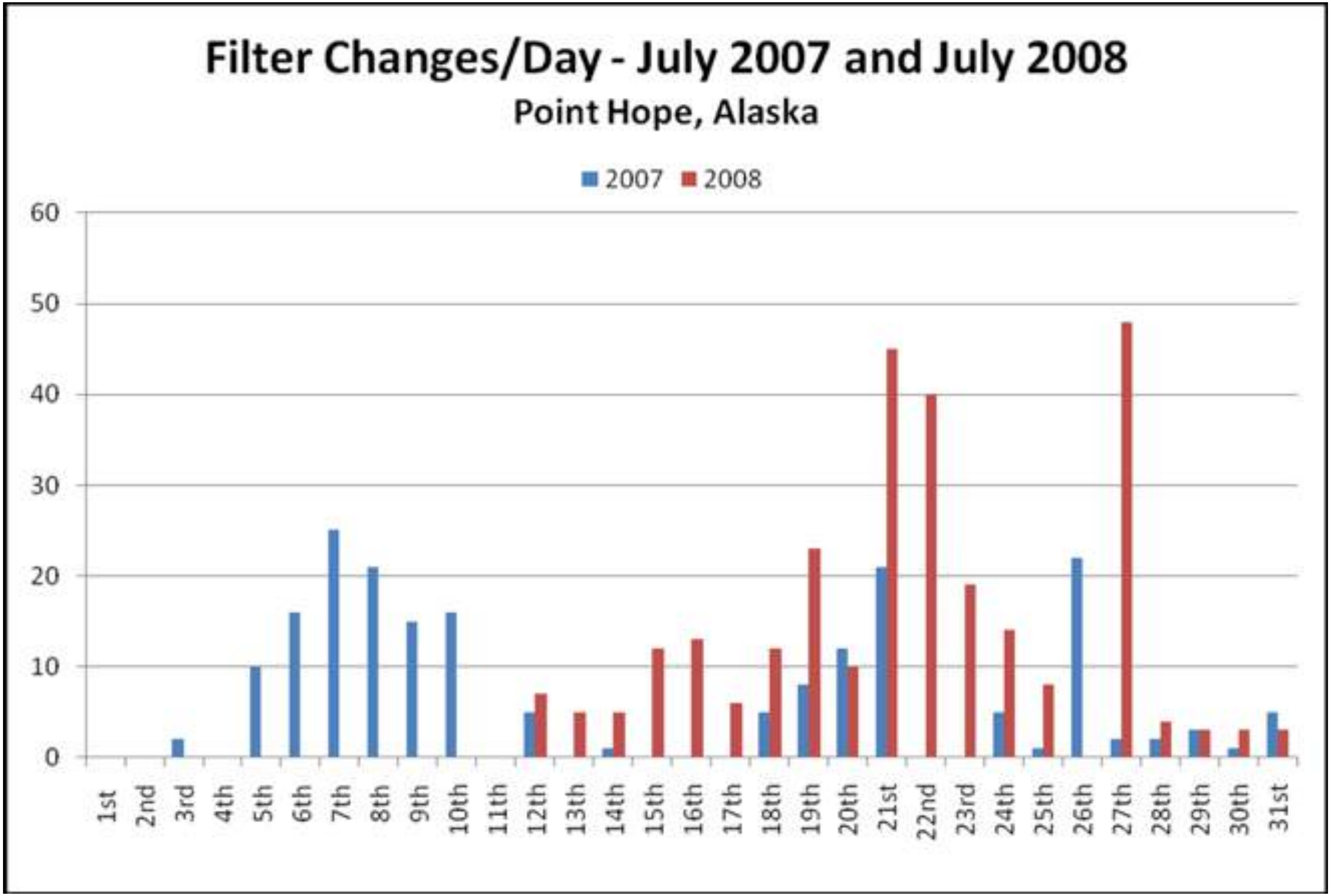
Disposal systems:

- Erosion intercepting the facility which spreads waste
- Flood water entering the facility which spreads waste
- Permafrost or waste melting and releasing contaminants

# How does changing Arctic affect water and sewer ?

- Foundations-Pipes/Buildings
- Contamination
  - Rising sea levels
  - Storm surge (seawater contamination)
  - Northward migration of animals with disease or parasites (Giardia)
  - Saline intrusion into coastal groundwater
  - Increased algae
- Reduced supply
  - Drought or drying tundra ponds
  - Damage to intakes or impoundments from sediments, ice, and erosion

# How does warming permafrost affect water chemistry and quality?


Filter Changes/Day - July 2007 and July 2008
Point Hope, Alaska
2007
2008
60
50
40
30
20
10
0
1st
2nd
3rd
4th
5th
6th
7th
8th
9th
10th
11th
12th
13th
14th
15th
16th
17th
18th
19th
20th
21st
22nd
23rd
24th
25th
26th
27th
28th
29th
30th
31st

In Unalakleet, erosion has exposed a water line.

In Kotlik, coastal flooding has damaged community infrastructure.

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In Noatak, failing foundations from permafrost warming

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# Point Lay Permafrost Sustainability Workshop

1. May 2016 - Anchorage, Alaska to discuss permafrost and water-wastewater system
2. Goal: identify options, best practices, and impacts in regard to permafrost
3. Participants: NSB, UAF, CRREL, Engineers and Murkowski representative
4. Expertise: geotechnical, environmental, construction, operations, and planning engineering

## The Problem: Snow and Ground Water


## The Long Term Implications: Reduced Sustainability of Point Lay





## Recommendations: Use Snow Management Strategies

Short term: Make sure to plow and shovel all snow away from each house, each structure and the entire village THOROUGHLY
Mid term: Use fine silt to fill-in cavernous water ponds and holes. Do not use gravel as water can penetrate it and melt the permafrost
Long term: Develop housing, structures, vehicle parking and utilities that allow the snow to blow through, rather than create drifts

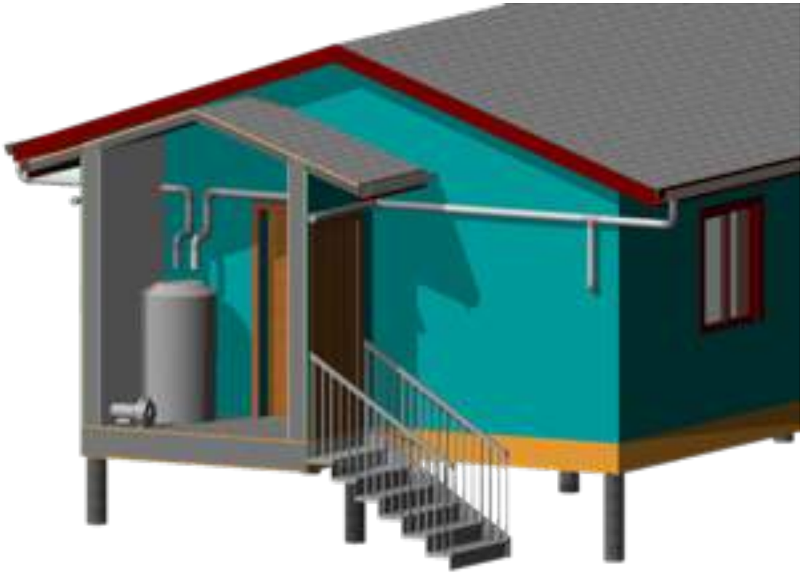
UAF Participants: Doug Reynolds, Billy Connor, Tony Nakazawa, Yuri Shur, Dave Barnes, Bill Schnable, Srijan Aggarwal, Misha Kanevskiy and Jon Skinner Special thanks to the Native Village of Point Lay, the North Slope Borough, CREL, UAF's School of Management, Natural Resources and Extension, the Geophysical Institute and the Center for Environmentally Sustainable Transportation in Cold Climates, ANTHC, Golder, and Umiaq

# What can be done to save the infrastructure that villages depend upon? Conversion of passive to active cooling of foundations on warming permafrost. This is soon to be built in western Alaska

# Adaptation: Portable Alternative Sanitation System (PASS) in Kivalina

This system is entirely homeowner-based and is designed to address the most basic sanitation needs and is portable so it can be moved with the community to a new location.

Typical system layout



Rain catchment system

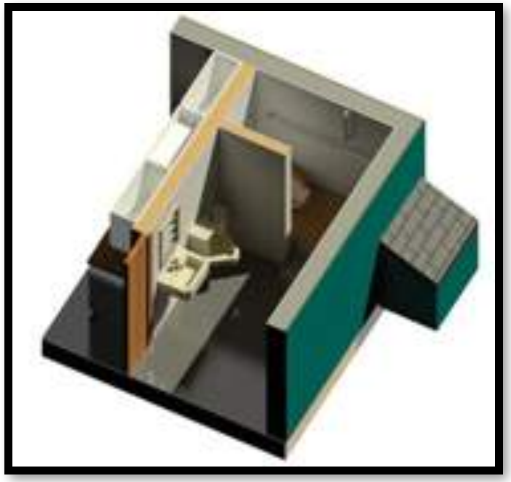
# Nine homes received demonstration in home PASS units to improve availability of water and lower risk of wastewater disposal. Can be moved with home or abandoned.

## Rain Catchment Systems

- Water tank equipped to accept hauled water and rainwater
- Point-of-use water treatment device to treat water from non-potable sources

## Grey Water Disposal Systems

- Tank equipped to accept liquids that are discharged from the kitchen and bathroom sinks, urinal, and separating toilet
- Shallow brackish ground water and gravely soils are freeze-proof and environmentally sound for disposing grey water



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# Adaptation to shifting foundations: Arctic Boxes replaced by Flexible Connection to homes

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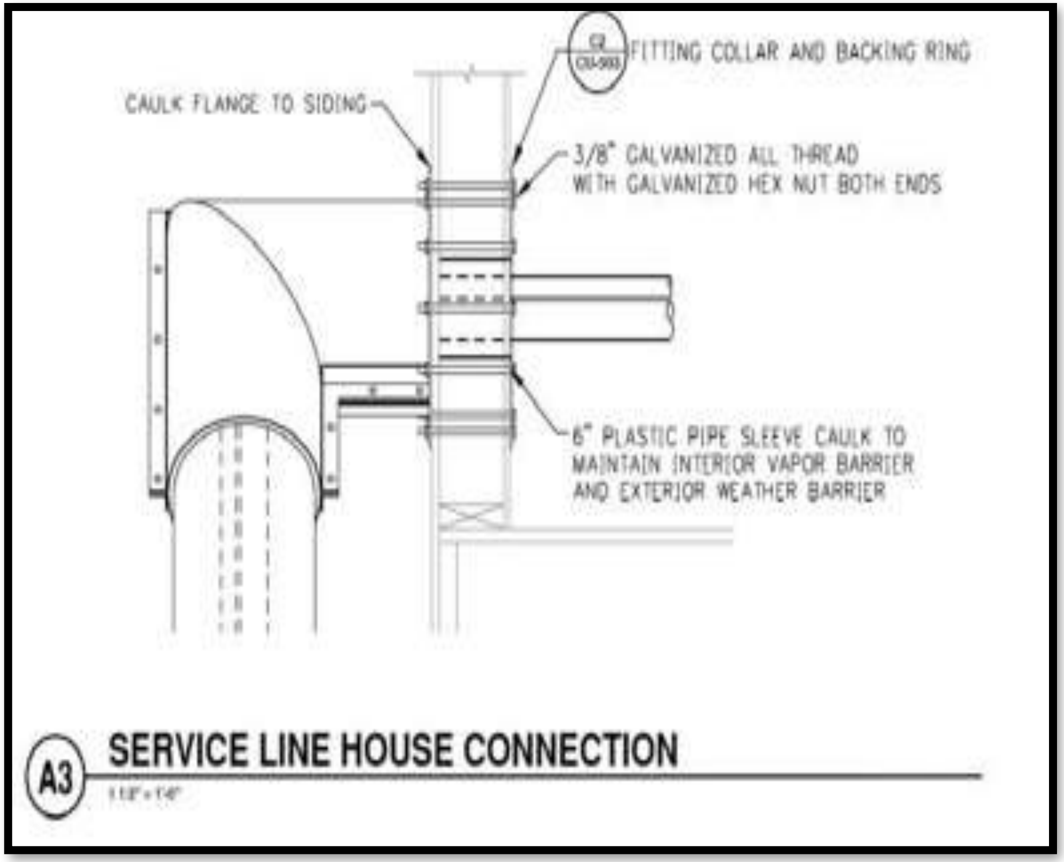
# Flexible Service

<u>SOLID</u> connection to the house.

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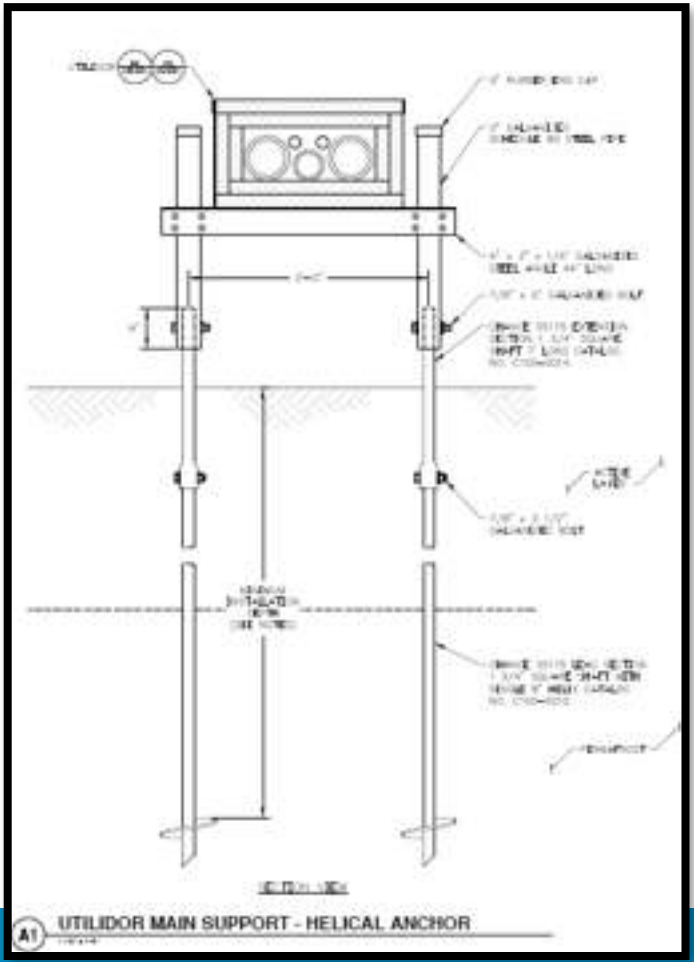
# Adaptation: Kotlik carrier pipes placed on Helical Piers instead of sleepers

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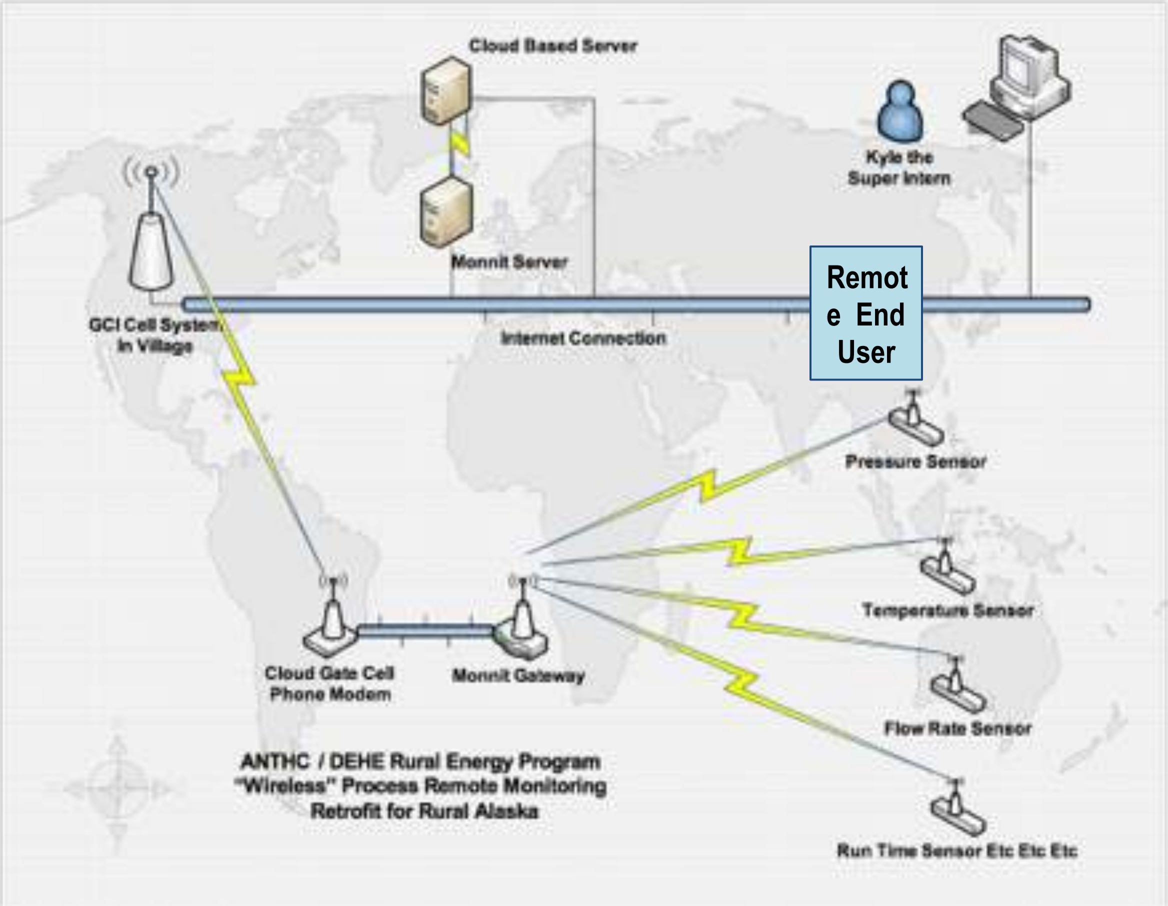
# Remote Monitoring:  System Concept



# ANTHC Remote Monitoring

# What can be done to save the infrastructure that villages depend upon?
# Environmental Atlas to ensure Climate Data is updated for Design Engineers

| Name of Village | Current Population (DEC) | Location (DEC Web) | | Historic Temperature (°F) (Average 1961-1990) | | | Projected (2031-2040) Temperature (°F) (SNAP) | | | Historic Precipitation (in) (SNAP: 1961-1990) | Projected (2031-2040) Precipitation (in) (SNAP) | Historic Freezing Index | Adjusted (2031-2040) Freezing Index | Historic Thawing Index | Adjusted (2031-2040) Thawing Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Lat (N) | Lon (W) | Min (ICCP) | Max (SNAP) | Ave (ICCP) | Min | Max | Ave | | | | | | |
| Ambler | 259 | 67.086110° | -157.851390° | -52.0 | 82.0 | 23.0 | -48.6 | 83.9 | 24.1 | 22.3 | 25.2 | 5657 | 5463 | 2933 | 3113 |
| Buckland | 458 | 65.979720° | -161.123060° | -49.0 | 86.0 | 22.0 | -45.8 | 88.0 | 23.1 | 13.2 | 16.1 | 6456 | 6229 | 2668 | 2842 |
| Deering | 133 | 66.074970° | -162.712740° | -45.0 | 75.0 | 23.0 | -42.1 | 76.7 | 24.1 | 10.2 | 12.8 | 6826 | 6371 | 1901 | 1950 |
| Kiana | 383 | 66.975000° | -160.422780° | -52.0 | 77.0 | 23.0 | -48.5 | 78.8 | 24.1 | 14.7 | 17.5 | 6051 | 5836 | 2753 | 2937 |
| Kivalina | 406 | 67.726940° | -164.533330° | -51.0 | 80.0 | 22.0 | -47.5 | 81.7 | 23.1 | 8.6 | 10.5 | 6962 | 6516 | 1827 | 1870 |
| Kobuk | 109 | 66.906570° | -156.881020° | -54.0 | 82.0 | 25.0 | -50.5 | 83.9 | 26.2 | 16.8 | 19.8 | 5657 | 5452 | 2933 | 3113 |
| Kotzebue | 3126 | 66.898280° | -162.596850° | -44.0 | 84.0 | 21.0 | -41.1 | 85.8 | 22.0 | 9.1 | 11.7 | 6659 | 6198 | 2465 | 2517 |
| Noatak | 512 | 67.571110° | -162.965280° | -49.0 | 91.0 | 26.0 | -45.6 | 92.8 | 27.3 | 12.4 | 14.9 | 6489 | 5953 | 3745 | 3917 |
| Noorvik | 642 | 66.838330° | -161.032780° | -52.0 | 77.0 | 23.0 | -48.5 | 78.8 | 24.1 | 12.2 | 14.9 | 6297 | 6129 | 2753 | 2929 |
| Selawik | 846 | 66.603890° | -160.006940° | -47.0 | 77.0 | 22.5 | -43.9 | 78.8 | 23.6 | 15.8 | 18.7 | 6487 | 6244 | 2753 | 2937 |
| Shungnak | 272 | 66.888060° | -157.136390° | -54.0 | 82.0 | 25.0 | -50.5 | 83.9 | 26.2 | 17.1 | 20.0 | 5657 | 5457 | 2933 | 3113 |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |

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# The take home

1. Communities across Alaska are increasingly fragile and vulnerable.
2. Permafrost thaw and erosion are leading threats to infrastructure.
3. Guidelines on design parameters and best practices is lacking.
4. Some infrastructure is operating outside of it's design parameters.
5. Monitoring is needed to address problems before catastrophic failures.
6. Rapid change is compounding existing problems in community systems.
7. Capacity to ensure compatibility between systems is needed.
8. Climate change is effecting the ability to provide basic health services.

# Future Possible Guiding Principles of Infrastructure Design

- Flexible instead of rigid
- Moveable instead of permanent
- Smaller
- Adaptable to changing conditions
- Efficiency and simplicity over complexity
- Innovative
- Increased monitoring
- Modular
- Light Footprint

## OUR VISION:

Alaska Native people are the healthiest people in the world.

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