

# Threats of Climate Change on Water and Sanitation

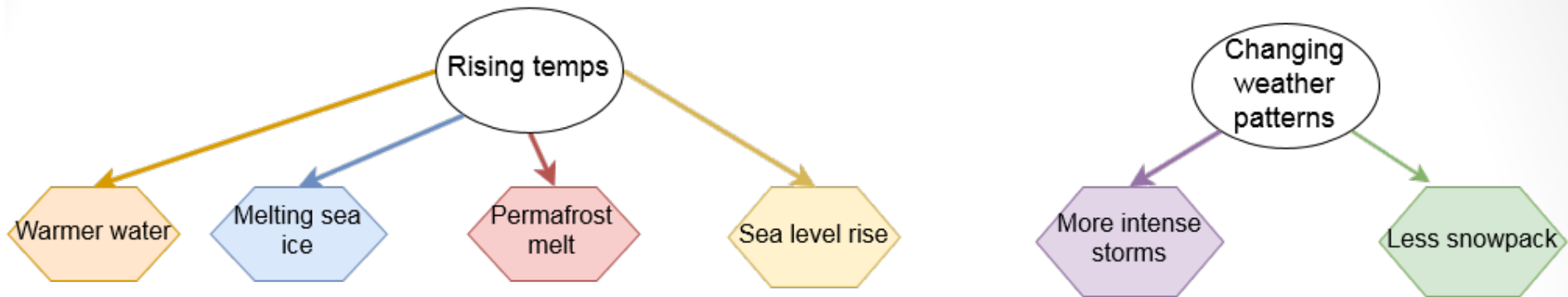
from an International Survey in the Arctic

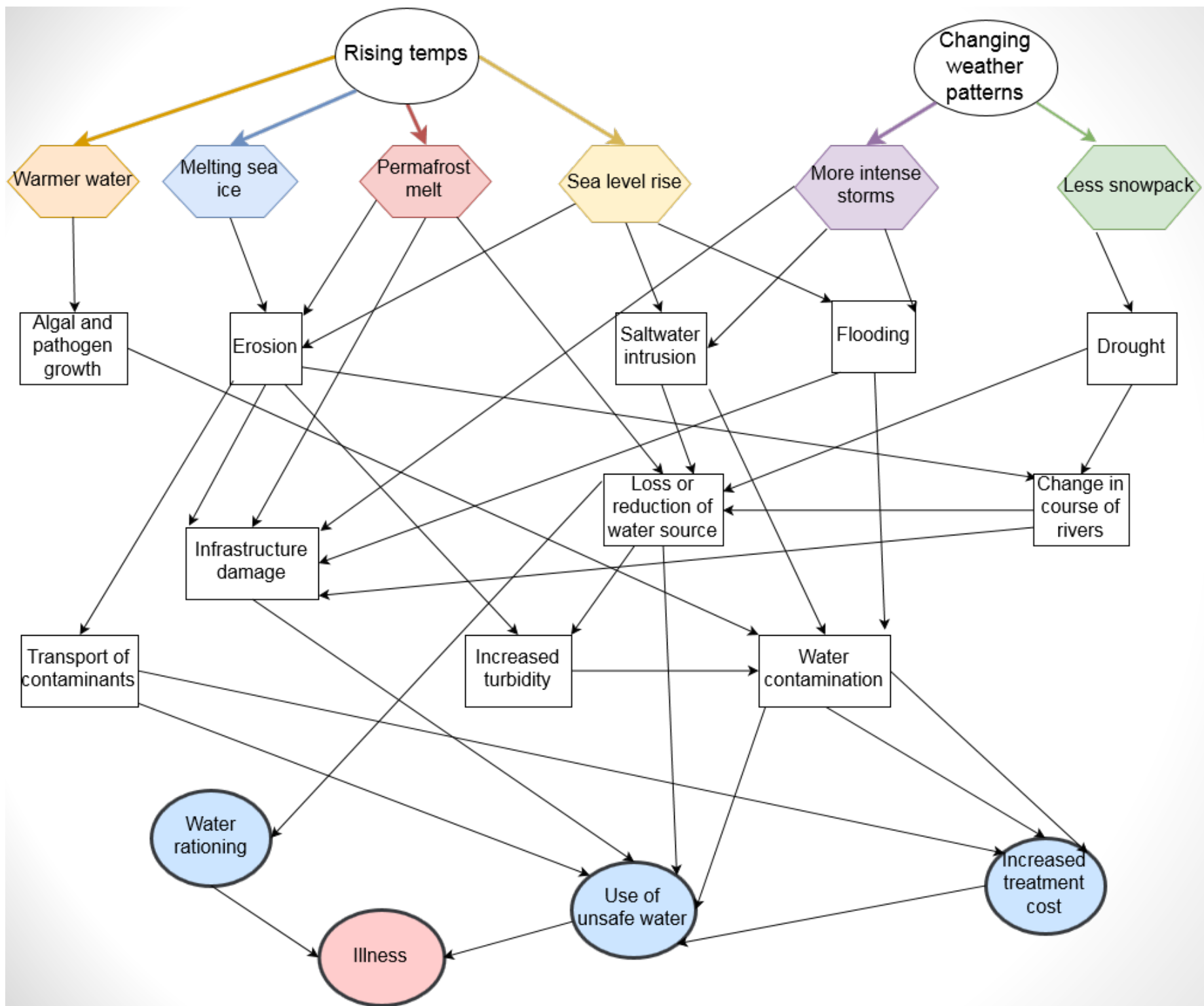
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# How does climate change affect water and health in the arctic?





# Mediating factors

- Population growth
  - Higher demand on outdated water & sanitation infrastructure.
- Melting sea ice opens transportation routes
  - Previously isolated communities may gain access to imports and new technologies.
- Investment, innovation, and collaboration in coping with climate change-related threats

# Arctic Council Water/Sanitation Project



[https://www.surveymonkey.com/r/arctic\\_council\\_water\\_sanitation](https://www.surveymonkey.com/r/arctic_council_water_sanitation)

# Survey Methods


## Survey on Water and Sanitation in the Arctic

- Three-part survey:
  - Access to water and sanitation services
  - Water- and sanitation-related disease surveillance
  - Effects of climate change on water and sanitation access
- Distributed to professionals in health, water and sanitation; government authorities; and residents in the Arctic nations.
  - Email lists, direct contacts, and a previously published article.<sup>1</sup>
  - Responses collected April through September 2016.
- Details and additional information solicited from known and recommended experts and WIHAH presenters.

<sup>1</sup>Hennessy TW, Bressler JM. Improving health in the Arctic region through safe and affordable access to household running water and sewer services: an Arctic Council initiative. Int J Circumpolar Health. 2016 Apr 29;75:31149.

# Survey Methods

- Respondents provided:
  - Organization
  - Affiliation
  - Location
- Countries surveyed:
  - Canada
  - Greenland
  - Finland
  - Iceland
  - Norway
  - Russia
  - Sweden
  - US (Alaska)



Survey on Water and Sanitation in the Arctic

### Respondent Information

**\* 1. This survey is for national, regional, provincial/state health authorities, community members, and other experts. Please choose the group that best describes you.**

☐ National government authority

☐ Regional government authority

☐ Provincial or State government authority

☐ Department or County government authority

☐ City or Township government authority

☐ Tribal or Indigenous organization

☐ Community member

☐ Other expert or interested person (please describe)

**\* 2. Information**

Name of person completing survey:

Title:

Institute/Organization:

**\* 3. Country:**

What region, community, or population of this country do you represent?

# Survey Methods



Survey on Water and Sanitation in the Arctic

**Climate or Environmental Changes Affecting Water and Sanitation**

**\* 7. Do you know about climate or environmental changes affecting water and sanitation in your area?**

☐ Yes

☐ No

Prev

Next



# Survey Methods

**\* 9. For this area, has there been a decrease in the *quantity (volume)* of source water during the last 20 years? (check all that apply)**

- ☐ Decrease in groundwater supply.
- ☐ Loss or decrease of tundra pond water or other surface water.
- ☐ Change in the course of a river that reduced access to water.
- ☐ Other decrease in quantity or volume not described here.
- ☐ No decrease in water quantity has been observed.
- ☐ I do not know of any decrease in water quantity in the area.

Please provide a link or citation (if available) and a brief description of the event(s)

**\* 10. For this area, has there been a decrease in the *quality* of source water during the last 20 years? (check all that apply)**

- ☐ Increased salt content, dissolved solids, or other contaminants in *groundwater*.
- ☐ Flooding of coastal areas by storms, causing contamination of *surface water* with seawater.
- ☐ Increased salt and bromide content in river intakes due to sea-level rise.
- ☐ Excessive algal, bacterial, fungal, insect, or other biological growth in source water.
- ☐ Other decrease in quality not described here.
- ☐ No decrease in water quality has been observed.
- ☐ I do not know of any decrease in water quality.

Please provide a link or citation (if available) and a brief description of the event(s)

# Survey Methods

**\* 11. For this area, has there been damage to water or sanitation infrastructure (such as buildings, machinery, pipes, or other systems) ? (check all that apply)**

- ☐ Damage to infrastructure due to high overland water flow (runoff) after intense storms.
- ☐ Damage to infrastructure from riverbank erosion after intense rainstorms.
- ☐ Damage to structure founded on frozen soil due to thawing permafrost.
- ☐ Other damage to water infrastructure due to event(s) not described here.
- ☐ No damage to water infrastructure has occurred.
- ☐ I do not know of any damage to water infrastructure in the area.

Please provide a link or citation (if available) and a brief description of the event(s)

**\* 12. Has a change in the climate or environment caused any of the following maintenance issues with water and sewer services in this area? (check all that apply)**

- ☐ Use of dirty, contaminated, or unsafe water due to high cost of repairing or replacing damaged structures or contaminated water sources.
- ☐ Increase in cost of operations and maintenance.
- ☐ Other operations or maintenance issue(s) caused by climate change not described here.
- ☐ No climate- or environment-related maintenance issues have occurred.
- ☐ I do not know of any climate- or environment-related maintenance issues in the area.

Please provide a link or citation (if available) and a brief description of the event(s)

# Survey Methods

**\* 13. Has concern over changes in the climate or environment affected the planning of water and sanitation projects or infrastructure? (for example, a change in design of systems, or use of different materials)**

- ☐ Yes (please describe)
- ☐ No
- ☐ I do not know if climate change concern has affected the planning of water or sanitation infrastructure.

Please provide a link or citation (if available) and a brief description.

**\* 14. Has water treatment been affected in any of the following ways? (check all that apply)**

- ☐ Rise in bromide concentration requiring treatment of water source.
- ☐ More difficult to appropriately treat water after increase in turbidity, pathogens, or natural contaminants in the water.
- ☐ More frequent or severe algal blooms affecting water treatment.
- ☐ Other treatment issue(s) not described here.
- ☐ Water treatment has not been affected by climate change.
- ☐ I do not know if water treatment has been affected by climate change.

Please provide a link or citation (if available), and a brief description.

# Climate change-related threats to water and sanitation access in the Arctic, as reported by survey respondents, 2016

		Number of responses						
		Canada: Nunavut	Finland	Greenland	Iceland	Norway	Sweden	U.S.: Alaska
<b>TOTAL RESPONDENTS</b>		<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>13</b>
Decrease in source water quantity?	Decrease in groundwater supply.						1	4
	Loss or decrease of tundra pond water or other surface water.	2						7
	Change in the course of a river that reduced access to water.	1						4
	Other decrease in quantity or volume not described here.	2		1				1
	No decrease observed	1				1		1
	Do not know	1	1		1		1	4
Decrease in source water quality?	Increased salt content, dissolved solids, or other contaminants in groundwater.						1	3
	Flooding of coastal areas by storms, causing contamination of surface water with seawater.							4
	Increased salt and bromide content in river intakes due to sea-level rise.	1						
	Excessive algal, bacterial, fungal, insect, or other biological growth in source water.							3
	Other decrease in quality not described here.			1		1		2
	No decrease observed	1					1	1
	Do not know	1	1		1			4

## Climate change-related threats to water and sanitation access in the Arctic, as reported by survey respondents, 2016 (continued)

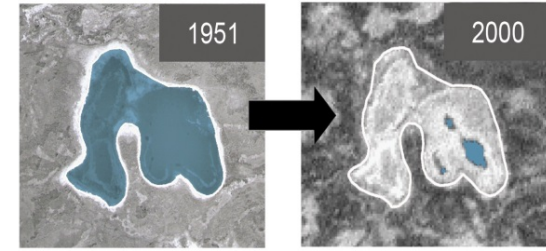
		Number of responses						
		Canada: Nunavut	Finland	Greenland	Iceland	Norway	Sweden	U.S.: Alaska
<b>TOTAL RESPONDENTS</b>		<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>13</b>
Damage to water and sanitation infrastructure?	Damage to infrastructure due to high overland water flow (runoff) after intense storms.					1	1	3
	Damage to infrastructure from riverbank erosion after intense rainstorms.	1		1		1		3
	Damage to structure founded on frozen soil due to thawing permafrost.	3		1				4
	Other damage to water infrastructure due to event(s) not described here.	1		1				1
	No damage occurred							
	Do not know		1		1			6
Climate-caused maintenance?	Use of dirty, contaminated, or unsafe water due to high cost of repairing or replacing damaged structures or contaminated water sources.	1					1	2
	Increase in cost of operations and maintenance.	2		1		1		6
	Other operations or maintenance issue(s) caused by climate change not described here.	1		1				3
	No climate-related issues/Do not know							
	Do not know		1		1			6

# Climate change-related threats to water and sanitation access in the Arctic, as reported by survey respondents, 2016 (continued)

		Number of responses						
		Canada: Nunavut	Finland	Greenland	Iceland	Norway	Sweden	U.S.: Alaska
<b>TOTAL RESPONDENTS</b>		<b>3</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>2</b>	<b>13</b>
Water treatment affected?	Rise in bromide concentration requiring treatment of water source.						1	
	More difficult to appropriately treat water after increase in turbidity, pathogens, or natural contaminants in the water.	2						4
	More frequent or severe algal blooms affecting water treatment.							
	Other treatment issue(s) not described here.			1		1		3
	Treatment not affected							2
	Do not know	1	1		1			7
Climate change affected planning?	Yes	2		1		1	2	6
	No							2
	Do not know	1	1		1			5

# Survey responses:

## Decreases in source water quantity



### CANADA - Nunavut

- “Some communities' principal water source is fed by receding glaciers and/or snow packs. Less melt has been witnessed in several communities over the last decade.”

### ALASKA – North Slope Borough

- “Decrease in groundwater aquifers and main tundra pond water source.”

### ALASKA – Gakona

- “Dry summers and warm winters have caused a loss of ground moisture and water in bog and pond areas.”

### ALASKA – Kotzebue

- “The lack of snow and rain, and the increased heat have been diminishing our water supply.”

# Survey responses:

## Decreases in source water quality



### CANADA – Nunavut

- “Storm surges are causing salt water intrusions near river intakes. Intake pipes need to be moved upstream to avoid drawing brackish waters into the pumping stations.”

### NORWAY

- “The color of water in river and lakes have gradually changed over time.”

### ALASKA - Northwest Arctic Borough

- “Stream bank erosion and permafrost thawing (i.e. sloughing) decreases water quality via turbidity.”



# Survey responses:

## Damage to infrastructure



### CANADA – Nunavut

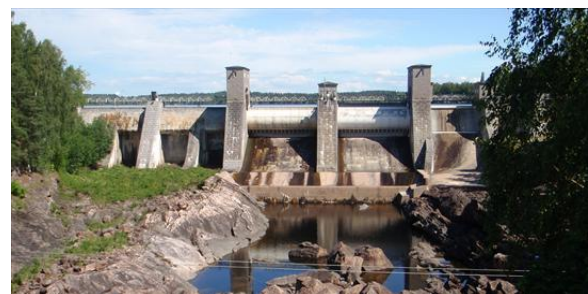
- “Leaks in reservoirs due to berm instability (thawing).”

### ICELAND

- “Damage to water infrastructure has occurred caused by volcanic eruptions or earthquakes.”

### FINLAND

- “Dam safety incidents due to power cuts during intense storms, land collapse, rising water level.”



### ALASKA – Kotzebue

- “More frequent and intense storms along with warm weather.”

### ALASKA – Shishmaref

- “The community has been suffering from erosion and flooding of the coastline which puts the facilities (like the sewage lagoon) in a vulnerable position.”

## Previous Occurrences of Flooding and Erosion



Storm erosion in Kotzebue, Alaska

**Kotzebue, September 4, 1990** An unseasonable storm and wind driven tides damaged public and private property in Kotzebue and surrounding traditional use areas. The Governor's declaration of disaster provided assistance to the City of Kotzebue and to individuals and families.

**94 Fall Flood declared August 26, 1994 by Governor Hickel then FEMA declared (DR-1039) on September 12, 1994** On August 26, 1994, the Governor declared disaster emergencies for the communities of Kobuk, Kiana, and Kotzebue as a result of flood damage. As a result of this disaster, the conditions continue to create unprecedented losses of personal and public properties.

**Northwest Fall Sea Storm Declared October 23, 2002** - Coastal storm surge flooding occurred in communities on the Northwestern coast of Alaska commencing on October, 8, 2002. A fall sea storm with 18-20 foot seas, extremely high winds, and strong tidal action caused severe damage. This storm was caused by a low pressure system moving down from the Arctic Ocean and settling over the Chuckchi Sea and the Kotzebue Sound resulting in widespread damage and coastal flooding, including damage to public roads and other public real property. The Governor declared a disaster for the cities of Kotzebue and Kivalina in the Northwest Arctic Borough.

**2004 Bering Strait Sea Storm declared October 28, 2004 by Governor Murkowski then FEMA declared (DR-1571) on November 15, 2004. Amended declaration to extend incident to October 24, 2004:** Between October 18 and 20, 2004, a severe winter storm with strong winds and extreme tidal surges occurred along the Western Alaska coastline, which resulted in severe damage and threat to life and property in the Northwest Arctic Borough, including Kivalina, Kotzebue.

**2005 West Coast Storm declared October 24, 2005 by Governor Murkowski then FEMA declared (DR-1618) on December 9, 2005:** Beginning on September 22, 2005 and continuing through September 26, 2005, a powerful fall sea storm produced high winds combined with wind-driven tidal surges resulting in severe and widespread coastal flooding and a threat to life and property in the Northwest Arctic Borough.

Table 11 Top 12 Kotzebue Storm Surge Events between 1954 and 2012

	Start Date	Maximum Surge above MLLW	Maximum Wind Speed (mph)	Direction
1	08/25/12	10.0' See Note	43	WSW
2	11/26/70	9.18'	47.9	W
3	11/14/66	7.12'	49.7	SSE
4	11/10/74	6.98'	51.9	S
5	10/25/96	6.46	30.0	SSE
6	08/29/62	6.03'	47.0	W
7	10/03/83	4.95'	25.7	ESE
8	11/08/78	4.85'	46.3	E
9	06/16/61	4.75'	28.9	S
10	10/01/60	4.72	36.0	SSW
11	08/25/75	4.69	28.4	SSW
12	02/25/11	3.0' See Note	45	WSW

# Survey responses:

## Water treatment effects



### NORWAY

- “Storm water infiltration of the sewage plant reduces the effectiveness of treatment.”

### SWEDEN

- “More frequent flooding in the past ten years though it has not yet affected the water wells. “

### ALASKA – Kotzebue

- “My 13 stage water filter now clogs with debris in 1/4 of the time it ordinarily would have.”

### ALASKA – Northwest Arctic Borough

- “Increased organic loads into source water, which when combined with chlorine as a disinfectant, causes disinfection by-products. Many of our water systems lack sufficient treatment to remove these by-products.”

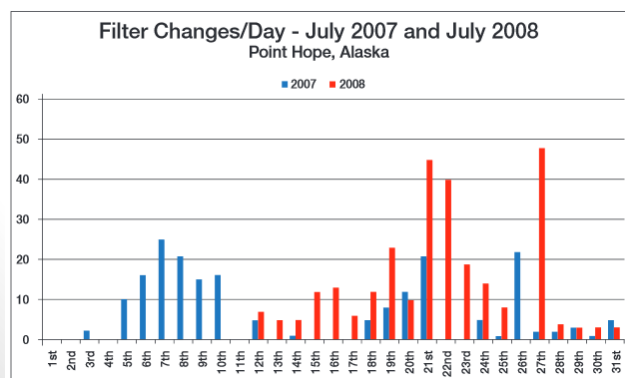


# Survey responses: Infrastructure damage, maintenance, and treatment (continued)



ALASKA NATIVE  
TRIBAL HEALTH  
CONSORTIUM

- ALASKA – ANTHC assessment reports
- Selawik:  
Uneven ground settling  
following permafrost melt  
causing damage to piping.
- Point Hope:  
Increase in amount of  
biologic slime requiring  
drastic increase in  
frequency of filter  
changes.



## Assessment Reports Archive

Assessment reports describing climate impacts observed in communities through  
Community Observations on Climate Change – Arctic Village, Fort Yukon and Venetie, Alaska |  
November 2016

Climate Change in Bering Strait Communities, Alaska | March 2015

Climate Change in Upper Nushagak River, Alaska | Sept. 2014

Climate Change in Atkasuk, Alaska | July 2014

Climate Change in Nuiqsut, Alaska | July 2014

Climate Change in Wainwright, Alaska | June 2014

Climate Change in Bristol Bay Communities, Alaska | April 2014

Climate Change in Levelock, Alaska | April 2014

Climate Change in Nondalton, Alaska | Nov. 2013

Climate Change in Pilot Point, Alaska | Sept. 2013

Climate Change in Selawik, Alaska | May 2012

Climate Change in Kiana, Alaska | Oct. 2011

Climate Change in Noatak, Alaska | June 2011

Climate Change in Kivilina, Alaska | Jan. 2011

Climate Change in Point Hope, Alaska | Aug. 2010

# Survey responses:

## Planning of infrastructure

### CANADA – Nunavut

- “Reservoirs are now being lined since relying solely on impermeability from permafrost is no longer an option.”

### GREENLAND

- “In cooperation with Nukissiorfiit (the national electricity and water supply company) we plan a larger research project in summer 2017 to develop solutions for Qaanaaq.”

### NORWAY

- “Change in design of systems to deal with storm water and sewage will be topics in the coming years.”

### SWEDEN – Älvsbyn

- “Due to repeated flooding and expected increasing rain/snow, the risk for contamination of water is expected to increase. The municipality has installed chemical and ultraviolet treatment in the water treatment plant and built protecting walls to prevent contamination of the ground water wells from flooding river water.”

# Survey responses:

## Planning of infrastructure (cont.)

### ALASKA – Point Lay

- “Thawing permafrost has caused our direct bury distribution & collection system to fail. Homes are being put on tanks to continue service until an above ground system can be built.”

### ALASKA – Northwest Arctic Borough

- “Federal and State funding agencies are hesitant to fund new water and sanitation projects in communities that are “highly threatened” and at risk of relocation.”
- “Shift of engineering efforts to serve homes with decentralized in-home systems rather than standard community/centralized systems so homes and systems may be portable with relocation.”
- “Flexible arctic service connection designs are being used to minimize service line damage when houses shift due to freeze/thaw cycles and permafrost melting.”
- “At least one water treatment plant project has been completely stalled because the project funded amount was insufficient. This community continues to sit with inadequately treated drinking water.”

# Recommendations & Workshop Objectives

- Under the AC Sustainable Development Working Group, create a regular forum for Arctic nations and communities to share innovations in water and sanitation technology, cost management methods, and **climate change adaptation strategies.**
- Workshop objectives:
  - **Design a plan for an “asset inventory” of at-risk water and sanitation infrastructure.**
  - **Assess community-based monitoring and response strategies involving health and water-related resources/infrastructure failure.**
  - Provide an update on the knowledge shared at the Water Innovations for Healthy Arctic Homes (WIHAH) Conference.