Remediation Challenges in the Arctic – Lessons from Alaska's North Slope

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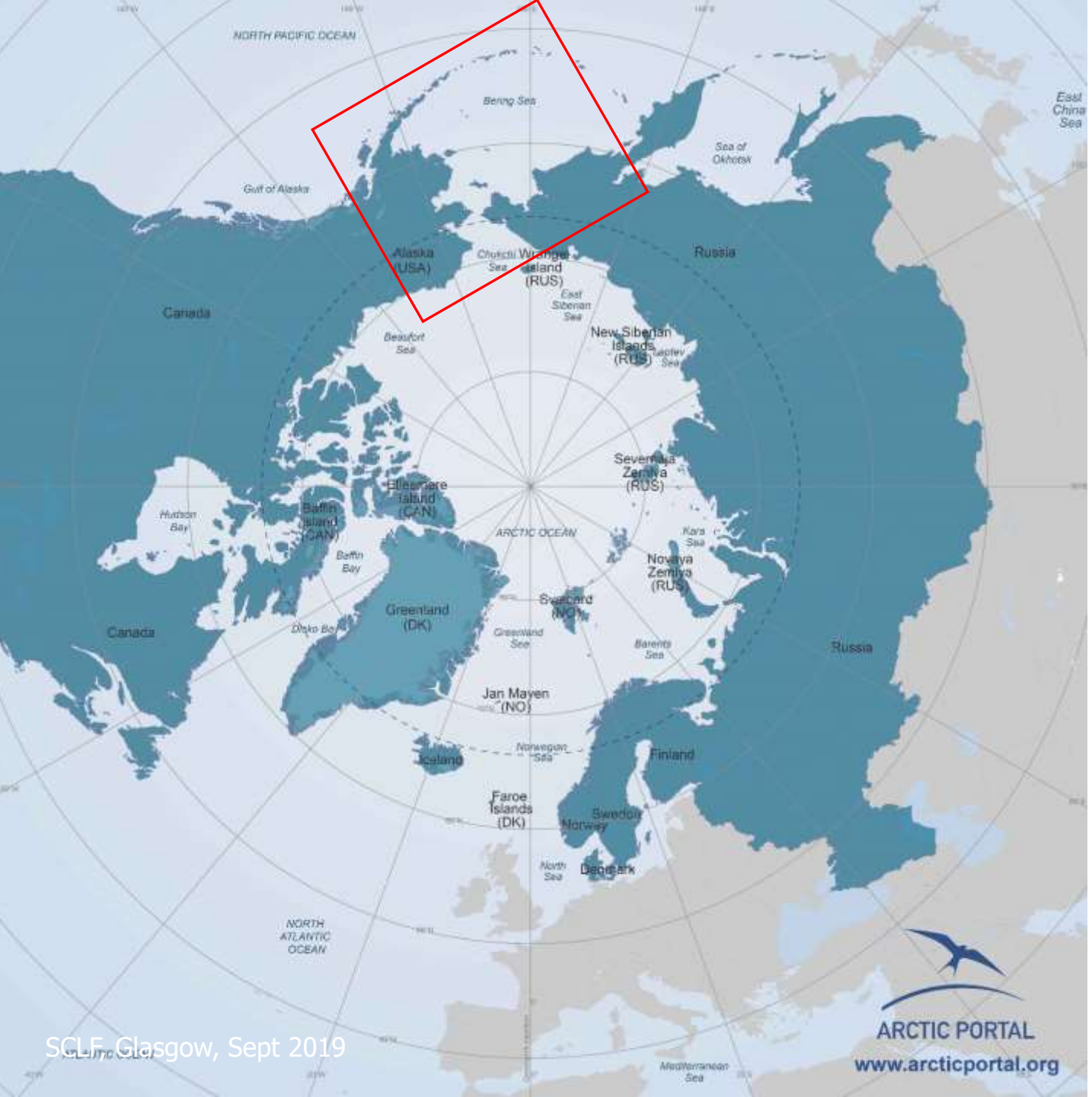
Presentation Outline

- Overview
- Why are there so many contaminated sites in Alaska?
- Case Study : Former Naval Arctic Research Laboratory
- Case Study : Red Devil Mercury Mine
- Impact of global warming on contaminated land remediation



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A long way from Scotland, but…..

- Juneau is at the same latitude as Wick.
- The majority of both populations live within 25km of the coast
- Both are mature oil producers with declining oil production

Image: Google Earth

SCLF, Glasgow, Sept 2019

Alaska is a pristine wilderness that has been described as “the last frontier” yet:

- There are over 7,900 contaminated sites listed in the Alaska CS database.
- There are an estimated 1,000 abandoned mines in the state.
- The Exxon Valdez spill in 1989 which caused extensive oil pollution in Prince William Sound.
- The Prudhoe Bay Oilfield in the Arctic, which has been in operation for over 40 years, will take decades to decommission and clean up.

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Question: Why are there so many contaminated sites in Alaska?

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- Extensive use of diesel fuel for heating and power generation in remote villages. Fuel transported by barge with extensive handling

Aerial Photo, Umiat, Alaska 1963 USACE

White Alice Sites

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- Cold war military sites, with associated infrastructure

Airfield Bases

Kaktovik White Alice Site

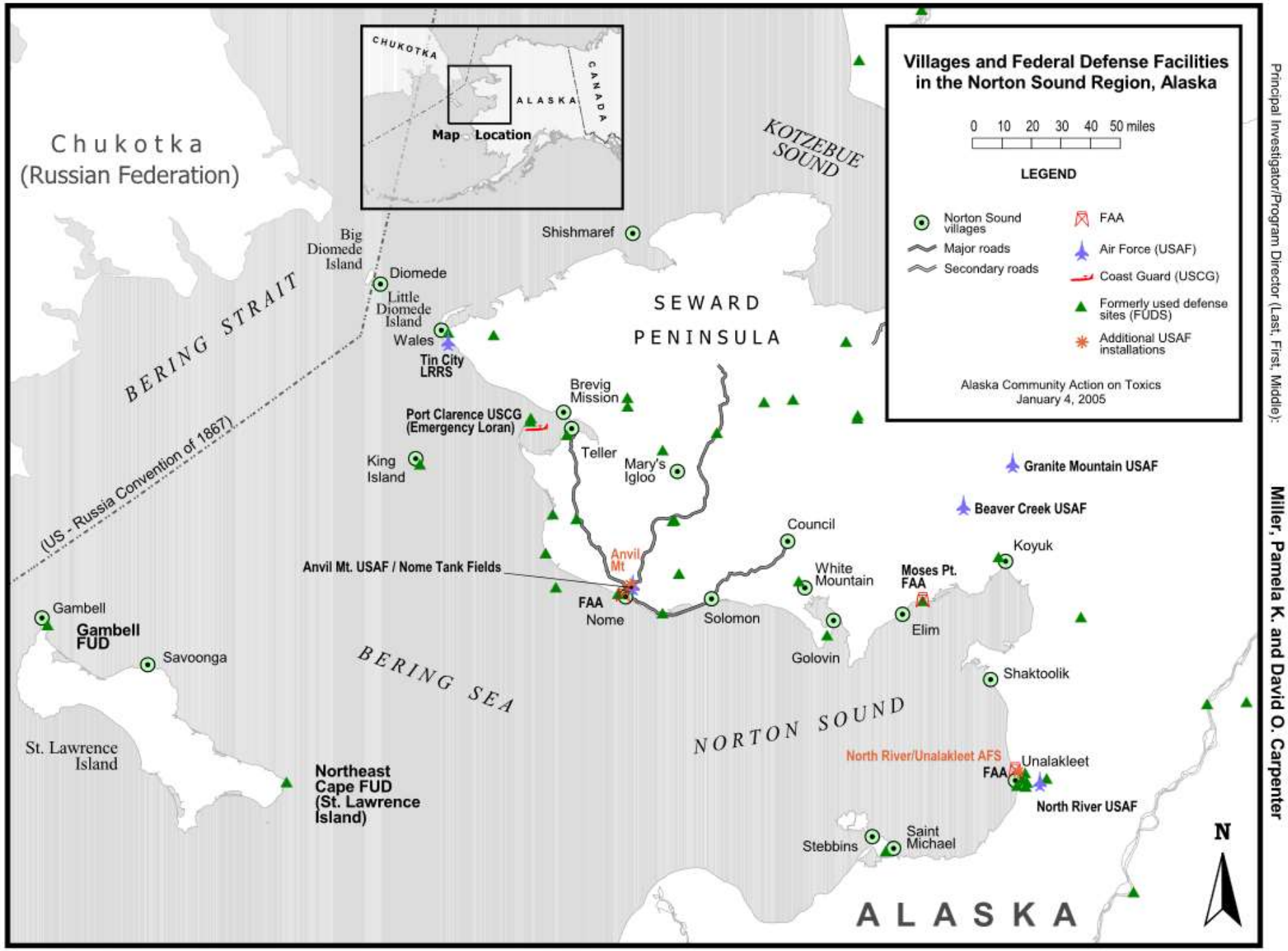

Figure 1. Norton Sound communities and FUDS

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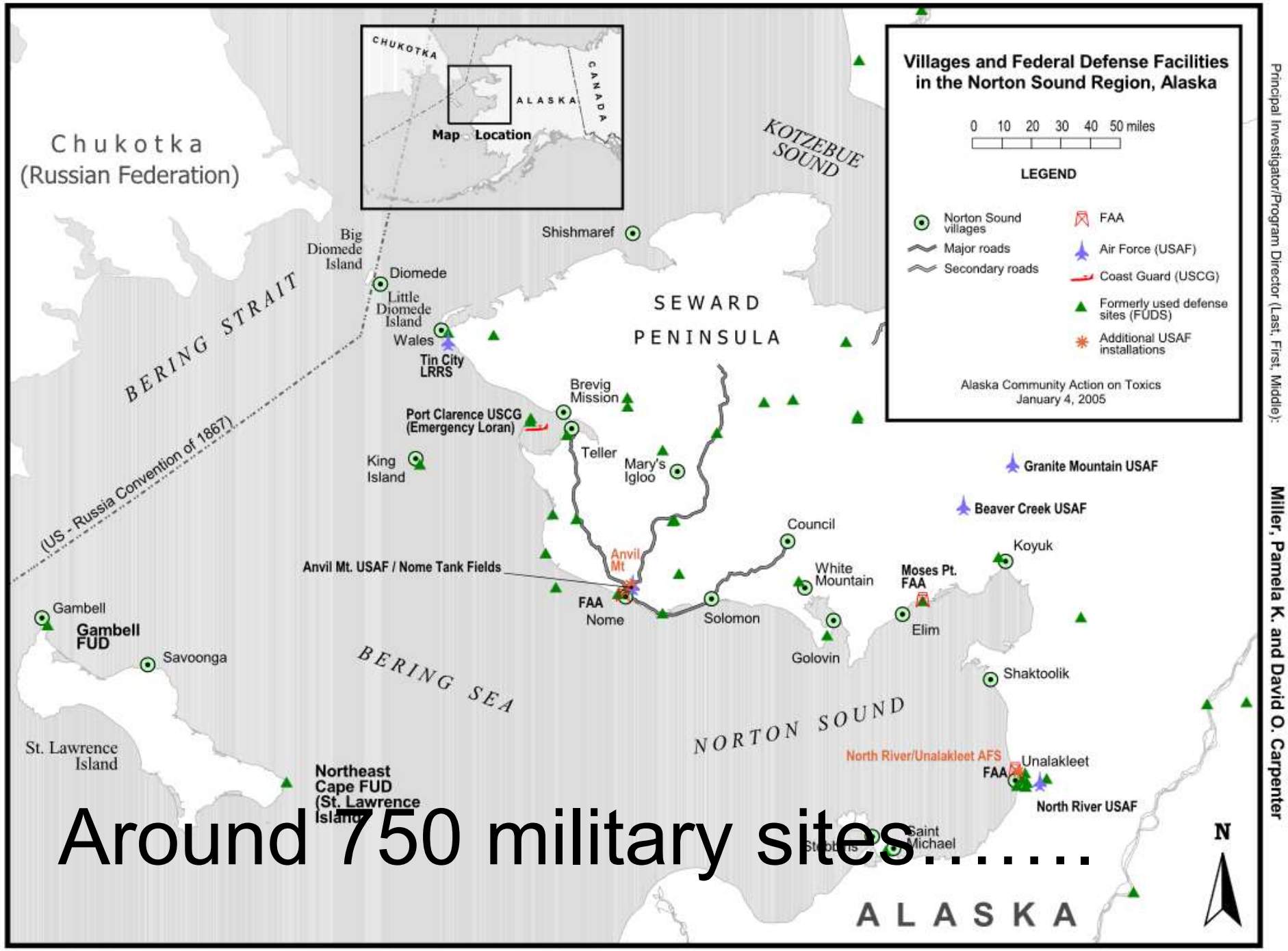
Principal Investigator/Program Director (Last, First, Middle): Miller, Pamela K. and David O. Carpenter

Norton Sound Region

- 37 FUDs
- 5 USAF
- 4 LRRS



Around 750 military sites……

PHS 398 (Rev. 05/01) Page 33 Figure 1. Norton Sound communities and FUDS

Principal Investigator/Program Director (Last, First, Middle): Miller, Pamela K. and David O. Carpenter

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Norton Sound Region

- 37 FUDs
- 5 USAF
- 4 LRRS

- Historical Mining

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- Extreme weather causes infrastructure failure

Case Study 1. Former Naval Arctic Research Laboratory, Utqiaġvik

Photo credit: Vince Pitelka

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Image: Google Earth

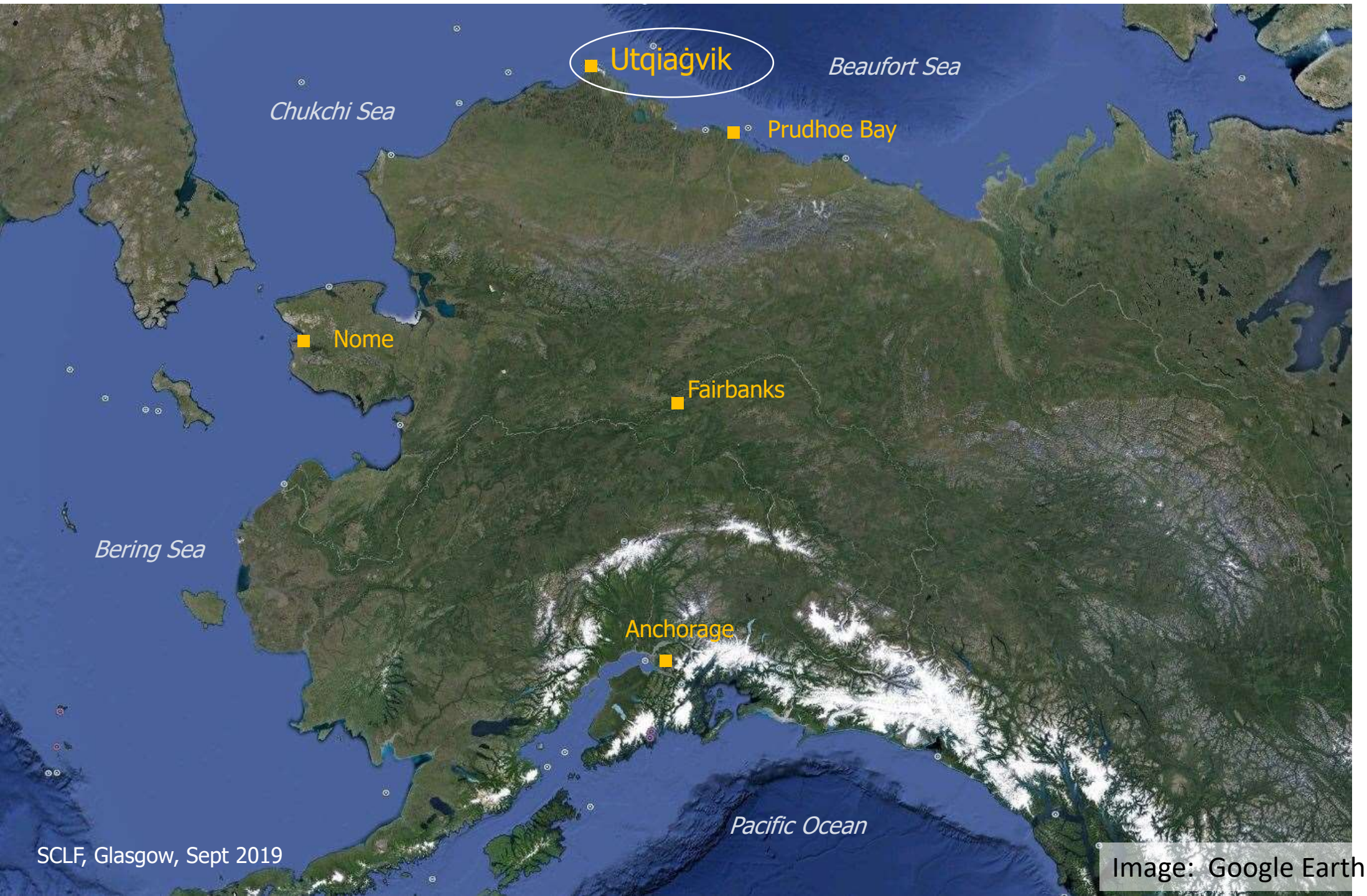

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Image: Google Earth

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Engineering

NARL - 1962

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LEGEND

- HISTORICAL CONTAMINATED AREAS
- CONTAMINATED AREA - ACTIVE
- CONTAMINATED AREA - CLEANUP COMPLETE
- CONTAMINATED AREA - CLEANUP COMPLETE, INSTITUTIONAL CONTROL

NARL MASTER PLAN

UIC NARL CONTAMINATED AREAS

BARROW, AK

DATE:	11/10/2016	DRAWN BY:	WDW	SHEET:	FIGURE
SCALE:	AS SHOWN	CHECKED BY:	CT	JOB No:	30040.16

UMIAQ ENVIRONMENTAL

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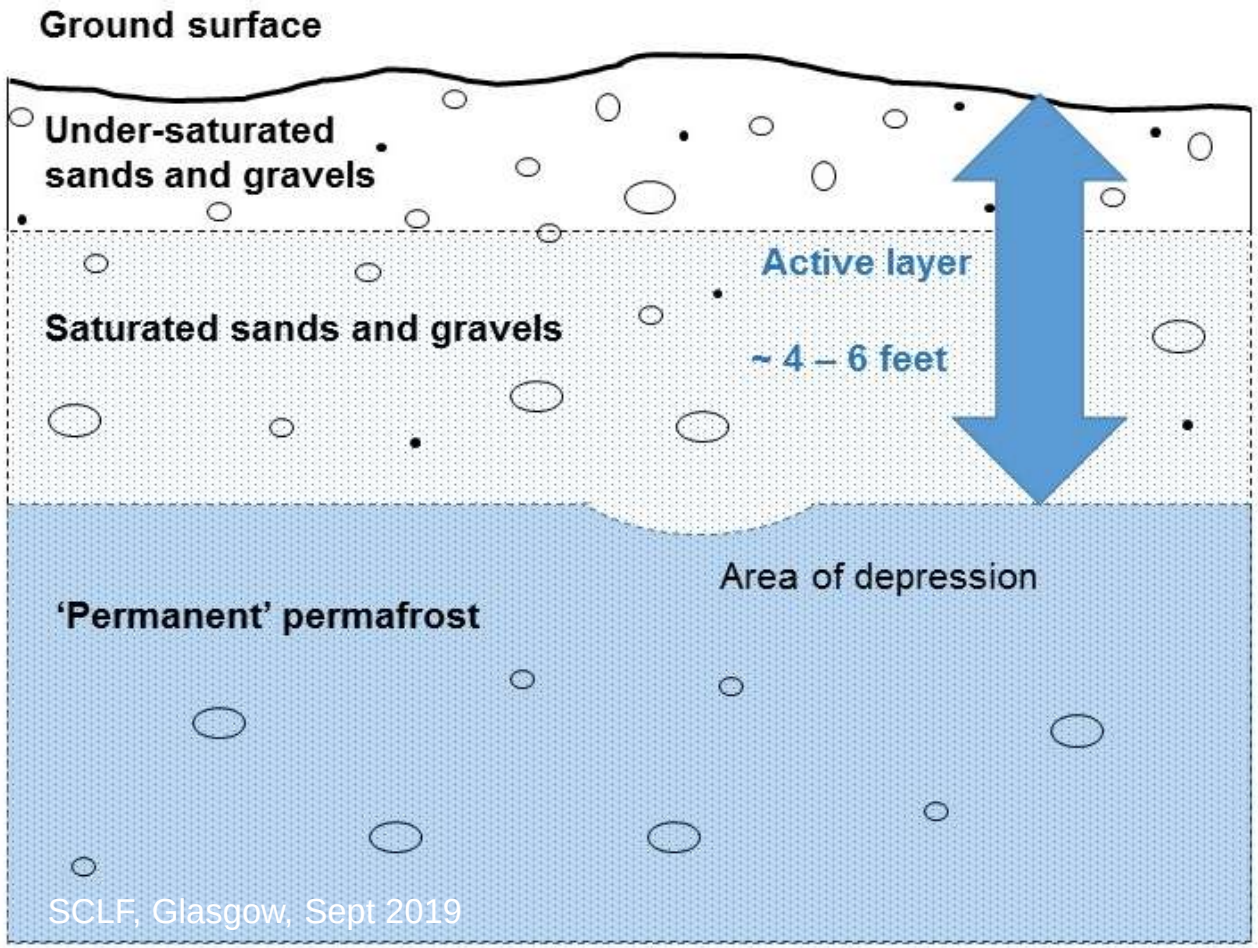
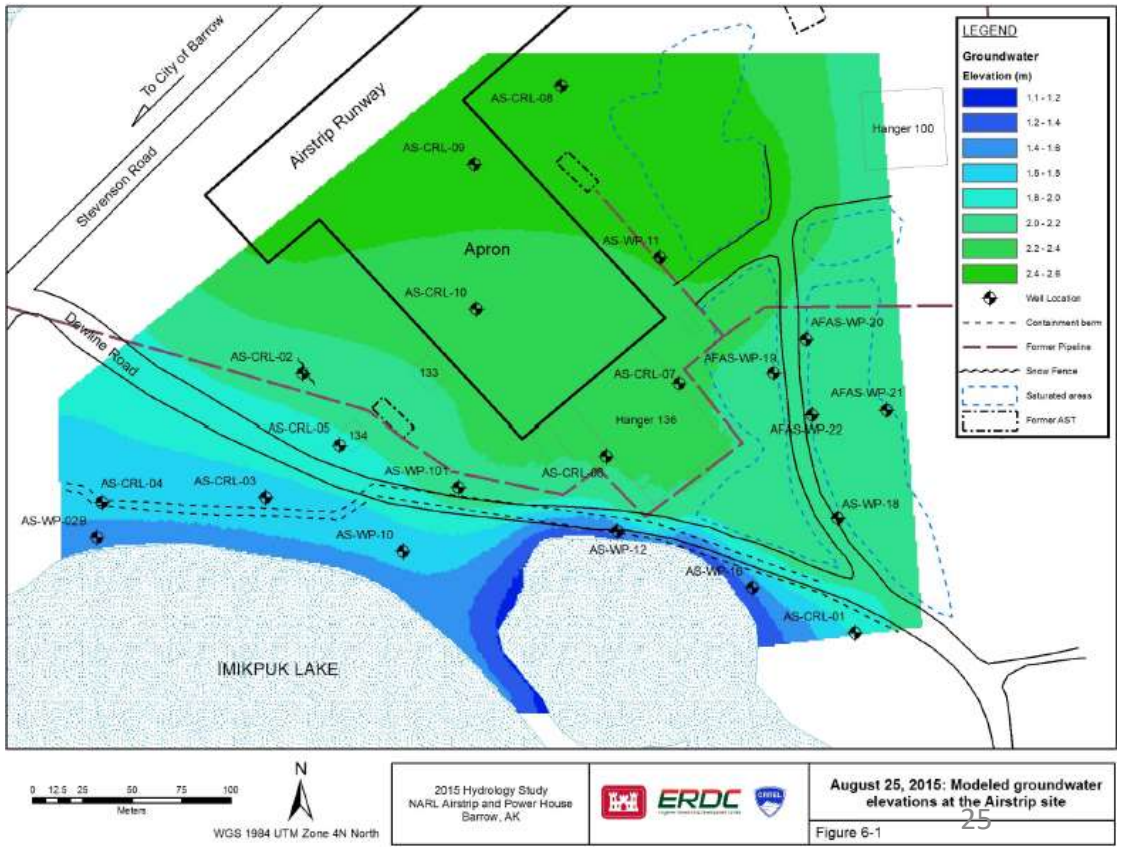
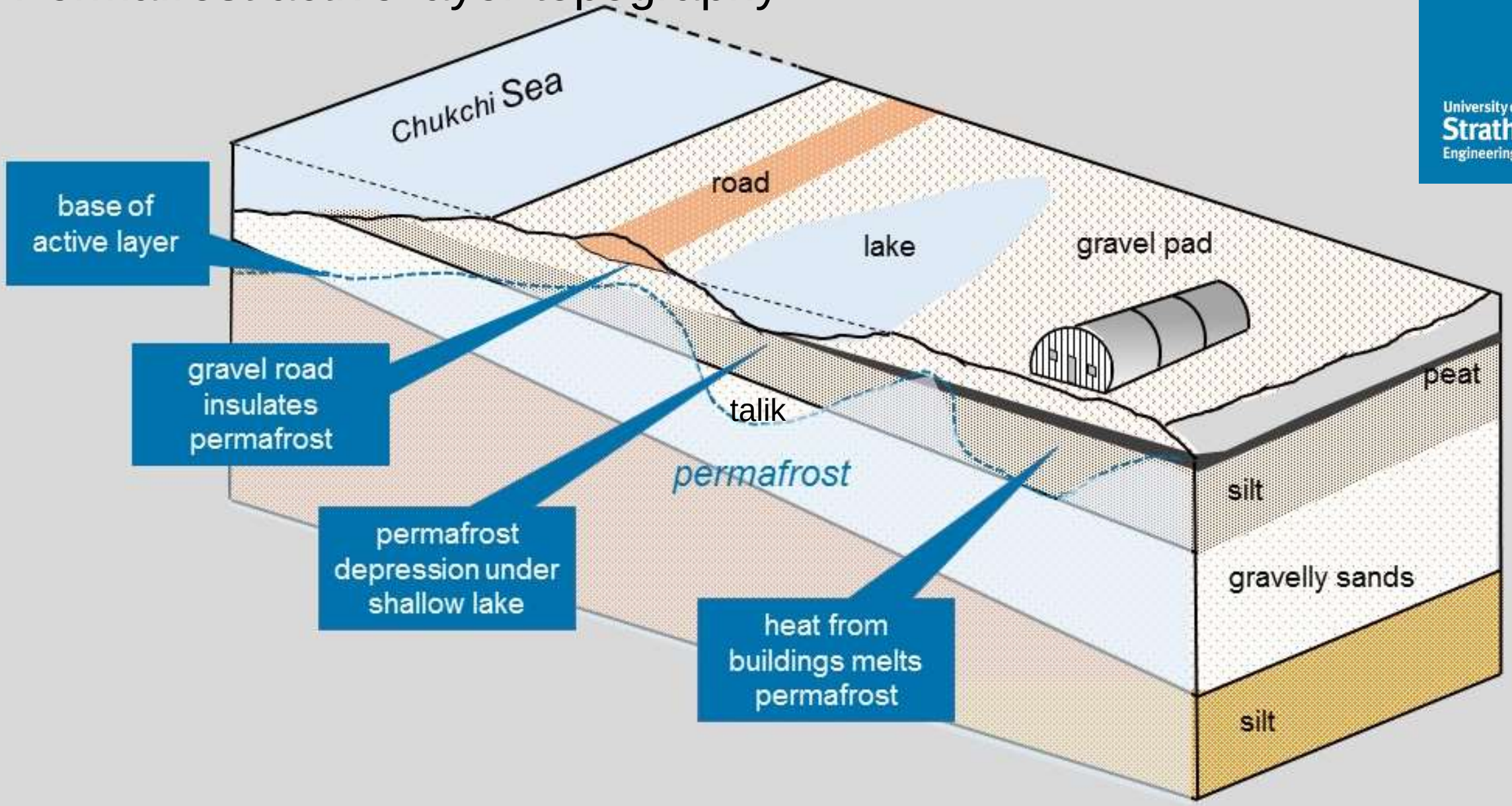
- Surface topography is flat – minimal hydraulic gradient.
- Underlain by continuous permafrost.
- Shallow active layer in summer allows contaminant migration.





Permafrost active layer topography



NARL Remediation Challenges

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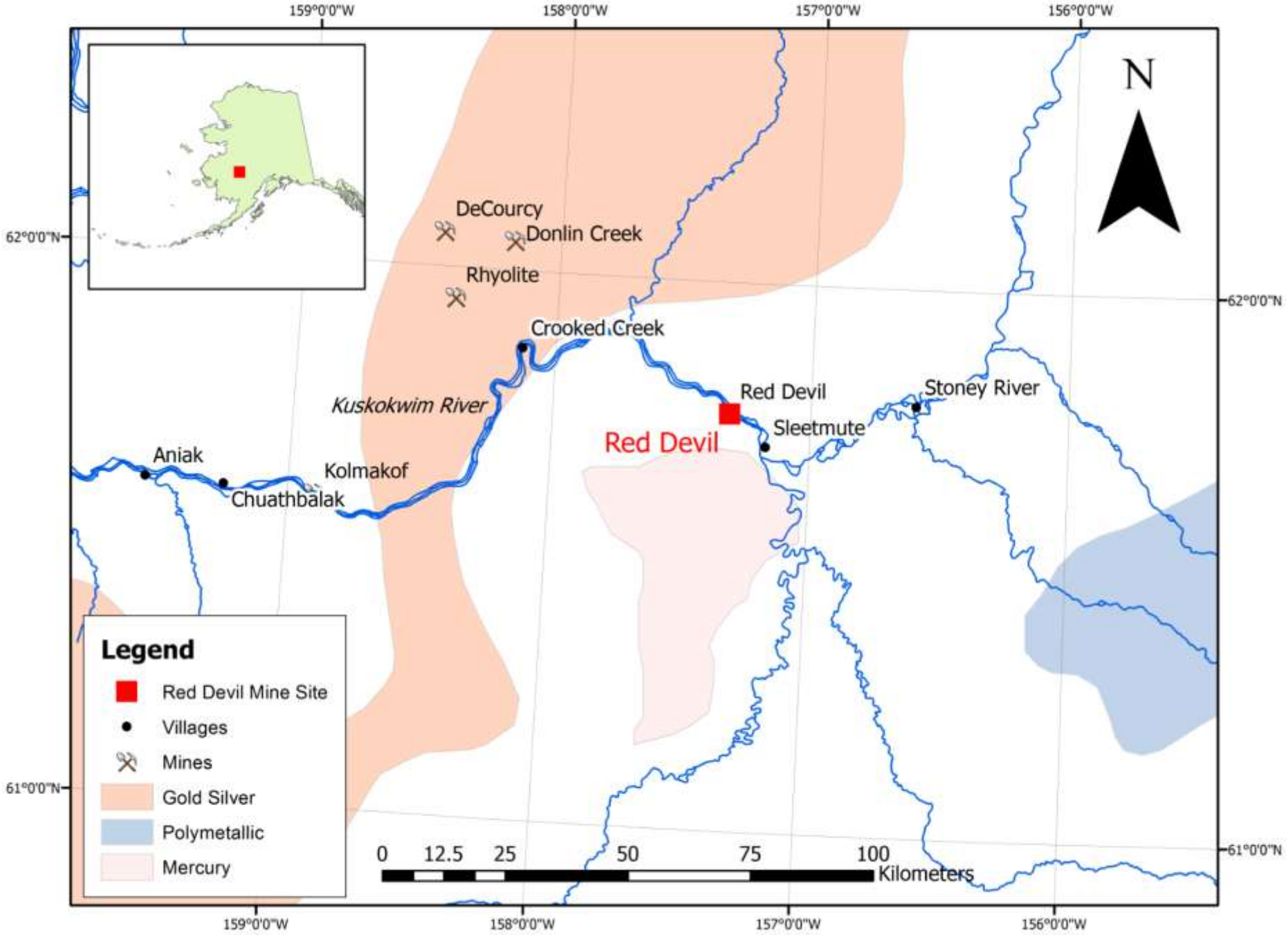
NARL Remediation Challenges

- Remote location accessed only by barge or air.
- Community is concerned over health impacts
- The region is underlain by continuous permafrost.
- Clean-up liability belongs to US Navy.
- Sub-surface hydrology poorly understood.
- Emerging contaminants present , including PFAS.

Case Study 2. Red Devil Mine



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- Operated from 1933 until 1971.
- Richest mercury (Hg) mine in Alaska; produced 1,224 tonnes of mercury.
- Mercury extracted at the mine site using a furnace and retort.
- Remediation and clean up on-going since 1986; funded through CERCLA programme.
- Source of elevated Hg in the Kuskokwim River sediments and salmon tissue.

Source - USGS

Ore Bin and Retort House, Red Devil Mine, 1941

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Source - USGS

Red Devil Mine ~ 1943

Source - USGS

Red Devil Mine ~ 1943

Furnace Building, Red Devil Mine, 1943

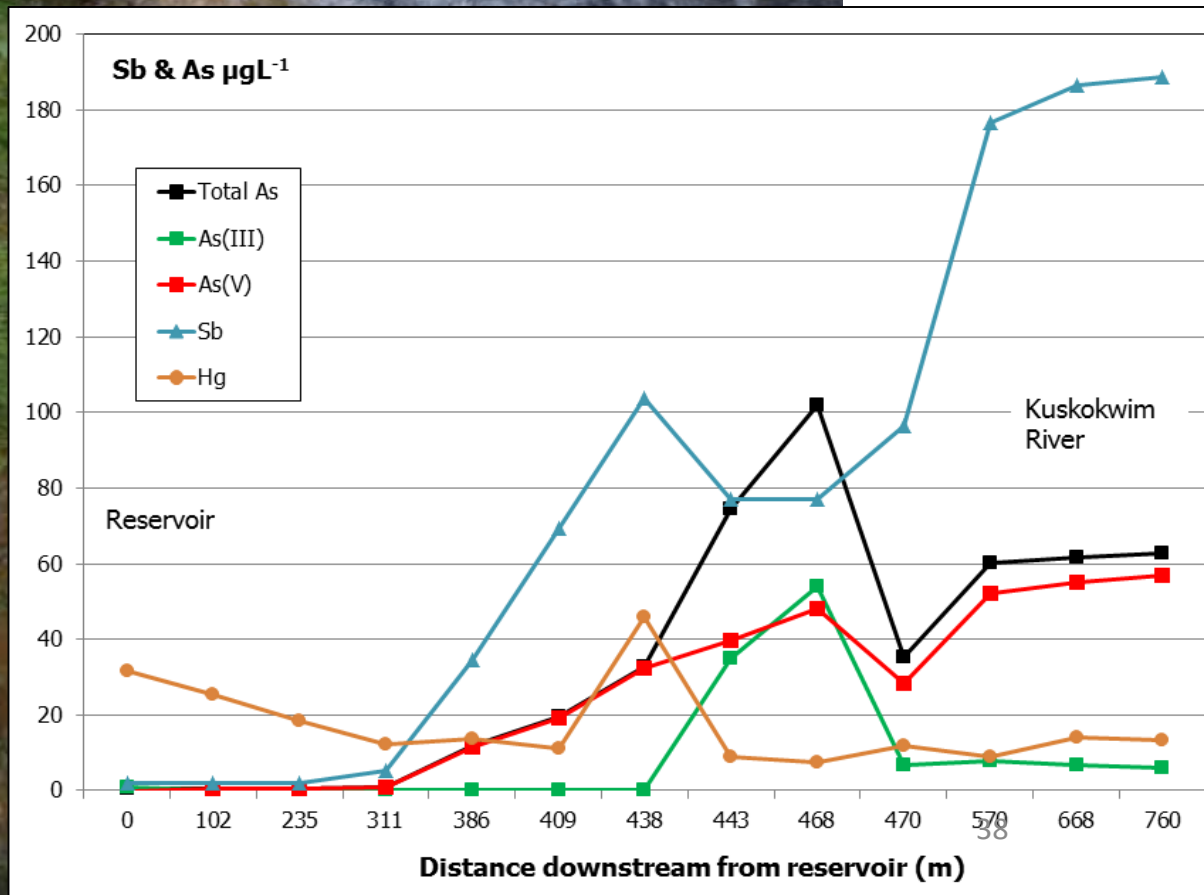
Source - USGS

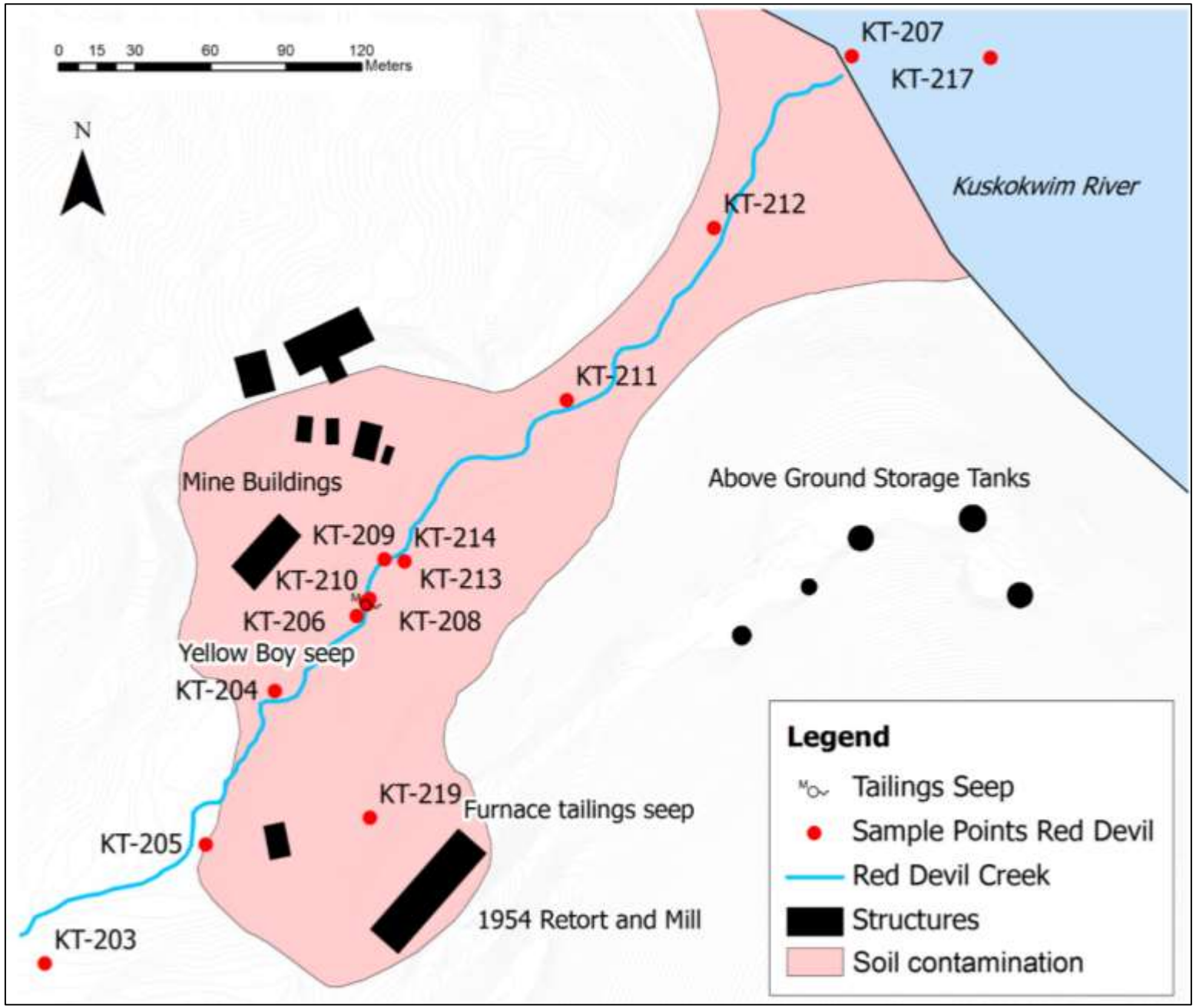
Red Devil Mine ~ 1985

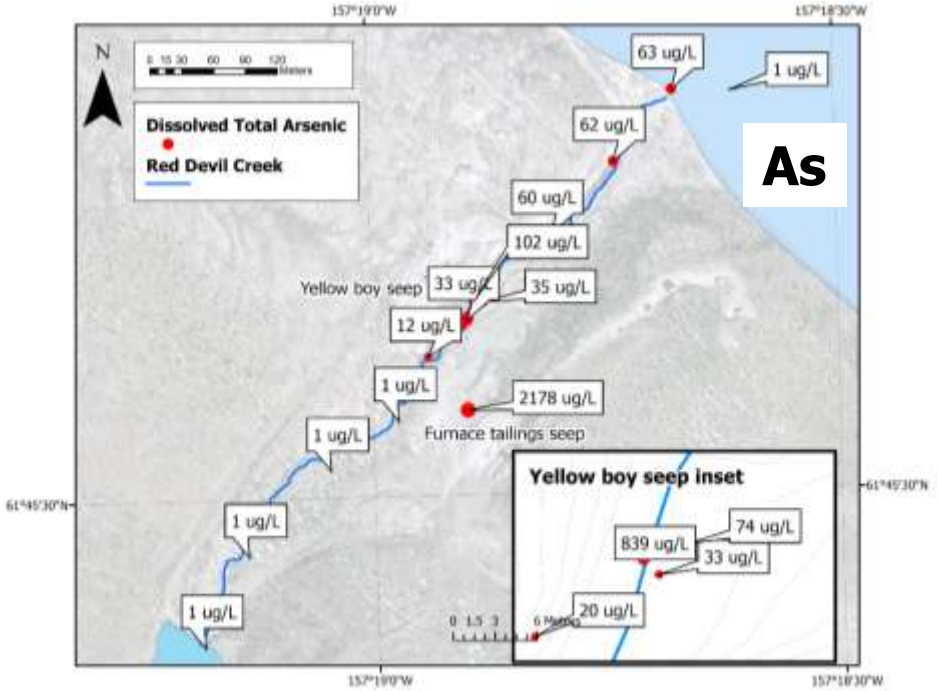
Source - BLM

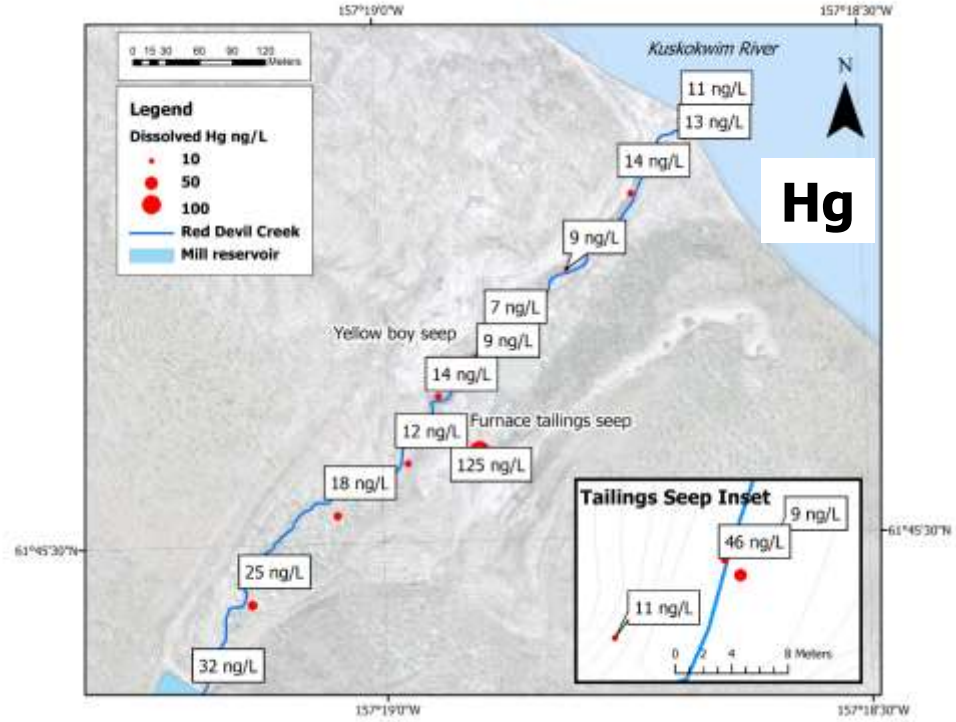
Erosion of mine tailings

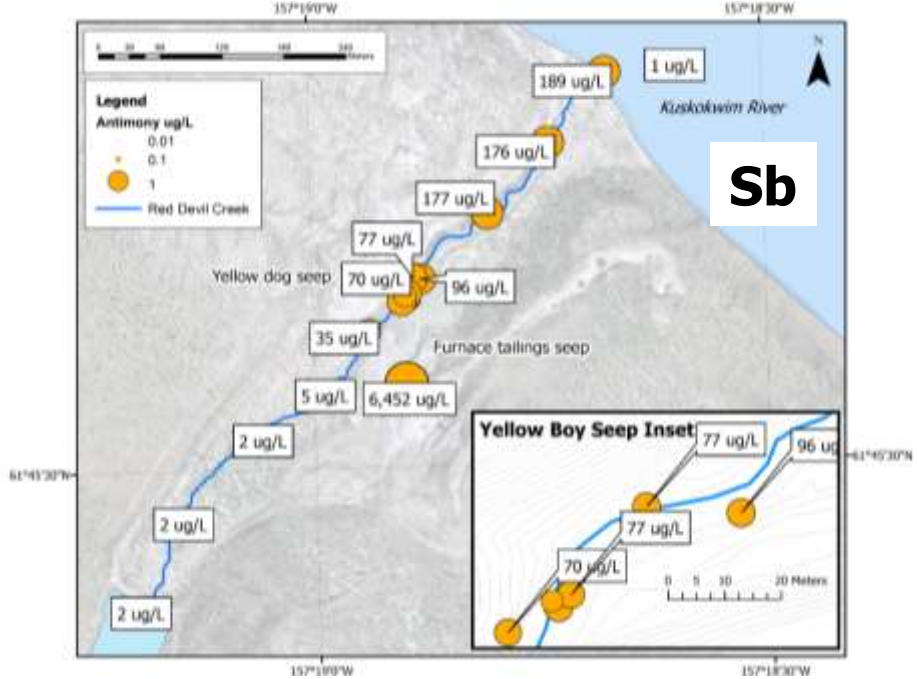
Red Devil Creek.

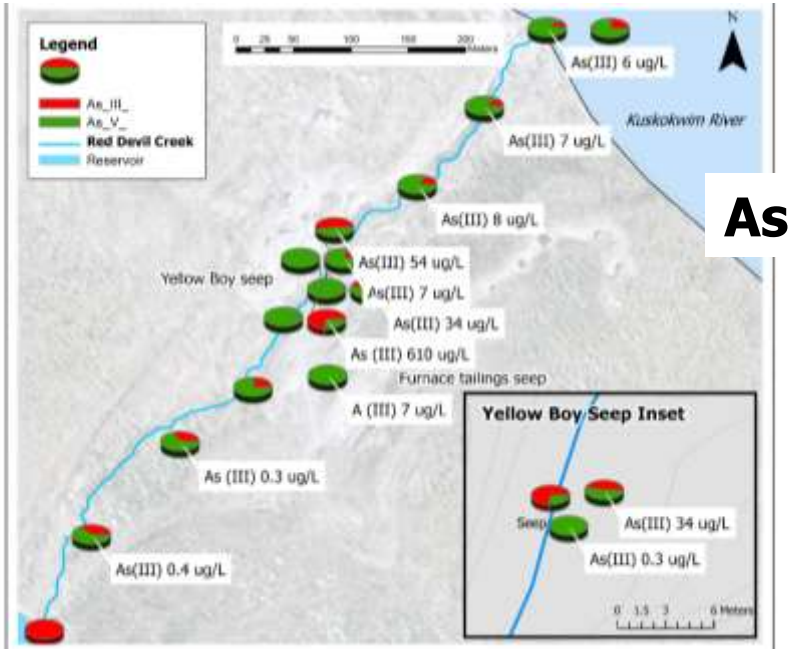



0 15 30 60 90 120
Meters
N
KT-207
KT-217
KT-212
Kuskokwim River
KT-211
Mine Buildings
Above Ground Storage Tanks
KT-209
KT-214
KT-210
KT-213
KT-206
KT-208
Yellow Boy seep
KT-204
KT-219
Furnace tailings seep
KT-205
1954 Retort and Mill
KT-203
Legend
Tailings Seep
Sample Points Red Devil
Red Devil Creek
Structures
Soil contamination









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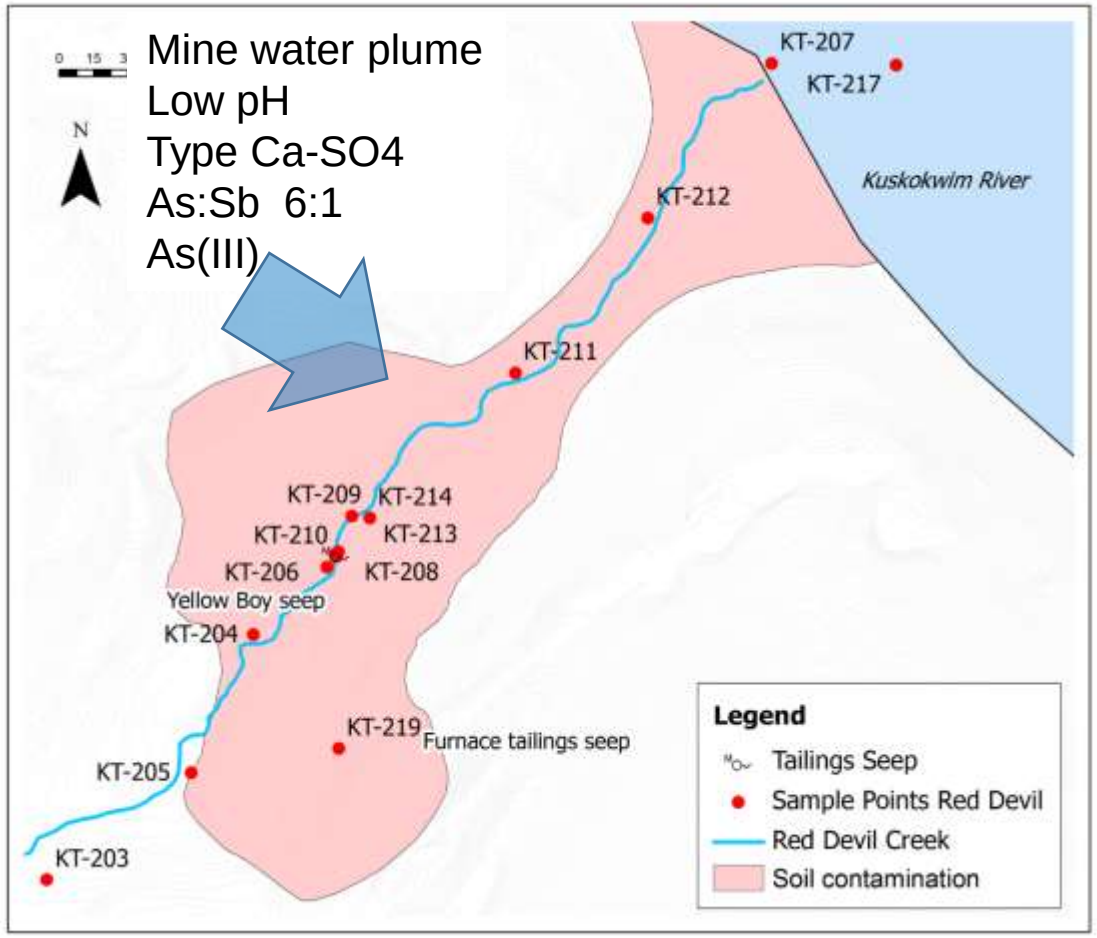
Mine water plume
Low pH
Type Ca-SO4
As:Sb 6:1
As(III)
N
KT-207
KT-217
KT-212
Kuskokwim River
KT-211
KT-209
KT-214
KT-210
KT-213
KT-206
KT-208
Yellow Boy seep
KT-204
KT-219
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KT-205
KT-203
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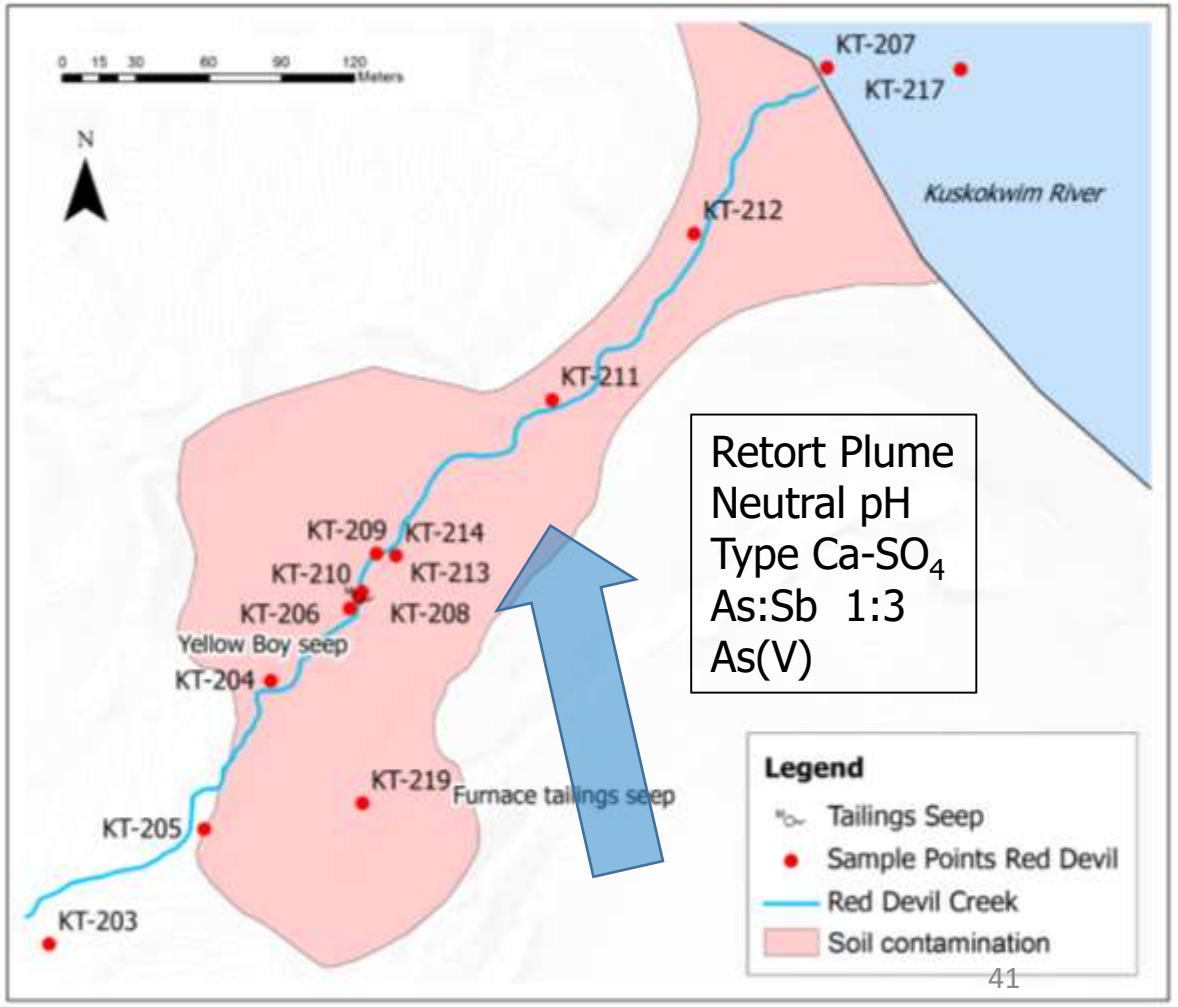
Soil contamination


N
KT-207
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KT-210
KT-213
KT-206
KT-208
Yellow Boy seep
KT-204
KT-219
Furnace tailings seep
KT-205
KT-203
Retort Plume
Neutral pH
Type Ca-SO4
As:Sb 1:3
As(V)
Legend
Tailings Seep
Sample Points Red Devil
Red Devil Creek
Soil contamination

Red Devil Mine - Remediation Challenges

- Remote location accessed only by barge or air.
- No responsible party and conflict over land ownership
- Unwillingness to consider more innovative approaches

Climate change

Photo Credit: Kenneth Dunton, Marine Science Institute, University of Texas at Austin

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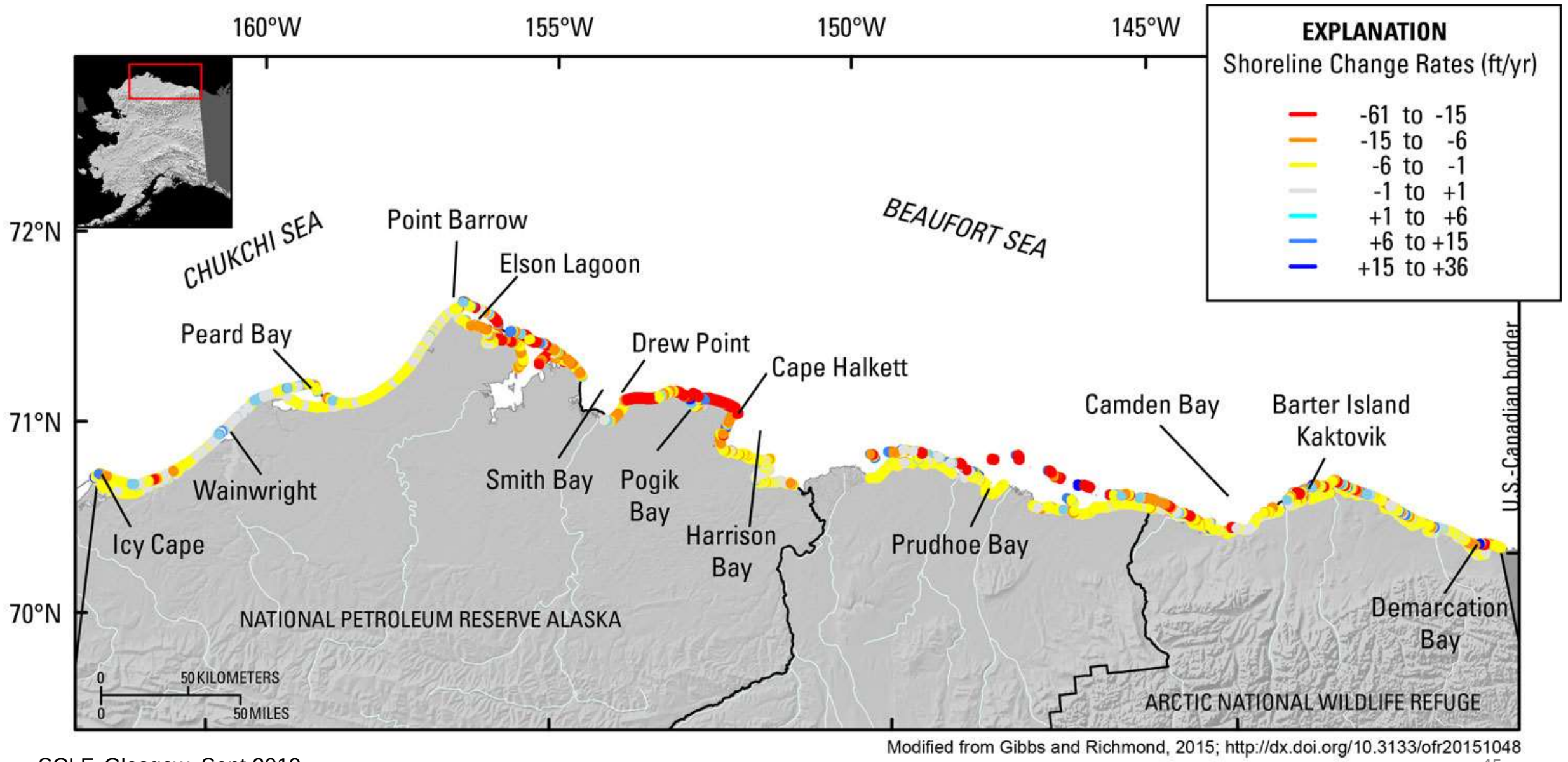

Modified from Gibbs and Richmond, 2015; http://dx.doi.org/10.3133/ofr20151048

SCLF, Glasgow, Sept 2019

Increased coastal erosion leading to exposure of landfills

Lessons from the Arctic

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Lessons from the Arctic

- Climate change is changing previous assumptions.
- Don’t discount alternative remediation strategies.
- Focus needs to switch from site characterisation of to active remediation.

Mycroremediation

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Questions?

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