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South Dakota Airport Conference

Cold Weather Airport Design and Construction

Carl Siebe, P.E.
April 7, 2016

HDR

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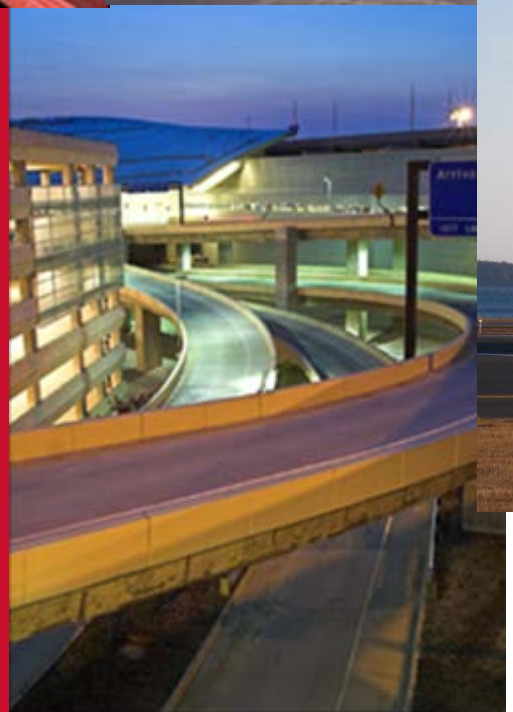

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KETCHIKAN
4K

01 Overview of the Alaska Aviation System

02 Design Issues

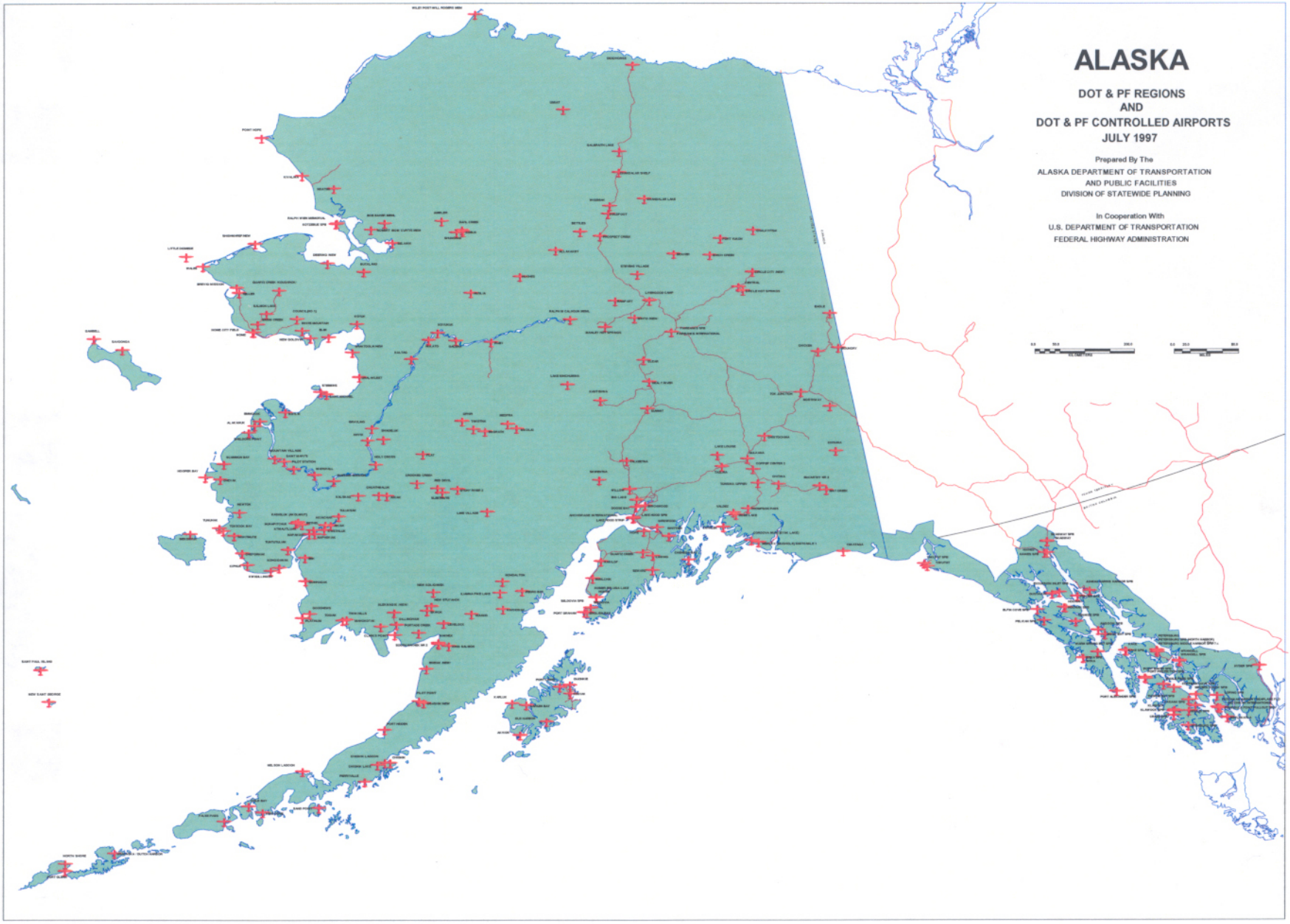
03 Construction Issues

04 Case Study

05 Closing

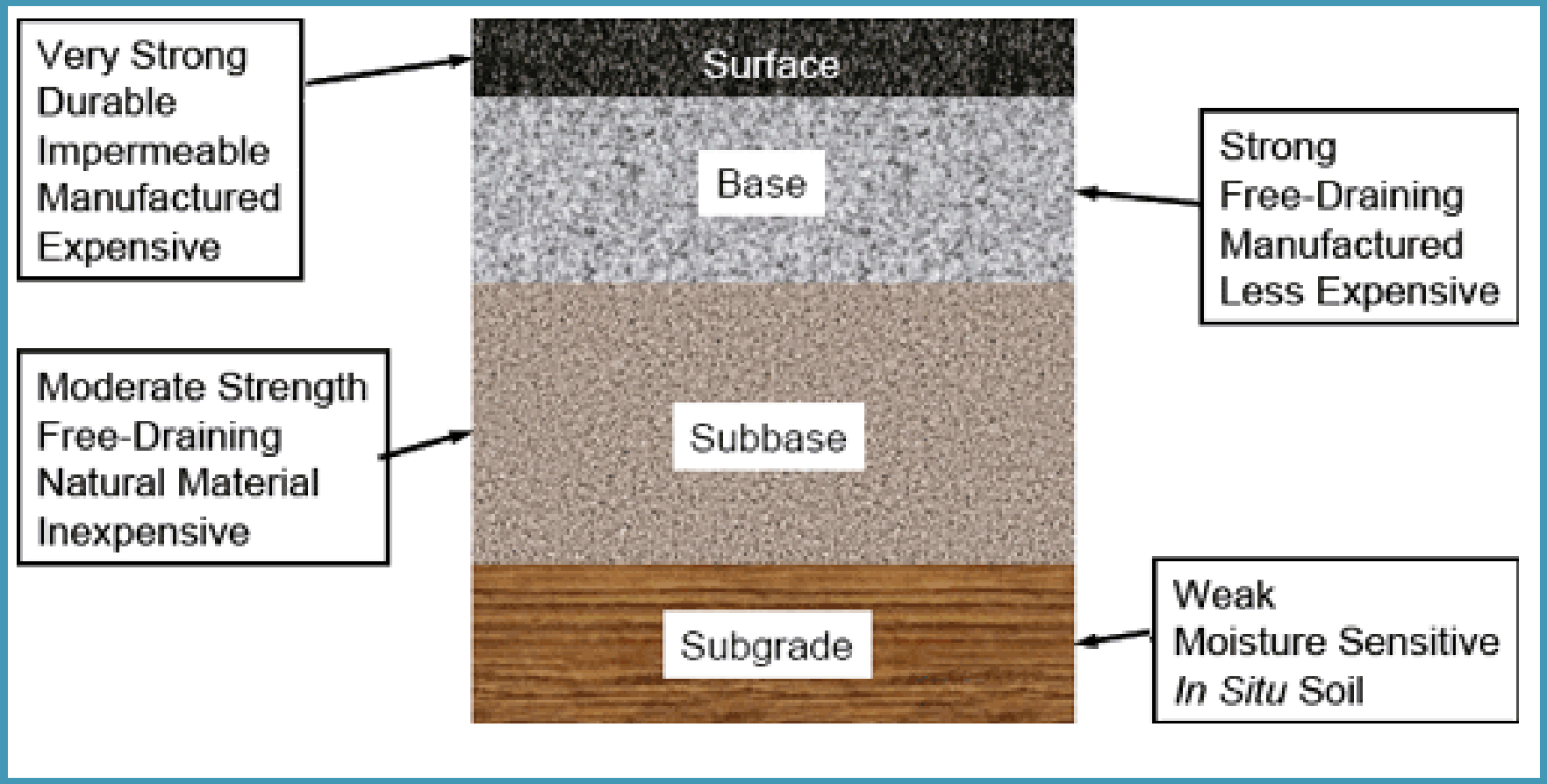
Overview of Alaska Airport System

- 300 public use airports
- Uncounted landing areas
- Uncounted lakes and saltwater bays (3,000)
- 90% of Alaska is off of the road system


ALASKA
DOT & PF REGIONS
AND
DOT & PF CONTROLLED AIRPORTS
JULY 1997
Prepared By The
ALASKA DEPARTMENT OF TRANSPORTATION
AND PUBLIC FACILITIES
DIVISION OF STATEWIDE PLANNING
In Cooperation With
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

Design Issues

- Foundation Soils
  - Permafrost
- Local Materials
- Water
- Capillary Action
- Erosion Control
- Fencing
- Snow Storage
- Pavement Design
- Climate


Very Strong
Durable
Impermeable
Manufactured
Expensive
Surface
Base
Strong
Free-Draining
Manufactured
Less Expensive
Moderate Strength
Free-Draining
Natural Material
Inexpensive
Subbase
Subgrade
Weak
Moisture Sensitive
In Situ Soil

Water

- Dry soils are stronger than wet soils
- Water will migrate to the freezing front
- Water migration most evident in fine grain soils

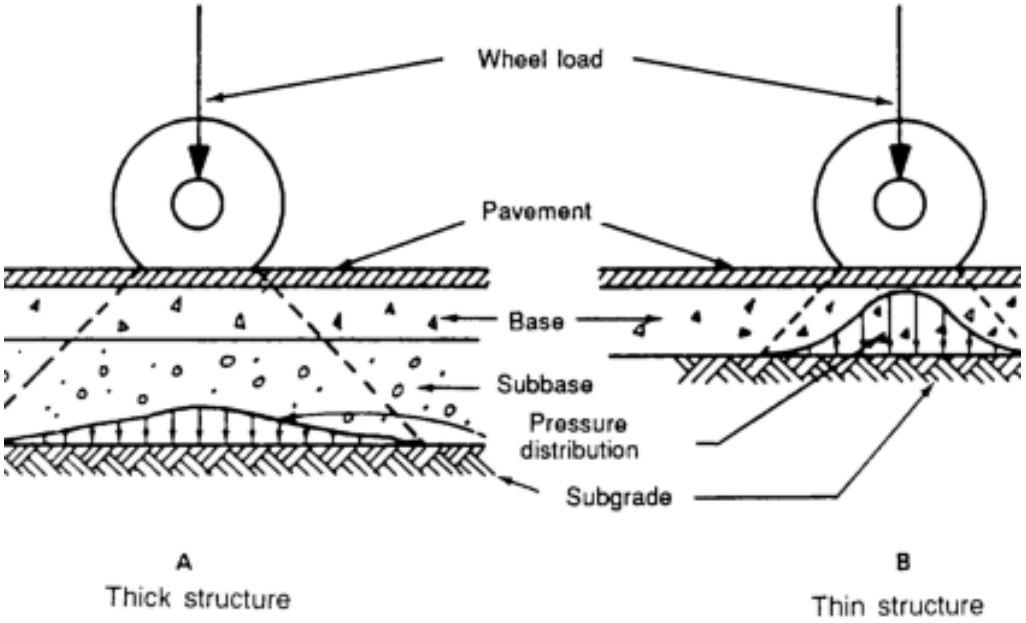
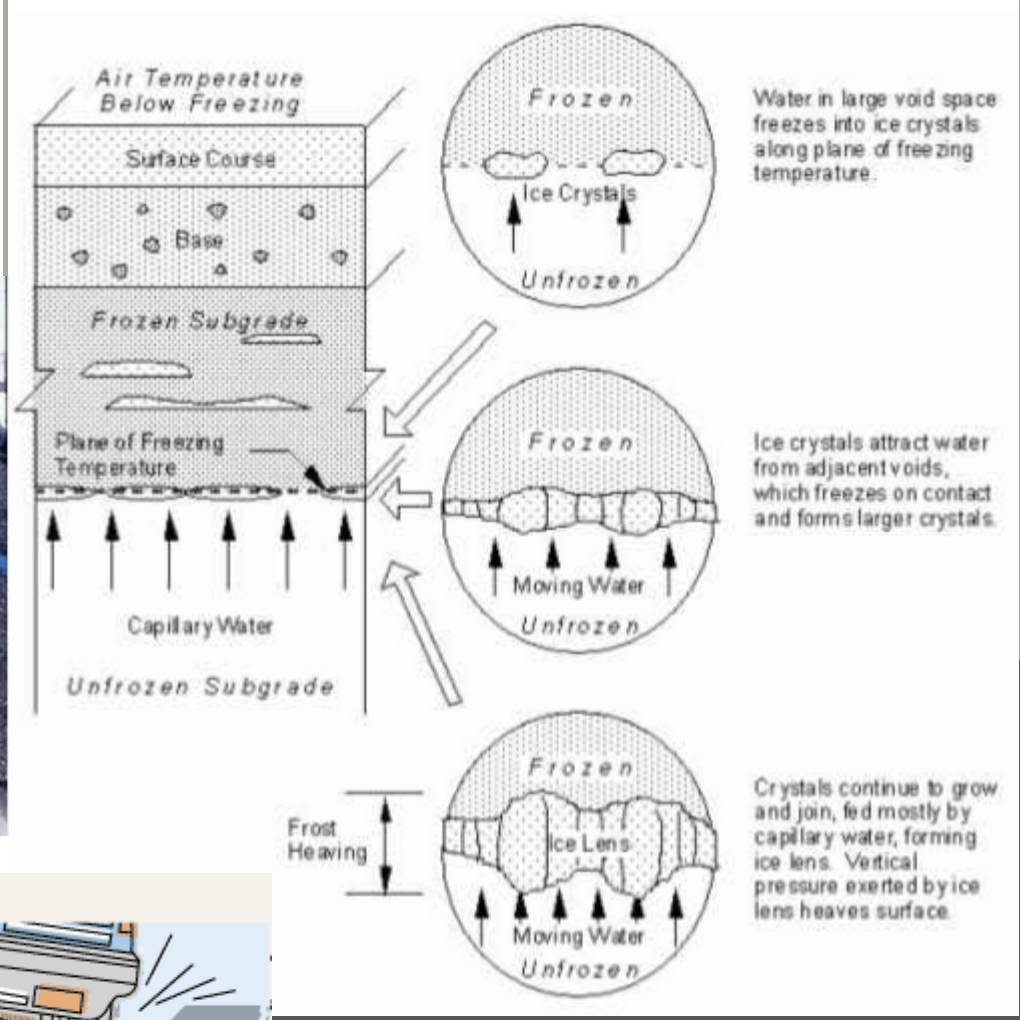
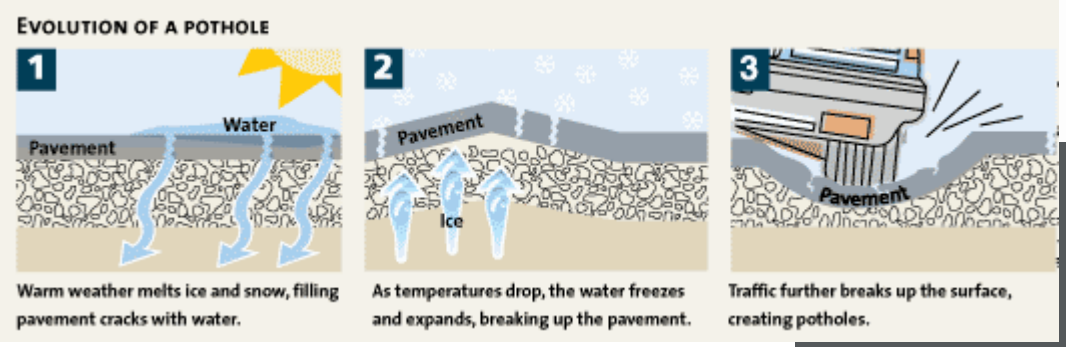


Figure 5-2. Distribution of pressures under single-wheel loads

Freeze/Thaw


Air Temperature Below Freezing
Surface Course
Base
Frozen Subgrade
Plane of Freezing Temperature
Capillary Water
Unfrozen Subgrade
Frozen
Ice Crystals
Unfrozen
Water in large void space freezes into ice crystals along plane of freezing temperature.
Frozen
Moving Water
Unfrozen
Ice crystals attract water from adjacent voids, which freezes on contact and forms larger crystals.
Frost Heaving
Frozen
Ice Lens
Moving Water
Unfrozen
Crystals continue to grow and join, fed mostly by capillary water, forming ice lens. Vertical pressure exerted by ice lens heaves surface.


EVOLUTION OF A POTHOLE
1
Water
Pavement
Warm weather melts ice and snow, filling pavement cracks with water.
2
Pavement
Ice
As temperatures drop, the water freezes and expands, breaking up the pavement.
3
Pavement
Traffic further breaks up the surface, creating potholes.

Embankment Performance Problems: *Slope Erosion*

Erosion
5/30/200

Embankment Performance Problems: *Culvert Failures*

Embankment Performance Problems:
Shoulder cracking

Thaw
5/29/200

Erosion
26 11:27AM

Embankment Performance Problems: *Wind Erosion*

Wind Erosion
SEP 11 2002

Seed
SEP 11 2002

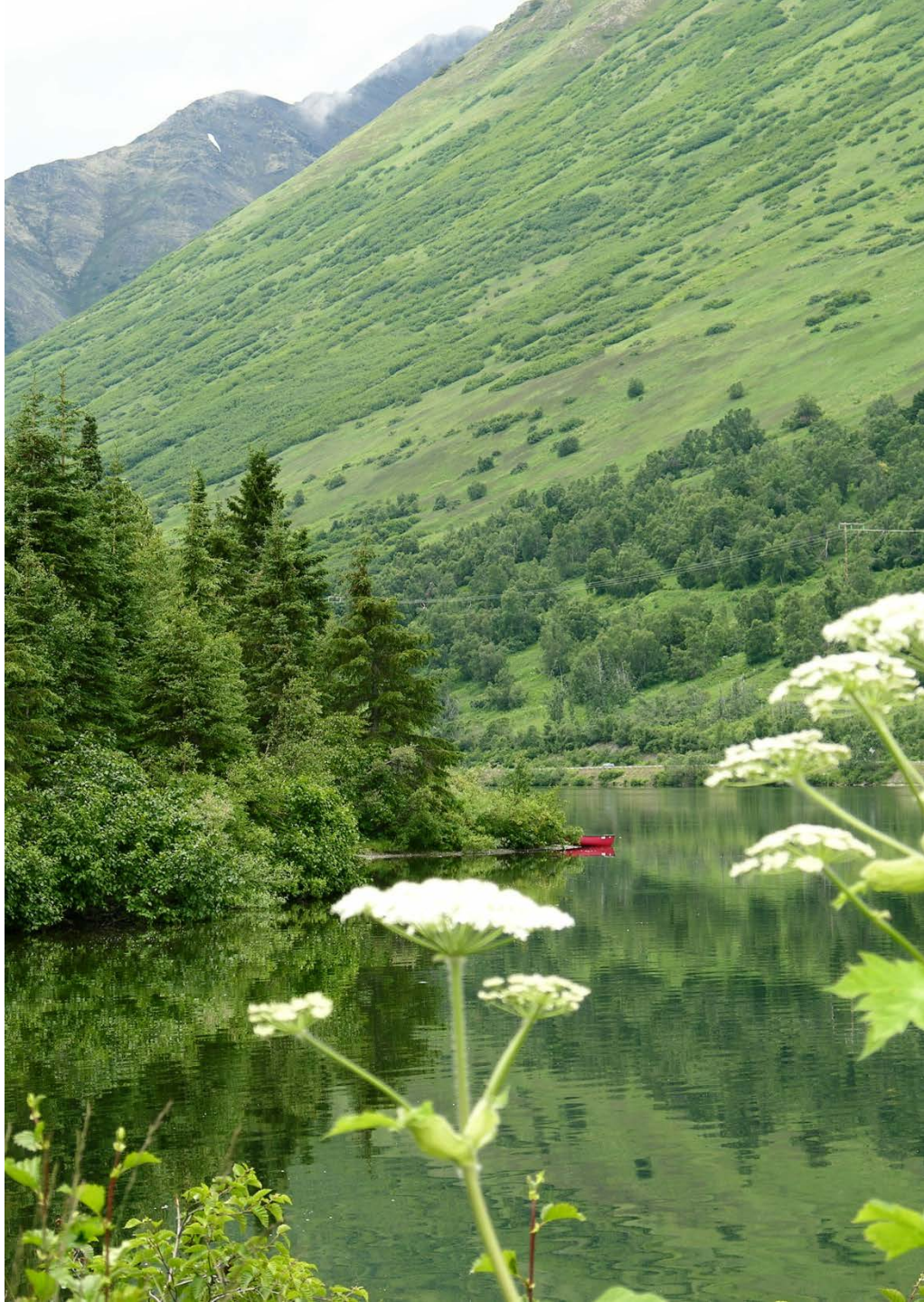
Seed
2001 9 17

FENCE
GATE LOCKED
CONTACT
AIRFIELD MGMT
552-2107

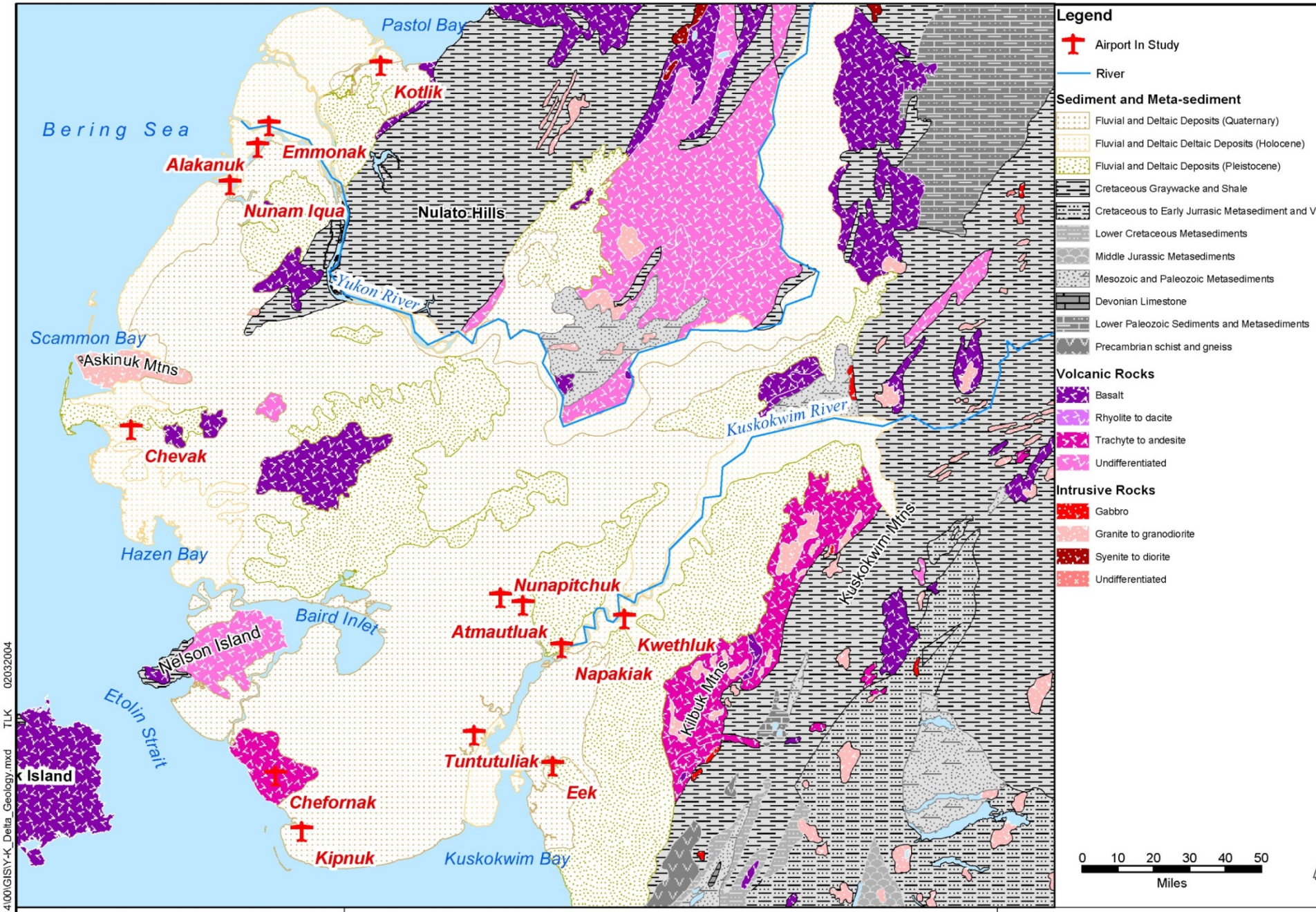
FedEx
Federal Express
The World On Time
492

Y-K Regional Setting

- 25,000 residents in 34 communities, relying on summertime barge and year-round air transport
- Remote and Roadless Region of 25,000 sq mi
- Deltas merge between the Yukon River on the north side and the Kuskokwim on the south
- Numerous lakes, ponds and sloughs cover nearly half of the land mass
- Discontinuous permafrost throughout region
- Only soil types are peats, silts and fine sands



Typical view of lakes and ponds



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4951 Eagle Street
Anchorage, AK 99503
www.geoengineers.com

State of Alaska Department of Transportation and Public Facilities

Yukon Kuskokwim (YK) Delta, Alaska

Surficial and Bedrock Geology

Figure 2

P:\0086801\014\00\GIS\Y-K_Delta_Geology.mxd TLK 02032004

Typical soil properties

- Gravels notably absent
- Fine silty sands available at Bethel, Hooper Bay and Chevak.
- Silt contents ranged from 3 - 60% in the region
- Most of Delta has only peats and organic silts
- Organic contents in silts commonly range 4-10% by weight or 10-20% by volume
- The organic components retain water, restrict drainage, and reduce the effects of stabilizers
- In-situ moisture contents in silts are commonly 30-50% when thawed and 50-100% when frozen

Permafrost Considerations

- Permafrost is warm and discontinuous
- Permafrost is present below elevated areas of dryer ground (palsas)
- Permafrost absent below lakes, ponds and swampy areas
- Historical Soil Temperature data is minimal
- The few existing records show soil temperatures almost always above 31° F
- Essentially all structures in region are supported by piling founded in permafrost
- Frozen moisture contents commonly exceed 50% while compaction optimums are 12-20%

Soil Compaction Procedures

- Moisture/Density controls can not be achieved due to high moisture contents and lack of summertime drying conditions
- Compaction effort is accepted by the Engineer based on rolling coverage
- Adopt CBR values for acceptance criteria

Materials Testing

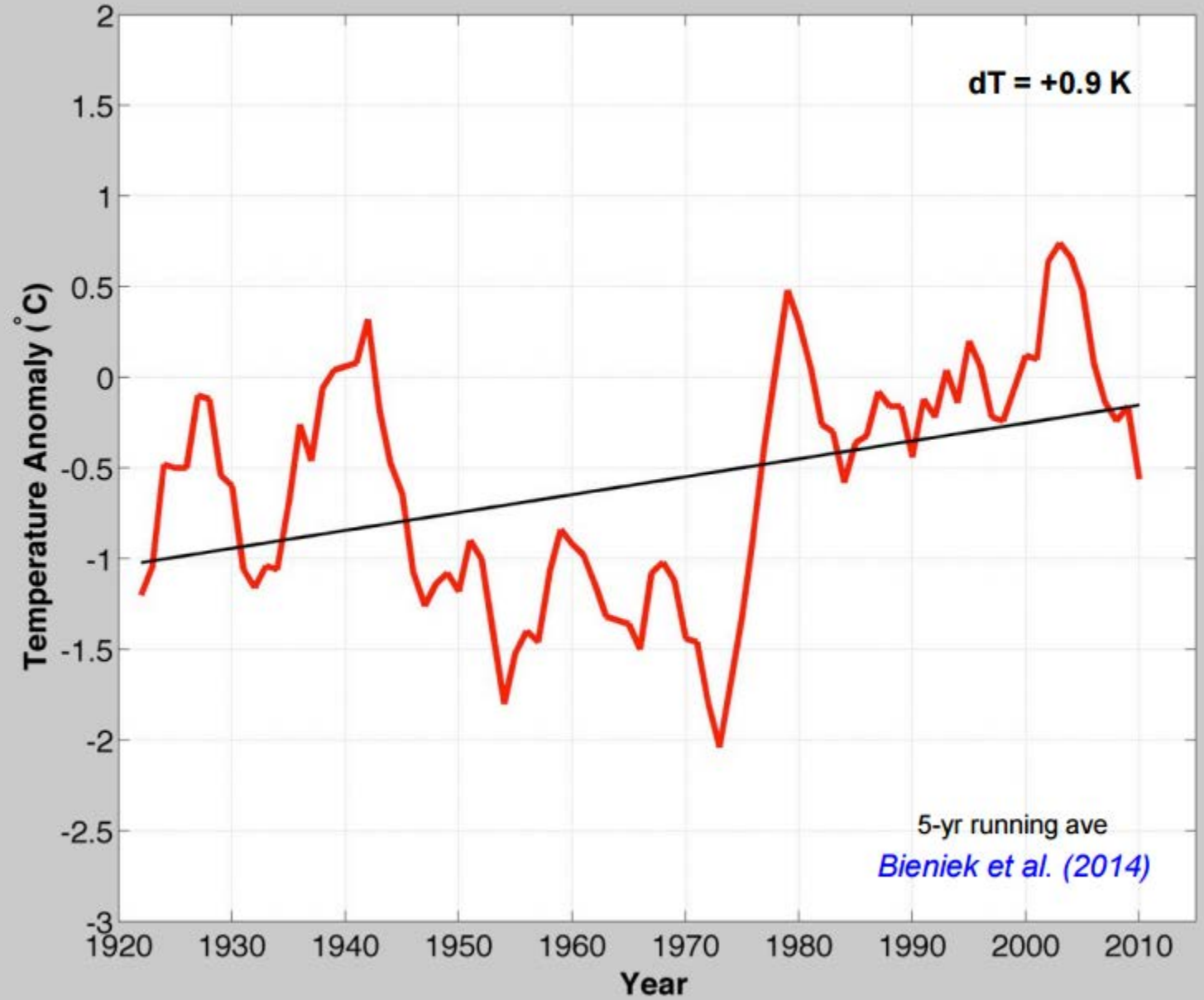
- FAA Advisory Circular 150/5370-10G
  - P152-2.6 says: “Earthwork operations shall be suspended at any time when satisfactory results cannot be obtained because of rain, freezing, or other unsatisfactory weather conditions in the field. Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material. Material shall not be placed on surfaces that are muddy, frozen, or contain frost. The Contractor shall drag, blade, or slope the embankment to provide surface drainage at all times.”

18 10:49AM

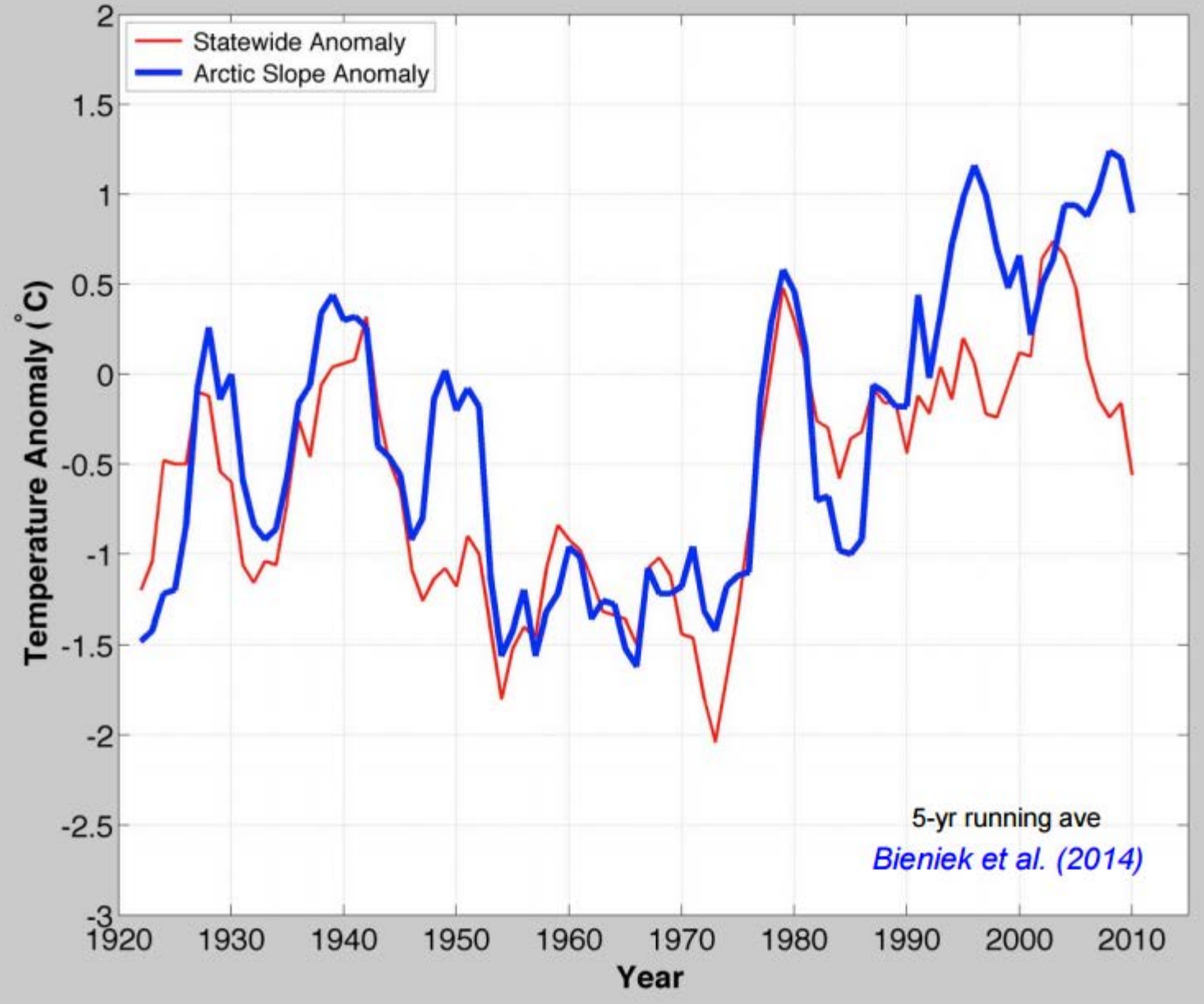
Climate

- Climatic conditions across Y-K Delta are relatively uniform in summer
- Thaw season from May 1 to October 15
- Winters are colder by 30% at upriver areas
- Summers are wet at 10-12” of rainfall
- Windy and cloudy conditions predominate

Statewide Air-Temperature Anomaly

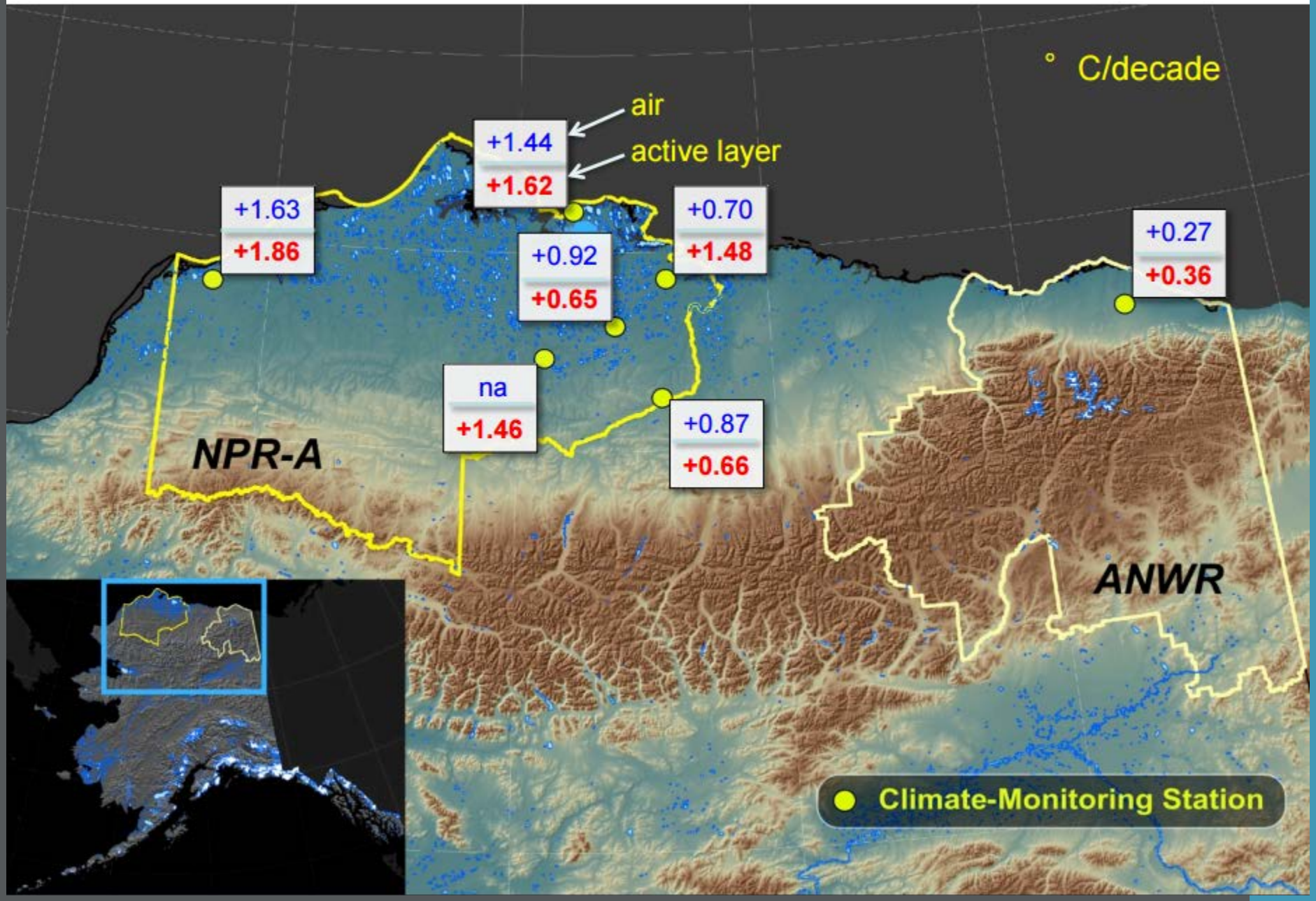


Arctic Slope Air-Temperature Anomaly



Mean-Annual Active-Layer Temperature Trends

Stations with at least 10 years of data



Climate and Trends

5 Year running averages at Bethel

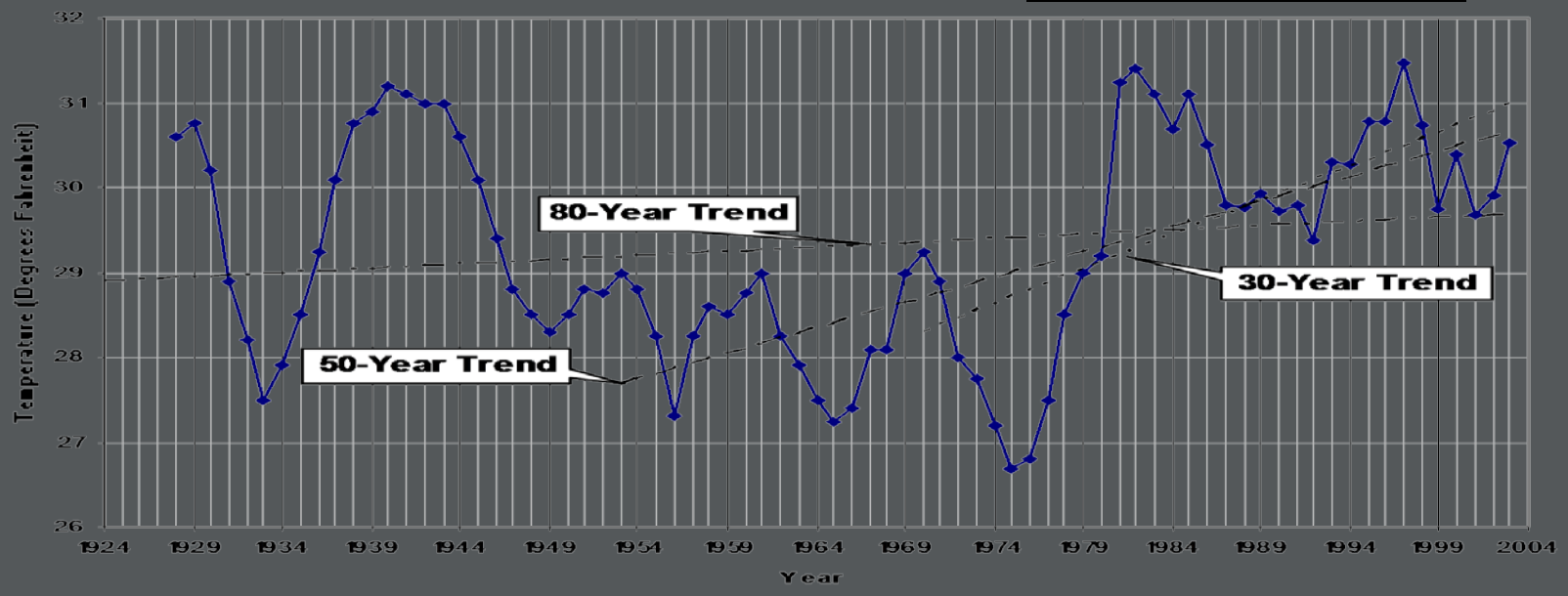


Figure 8
5-Year Running Average Temperatures and Temperature Trends - Bethel, Alaska

Fine Grain and Poor Soils

- Winter construction to build basic embankment
- Barge gravel in the summer for surfacing

Borrow

Borrow

Borrow

Moisture/Density Controls cannot be achieved due to high moisture contents

Embankment

Geo Drain Layer

Geotextile

Barge Landings

Barging Gravel

Barge Landing

Barging

Barging

Barging

Barging

Barging

Historical Construction Methods

- Local silts always used for embankments
- First 40 x 2,000 ft strips built by “side borrow” method and pushed up by bulldozers
- Current standards require lighted 60 x 3,200 ft airstrips
- Remote silt borrow pits and early winter hauls used
- Several years allowed for drying out of wet silts
- Second project places gravel surface from barge haul

Cold Weather Equipment Issues

3 30'99

D300E

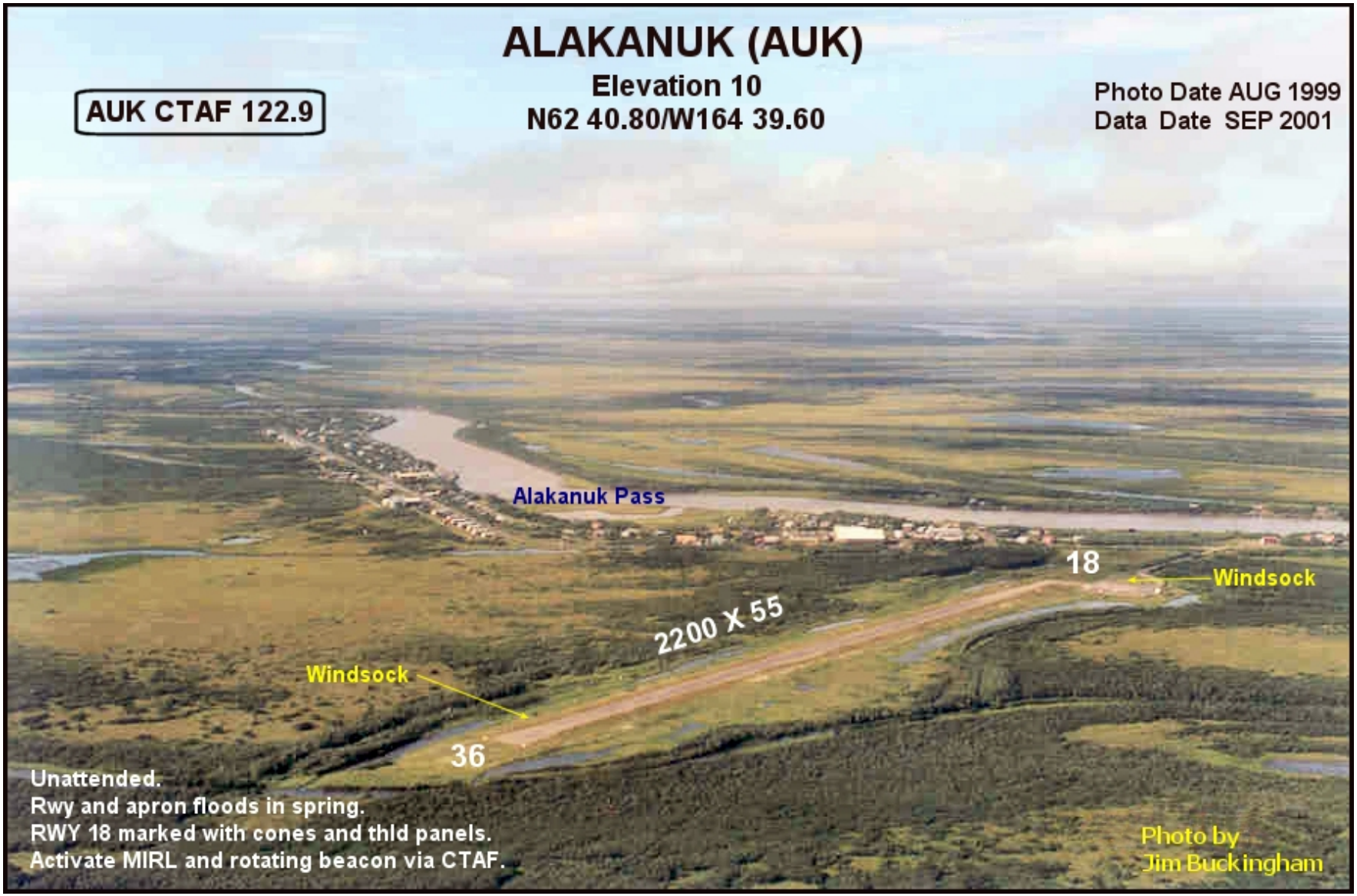
Equipment Wear Issues

3 30 '9

Equipment

3 16 '9

3 16 '9


ALAKANUK (AUK)
Elevation 10
N62 40.80/W164 39.60
AUK CTAF 122.9
Photo Date AUG 1999
Data Date SEP 2001
Alakanuk Pass
18
Windsock
2200 X 55
Windsock
36
Unattended.
Rwy and apron floods in spring.
RWY 18 marked with cones and thld panels.
Activate MIRL and rotating beacon via CTAF.
Photo by
Jim Buckingham

AKAKANUK (AUK)
Photo Date May 1995
Flood Stage
ALAKANUK
PASS
36
18

Staging at the Pit for Winter

Breakup

Test Hole at the Apron

Opening the Pit

Pit

Alakanuk

windsock
15
KIPNUK (IIK)
ELEVATION 20
N59 55.99/W164 01.85
IIK CTAF 122.7
IIK RCO 122.6
Photo Date July 1996
Data Date August 1998
2120 X 35
Frequent crosswinds
Heavy bird activity near rwy
Rwy slopes off to tundra sharply
Erosion in safety area
33
Tower 30 ft AGL unlighted 300 ft NE
Windsock RWY 33 damaged not reliable
RWY 33 right traffic pattern
Acitvate MIRL via CTAF

Kipnuk Airport study site

Test Data & Conclusions

- Kipnuk Site after 2 years; depths 0-4 ft
- Moisture Contents still 33 to 51% in Organic silts
- CBR values 1.4 to 3.6 after 2 years stabilization
- Moisture and CBR values show little surface drying
- Samples below old active runway still show 32 to 34% water contents and CBR values from 3 to 5 after 17 years service
- Concluded that silts remain above optimum moistures for compaction (12-18%) for many years
- Seasonal thaw depths from 5 to 7 ft in September

EEK (EEK)
ELEVATION 40
N60 12.95/W162 00.34
EEK CTAF 122.8
Photo Date July 1996
Data Date August 1998
35
1400 X 35
17
Thresholds RWY17 and RWY 35 located
at rivers edge and lake edge
RWY 35 first 100 ft very soft gravel
Runway slopes uphill to the north
Runway has shallow ruts and dips
Runway has ponding and soft surface
after rain
EEK RIVER

Eek Airport Study site

Embankment drainage and strength gains over time at Eek Airport Site after 4 years

- Moisture Contents at 33 to 38% from 0 – 3 ft
- CBR values at 2.8 to 6.3
- Strengths do not vary significantly with depth
- Seasonal thaw depths from 7 to 8 ft on September 19th
- Embankment still too soft for placement of granular surfacing for project completion
- Use of Enkagrid (geogrid) and geotextile below granular layer still results in excess deformation

Construction Cost Considerations

- Local silt borrow Placed in embankment costs = $15 /CY
- Costs of Imported crushed gravel for surfacing average $120 CY
- Costs of Mobilizing equipment, supplies and offices to site: $500,000 to $1,000,000 US
- Equipment dedicated to site for project duration
- Low water levels restrict barge access
- Lack of local roads require road construction
- Wet summer conditions prevent equipment movement and compaction work

NUIQSUT (AQT)
Elevation 38
N70 12.60/W151 00.33
AQT CTAF 122.8
AQT RCO 122.5
AQT ASOS 135.35
ANC CENTER 134.4
Photo Date Aug 1998
Data Date Mar 2001
Nechelik Channel
Unattended.
Rwy may be soft during break up or heavy rains.
Contact 480-6223 for current rwy conditions.
Birds and caribou on and vicinity of airport.
Lighted tower 1/2 mi east of airport.
Some rwy edge lights may be out of service.
RWY 22 REIL out of service indefinitely.
Activate HIRL, MALSF, REIL andVASI via CTAF.
Windsock
UQS
NDB
4
22
4343 X 90
Photo courtesy
Alaska DOT, Fairbanks

NIVAKT

Conclusion

- Arctic airport construction is expensive
- Arctic airport construction takes a good contractor
- When soils are good, normal construction techniques work.