Construction of the Alcan Highway in 1942

"One of the Top 10 Construction Achievements of the 20th Century"

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Outline

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  - Specifications
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- Surveying the land
- Construction of the pioneer road
  - Plan of Attack
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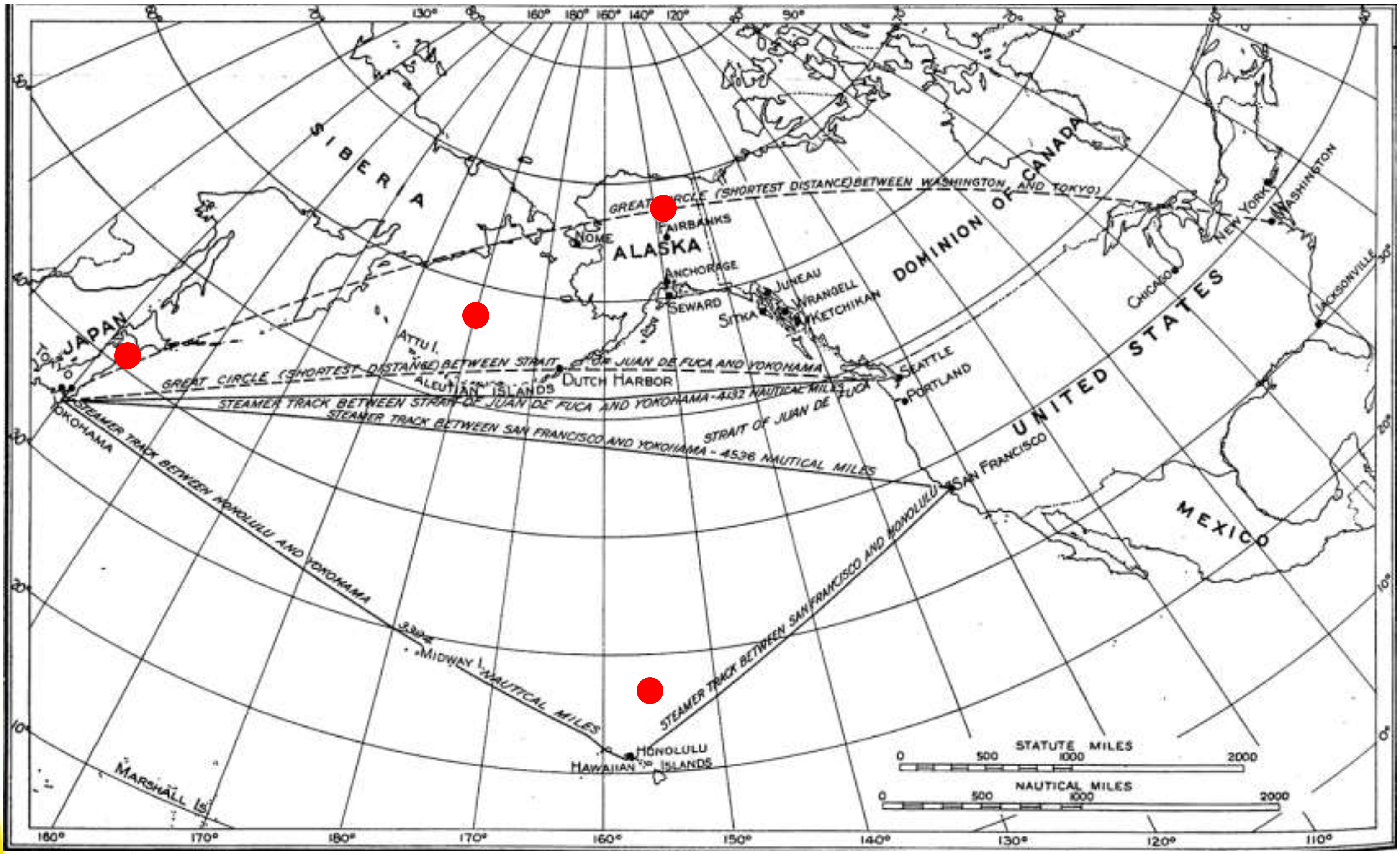
- Final Details of the Alcan Highway

Purpose of the Alcan Highway

- Since the 1930’s there had been discussions about developing a road that would link the western United States to Alaska.
- There was not a strong push for the development of the highway until the Japanese defeat of the American Pacific Fleet at Pearl Harbor on December 7, 1941.
- Military planners realized how vulnerable Alaska was to seaborne attack and invasion. It was decided to develop a land link to our small forces in Alaska and for the airfields currently located and planned between Seattle, Washington and Fairbanks, Alaska.
- This dream became the Alaska-Canadian, or Alcan Highway

- **On June 4, 1942 Japanese carrier-based aircraft attacked Dutch Harbor on the Alaskan Coast and occupied Attu and Kiska, in the western Aleutian Islands.**

Strategic Position of Alaska



Traverse Polyconic Projection Showing Strategic Location of Alaska

Army Corps of Engineer's Mission

- The Corps' mission, under the guidance of BGEN Clarence L. Studevant, was to build a pioneer road suitable for supply trucks as fast as humanly possible. Civilian contractors working for the U.S. Public Roads Administration (PRA) will then upgrade the road to status of a permanent highway.
- SPECIFICATIONS

  Clearing: 32 feet wide minimum

  Grade: 10% maximum

  Curves: 50 foot radium minimum

  Surfacing: 12 feet minimum

  Shoulders: 3 feet minimum

  Ditch depth: 2 feet

  Crown: 1 inch per foot maximum

  Bridges: Single lane with H15 minimum loading

Plan of Action

- Provide aerial photos to route survey parties to provide general location and bearing.
- Using bearing, surveyors blaze trail and mark center line by tying red cloths to bushes and trees.
- A plane table party would then traverse the alignment and record relative elevations.
- If this preliminary pass along the proposed alignment proved satisfactory, construction units would begin dozing.
- Civilian contractors followed to improve the pioneer road cut by the Army Engineers.

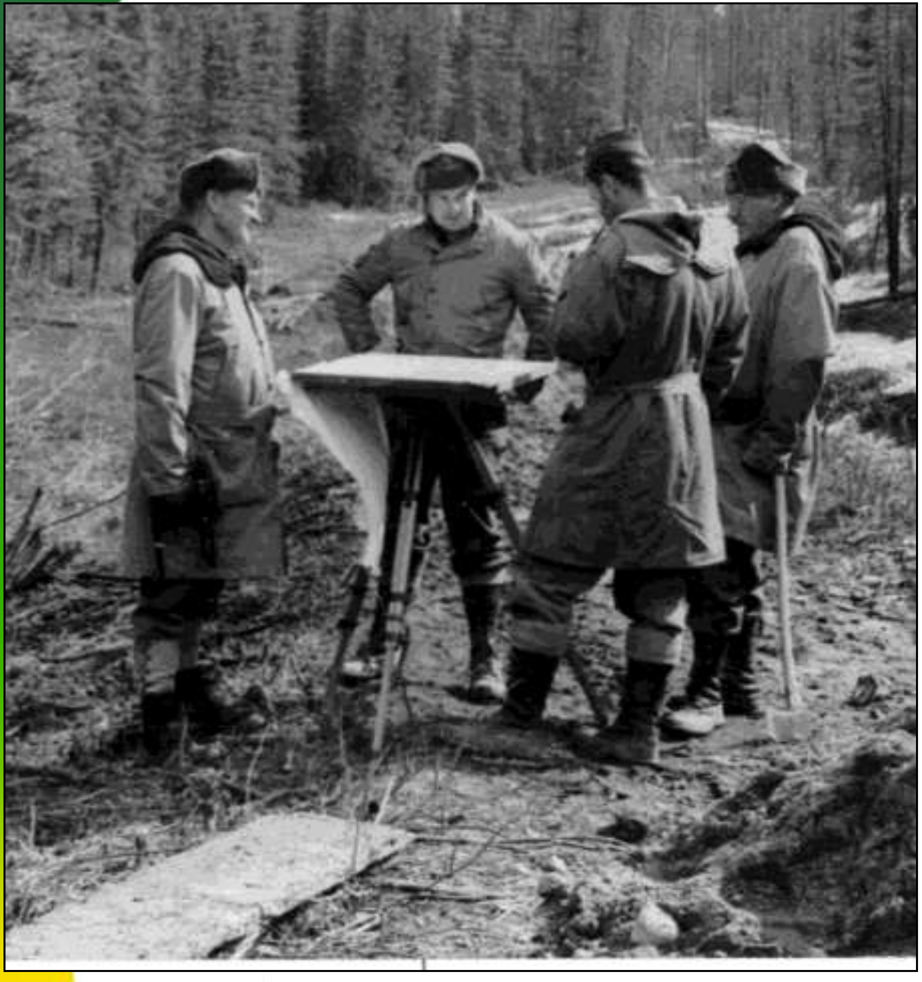
Survey Party recording and marking center line

Pathfinding Methodology

- When the first surveyors of Company D, 29th Engineer Topographic Battalion and Company A of the 648th Engineer Topographic Battalion hit the ground in February of 1942, the base maps were simply aerial photographs.
- Only one map was provided of the area from Dawson Creek to Fort Nelson.
- Paucity of maps and snow up to 18 inches deep posed the biggest problems for the route surveyors. Other problems were the mosquitoes, gnats, and yellow jaundice.
- The surveyors also had to comply with orders to have the pioneer road service the airfields in the Yukon Territory and Alaska, as well as avoiding steep terrain and muskegs, as much as possible.
- A survey party would normally consist of 1 Officer and 9 Surveyors. The first group to enter the forest would split up into teams and venture out for a mile or two to see which alignments held the greatest potential. The teams would then back track and reunite. This separating and coming back together, along with updated aerial photos, was the only way for the surveyors to blaze the best path.
- Another survey team would follow behind, running a level survey and tape the centerline. Shortly behind them came the transit team that would record the centerline and elevations of the proposed road.
- The teams would average about 2 to 4 miles per day. They used local Indians as guides.

Route surveying was made difficult by the adverse weather and heavy vegetation, which limited sighting distance

A traverse team and recorders do final calculations to verify that the intended road meets specifications.



These shots show two of the plane table survey teams, who fixed vertical elevations along the path

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LOGISTICS NIGHTMARE

Getting the necessary supplies to the engineer troops was the greatest obstacle during the project, especially fuel and oil for the trucks, machinery, and stoves

DOG SLEDS

- **With no defined road established during surveying, supplies were brought to the parties either by dog sled teams or horses. From the start, the supply team would leave with a month's supply carried by dog sleds.**

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Construction of Pioneer Road

- The first Engineer Construction regiment (341st) arrived on March 10, 1942 at Dawson Creek. They started north to St. John. Their initial goal was to get past Peace River just north of St. John before the spring thaw. Otherwise, they had no means of transporting their equipment any farther.
- By June of 1942, seven engineer regiments were on the ground and constructing the pioneer road. Each regiment was assigned a strip of land approximately 350 miles long. Their goal was to reach the next regiment's pioneer road before winter set in.

  18th Engineer Combat Regiment

  35th Engineer Combat Regiment

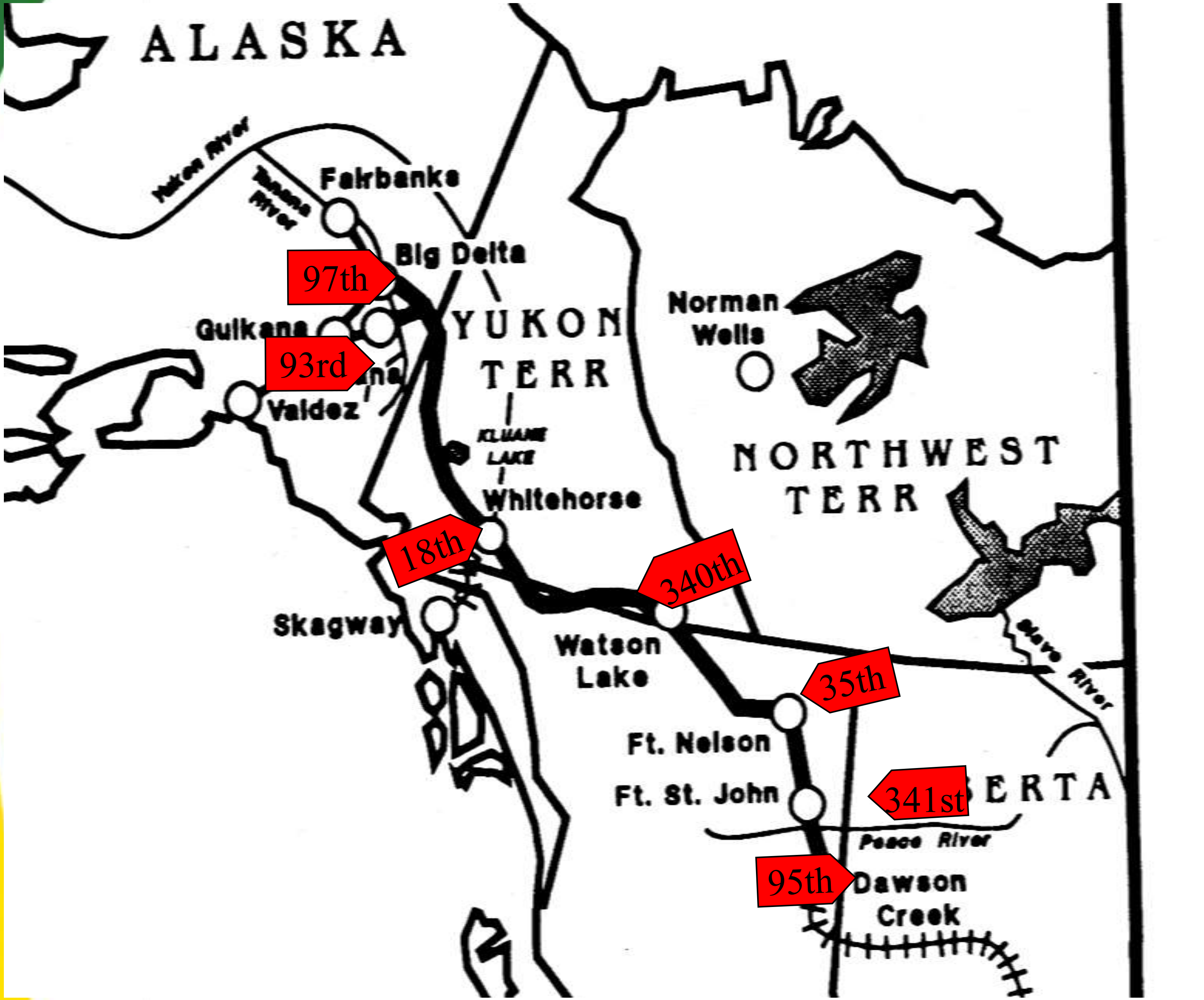
  93rd Engineer General Service Regiment (colored)

  95th Engineer General Service Regiment (colored)

  97th Engineer General Service Regiment (colored)

  340th Engineer General Service Regiment

  341st Engineer General Service Regiment



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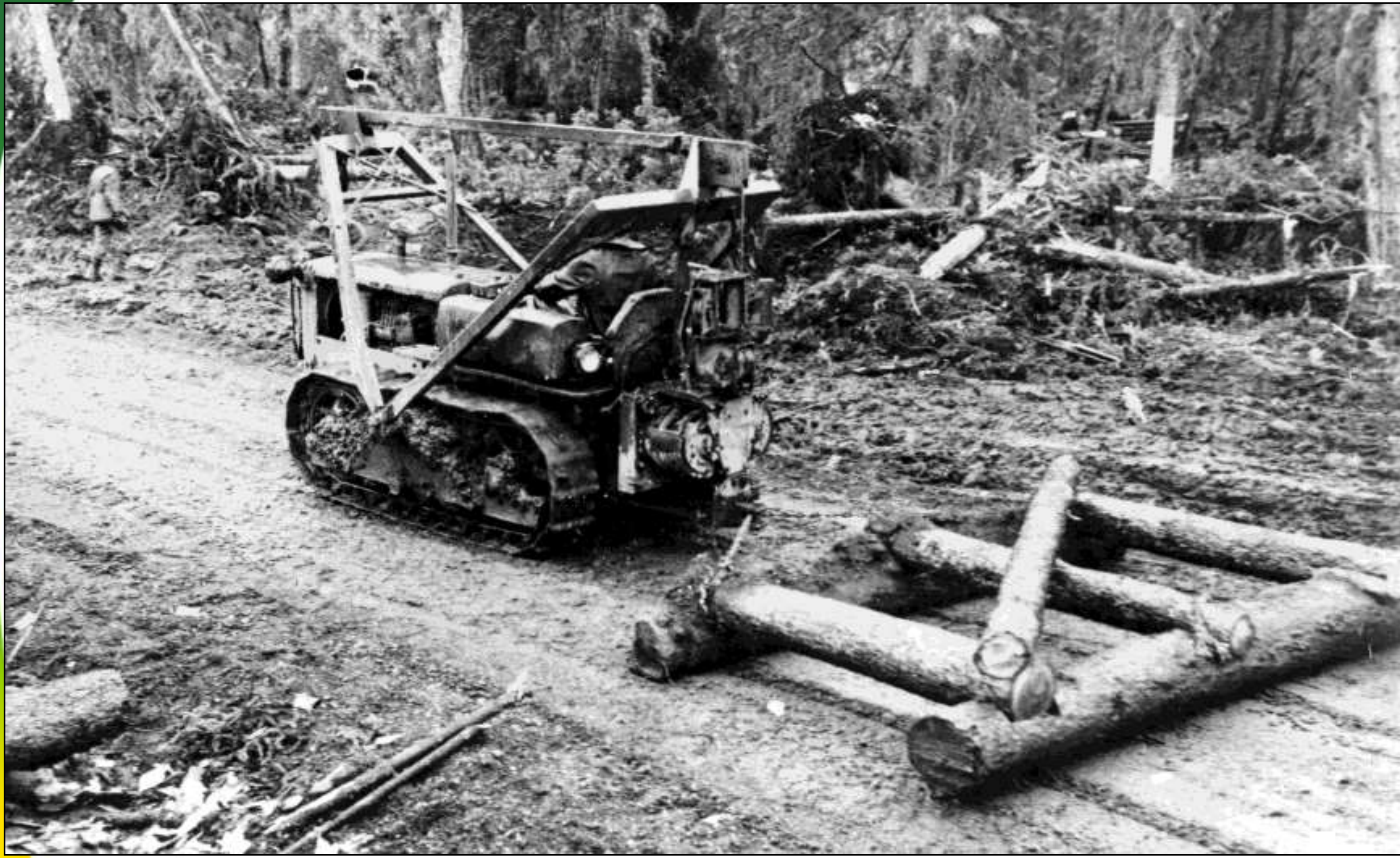
Leap Frog Grading

- Within each Regiment, the companies constructed a portion of the road using a leap-frog method. One company would grade their assigned section, another just ahead of them (about 30 miles). When a company worked up to the next company's road, then they would "leap ahead" and start again.
- During the spring and summer months, daylight could last up to 20 hours with twilight for the remaining 4 hours. This allowed the construction crews to work 3 shifts of 8 hours each, round the clock.
- The units only had a short supply of equipment until the arrival of heavier equipment (CAT D-7's and D-8's). For the most part, they were using hand saws, hand axes, and small D-4 bulldozers. Building the road took a lot of brute force and creativity.

For the first few months of construction, the Engineers had to use muscle and determination to blaze a road.

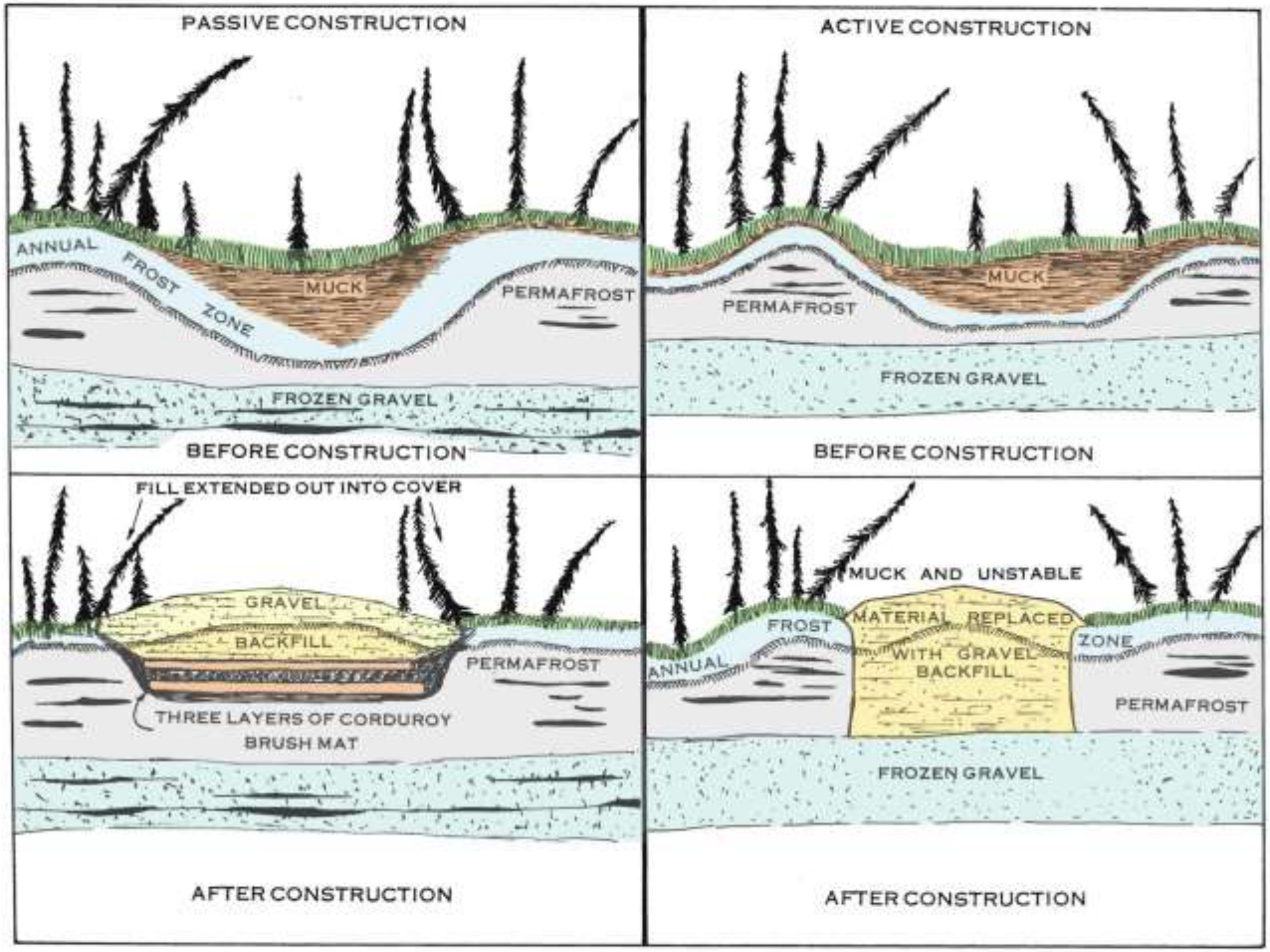


Until heavier equipment arrived, the Engineers had to be creative, using local supplies to continue construction. Here, a D-4 dozer pulls a makeshift grader crafted from local timber.

Once the heavier equipment arrived, clearing a path became easy. Here a D-8 bulldozer clears a path.

Excavation & Grading

Army Engineers used the best equipment available at the time, including Dodge and GMC dump trucks, various crawler tractors, like the D-4 shown here, and Letourneau Carryall scrappers. A decade earlier very little of this earthmoving equipment existed.



- **The treatment of areas other than drainage zones were best addressed using gravel fills, as shown here. Once frozen, the gravel reacts more favorably than other fill materials, and serves to broaden the base of the highway. Care was taken to remove excess quantities of fine sand and silt which tended to heave when the fill froze.**

Improvising was obligatory

Left – Soldiers using an Ingersoll-Rand pneumatic drilling rig to excavate blast holes for a rock cut

Right – Small dozer pulling a log dump sled, which were fashioned by the men on site to better spread loads on the mushy, muddy ground

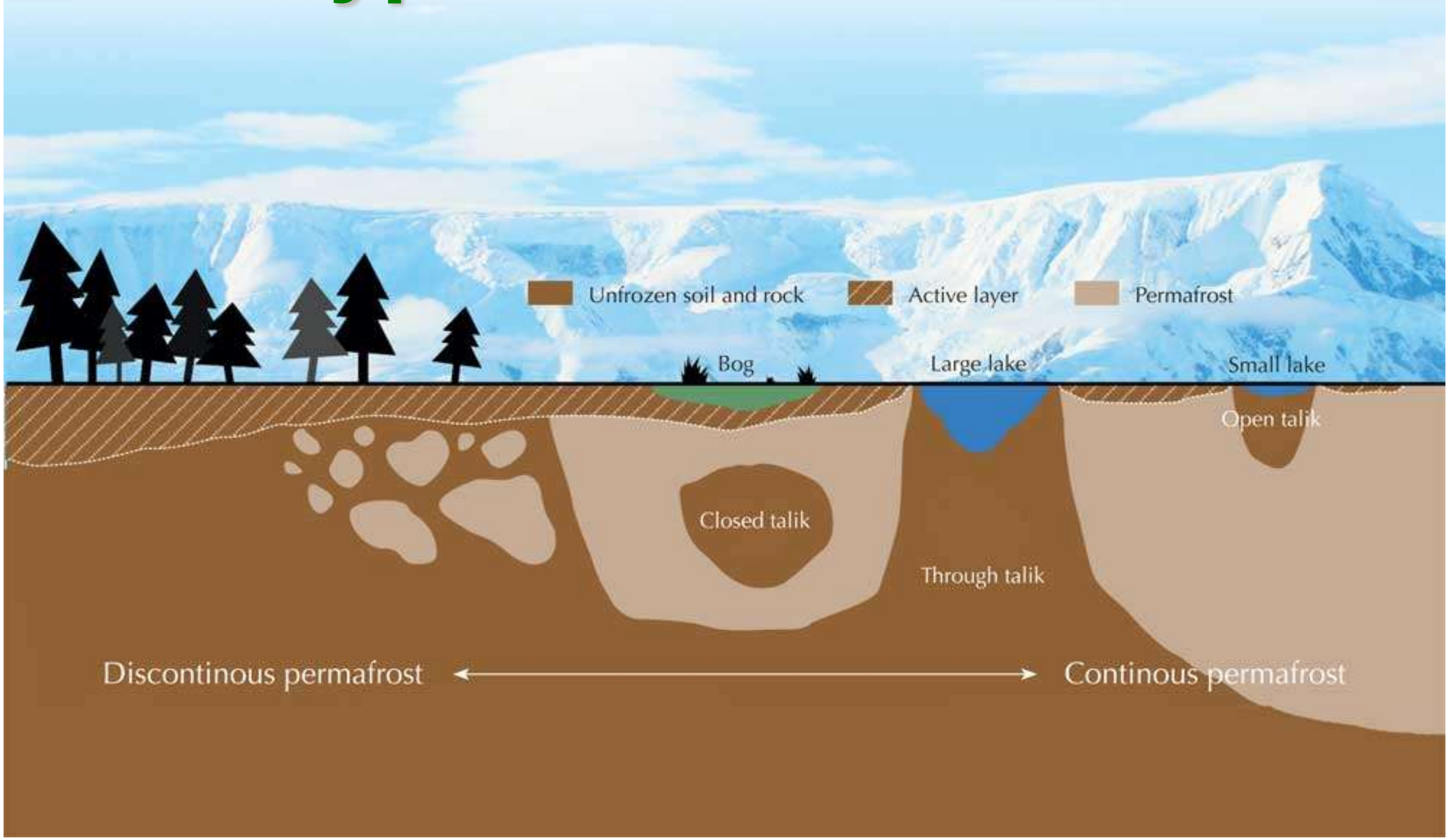
- **The biggest surprise on the project was the ability of modern American equipment to make short work of excavating the highway across mountains, which a few years previous, would have required expensive and time-consuming tunneling. This shows the pioneer road, before the grade was dropped another 22 feet.**

Father of "Permafrost"

- In 1943 Stanford University Geology Professor Si Muller was loaned to the Army by the USGS to provide insights on the frozen ground conditions in Alaska because he wrote and spoke fluent Russian, and all of the published literature on this subject was then in Russian
- It was Muller who originally coined the term ***"permafrost"*** to describe permanently frozen ground
- He remained in Alaska until 1945, and published the first book on engineering problems with permafrost in 1947.

Professor Miller wearing the uniform of a US Army officer in Alaska in 1944, but without any rank. His second book was published posthumously by ASCE in 2007.

Types of Permafrost



Permafrost is the ***permanently frozen subsoil*** beneath cover of vegetation and top soil (the active layer). The active layer topsoil insulates the frozen subsoil.

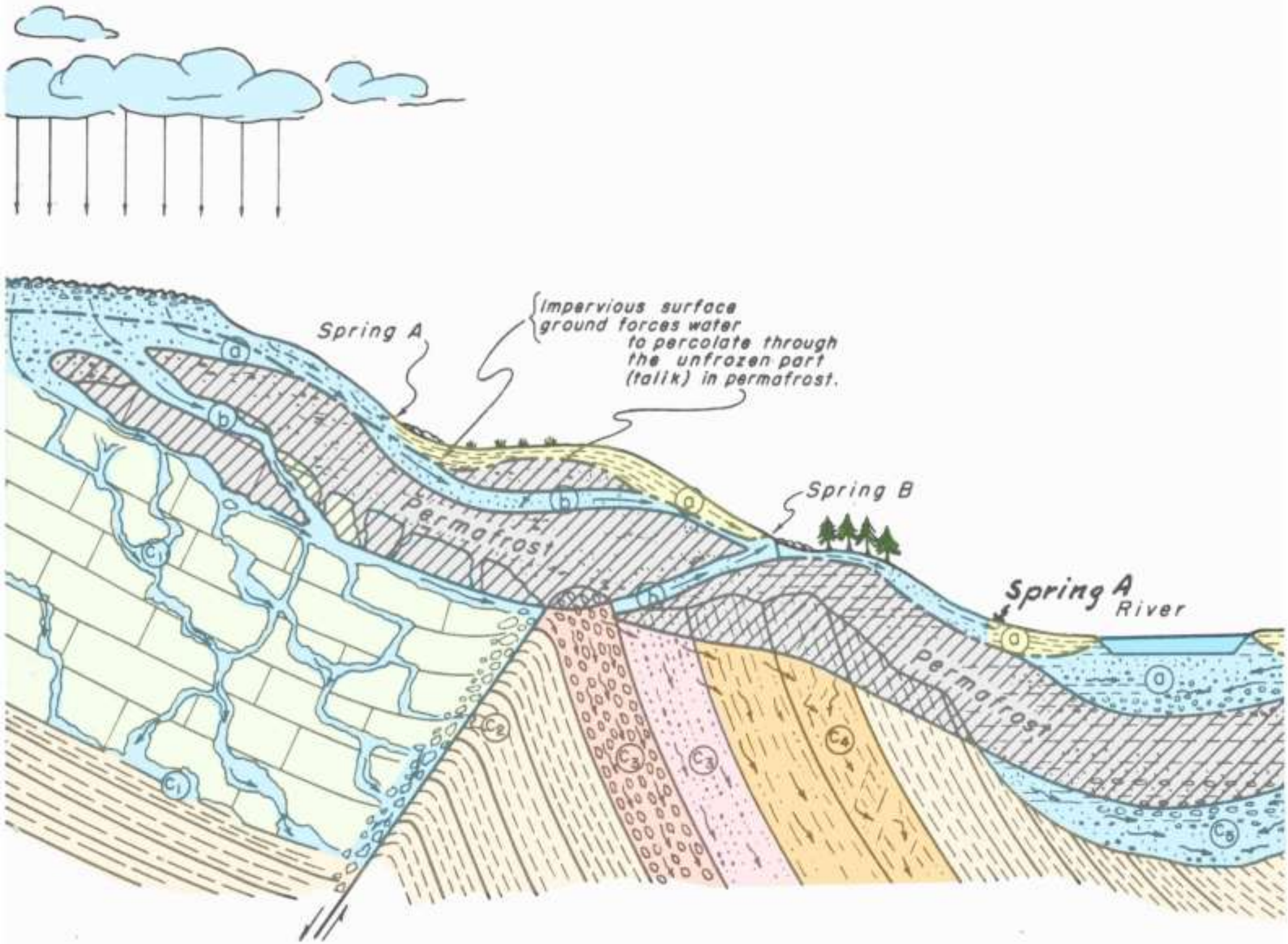
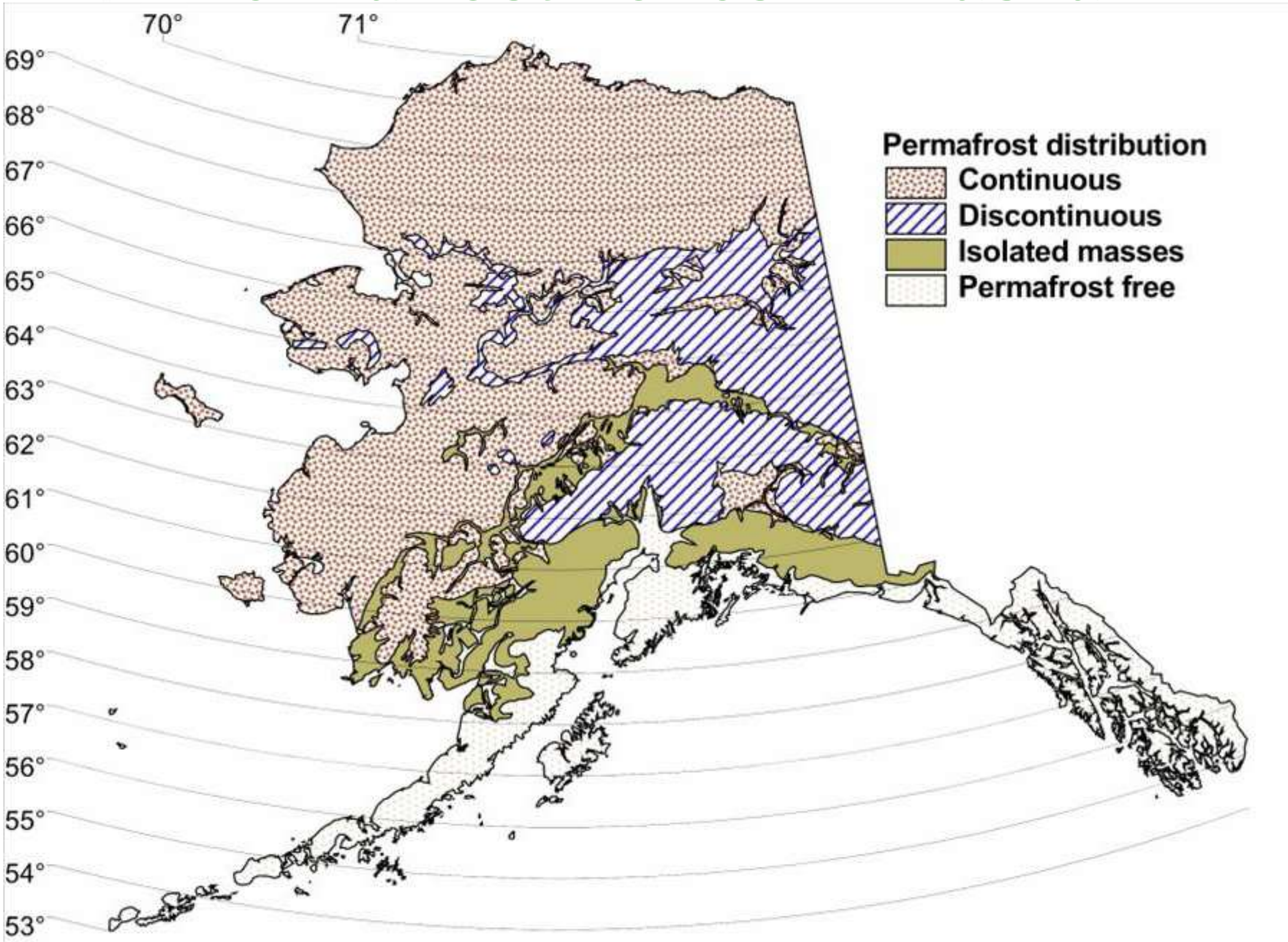
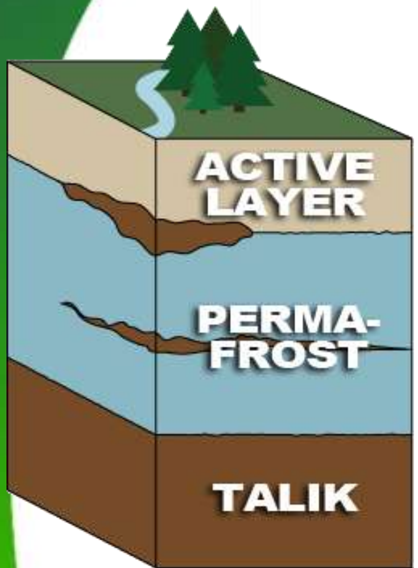


DIAGRAM SHOWING DIFFERENT OCCURRENCES OF GROUND-WATER IN THE PERMAFROST REGION

Taken from Muller (1947)

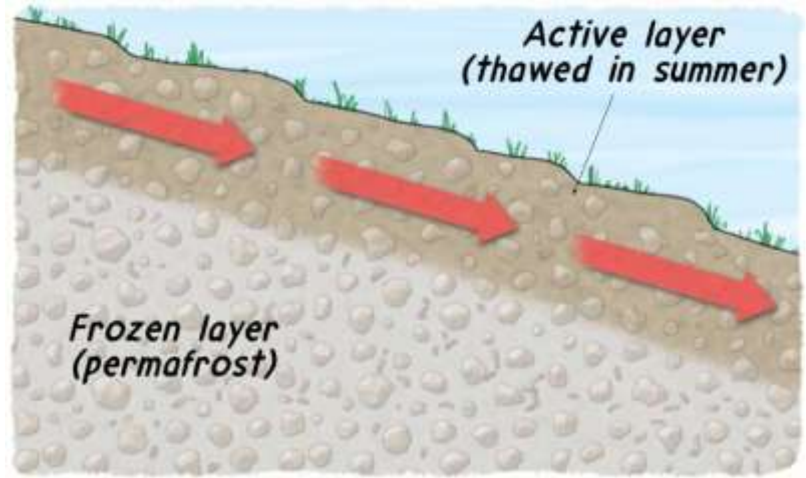
Permafrost Zones in Alaska





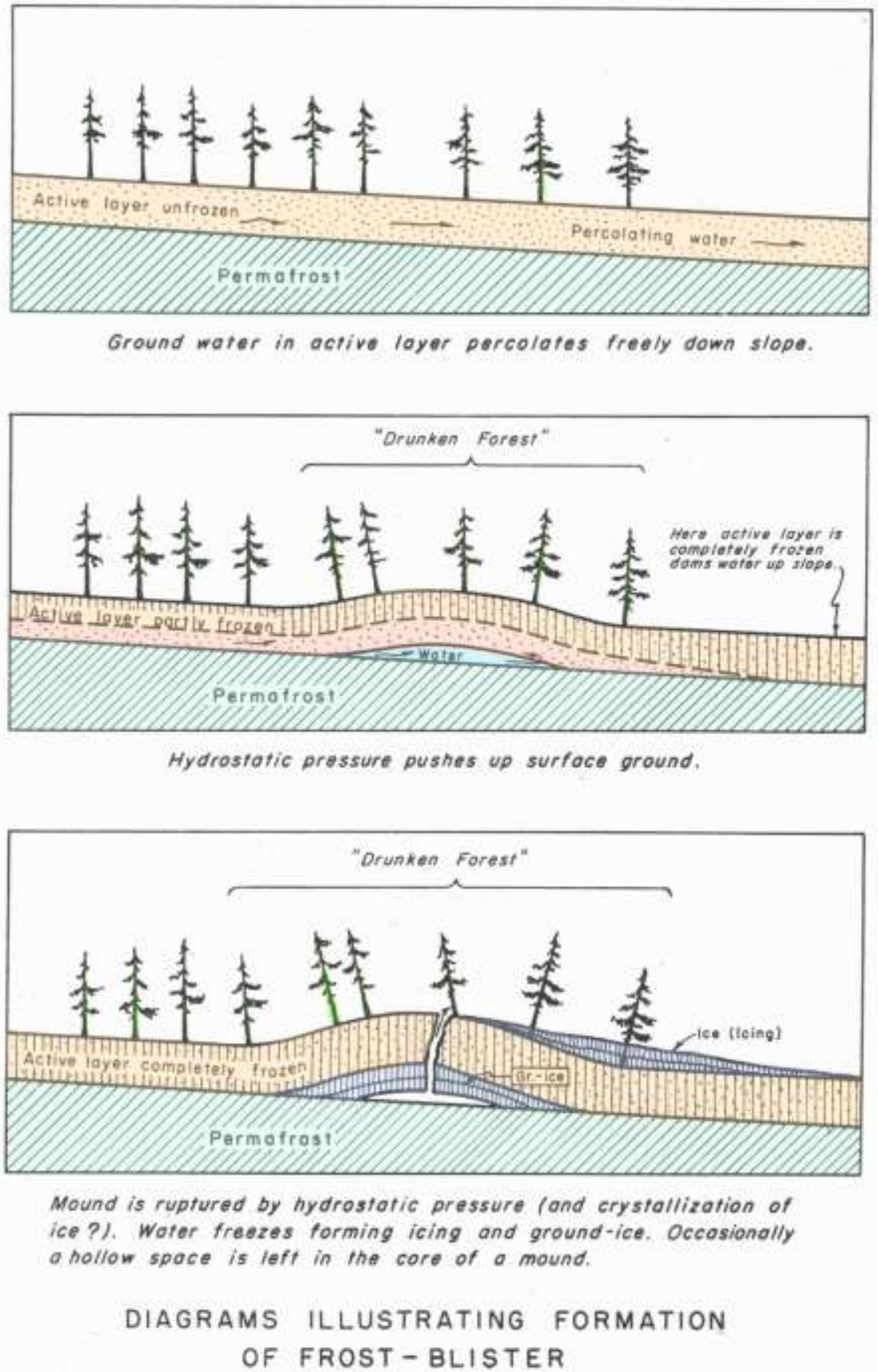
Inclusions of glacial ice are commonly found in permafrost. These were impediments to grading, like large boulders.

SOLIFLUCTION



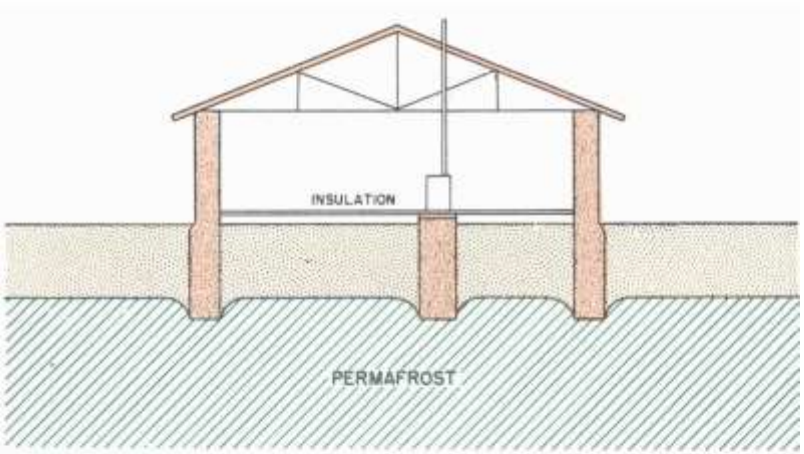
- **Soils in the thawed active layer overlying the permafrost tend to creep downslope during the warm season through a process known as “solifluction.” This process is exacerbated by the inability of percolating rainfall to penetrate the permafrost, leading to the active layer becoming super saturated.**

Frost Blisters

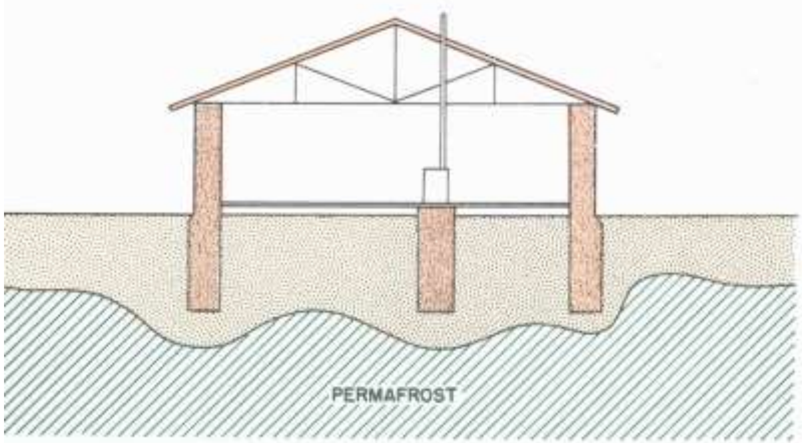


- Seasonal percolation is restricted to the active zone, just beneath the ground surface
- When the ground begins to freeze, flow becomes blocked, leading to the formation of “frost blisters,” as shown in the center sketch
- These blisters occasionally “erupt,” releasing water to the surface, which then becomes frozen.

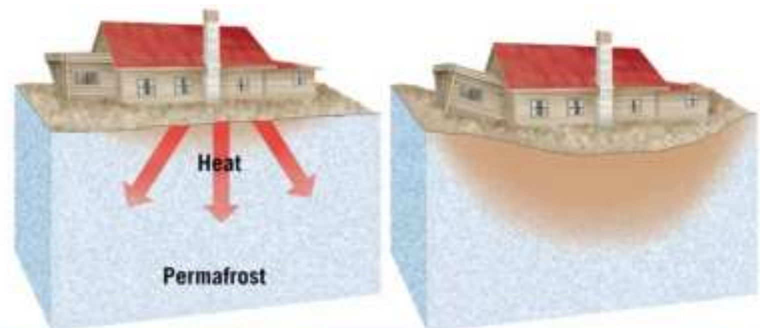
Differential Settlement



Maximum permissible lowering of the permafrost table beneath a foundation.

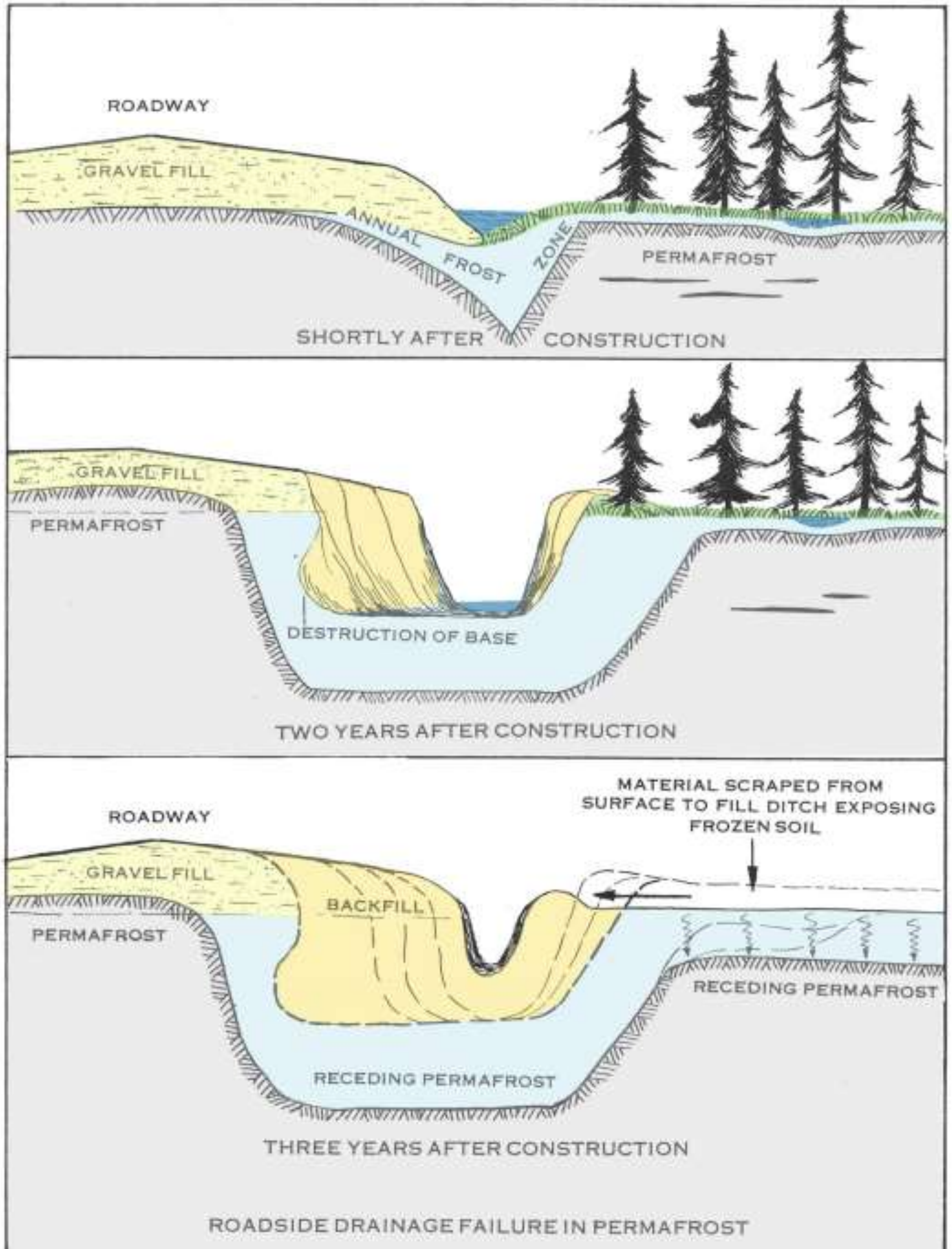


Insufficient insulation or excessive heat transfer into ground caused thawing of ground. If thawed ground has low bearing strength the building is likely to settle and be damaged.



Heat radiated by structures or their supporting elements can trigger differential settlement by thawing portions of the underlying permafrost

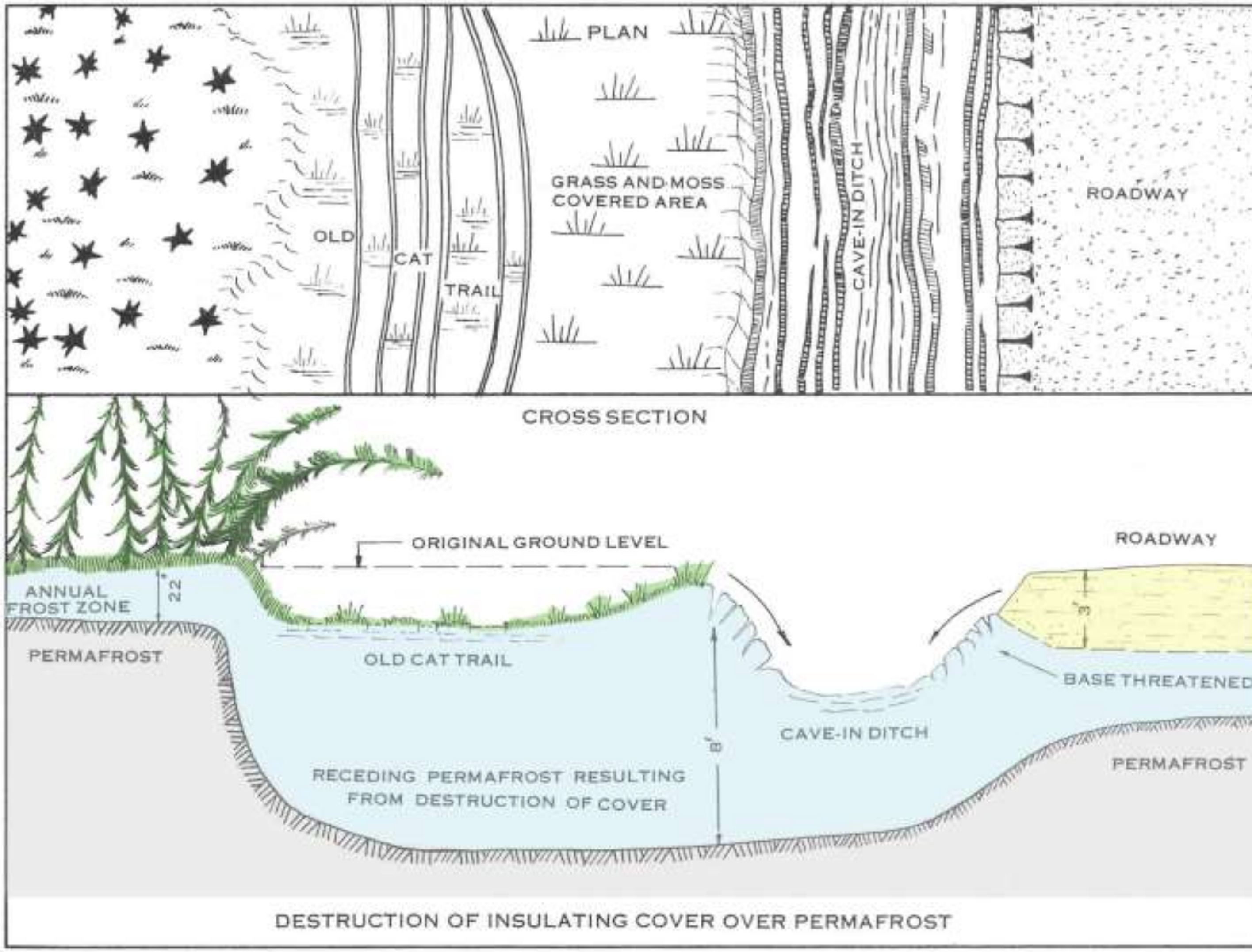
MUSKEGS are like a muddy version of quicksand. A vehicle would pass through a muskeg once, but within a short time, the area would turn into liquid mud, losing shear strength. Once caught, a vehicle had to be pulled out.



Roadside drainage failure in permafrost

- **The roads subgrade was almost completely undermined by thawing of permafrost, which resulted in the sloughing of the saturated soil.**
- **This problem was caused by the excavation of the roadside ditch, which was unnecessary**
- **The problem was exacerbated by drifting in fill from adjacent to the highway to fill in the collapsing ditch, as shown in the lower figure at left**

A road in a muskeg without corduroy surfacing. The dozer is fine ridding on the permafrost until it encounters a unfrozen muskeg.



- **Old Caterpillar tractor trails excavated on permafrost allowed water to pond and infiltrate zones adjacent to the Alcan Highway, causing it the highway subgrade to be undermined.**

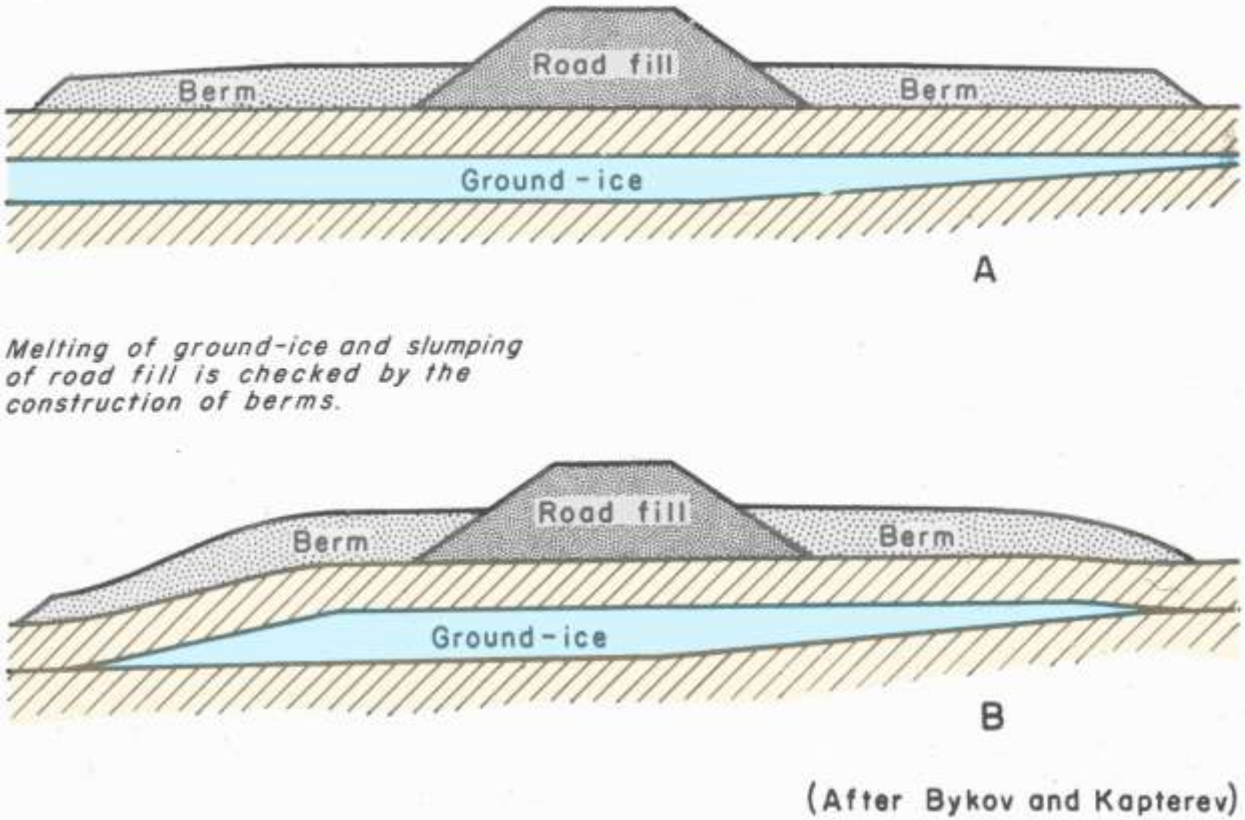
- **Muskegs are deep bogs of sphagnum peat, frequently covered by grassy tussocks, which grow in wet, poor drained boreal regions, usually areas with permafrost. They are sometimes referred to simply as “peat bogs.” These pool are insulated if > 6 or 8 feet deep.**

- **Muskegs sometimes appeared to “swallow” the heavier equipment, then exhibiting *thixotropy*, by “setting up.”**

OVERCOMING MUSKEGS

- To overcome the liquid mud created by disturbed Muskegs, the Engineers laid corduroy, just like the Romans.
- Corduroy road surface is constructed by first laying piles of brush, then logs, then more brush, and more logs, and finally a layer of gravel.
- In one stretch, two miles of corduroy was laid. Overall, over 100 miles of muskeg was corduroyed in this manner.

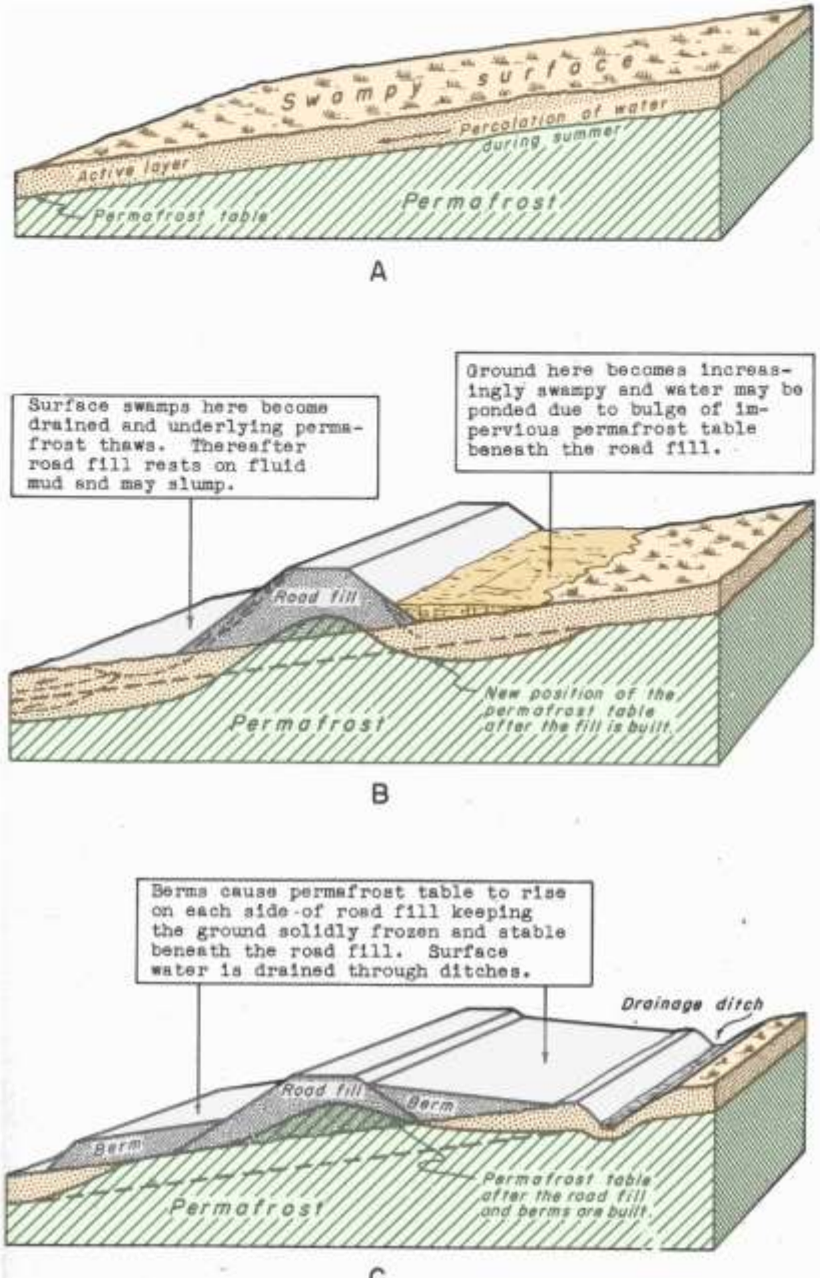
Corduroy road surface under construction. Some 100 miles (160 km) of route between Burwash Landing and Koidern, Yukon, became nearly impassable in May and June 1943, as the permafrost thawed, no longer protected by a layer of delicate vegetation. A corduroy road was built to restore the route, and corduroy still underlays old sections of highway in the area.



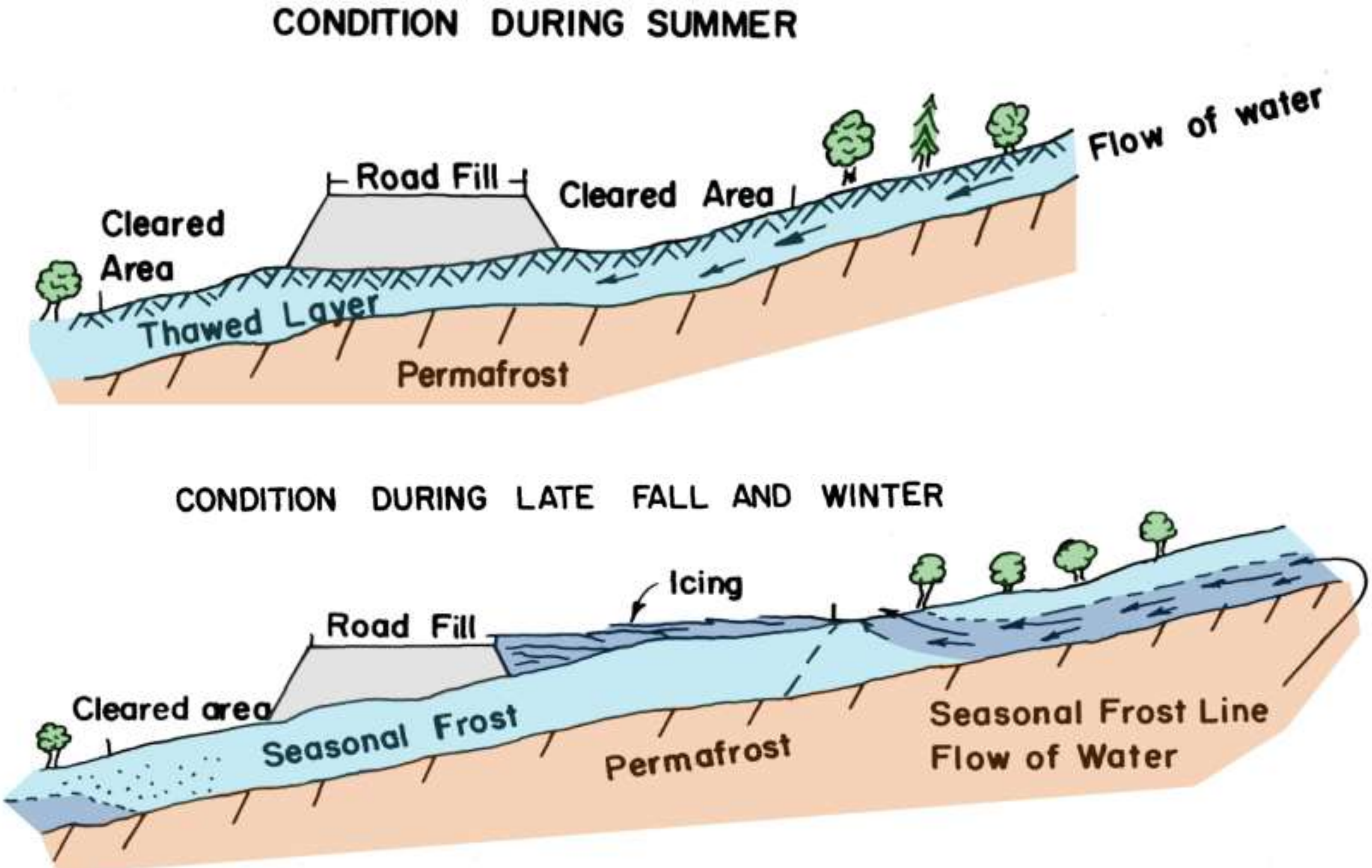
Effect of berms in preserving the frozen condition beneath a road fill.

- **In reviewing the Russian technical literature, Muller soon discovered that they employed shoulder berms to check shoulder slumping and deterioration.**

Thawed permafrost becomes swampy

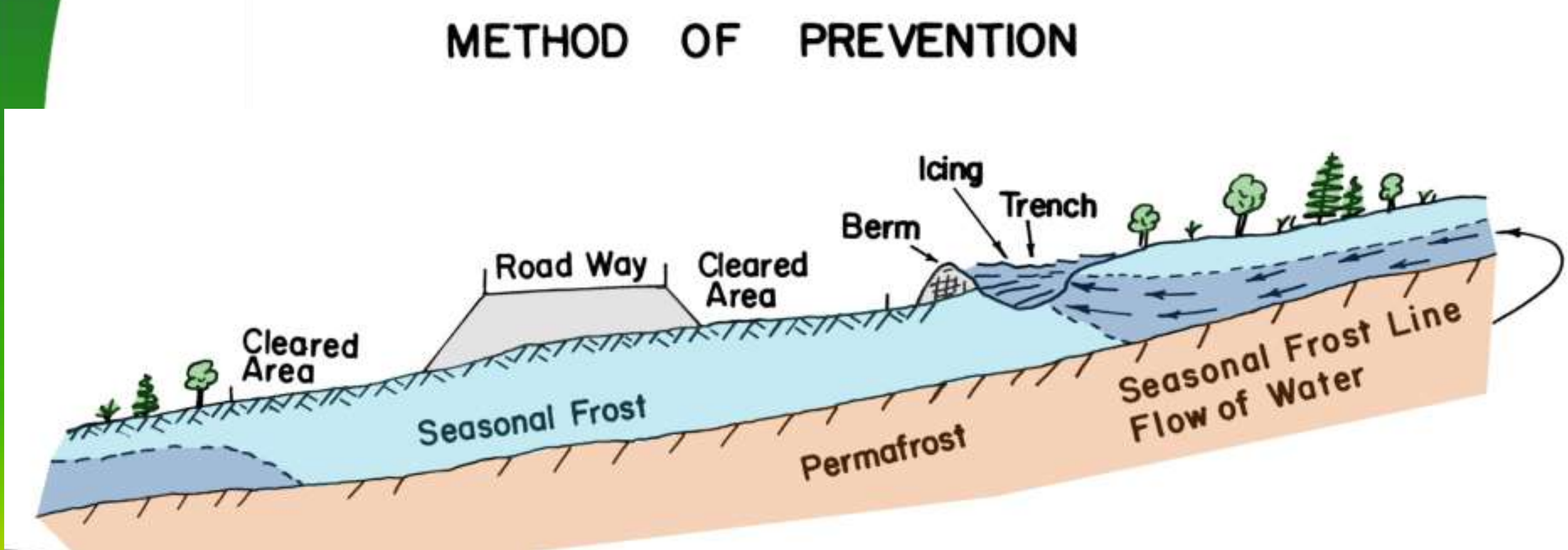


- When constructing a road, it is common procedure to remove the topsoil. But, when the active layer was excavated, the underlying permafrost thaws out and deforms easily because of the high water content.
- Stabilizing fill berms on either side of the highway fill prism help to alleviate this problem, as shown here



- **Seasonal permafrost problems were the largest engineering problem to overcome in maintaining the Alcan Highway. Most of these were described in S.W. Muller, *Permafrost or Permanently Frozen Ground and Related Engineering Problems*, 1943.**

SOLVING THE PROBLEM

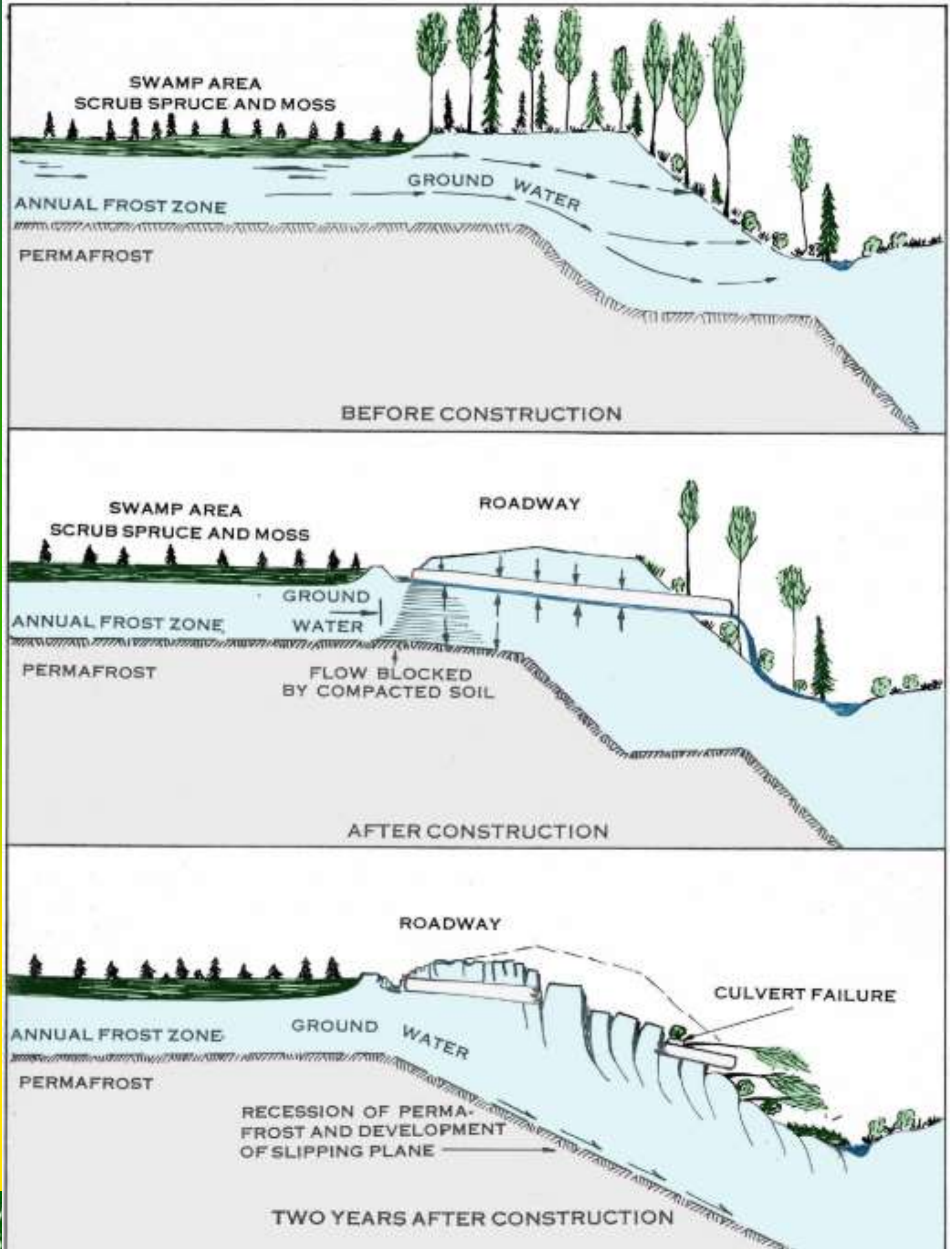


- **Drainage trenches** and **diversion berms** had to be constructed upslope of highway embankments to control seepage during seasonal thaw, as sketched here.

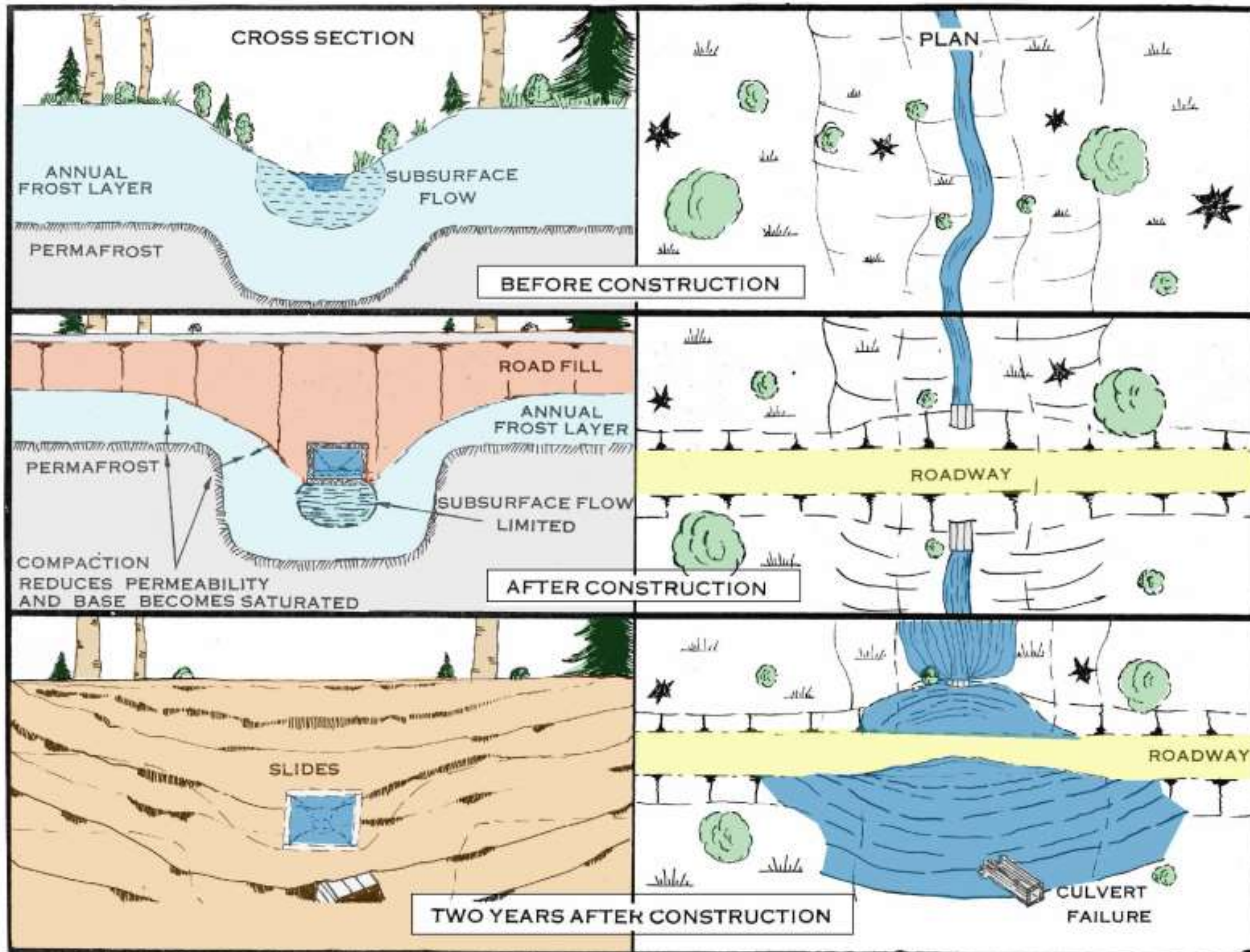
- **Portable sawmill operations set up by one of the regiment's sawmill companies. Prior to the Army's January 1943 reorganization, Combat Engineer Regiments included quarry, sawmill, construction, and camouflage companies.**

- **Log box culverts** were used everywhere along the highway to speed up construction because timber was the only material that was readily available.

“Compaction Dams”

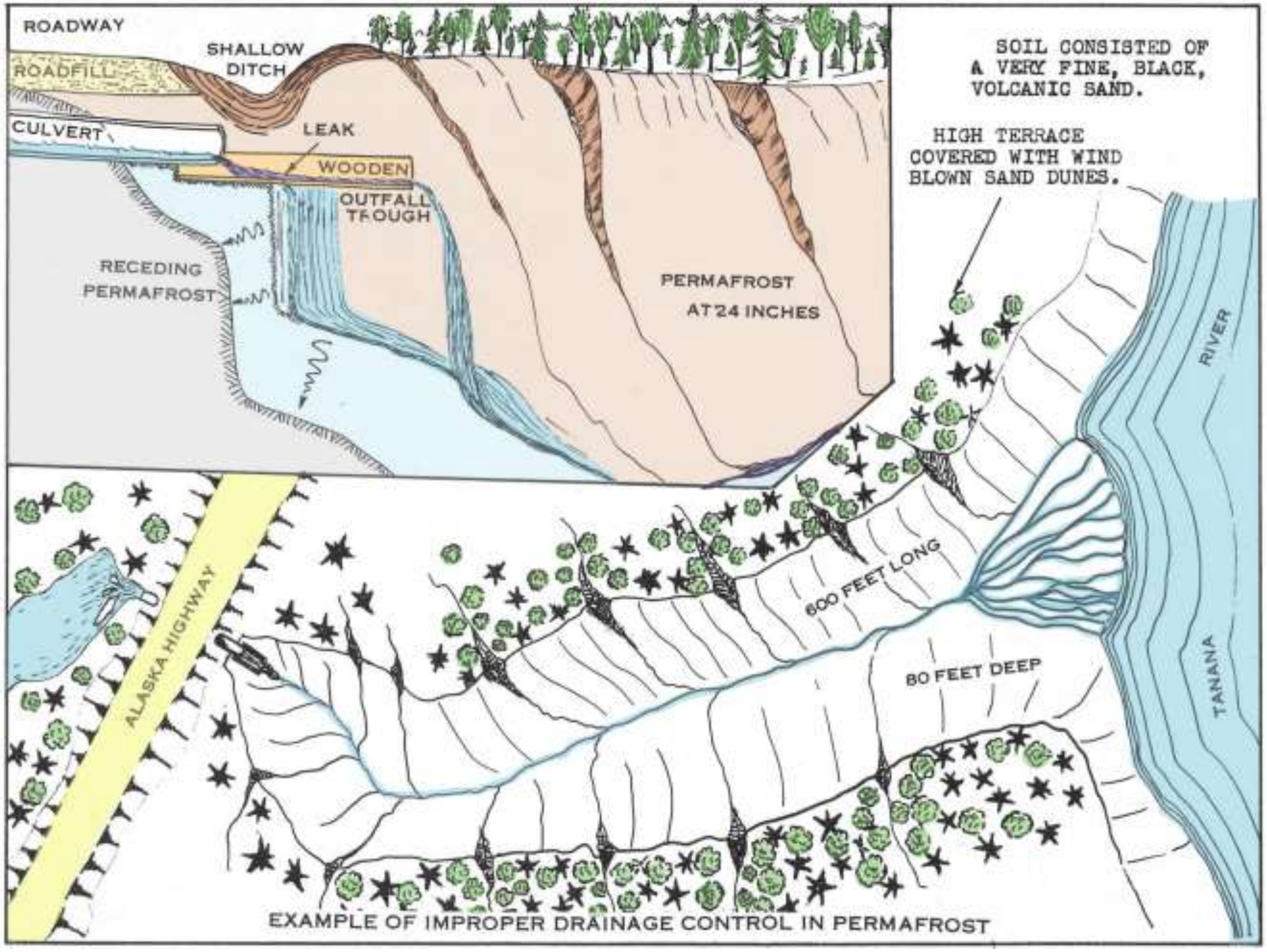


- One of the biggest surprises on the Alcan project was the formation of so-called “compaction dams,” formed by the fill prism for the highway.
- The lower permeability of the compacted fill served to block shallow subsurface seepage, in some cases leading to destruction of the fill prism, as sketched at left



- **"Compaction dams"** could also trigger wholesale landslippage along even the smallest culverts, as sketched here.

- **Wooden stave pipe culverts** were the most common type used on the ALCAN Highway, usually fashioned by the Engineer Regiments’ saw mill companies.



- **This drainage ditch was cut by a dozer to channel discharge from a culvert to the Tanana River in 1942. Within a year this seemingly innocent ditch had excavated itself over 80 vertical feet, as a result of exposing permafrost to thaw.**

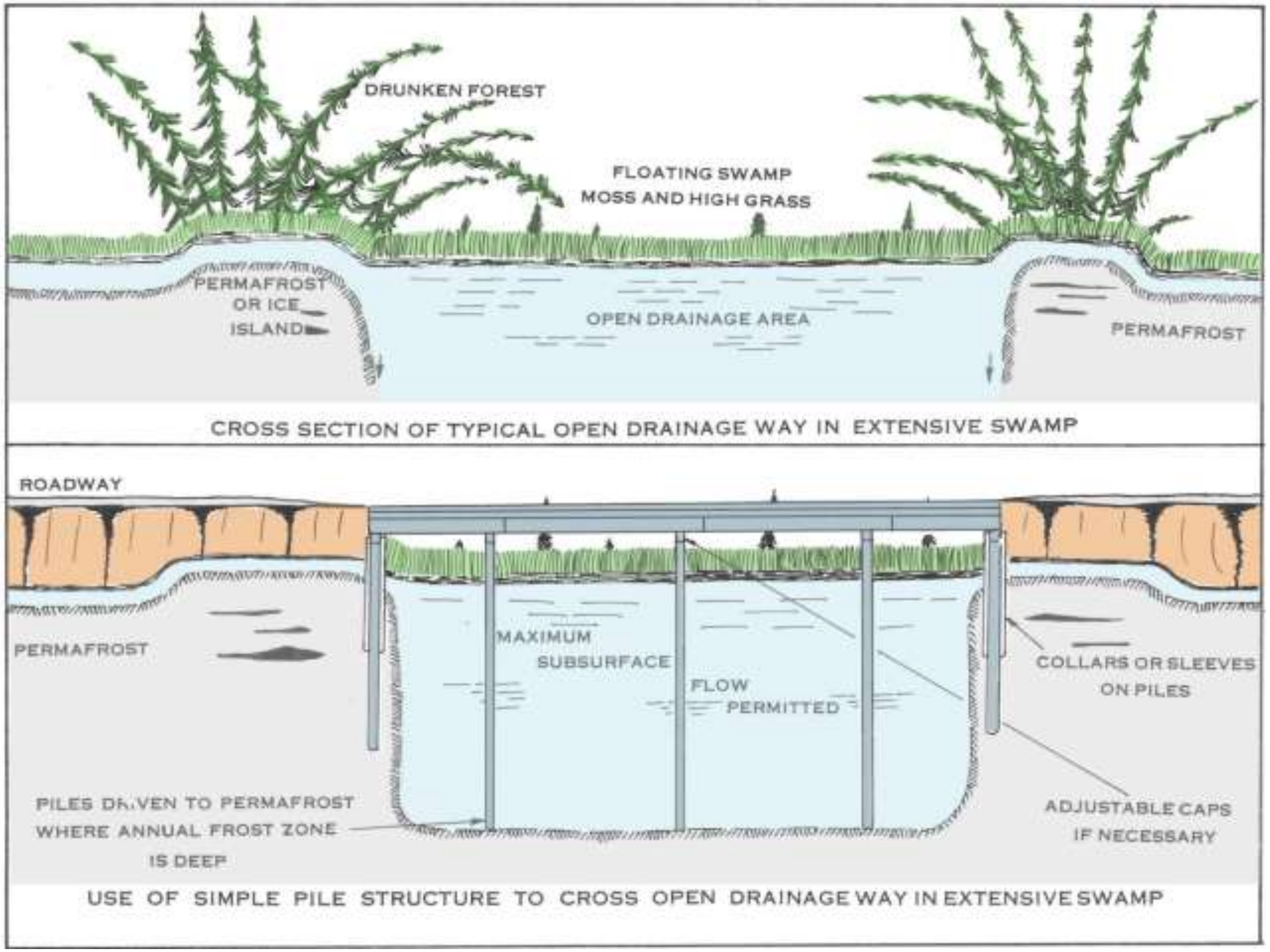
LARGE TIMBER CULVERTS

- The larger culverts were generally constructed from the surrounding wood.
- They were intended to be temporary until the contractors came through to improve the road.
- Here you see construction of one of these temporary culverts. After the wood frame was erected, a brush layer was placed to protect the supporting logs and prevent the base course from sifting through. A bulldozer would then fill and level the basecourse over the top of the timber culvert.

Dozer drifting roadway fill over a protective evergreen brush layer that served as an effective filter and aerator, protecting the logs from dry rot and preventing the fill from spilling through the slits between the logs.

Bridges and Pontoons

- Throughout the construction of the Alcan Highway, Army Engineers *crossed more than 200 rivers*. During the colder months, most traffic crossed ice-covered rivers and forded the smaller streams. Once the spring thaw arrived, the 73rd and 74th Engineer Light Pontoon Companies went to work constructing temporary pontoon bridges.
- The first bridges constructed by the Army Engineers were temporary. They failed when the spring thaw increased water levels. Spring freshets also brought flotsam in the form of tree trunks and brush, which slammed into the pilings, damaging them and capturing more and more debris because of the obstructions.
- When the water levels were high during the spring thaw and flood seasons, equipment crossed the swollen rivers by ferry or treadway pontoon bridge.



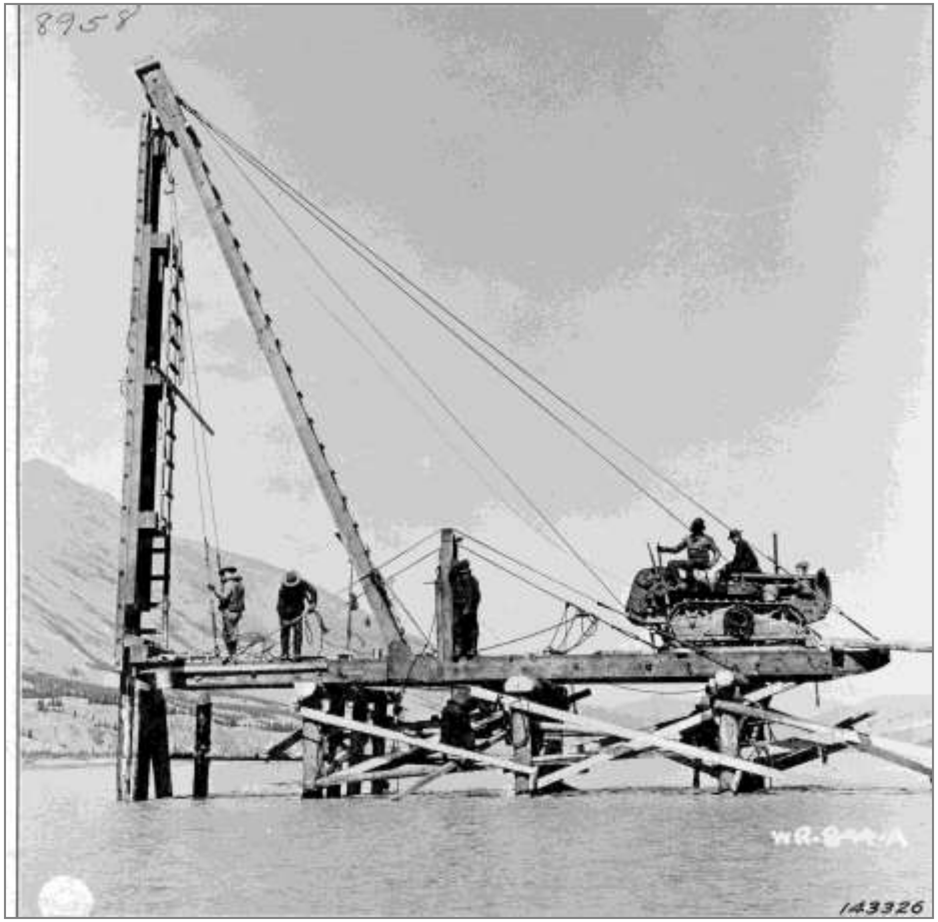
- **This shows an open drainage way crossing the highway. These features convey large volumes of seasonal subsurface seepage flow. These situations were eventually met by using low pile supported bridges with adjustable caps on either end to allow for settlement and heave.**

Use of Pontoons to support construction

- A temporary pontoon bridge used to expedite construction.

- Pontoons ferrying across equipment

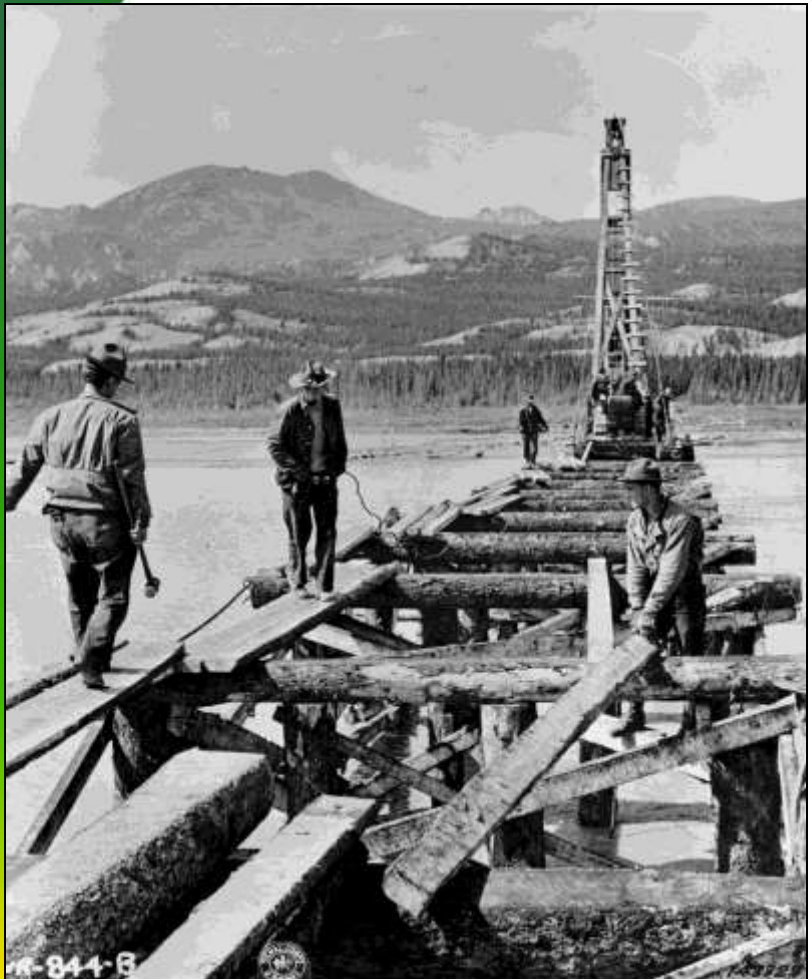
These views show combat engineers erecting the old prewar pontoons, only capable of supporting 15 ton/axle loads.



Pontoon bridges were of the prewar type, which were not suitable for heavy loads or sustained operations by bridging companies. Civilian contractors were brought in to construct timber trestle crossings of most rivers and streams.

SEASONAL BRIDGES

- The pontoon bridges and ferries were only temporary solutions until permanent bridges could be built.
- Using three sawmills, construction crews and members of the Public Roads Administration constructed bridges along the entire alignment, even during winter.



PRA crews and civilian contracting firms built most of the timber trestle type bridges, which were expedient but temporary. The timber was harvested onsite. All of these were eventually replaced with more permanent timber, concrete, or steel bridges. Some the timber bridges lasted into the 1980s.

- **Timber trestle bridges like this were unable to handle summer freshets, which brought innumerable driftwood and fallen trees into the pilings.**

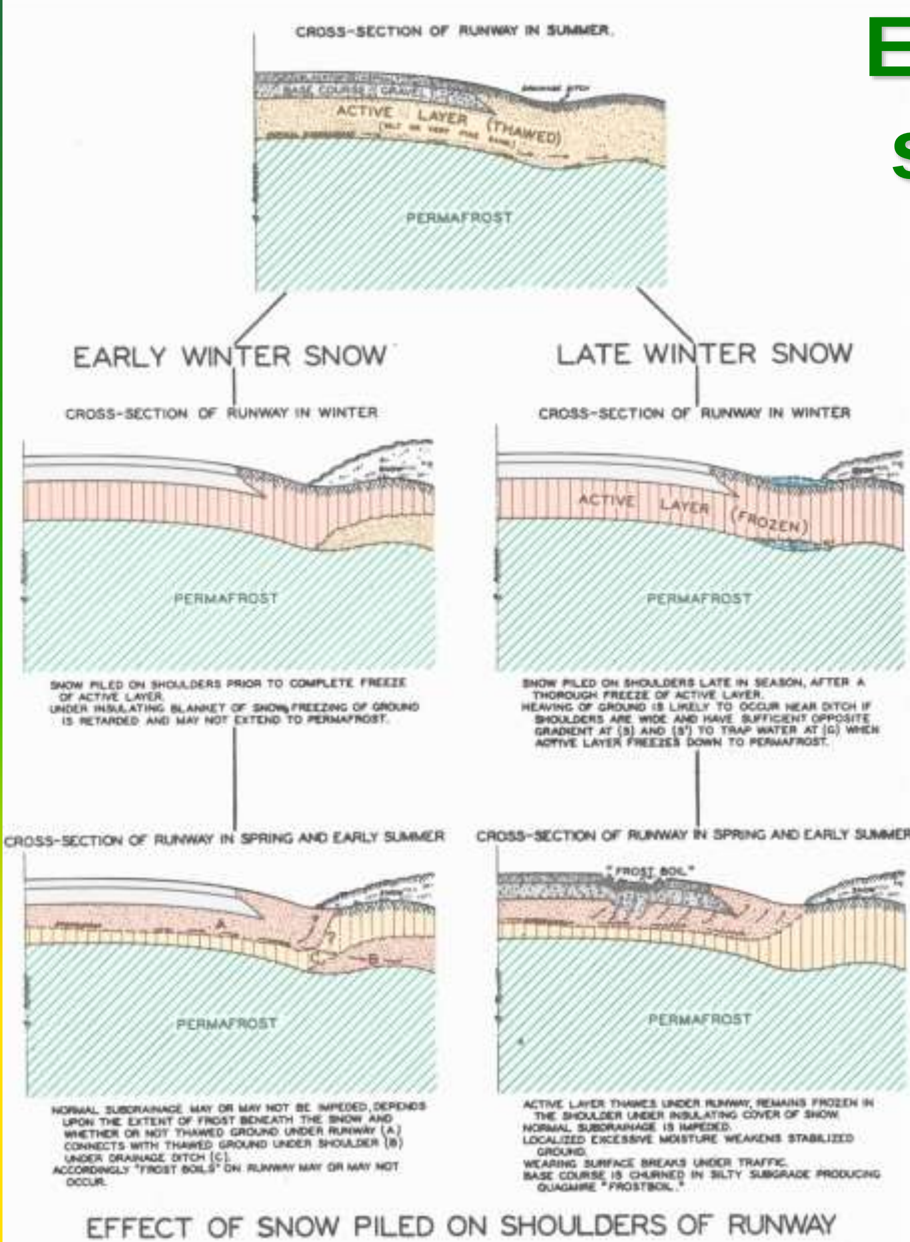
Maintaining Bridges

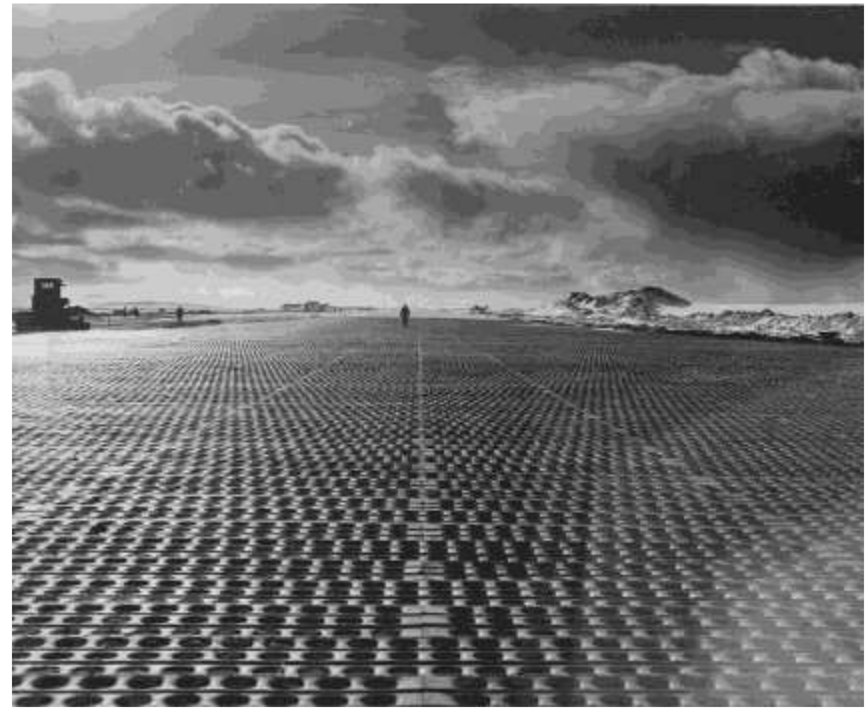
- Maintaining the bridges posed the biggest problem. During construction, a guard was posted to make sure that large trees brought downstream did get snagged by the bridge pilings, which could easily damage or destroy the bridge.

Airfields

Airfields were constructed across the Northwest Territory, Yukon, and Alaskan frontiers to protect American bases and stage patrols

Effect of snow piled on shoulders of runways



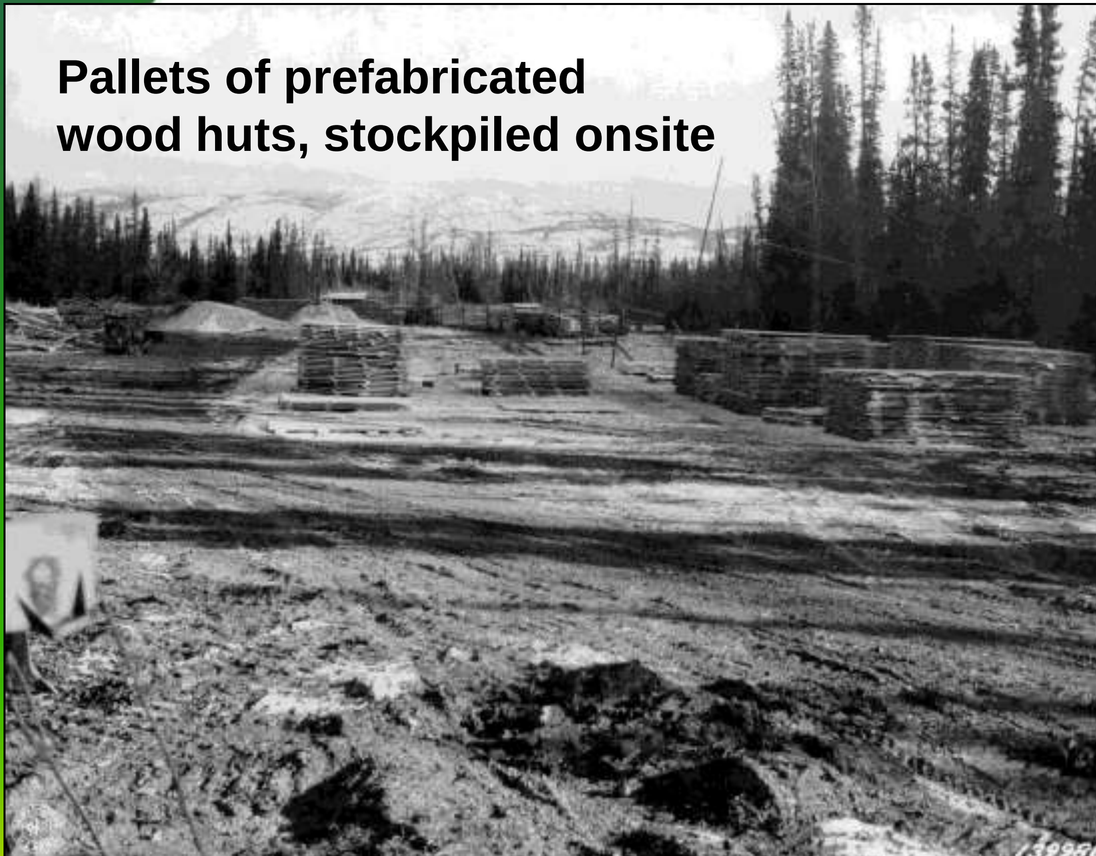


Snow piled along shoulders of Alaskan runways often prevented the active layer from thawing, leading to deterioration of the shoulders, as shown at lower right.

Billeting the workers

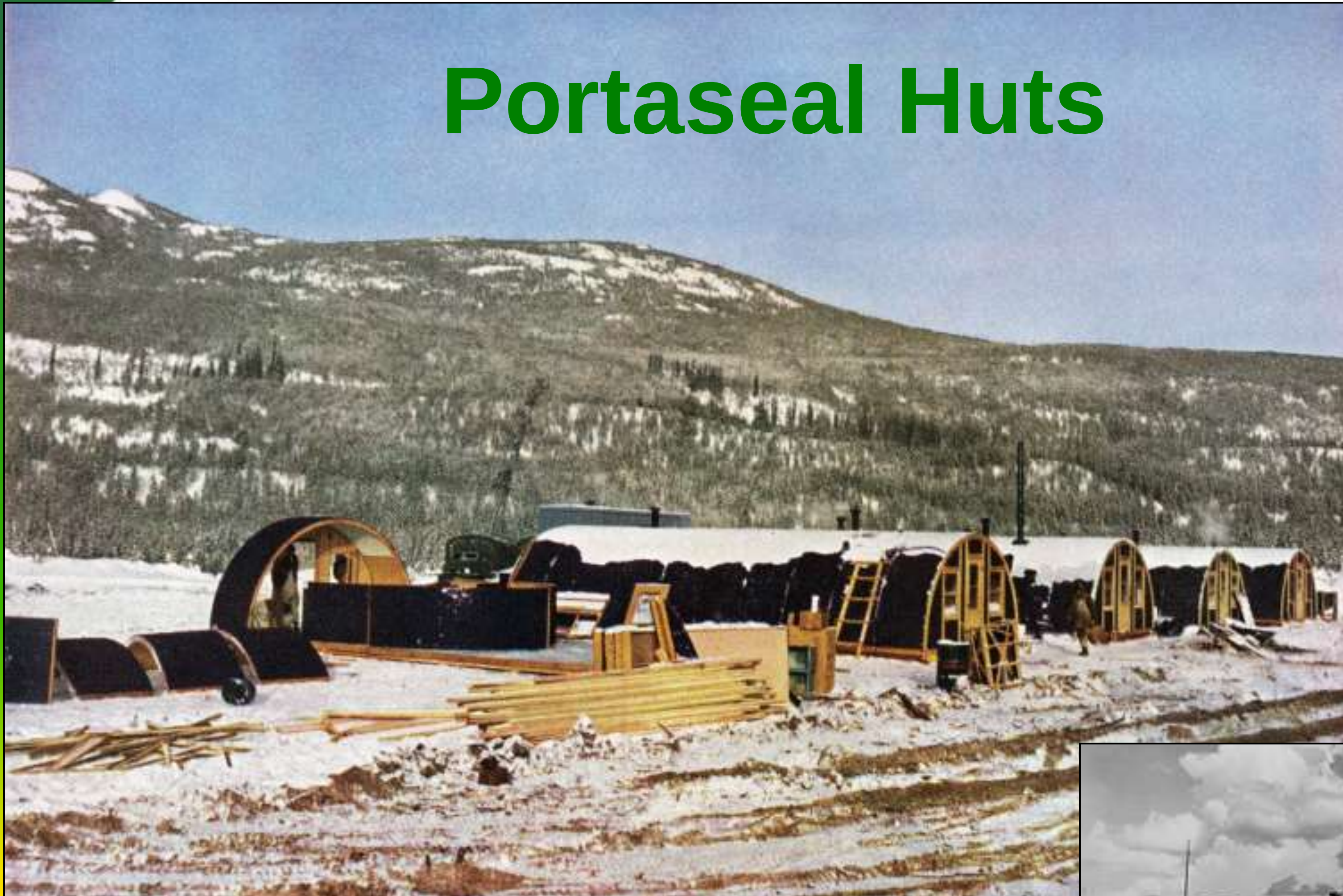
- Left – Tarpaper Huts were commonly employed for billeting troops at training facilities all over the world
- Right - Jamesway Huts were fashioned from multiples of 4’ x 16’ hemispheres, produced by the James Manufacturing Co of Fort Atkinson, Wisconsin. These used wooded ribs and insulated fabric covering, the only metal parts being nails, fasteners, and connecting bars.

Provision of temporary and more permanent housing



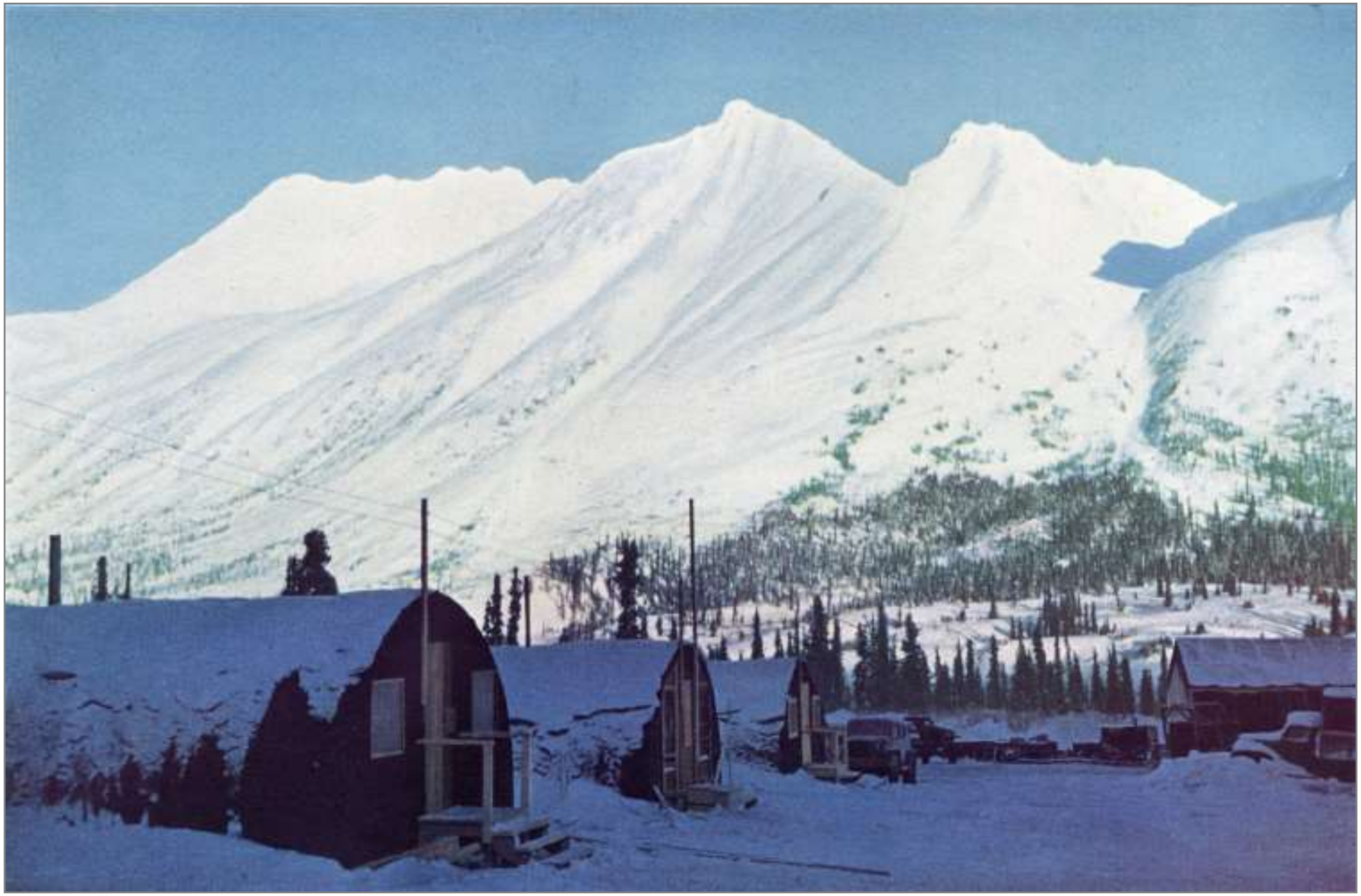
- This shows the erection of 20’ x 48’ prefabricated wood huts for billeting base personnel. These were made of plywood and shipped all over the world, especially for Army Air Corps facilities.

Portaseal Huts

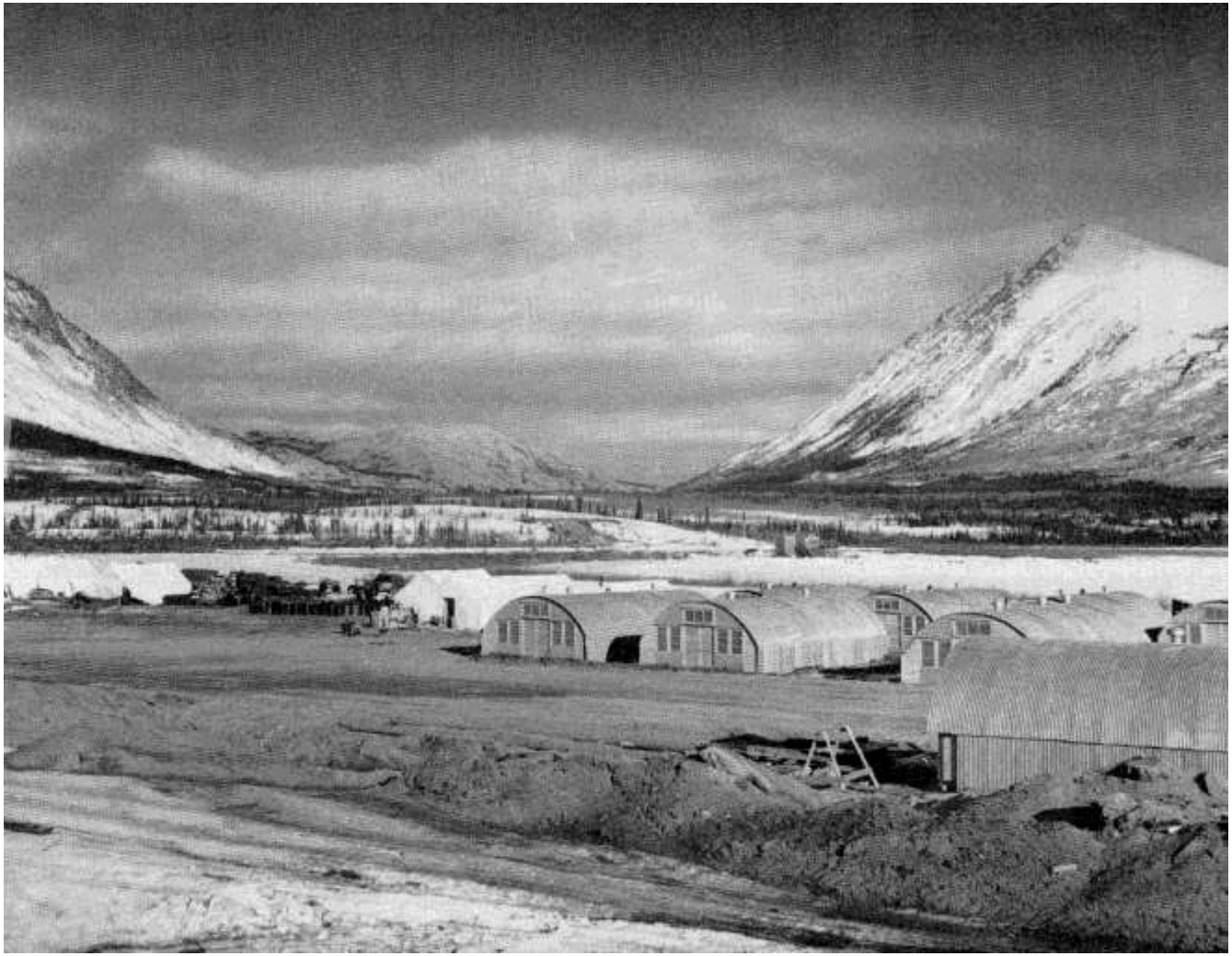


- **Portaseal Huts** were a Canadian version of the wood framed plywood clad Quonset Huts. They were precut at the factory and could be erected very quickly.

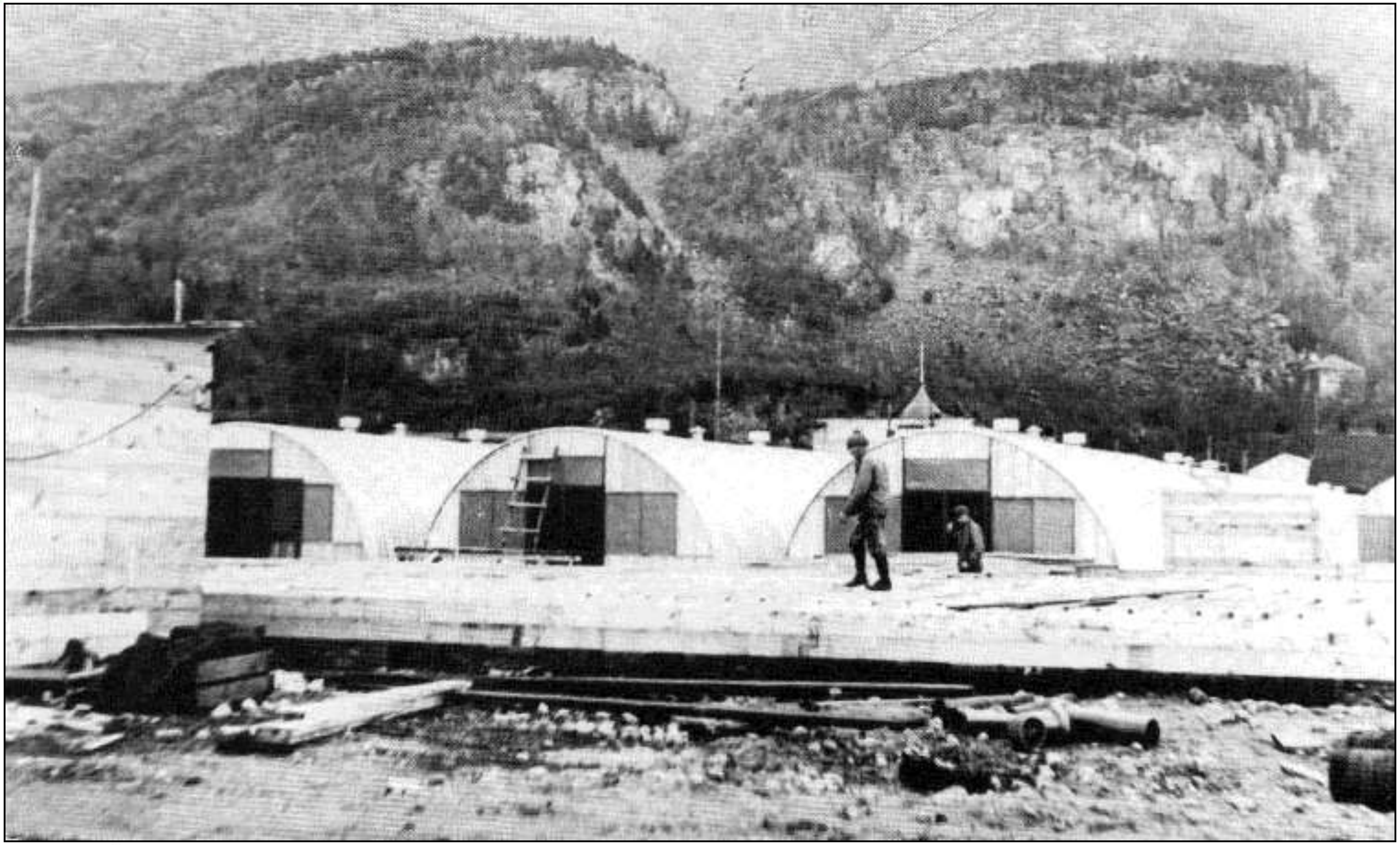
- **Portaseal Huts** utilized a tar-paper exterior nailed to plywood sidewalls, end walls with large windows, and wide batten-type trim boards over the joints.



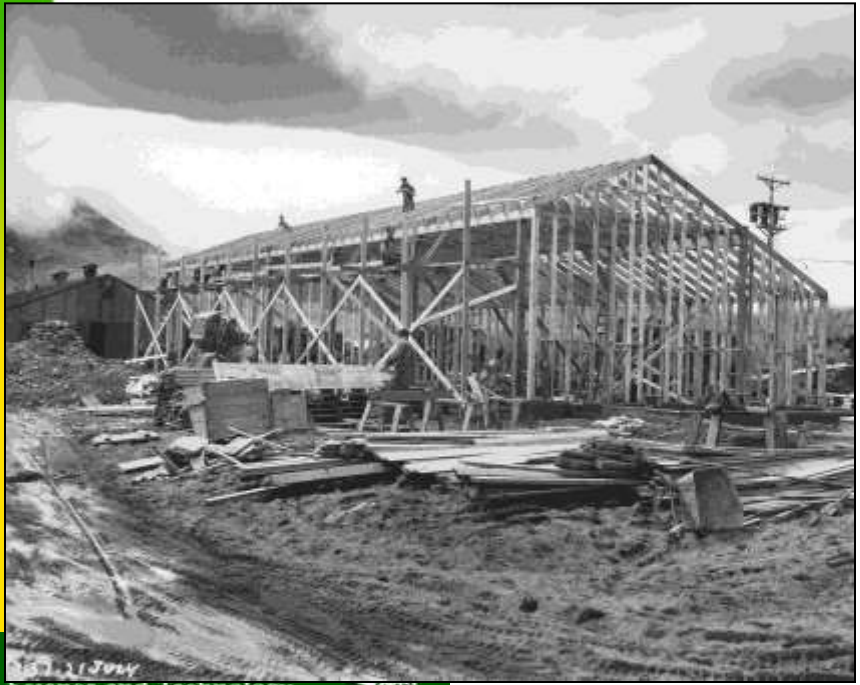
- **Portaseal Huts** were used on the Canol Pipeline Project and on the Alaska Highway, where it crossed the Yukon Territory. They were heated with improvised oil drum stoves.



- This view shows **24’ x 60’ Quonset-Redesign Huts,** which appeared in 1943. These used a lighter I-shaped steel arch with four foot high vertical walls. Note canvas tents that provided temporary quarters during erection.



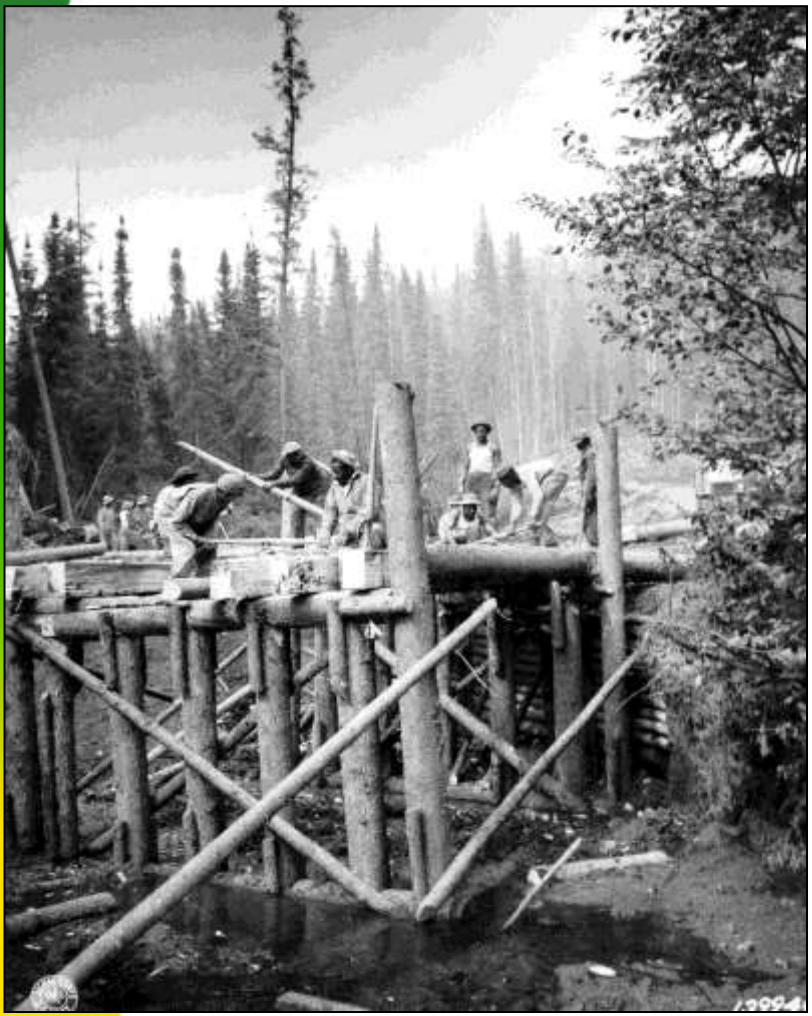
- **20' x 48' Stran Steel Quonset Huts were manufactured in Detroit and were the third and final design employed during World War II. Note the ventilators. The men in the foreground are walking on the floor ribs of a much larger structure under construction.**



- **Wood frame structures** were normally constructed for military bases, as seen in these images from Attu. These views show a motor pool structure at lower left, and a dispensary being disassembled and moved using dozers and skids.

- **Glue-laminated wood ribbed huts** began appearing towards the end of the war, as a means of conserving steel. These kits allowed considerable alteration to accommodate the prevailing weather conditions.

African American Engineer Units



Prior to the Alcan Highway Initiative, African American units did not work under "white" supervision. When it was foreseen that the highway would not be built in time if more troops were not available, Congress allowed three colored regiments (93rd, 95th, 97th) to work along side the non-colored units. Due in part to the hard work and dedication of these men, African Americans were integrated into all military units in 1947.

The Alcan Road Today

Jeep on the ALCAN in 1944


The highway serves as an artery for all manner of traffic, even offroad mining rigs like the one shown here.

What a bridge on the Alcan Highway looks like today

Final Details of the Alcan Highway

- The highest pass is only above 4,000 feet elevation, as opposed to the initial predicted elevation of 6000+ feet.
- There are over 200 bridges (H20 and H15) and 8,000 culverts along the highway
- Final specification of the highway:

Highway Feature	Army Pioneer Road (1942)	Public Roads Administration Finished Road (1943)
Road width	12 feet minimum	24 feet
Shoulders	3 feet minimum	6 feet maximum
Grades	10% maximum	7% maximum; 5% average
Curves	< 50 foot radius	717 foot radius
Surface	compacted earth	2 feet crushed stone and gravel
Bridges	one-way H-15 loads	two-way H-20 (20 tons/axle)

CONCLUSIONS

- All the locals thought that a road through the wilderness would be impossible. Not only did the Corps of Engineers construct a road through the Yukon Territory to Alaska, they did it in a record time of 8 months and 11 days!
- Total pioneer road constructed: 1,543 miles
- 10,670 Engineers were used to construct and improve a total of 1,685 miles of highway. 41 American and 13 Canadian contractors assisted in the construction and improvement of the highway.
- November 20, 1942 marked the official opening of the Alcan Highway. It has been in continuous operation ever since.

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