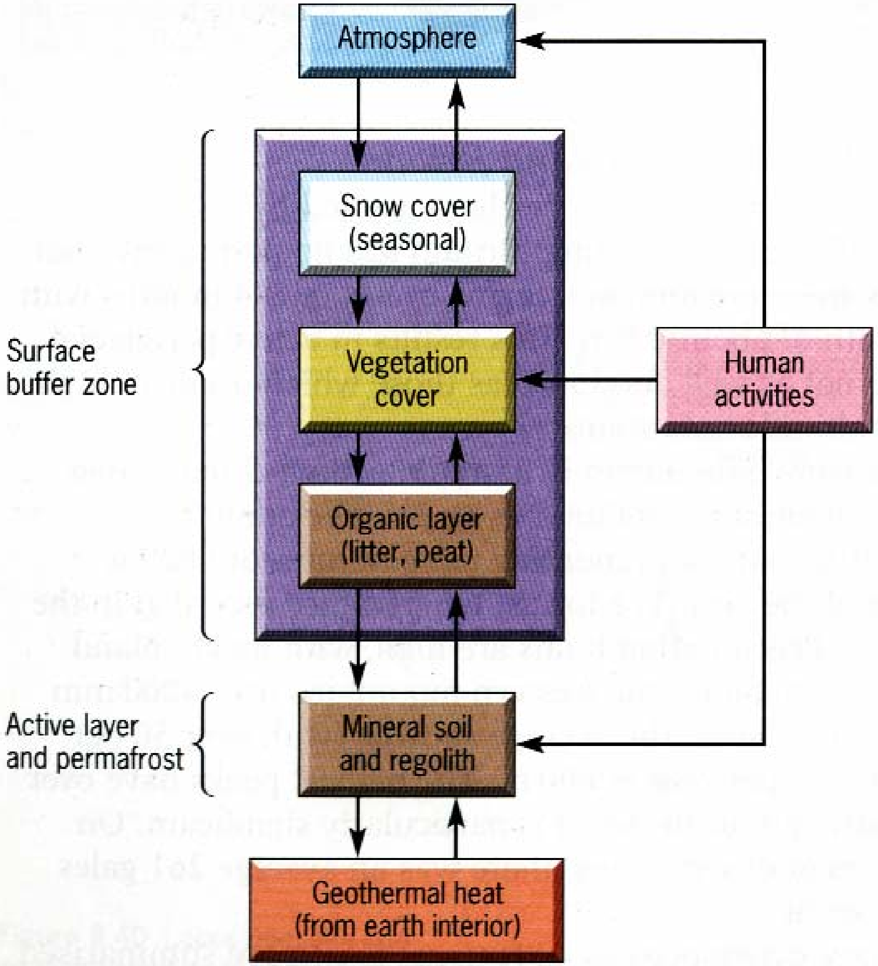
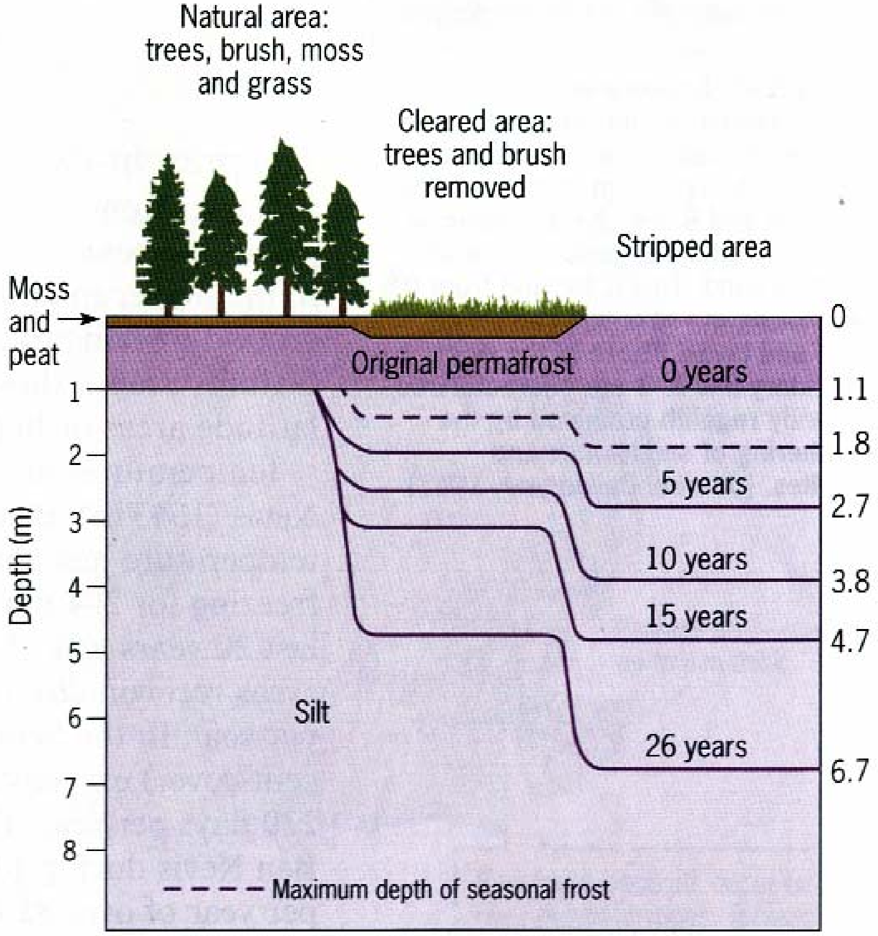
Human Activity and Periglacial Environments

The influence of human activity on Permafrost



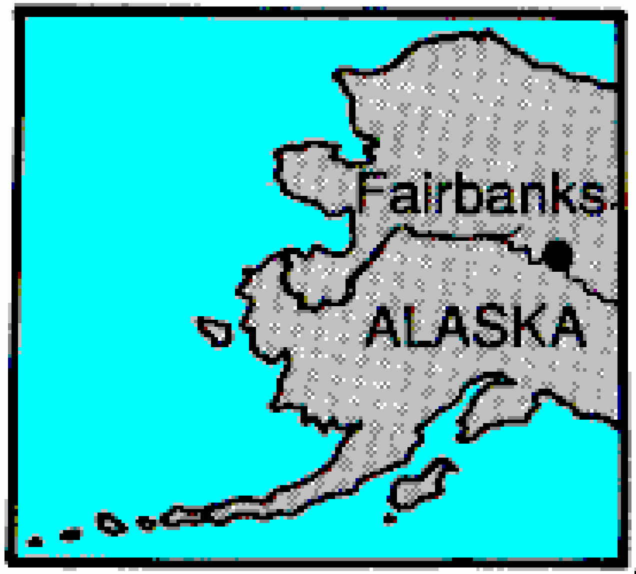
Heat energy transfers and permafrost

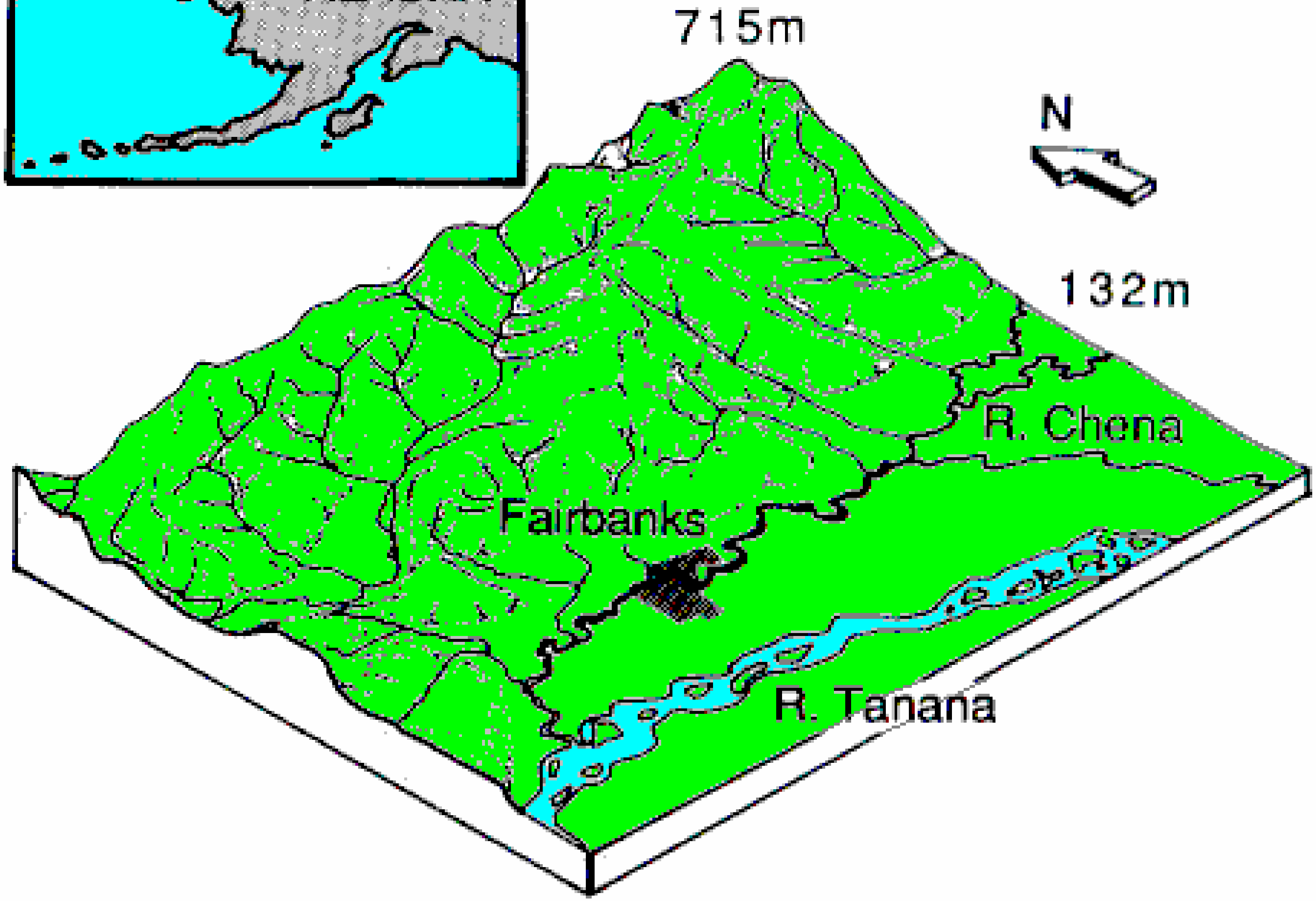


Permafrost degradation under surface disturbances in central Alaska over a 26-year period

Coping with Permafrost in Fairbanks Alaska

Fairbanks is on the Chena River in an area of discontinuous permafrost between the Brooks Range and the Alaskan Range





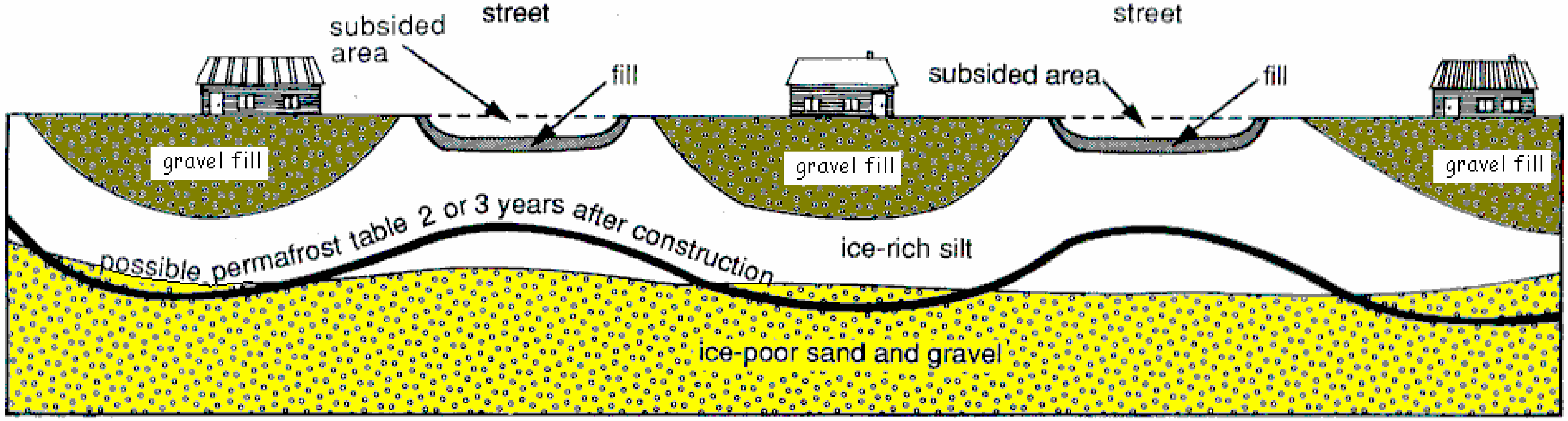
Problems facing Human Activity in the Permafrost Zone:

- When ice-rich permafrost thaws, this can result in problems of subsidence of buildings, roads and other structures.
- Intense frost action can damage buildings, roads and other structures, particularly in areas of poor drainage.
- Freezing of buried sewers, water supply and oil pipes.
- Rupturing of trapped throughflow (soil water) as freezing sets in in Autumn.

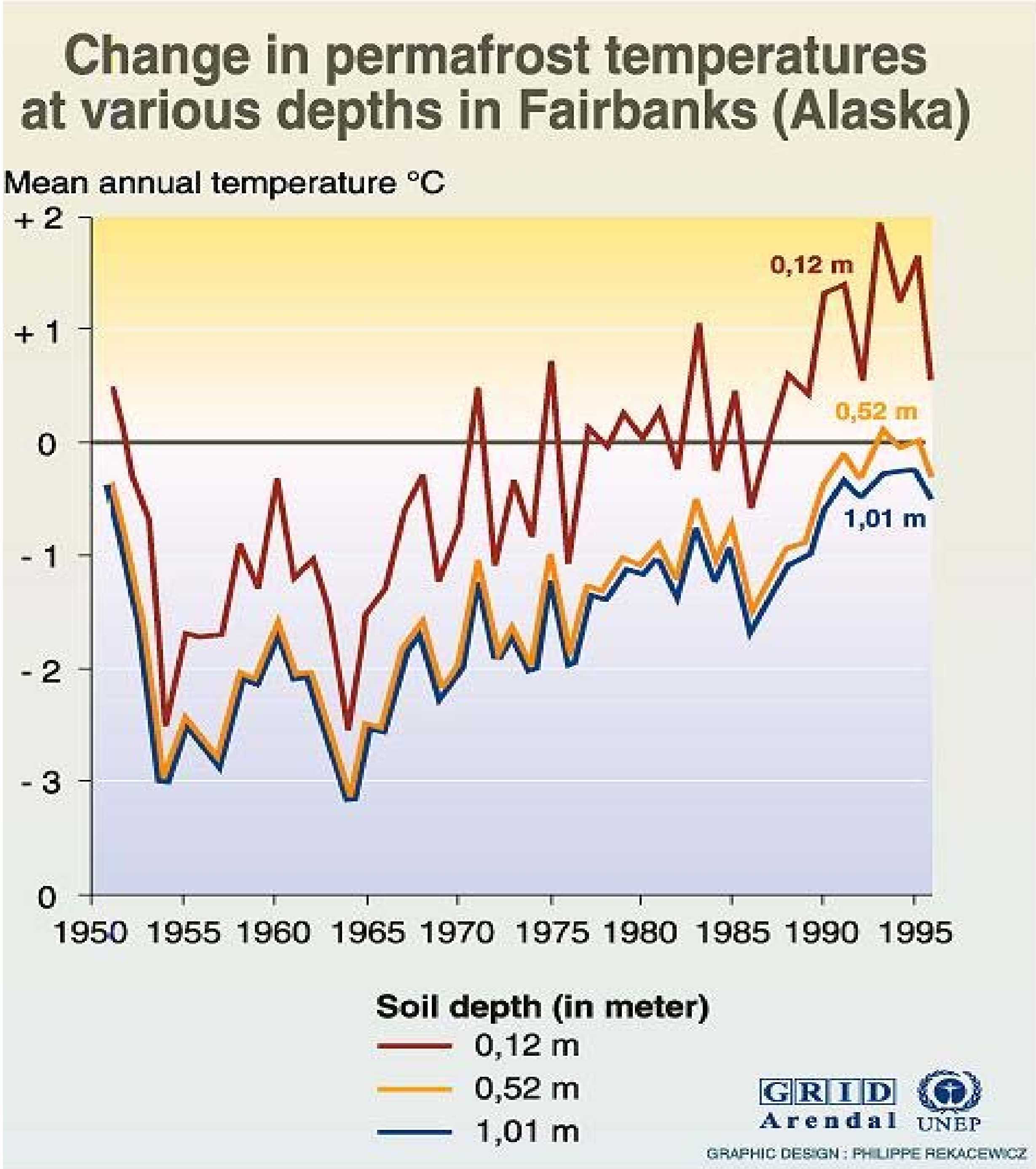
Thawing of Permafrost

- This occurs under both heated and unheated structures including roads, airfields, agricultural fields and parks as well as buildings.
- When settlement and subsidence occur due to thawing, the landscape is described as ***thermokarst*** as it can contain sink holes, tunnels and caverns similar to those found in limestone karst scenery.
- Thermokarst mounds can develop where land has been cleared, such as in front gardens or parks. They can be up to 15m in diameter and 3m high. Trenches form where ice-wedges once occurred causing differential settlement often with polygonal patterns. In other areas, ground ice may melt leading to the development of deep pits.
- Thermokarst landscape are hazardous to farmers as machinery cannot be used.
- Airfields, roads and railway tracks require regular costly maintenance. Settlement on one section of railway track near Fairbanks in Alaska has maintenance costs of over $1 million a year.
- In some cases thawing of permafrost can be beneficial as it may improved drainage and increase the potential for agriculture.

Disruption of ground in Fairbanks suburbs



A housing project in the 1980's, built on the flood plain in Fairbanks was severely affected by subsidence after just one year. Paved streets, and even garages began to subside dramatically, although houses were untouched. This was because ice-rich silt at the house locations had been excavated to a depth of 9m and replaced with a **gravel pad**, whereas roads were only dug to a dept of 2m. Summer warming of energy absorbing paved areas and the watering of nearby lawns were the main causes of melting.



ce: Romanovsky, in Impacts of global climate change in the Arctic regions, IASC, Tromsø, April 1999.

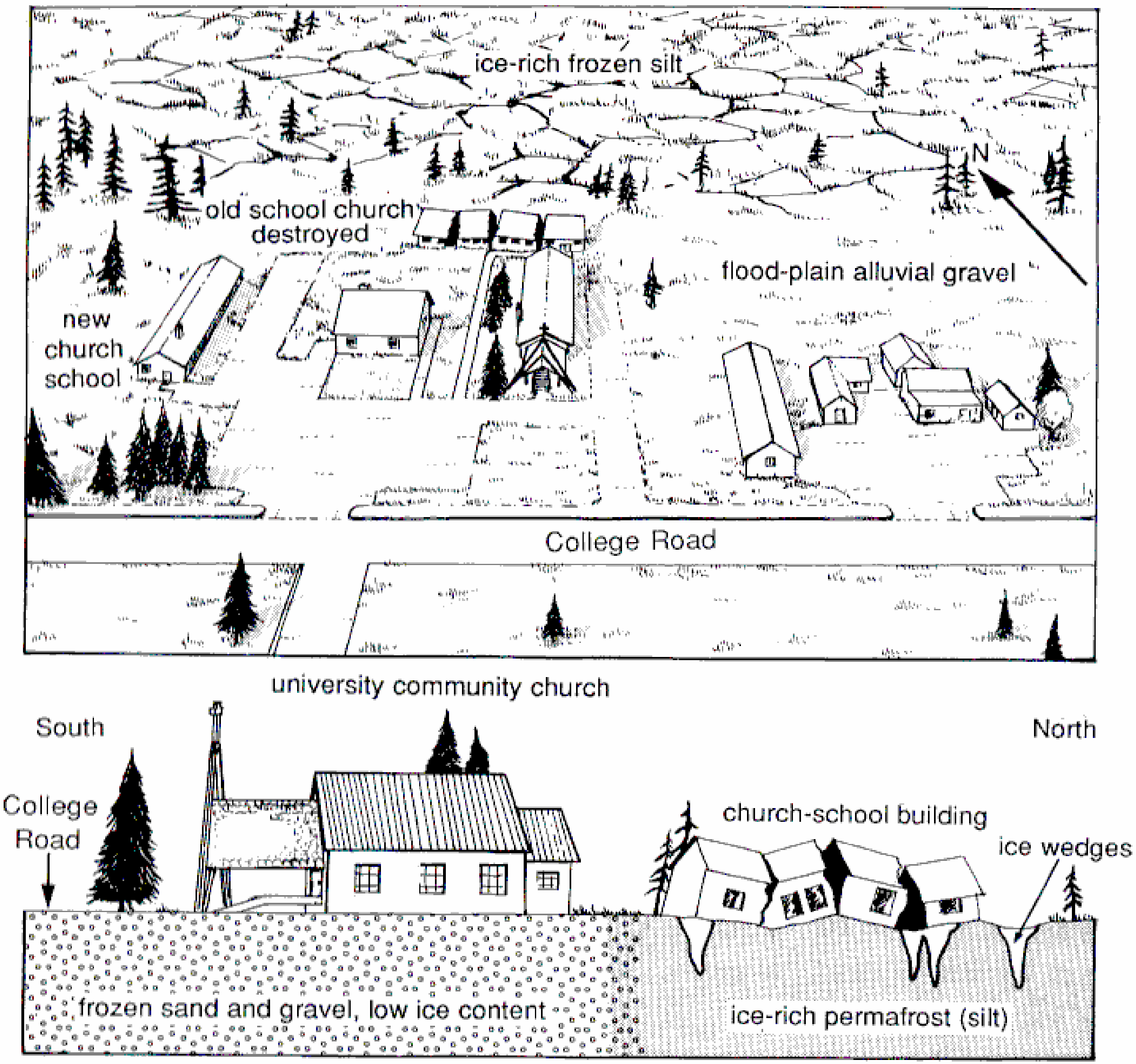
As global warming affects soil temperatures in Fairbanks, the problems of thawing permafrost could increase. Measurements also suggest that the thickness of the active layer is increasing.

However, some commentators believe that higher temperatures could increase vegetation growth which might help to insulate the near-surface ground layers and keep them frozen.

Which view does this graph support?

Poor Drainage and Intense Frost Action

- Frost heaving is a major problem in permafrost areas and it can occur very quickly. In one season, roads and buildings that have not been constructed properly can be destroyed.
- On ice-rich sediments, engineers may remove part of the active layer and replace it with an insulating and freely drained gravel pad. Alternatively, houses can be built on piles driven deep into the permafrost. Most piles are dry-augered and then backfilled with a silt and water slurry. This freezes and cements the slurry in place. An air gap is left below the building so that they do not rest directly n the ground.



Problems with frost heaving in Fairbanks.

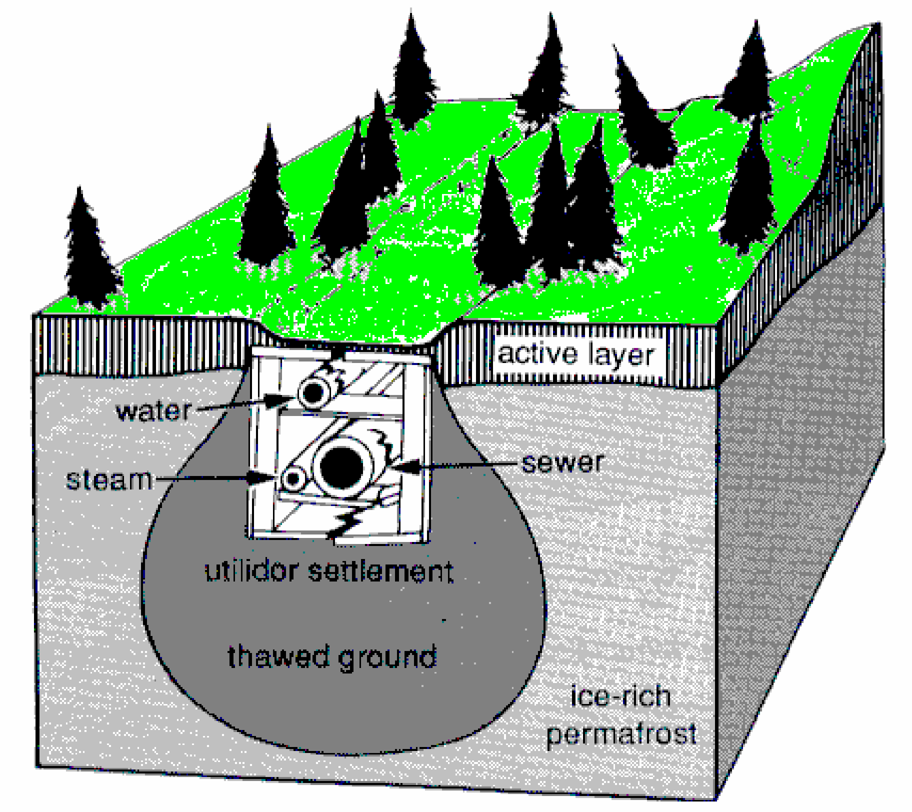
Notice that the old school-church was located on ice-rich silt and was destroyed by thawing and heave processes.

Newer buildings are on frozen sands and gravel which have a low ice content and are less prone to heave.

Freezing of Buried Utilities

Winter water supply is a problem in permafrost areas. Reservoirs have to be deep enough to avoid freezing and transferring water is also extremely difficult.Similar problems occur with sewage waste pipes where there is a real danger of sewage freezing and blocking the system.

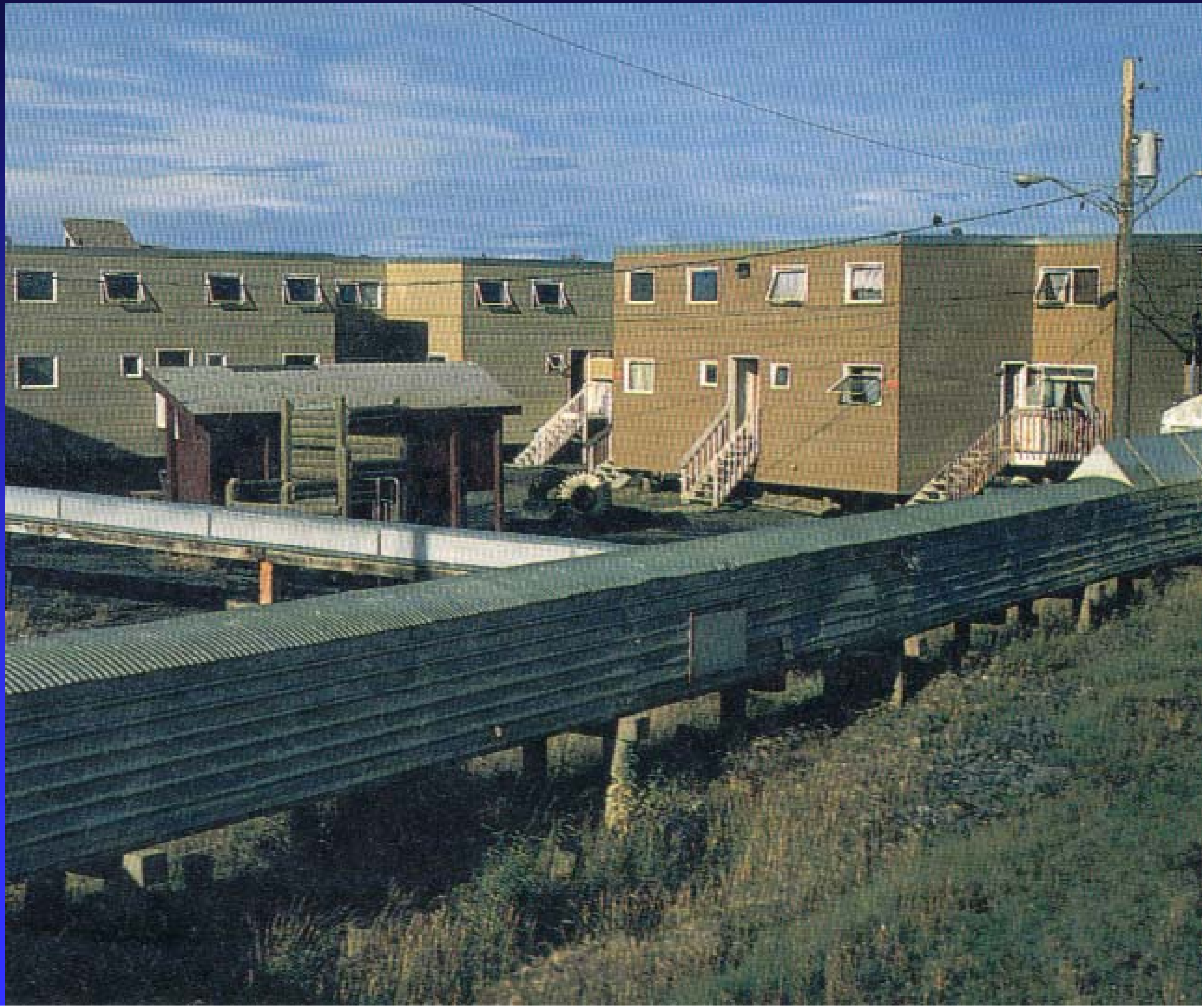
One answer is to heat the pipes which are held in utilidors using steam.



Buried utilidors, unless well insulated, can heat the surrounding permafrost which leads to irregular subsidence of the utilidor resulting in broken pipes.

Another solution is to elevate the insulated utilidor above the ground surface, supported on stilts which are buried in the permafrost. This is effective but expensive, an eye-sore and inconvenient in more densely populated urban areas where they have to be built to avoid roads and other transport links.

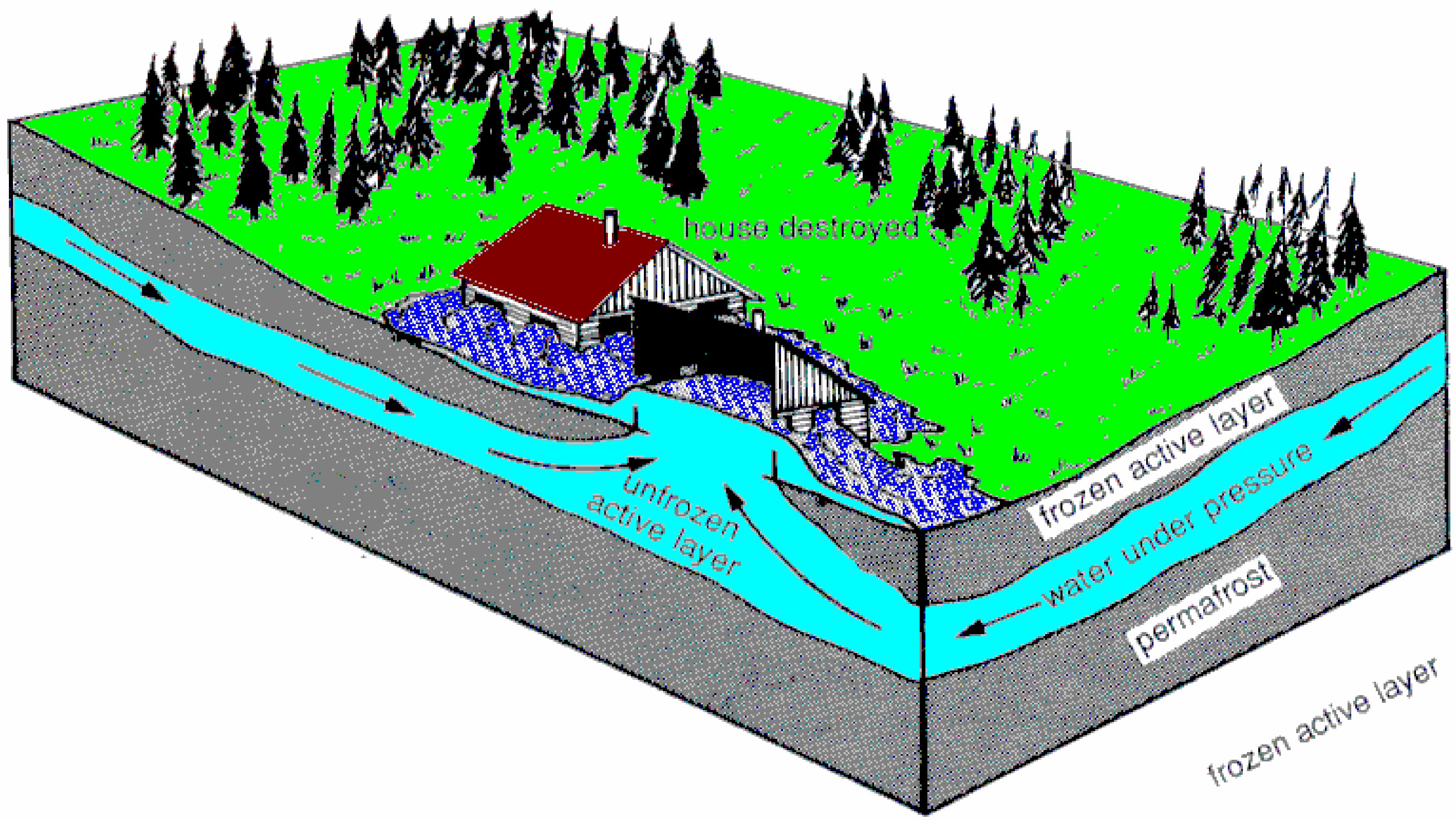
Elevated utilidors in Inuvik, Canada. They are built with a steel frame and aluminium panels. They are heated by steam to prevent freezing but heat loss is minimised by fibrous insulation.



Freezing of Trapped Throughflow

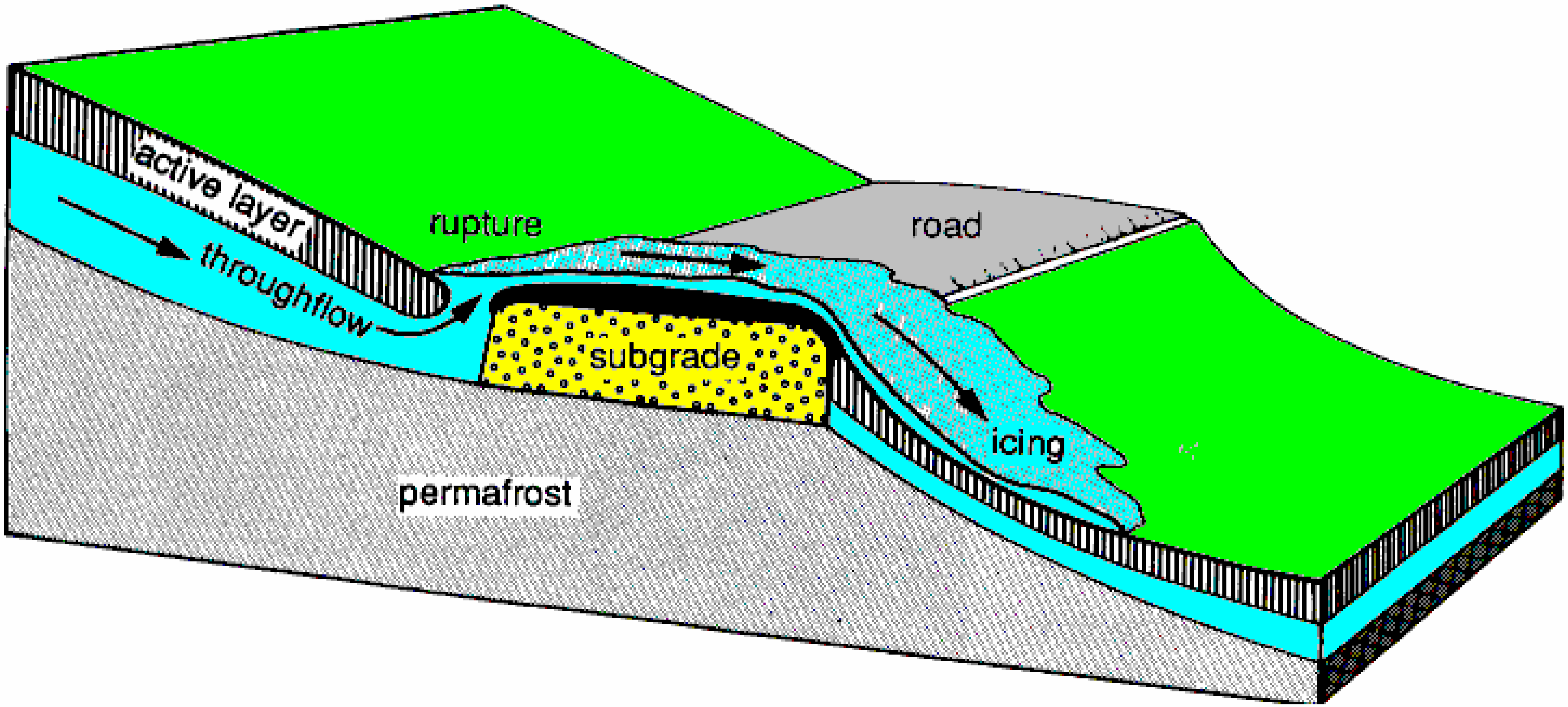
Soil water can be a problem in permafrost regions, particularly in Autumn. It can flow downslope and can be trapped between the permafrost and the thickening frozen part of the active layer which freezes from the surface downwards.

As the freezing (and consequent expansion) continues, the remaining soil water is put under increasing pressure and it may break through where the frozen surface is at its thinnest. This may be where human activity has disturbed the surface or where an artificial heat source, such as a house, has led to a thinning of the frozen part of the active layer.

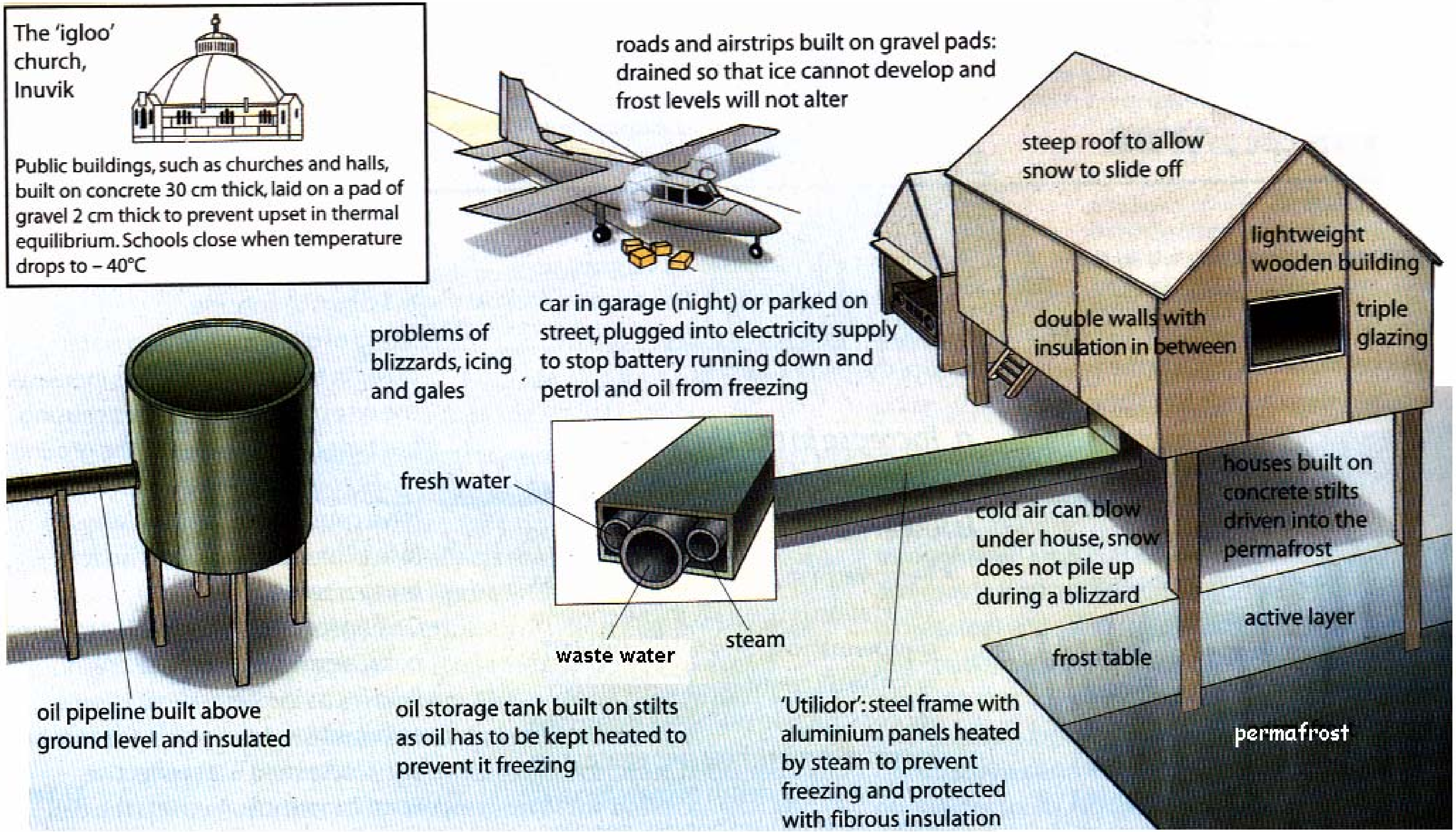


Water moving downslope under hydrostatic pressure is trapped between the thickening surface frozen layer and the underlying permafrost. The unfrozen ground beneath the building provides an exit for the water and it burst through the floor. As the water freezes, the building fills with ice.

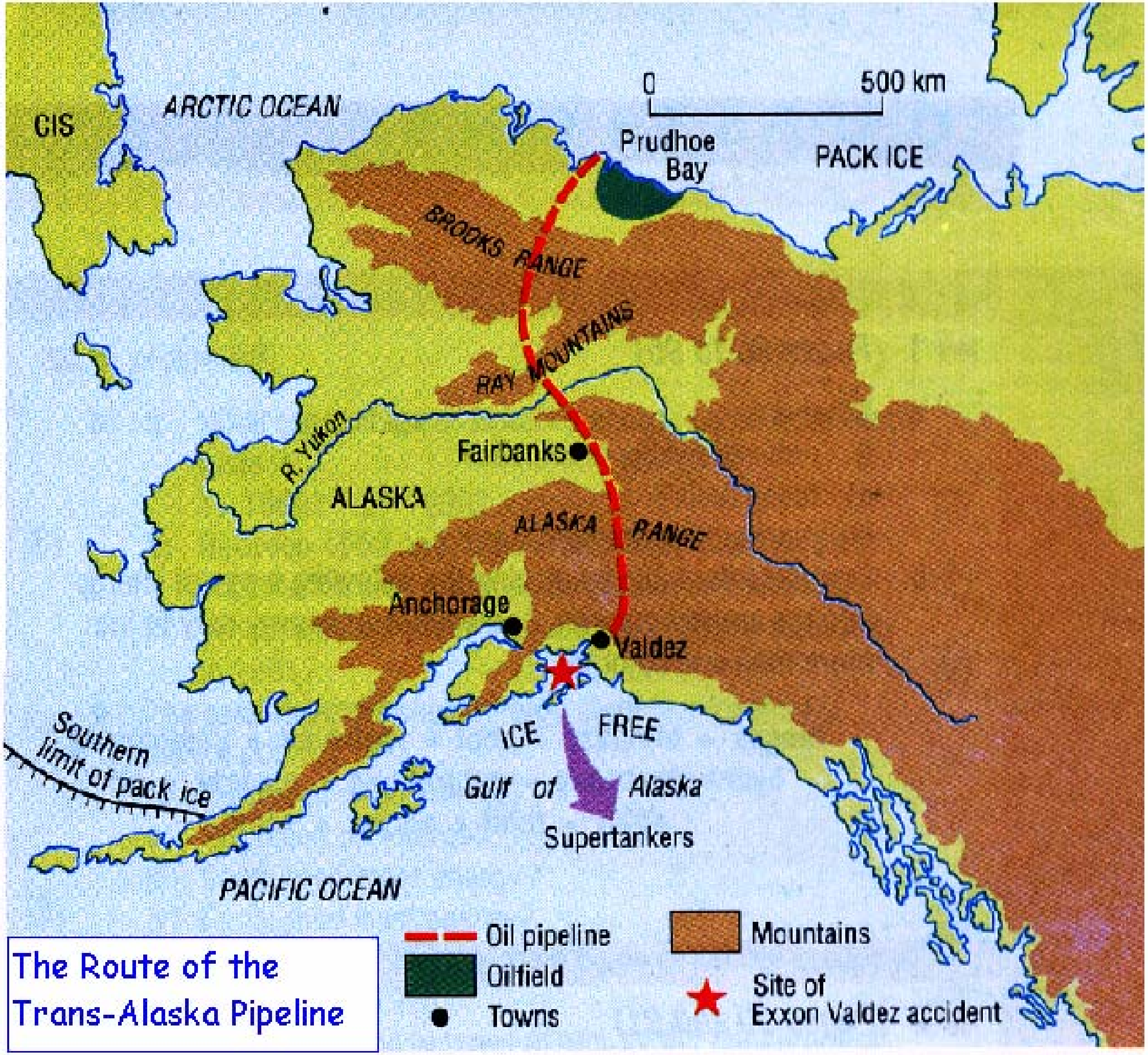
Where springs emerge at the foot of a hill or above a road or rail cutting, the seeping water will freeze and produce “icings”. Autumn frost penetration is greater where there are artificial materials or where the natural vegetation has been removed, so the active layer will freeze to the permafrost more quickly. This may block natural throughflow. The frozen soil will rupture and water trapped upslope will spill out onto the road or railway leading to icing.



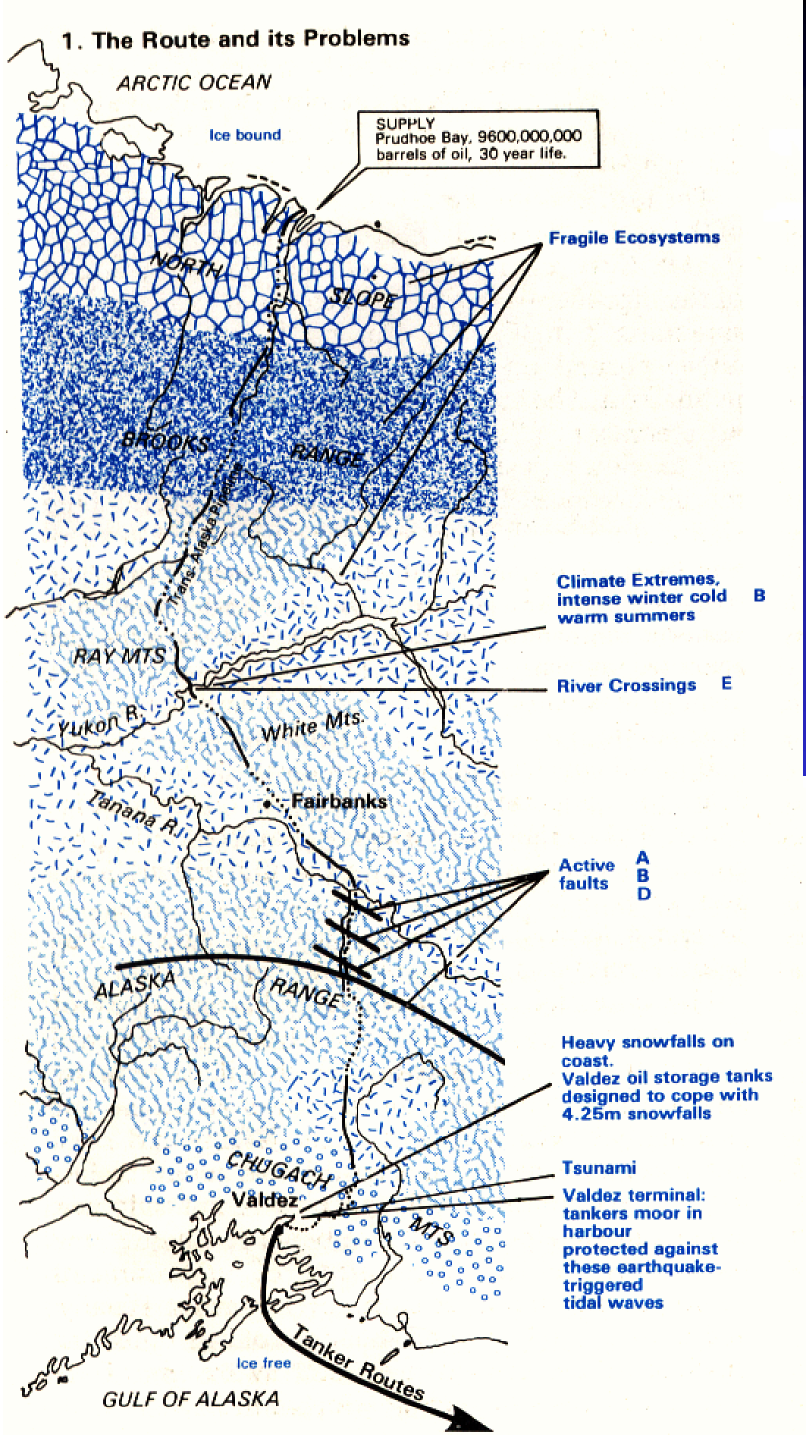
A Summary of Some of the Engineering Solutions in Permafrost Landscapes.

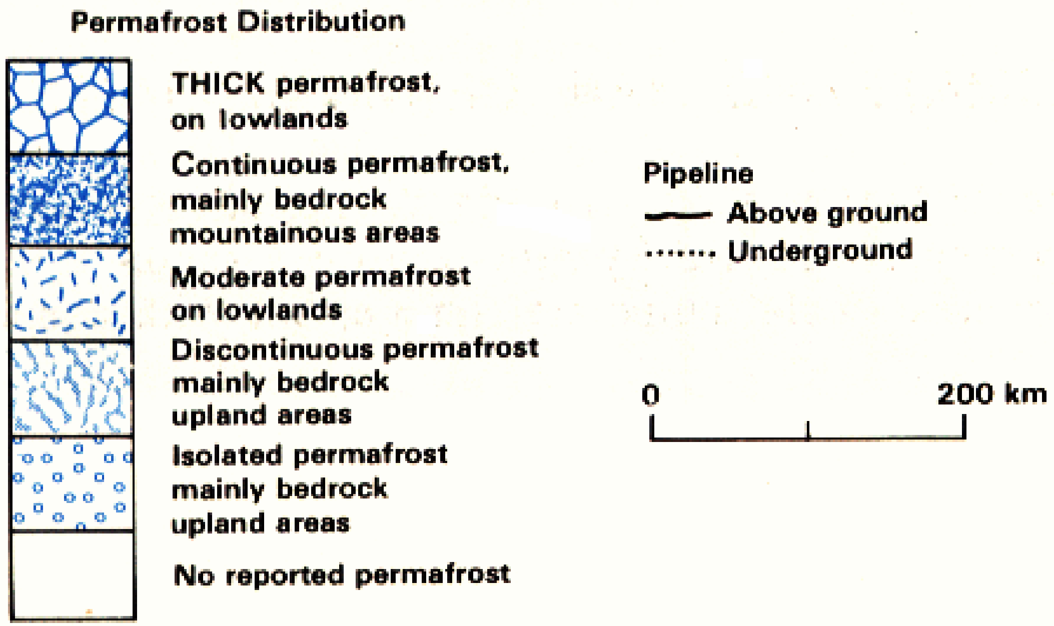


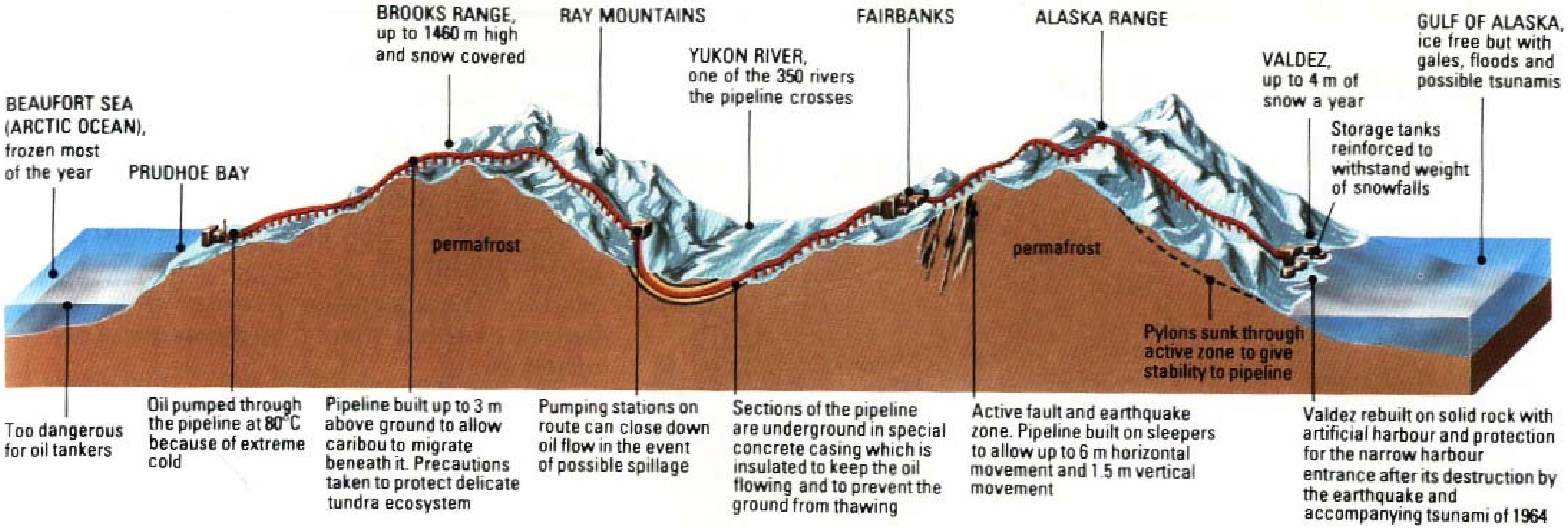
The Trans-Alaskan pipeline was a major challenge for engineers working in permafrost areas.



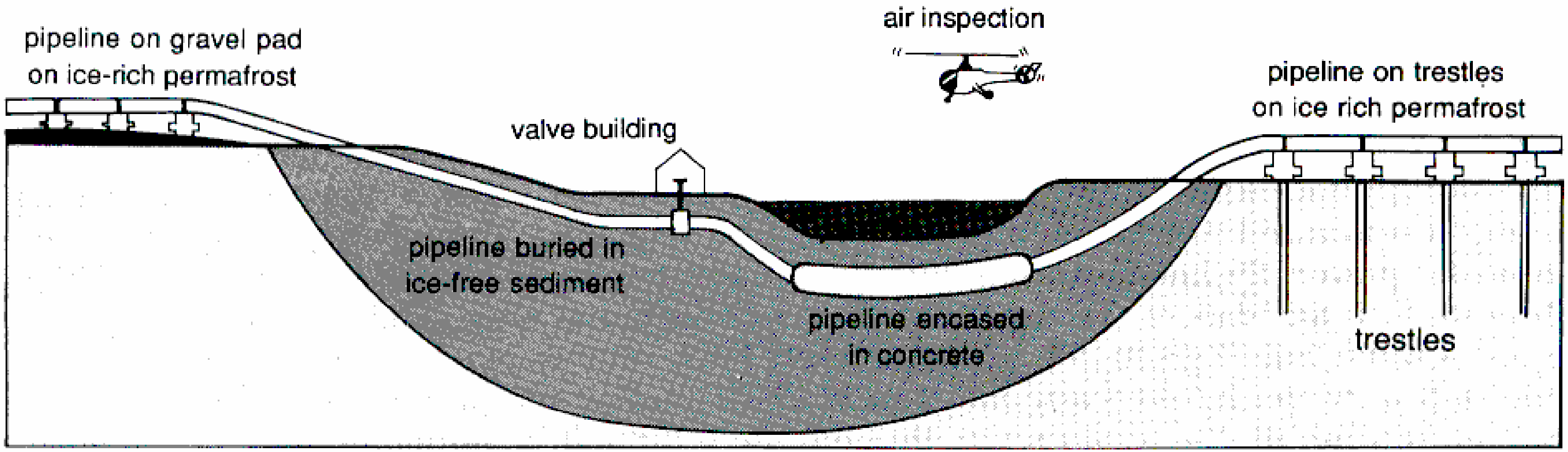
Some of the Challenges of the Trans-Alaskan Pipeline Route

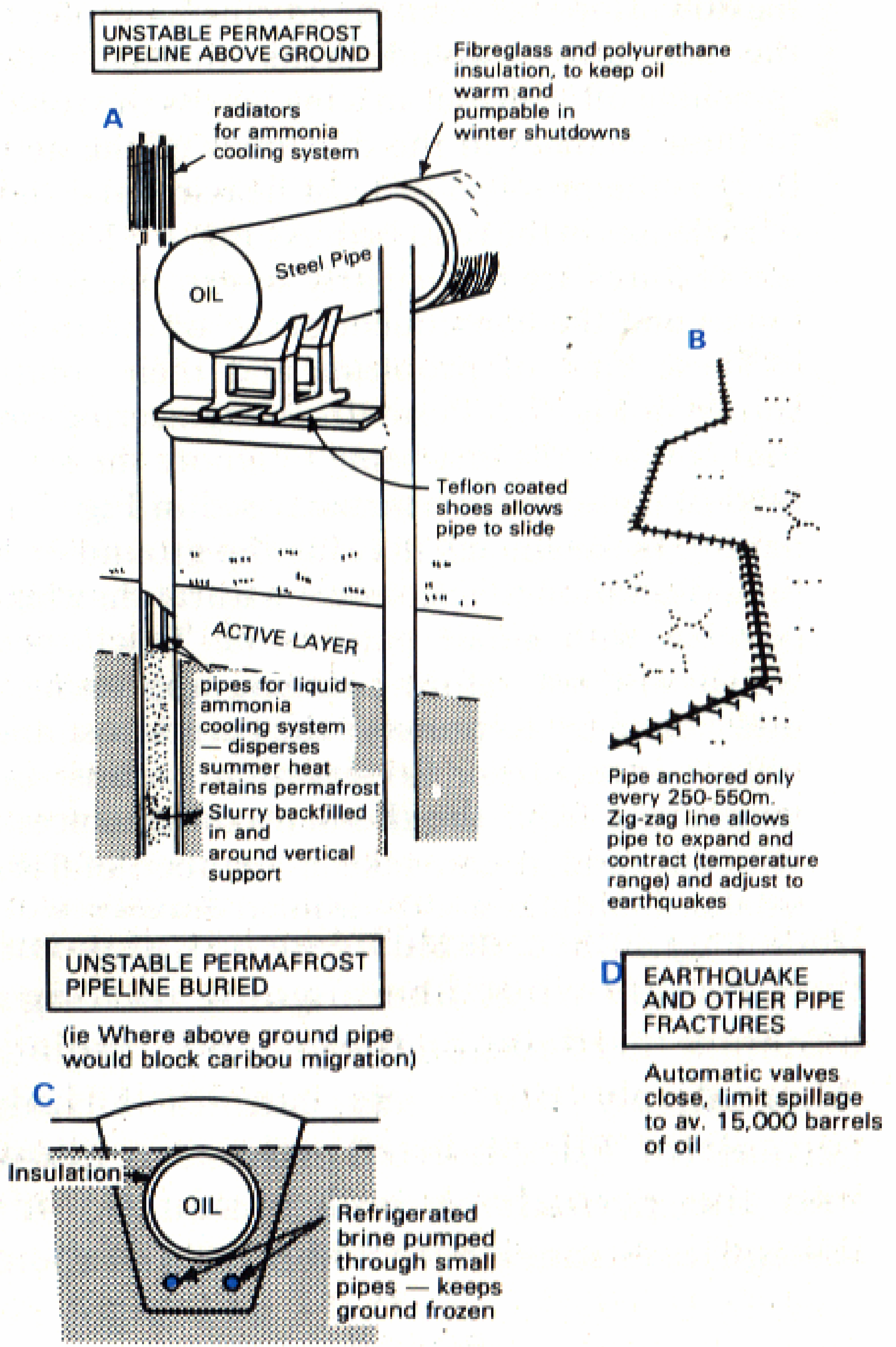


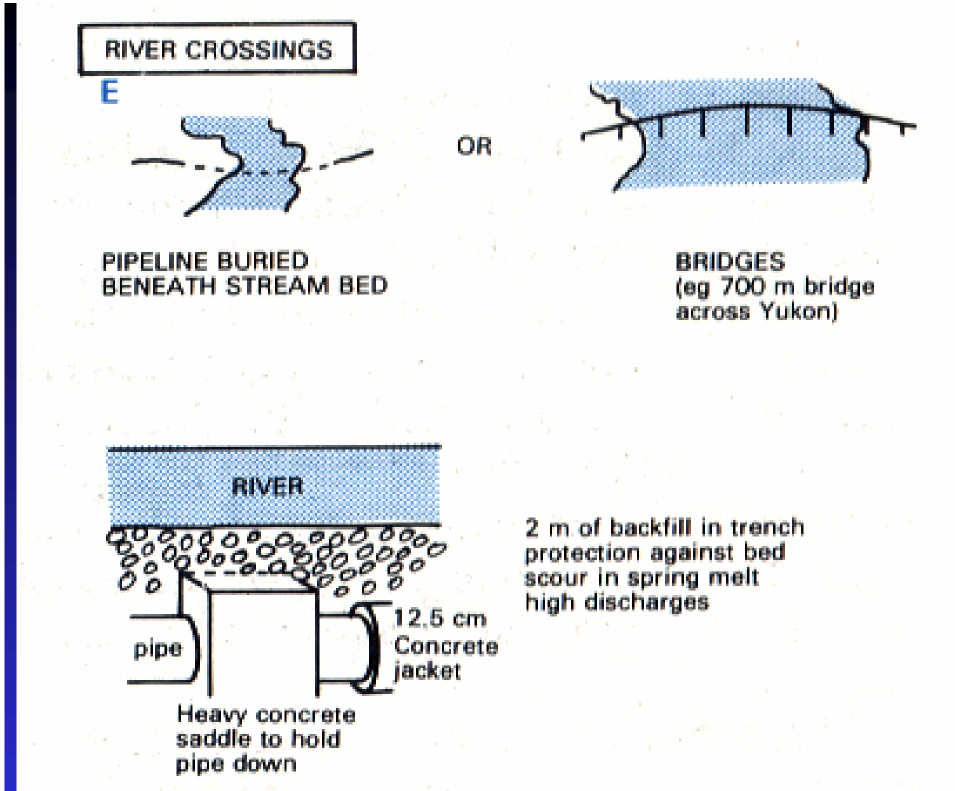




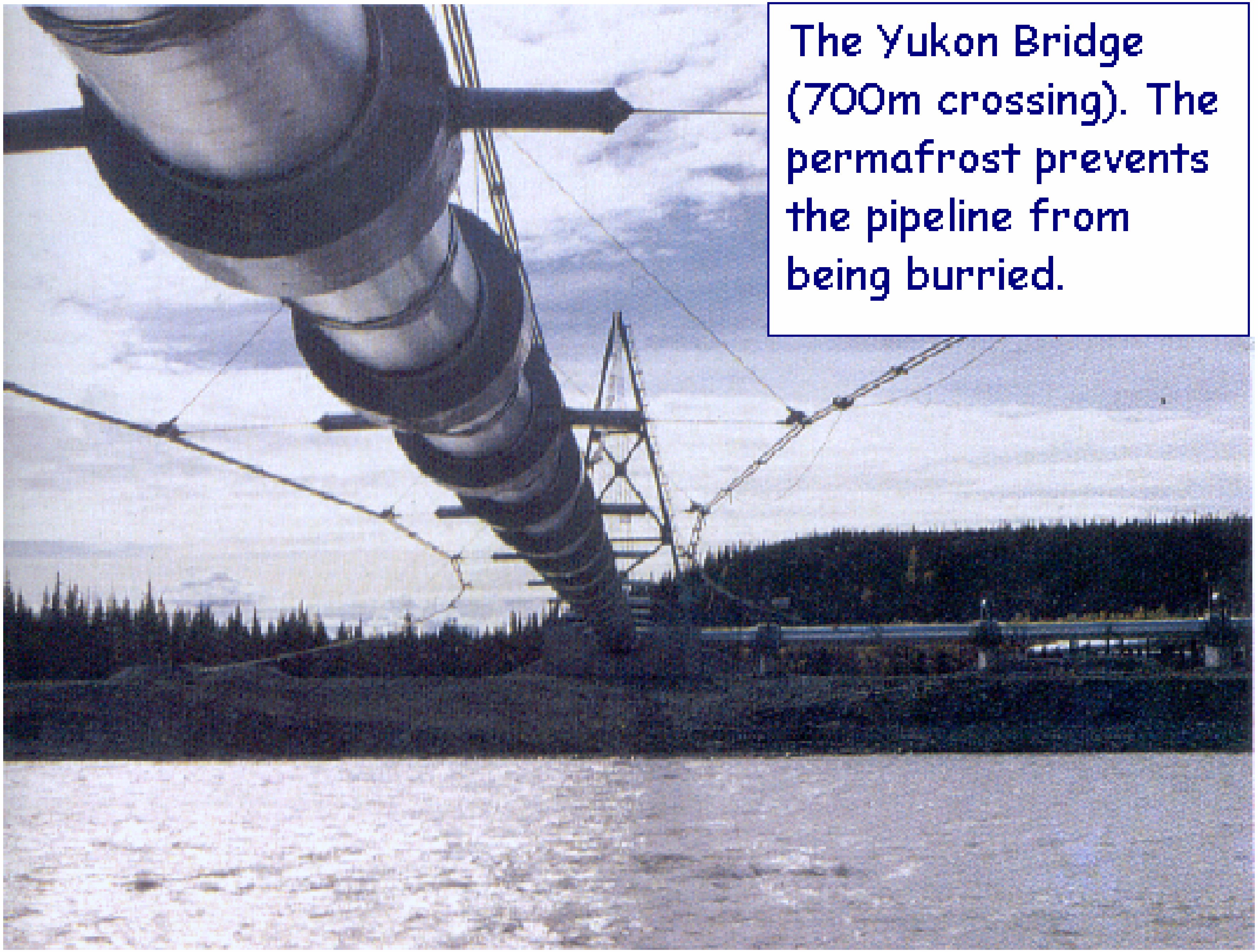
Engineering Solutions to the problems of Permafrost







Engineering Solutions to the Problems of the Trans-Alaskan Pipeline Route.



The Yukon Bridge (700m crossing). The permafrost prevents the pipeline from being burried.

Human Activity in Areas of **Periglacial Landscapes**

The impact on **building** and **communications** has already been looked at in depth.

Consider the impact of the landscape on:

- Agriculture.
- Mineral extraction (such as oil).

Agriculture

Advantages

The “coombe rock” in the Downs and Chiltern Valleys, which was formed by gelifluction (solifluction) processes in the Devensian Glacial, now provides a relatively fertile and freely drained base for cereal farming and cattle pasture.

Loess or limon (or brickearth) deposits are windblown silts which have been blown away from glacial outwash deposits. Thick deposits are found across central Europe, Russia the Ukraine and China. The soils derived from loess are of the highest quality and are used for grain farming, market gardening and horticulture.

Disadvantages

Farming in present periglacial environments is very restricted because of the short growing season. In favourable areas, for example on south facing slopes near Fairbanks, summer pasture is grown for commercial sheep, dairy or beef farming but livestock have to be housed and stall fed in the long cold winters.

Mineral extraction (such as oil).

Advantages

There are few advantages of peri-glacial environments for mineral extraction.

Disadvantages

Oil exploration and extraction in Prudhoe bay in northern Alaska is set major challenges by the unstable nature of permafrost. Oil rigs access roads and other installations have to be built on large gravel pads.

Considerable long-term environmental damage can be created by human activity in such areas.