10. Permafrost

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10.1 Introduction

Approximately eighty per cent of Alaska is underlain by permafrost. Much of this permafrost is warm and ice-rich and some of it is currently thawing (Osterkamp 1994; Osterkamp and Romanovsky 1997). If the current climatic warming continues, additional ice-rich permafrost will thaw creating thermokarst terrain. This is an uneven surface topography consisting of pits, troughs, mounds, and depressions (which may be filled with water) that forms as a result of thawing large volumes of underground ice. Thermokarst terrain severely impacts human and animal activities and can damage or even destroy the infrastructure and ecosystems that rely on the permafrost for a foundation (Osterkamp 1982, 1994).

The ice in ice-rich permafrost occurs primarily in the top 10 to 15 m of permafrost. Since permafrost thaws slowly from the top downward in response to warming at its surface (sparse data indicates values <0.2 m yr-1; Osterkamp and Romanovsky 1997), the problems caused by thermokarst terrain will be long-term. They would begin at the time that thawing starts and can be expected to last for a century or more. The amount of vertical settling produced by thawing ice-rich permafrost depends on the amount of ice in the permafrost.

In Interior Alaska, maximum values for subsidence of the ground surface because of thawing ice-rich permafrost are in the range from 5 to 10 m (Osterkamp et al. 1997).

The past is replete with examples of the effects of ice-rich permafrost on human activities and ecosystems (Pewe 1982; Osterkamp 1982, 1994; Osterkamp et al. 1997). These include:

- Abandoned and damaged houses in Alaskan communities (Fig. 10.1).
- Abandoned building at a radio transmitter site near Fairbanks.
- Abandoned hospital in Kotzebue.
- Abandoned and damaged roads and bridges (Fig. 10.2).
- Specialized and more expensive construction methods for roads, airports, pipelines and other structures (Fig. 10.3).
- High maintenance costs for roads, buildings and airports.
- Shortened lifetimes for roads and airports requiring short reconstruction cycles.
- Relocation of roads and airports caused by the presence of ice-rich permafrost and other related factors such as land slides.
- Thermokarst damage to agricultural fields.
- Increased sediment loads and siltation in rivers (Fig. 10.4).
- Destruction of trees in the boreal forest (Fig. 10.5).
- Ecosystem damage and destruction such as that occurring in the Tanana Flats, Mentasta, Healy and Cantwell areas (Fig. 10.5).

Figure 10.1. This house damaged by thermokarst in the Fairbanks area had to be abandoned.

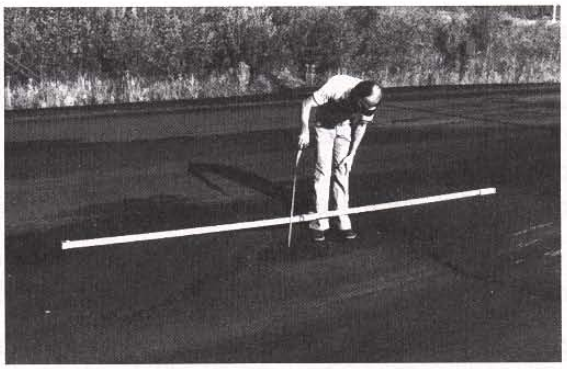

Figure 10.2. Thawing of ice-rich permafrost and the resulting thermokarst caused this road to settle which required repeated patching to keep the road in service.

Figure 10.3. Trans-Alaska pipeline showing the above ground portion of the pipe supported by naturally refrigerated pilings. This expensive construction mode was required because of the presence of ice-rich permafrost which had to be kept frozen.

Figure 10.4. This river bank in ice-rich permafrost has been undercut a distance of several meters. The bank will eventually collapse putting trees, shrubs, organic material and large volumes of silt into the river increasing the sedimentation problem.

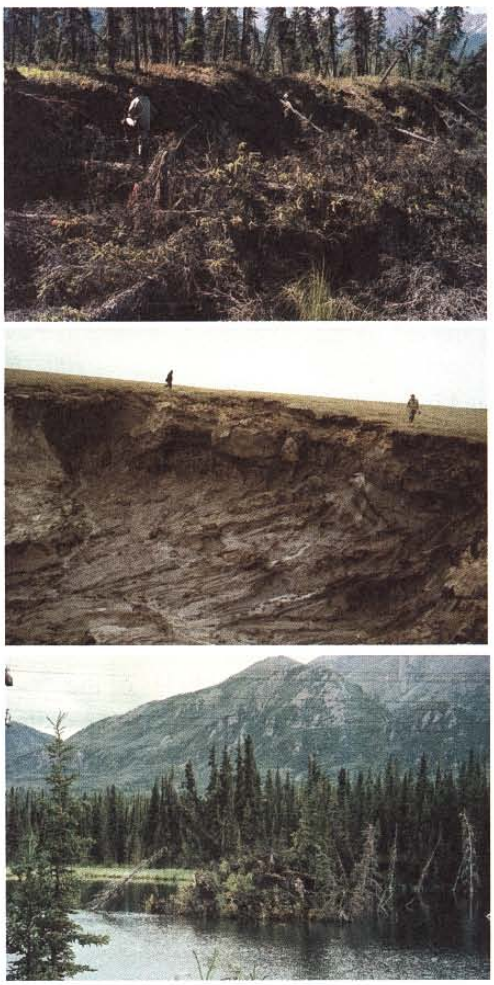

Figure 10.5. Examples of how existing ecosystems have been destroyed and are being replaced by new ecosystems as permafrost thaws:
a. Active thermokarst that is altering the boreal forest near Tok, Alaska, in an area of warm, discontinuous permafrost;
b. Active thermokarst in an area of continuous permafrost on the Gydan Peninsula, Russia;
c. An active thermokarst that has resulted in a pond. More than 5 m of vertical settling occurred. Note the dead trees in the water and tilted trees on the island, indicating that settling is still in progress (photos by Tom Osterkamp)

These impacts are a direct result of thawing ice-rich permafrost, subsequent settlement of the ground surface and creation of thermokarst terrain. Individuals have most often abandoned or moved houses and cabins when the effects of thaw settlement made them unusable. In a few cases, innovative designs were developed to retard or reverse the thawing which allowed continued use of the structures.

The human infrastructure that is affected by changes in the permafrostconsists of the basic installations and facilities on which individuals, families, communities and governments depend for their continuance and growth. In a broad sense, these systems include providing for food (including subsistence activities), water, waste disposal, transportation, communication, education, health and medicine, power, and goods and services for society. Disruption of these systems, including increased costs as a result of climatic warming, would have negative impacts on individuals and directly influence social, economic and political functions.

Much of the public infrastructure in Alaska has been placed under the Alaska Department of Transportation and Public Facilities (DOTPF) which is responsible for design, construction and maintenance of most roads, airports and many public buildings. Local government, federal agencies and industry are also responsible for design, construction and maintenance of the infrastructure. In 1990, in a cost-cutting move, the Alaskan legislature dissolved the DOTPF research laboratory which was involved in geotechnical research on permafrost. This may have led to the failure of remediation schemes used in recent road reconstruction efforts over ice-rich permafrost. Current and future projects where thermokarst degradation has occurred or is expected to occur include:

- Chena Hot Springs Road near Fairbanks which is being reconstructed because of thermokarst damage to the roadway. However, no special precautions are being taken to mitigate thermokarst problems. Pavement failures are expected soon after construction.
- The Deadhorse Airport runway and taxiway are being reconstructed because of settlement due to thawing permafrost. That permafrost has warmed about 4°C during the last decade.
- The recently proposed route for a road or railroad into Kantishna is over warm ice-rich permafrost and some of that permafrost is currently thawing (Osterkamp 1994).

Thermokarst reduces the useful lifetime of highways and airports and many highway and runway sections on permafrost must be releveled and repaved on a 6 to 8 year cycle. It is sometimes necessary to shorten airport runways due to a lack of funds for pavement repair which necessitates the use of smaller and more expensive aircraft. Some airports and road sections have been abandoned because of thermokarst problems.

It appears that engineers have few solutions to thermokarst problems. The policies of the DOTPF and other state entities and federal agencies have resulted in large maintenance costs for Alaska and direct public impacts. Apparently, there are no studies evaluating these policies.