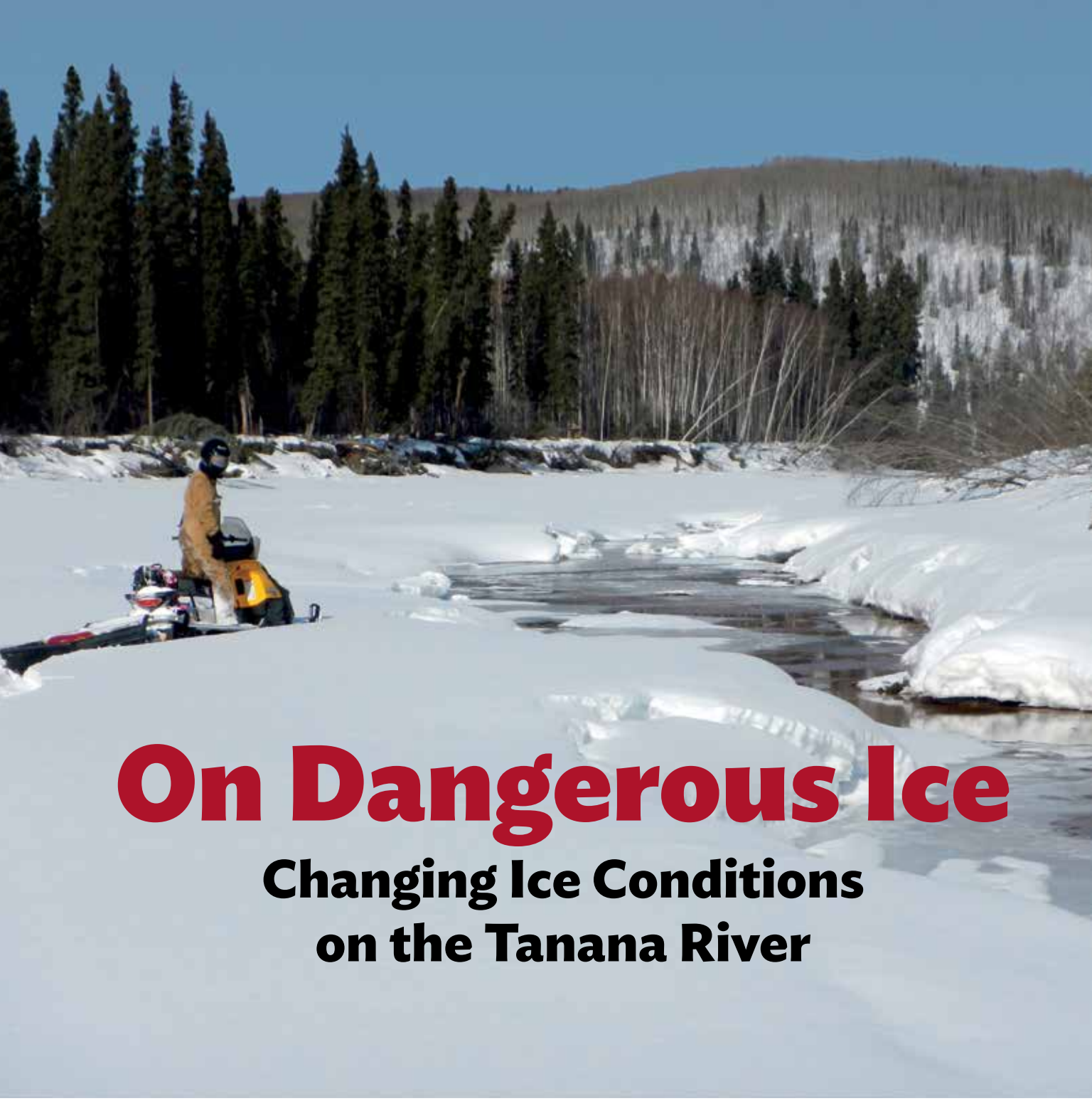

On Dangerous Ice

Changing Ice Conditions on the Tanana River

By William Schneider, Karen Brewster, Knut Kielland, and Chas Jones

In consultation with Charlie Campbell, Wally Carlo, Sam Demientieff, William Demoski, Ronnie Evans, Espen Jervsjo, Dave Norton, Neil Scannell, and Charlie Wright

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Contents

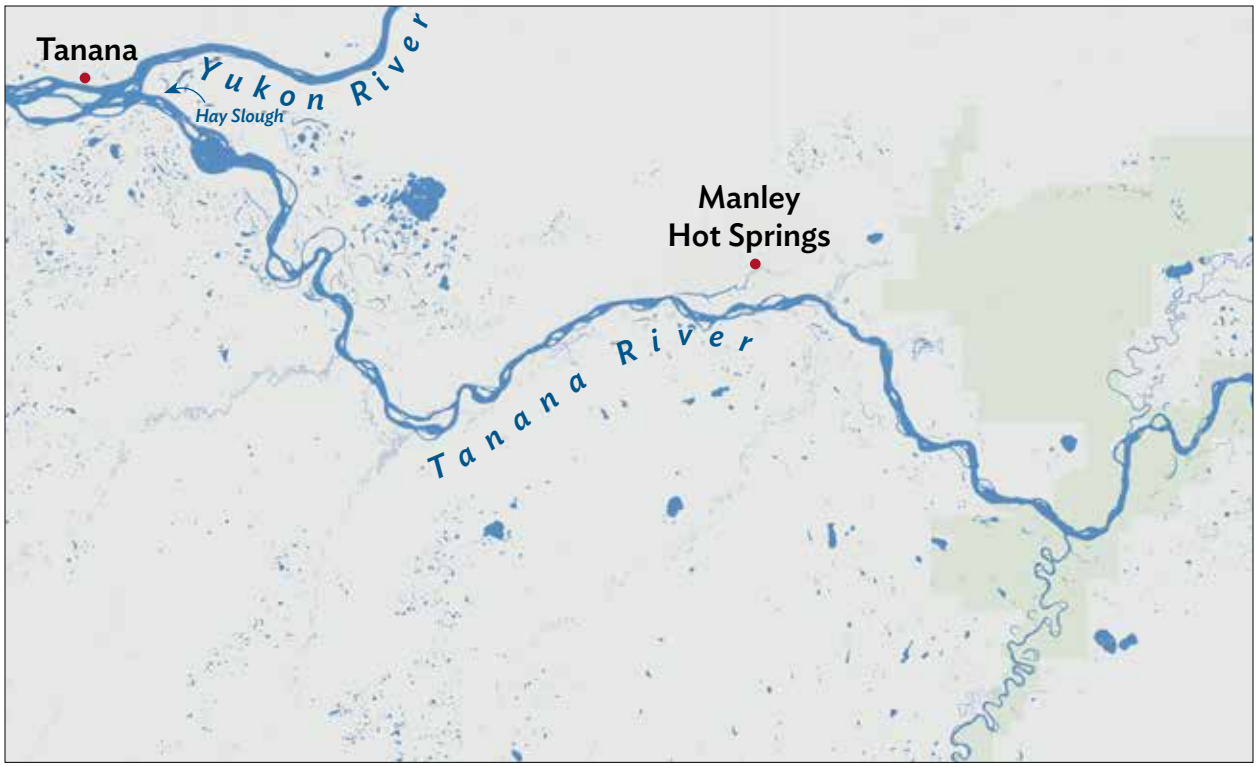
Welcome!

For many Alaskans, fall freeze-up and the subsequent blanketing of the country in snow means increased freedom for travel through the country. In contrast to more southerly latitudes, Interior Alaskan winter is a time of predictable stability — consistent snow cover and firm ice from November through March. No problem there. But as seasoned winter travelers know all too well, there are dangerous exceptions to this generalization. The Tanana River, by accident of geography and geology, exhibits unique hydrological characteristics. One of these is extensive ground water upwelling that results in ice thinning or outright melting in mid-winter. Another is bank erosion, where car-sized chunks of river bank may break off during a 30-below January day and smash through two feet of river ice! Over the last twenty-some years of traveling the Tanana River with my dog team doing science or trapping, I have had the privilege to observe these events on numerous occasions. My friend Bill Schneider and I finally put together a project — Dangerous Ice — to more formally look into this fascinating feature of the Tanana River. With support from the National Science Foundation, the guidance and help from several knowledgeable old-timers and young-timers, scientists, and students, we examined both the physics and human dimensions of dangerous ice. This booklet is an attempt to reach the public in a continuing exchange of knowledge regarding this fascinating environmental phenomenon.

—Knut Kielland
Institute of Arctic Biology, UAF
Principal Investigator, *Dangerous Ice: Human Perspectives on Changing Winter Conditions in Alaska*

Introduction

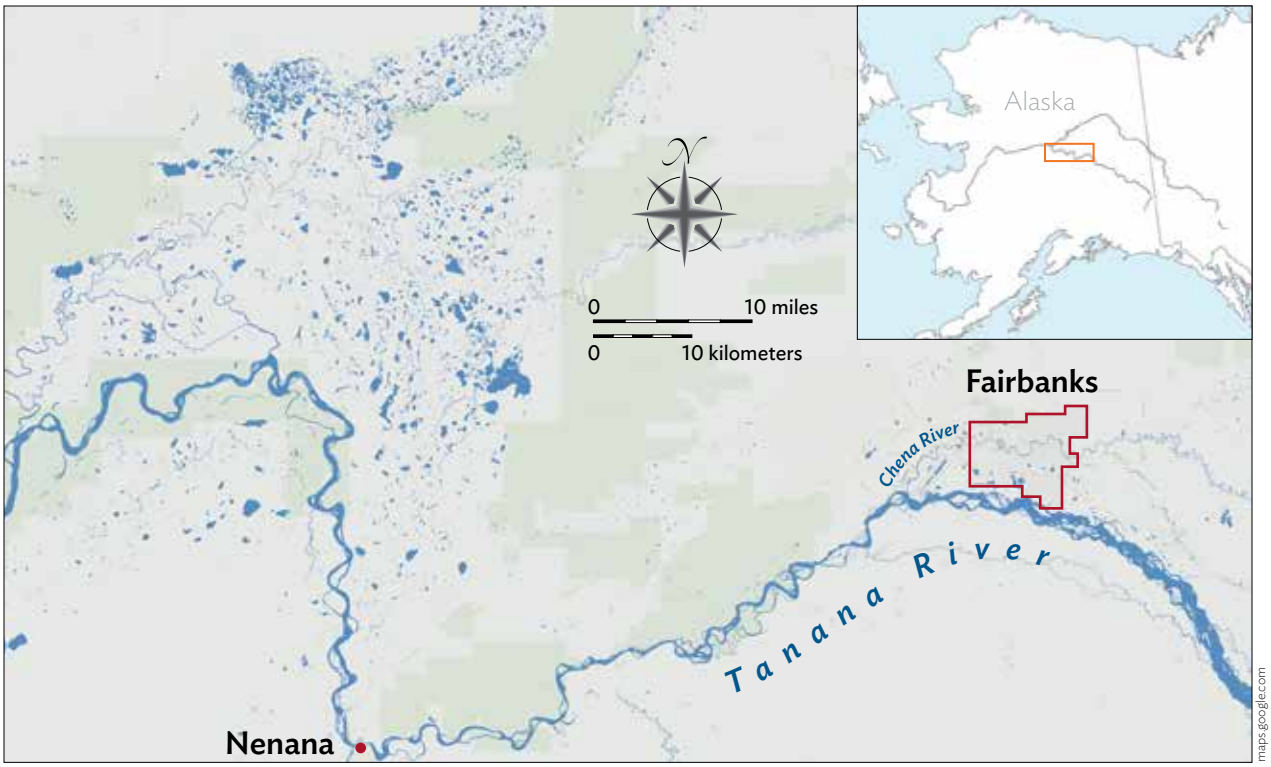
This booklet is about river ice conditions and provides general tips and guidelines for safe wintertime travel on the Tanana River. We focus specifically on three sections of the Tanana River: between Fairbanks and Nenana; between Manley Hot Springs and the village of Tanana at the confluence of the Tanana and Yukon rivers; and Hay Slough, a commonly used route between Manley and Tanana.



This is not meant as a guide for all rivers in Alaska. Each river behaves differently. And even on the same river, conditions will not necessarily remain constant. Conditions can change very quickly from day to day, from one section of river to the next, as well as from season to season and year to year.

The Dangerous Ice Research Project was a National Science Foundation supported investigation of ice conditions on the Tanana River from 2004 – 2007 and 2010 – 2012. The purpose of the project was to engage local river travelers and scientists in an investigation of "dangerous ice."

From the start, local river experts were asked to lead the team to places they identified as dangerous based on their experiences and observations over time. Discussions at the sites were videotaped and photographs were taken to create an audio and visual record of what we were seeing on the river. Scientists on the team used measurements of ice thickness, water and sediment temperature, and conductivity to help explain the observed conditions, and demonstrate scientific principles related to freezing and thawing of river ice. By virtue of the way the research was done and the composition of the team, the distinctions between local experts and scientists became less important as the team



gained common experiences at the sites and shared their different perspectives.

This booklet was developed because local river travelers wanted the findings of the research group to be shared in a practical way with the general public. Based on the range of conditions observed, we are able to illustrate and describe particular significant situations that the members of the group all recognized were dangerous. In the following pages, we visually show and explain dangerous ice conditions; describe some of the underlying physical processes; and provide general safety tips for avoiding and getting out of danger. The hope is that river travelers will find this booklet useful for learning about conditions they may encounter and how to stay safe. We want to emphasize that this booklet is not a substitute for experience on the river, common sense, and communication with other river travelers.

The results of the larger dangerous ice research project are available on-line. For more information on our site visits and scientific findings, and to watch the videotaped discussions, visit our website at **www.jukebox.uaf.edu/dangerice**.

Recognizing & Understanding Dangerous Ice Conditions

"If you have to go on the river, the best thing to do is to converse with people who know the river and have been out on it. They will tell you to watch out for this point or that slough, tell you these places. Then when you go down there, you're thinking about the people you talked to and just keep your eyes open for whatever's out there. And then it's your best judgment after that. I think the best way to get down river is to use that knowledge from talking to people and your own experience."

— Sam Demientieff, March 1, 2010

Open Leads

Open leads in the river are common and unpredictable. They may be present at any time during the winter. Attempts to "skip" across areas of open water with a high-powered snowmachine is very dangerous.

Knut Kielland

Indicators of Open Water

Look for frost on trees and rising steam as signs of open water ahead.

Knut Kielland

Collapsing Ice

As water level decreases through the winter, gaps form between the bottom of the ice and the new lower water level. Weight of this now unsupported ice can cause areas to collapse, exposing the open water below. This phenomenon may happen anywhere, but it is most common in sloughs.

Collapsing ice can cause the trail to change quickly, even if the air temperature or other weather conditions do not change.

Ice that collapses can create an ice dam if it does not erode or melt fast enough to be absorbed into the river water. Water can back up behind the dam and create overflow. Water can also back up if the channel freezes to the bottom and the flow is obstructed.

Knut Kjeland

Collapsing ice can create hidden ice ledges or holes.

Holes with ledges can form after an area has collapsed. These areas may not be obvious, because after they refreeze they may be covered by frost or new snow.

Hidden ledges can be dangerous if a snowmachine catches a ski. If you are traveling fast, you may not see ice ledges and you could easily catch a ski, get stuck, or worse, get thrown from the machine.

Ice Crystals

Ice crystals (commonly known as hoarfrost) in a crack may be caused by rising water vapor, which means that open water may exist beneath. This is often a sign of unstable ice conditions below.

"Frost flowers" (ice crystals growing from the ice surface due to moisture) are frequently found on new ice or recently re-frozen overflow (*aufeis*). On newly formed ice, frost flowers are warnings that the ice still may be thin and not strong enough to support the weight of a person or snowmachine. On re-frozen overflow, they may be a sign of solid ice. An area with frost flowers should always be tested with an axe or ice chisel.

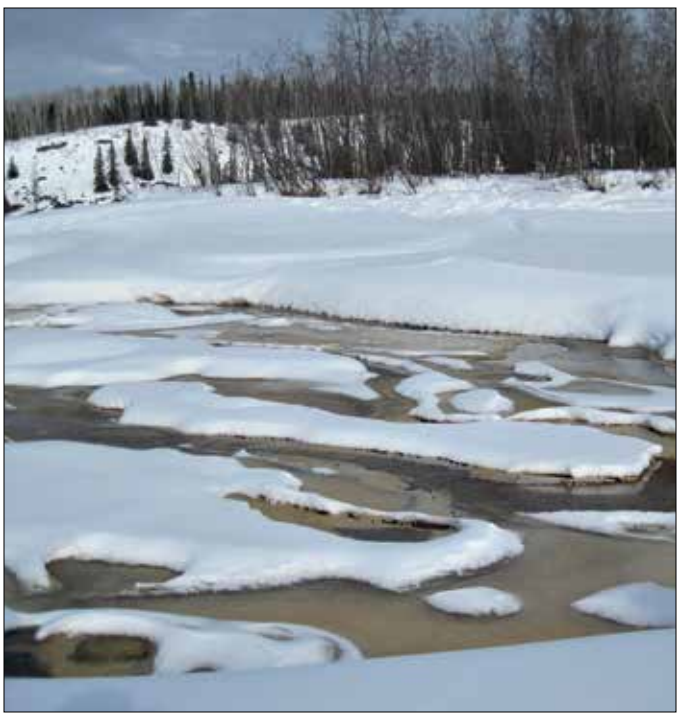
Knut Kieland

Heat Absorption Affects Ice Conditions

Warm weather, southern exposure, silt, wood, exposed cutbanks, and sandbars can accelerate ice melting.

Karl Olson

Knut Kielland



Warm weather in late spring accelerates heat absorption and ice deterioration.

Windblown silt on ice accelerates melting from the sun in the spring, which weakens the ice. This is common on the lower Tanana River.

Chas Jones

The Dangers of Steep Cutbanks and Sandbars

Sandbars with steep cutbanks can be problematic on the downwind side where drifting snow accumulates. This deeper snow insulates the ice and can keep it from freezing as thick. Southern exposure may accelerate surface melting. Care needs to be taken when approaching or exiting sandbars due to these areas of potentially thin ice.

A swift current also can accelerate ice deterioration along or underneath a bank by eroding the ice from the underside.

Knut Kielland

Dangers from a drop-off may not be obvious, depending on the direction of travel.

A steep drop-off from a cutbank or sandbar can be hard to see up ahead when traveling in low light or poor visibility. A fall from such a drop can cause serious personal injury and equipment damage. In addition to the danger of impact from a fall, there could be thin ice or open water below the bank.

Knut Kjeland

Low Flow Erosion

During the winter, there are places where the riverbank continues to erode underneath the ice. The water undercuts the bank, even at low water levels, causing the unsupported bank to be weakened or even collapse and expose open water.

"Low flow erosion takes place during low volume/ flow of the river. We see it best in the fall and winter. The top picture at right shows a portion of the river bank that has eroded and is caving in from low flow erosion. At this particular place, there is a gravel bar that was built up farther out during the summer. When the low flow of the river meets the gravel bar, water is diverted toward the cut bank, causing the erosion… The other places we see this erosion is along the lower end or downstream side of sandbars. The river flow erodes into the sandbar; it falls in, gets washed away, and leaves a big hole."
— Sam Demientieff, December 20, 2012

Knut Kielland

Chas Jones

Pits and Sinkholes

Snow may conceal thin ice. Wind blown snow can exacerbate this situation. Pits and sinkholes are signs that an area is unstable and unsafe.

Overflow

Overflow (water on ice or slushy ice) can be caused by a number of conditions.

- In **cold weather**, as ice thickens, the channel under the ice becomes constricted. Water pressure may build up forcing water through cracks to the surface.
- In **warming weather**, the higher rate of water flow increases water pressure in the narrow channel, which can cause the ice to be pushed up and crack, allowing water to seep onto the ice surface.
- **Heavy snowfall** also can cause overflow by weighing down the ice causing it to crack and allowing water to seep through.

Discussing and investigating overflow conditions on Hay Slough, March 16, 2010.

Overflow may be concealed by snow cover.

Karl Olson

Ice bulges can form when more water begins to flow into narrow channels of frozen rivers, creeks, and sloughs. The higher water volume builds pressure beneath the ice, pushing it up into a dome and causing cracks to form around the edges. Water seeps to the surface through these cracks, creating open water (overflow) or buildup of frozen overflow (*aufeis*) around the sides. A snowmachine traveling over one of these domes can lose traction and slide sideways down the dome.

Water mixing with snow creates a "mashed potato" slushy ice consistency that sticks to sled runners and snowmachines, making travel difficult and often impossible. It is easy for heavy snowmachines to get bogged down and stuck in this soft, slushy mix.

Courtesy of Knut Kielland

Knut Kielland and his dogteam navigating overflow on the Anaktuvuk River.

Knut Kielland

Hugh Richards' dog team and sled wallowing in water mixed with snow on the Tinayguk River.

Groundwater Seepage

Regardless of air temperature, water from groundwater springs can seep up through degraded or cracked ice. This can create pools of water on the ice.

Overflow on Hay Slough, March 16, 2010.

The heat from warm groundwater can melt ice from **below**, causing open areas to form even in very cold weather.

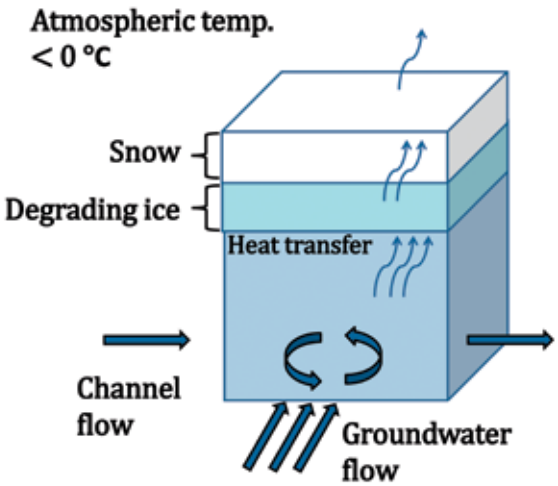


Diagram by Chas Jones

"Earlier in the winter, the water levels are higher so the ice is sitting up. There's a good flow of water so that heat in the water is being carried away. But as the general water level in the slough and the river drops, then the ice falls with it, and a lot of this ice now is sitting on the bottom. If there's a spring, now it is in direct contact with the ice. And it's going to be much more effective at melting that ice."

— Martin Jeffries, February 2, 2006

Water temperature readings at the mouth of the Chena River indicate possible seepage of warm water in the shallow channel.

"Hay Slough opens in the fall time, then it heals up, then when it warms up in the spring it opens up again. I think every time the weather warms up the sunny side of the ridge back there, it contributes to all the water coming down through contributaries, and hitting the slough here [and making it dangerous]."
— Charlie Wright, March 2, 2011

A notoriously bad spot on Hay Slough that people can avoid by following a portage trail, March 2, 2011.

Beavers Can Cause Areas of Thin Ice

Thin ice or open water may be found around beaver houses, dams, and feed piles. The animals' constant activity keeps the ice from getting thick.

Knut Kieland

Year-round River Observation

"Every year things change on the river. You have to be paying attention. You have to be watching the river all year long to see what it is doing, and how that will affect things later in the season."
— Sam Demientieff, March 1, 2010

For example, if you watch the river during the summer, you know where the river channels are, and in the winter you may be able to estimate water depth in places where there is open water.

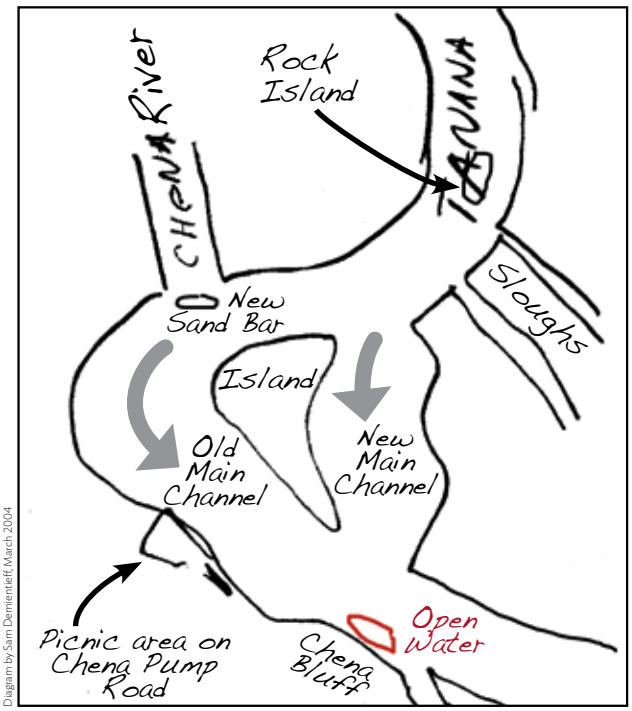


Diagram by Sam Demientieff, March 2004

maps.google.com

Changing flow patterns of the river may change ice conditions and locations of previously known ice hazards.

These diagrams show the new main channel of the Tanana River hitting the Chena Bluff. The increased water and turbulence causes this area to freeze later and break up earlier than it used to. Sometimes, the only safe way to travel through here is along a narrow strip of safe ice between the bluff and the deep, fast-moving open water. Also, the turbulent water here now often creates rough ice that piles against the bluff.

Getting To Know Dangerous Ice Through Science

Scientific instrumentation is used to measure water temperature, the water's chemical composition, water depth, ice thickness, and air temperature.

Karl Olson

Knut Kielland

An ice drill is used to measure river ice thickness.

Data loggers are used to record the temperature profile from the groundwater through the water column, ice, snow, and into the air to better understand how groundwater can control river ice thickness.

The source of the river water is determined by measuring its chemical and physical properties. Scientific analysis can tell us where the water in the river comes from; whether it is groundwater, snow melt, or direct precipitation.

Groundwater Sources

"Water chemistry and isotopic composition can be used to gain insight about the original source of a particular water sample. For example, the isotopic signature of groundwater adjacent to the Tanana River may indicate that the water had likely traveled within the groundwater system from the Alaska Range over a long period of time, or it may indicate that the water recently fell as precipitation and had only traveled a short distance through the floodplain before being sampled."
— Chas Jones, February 19, 2013

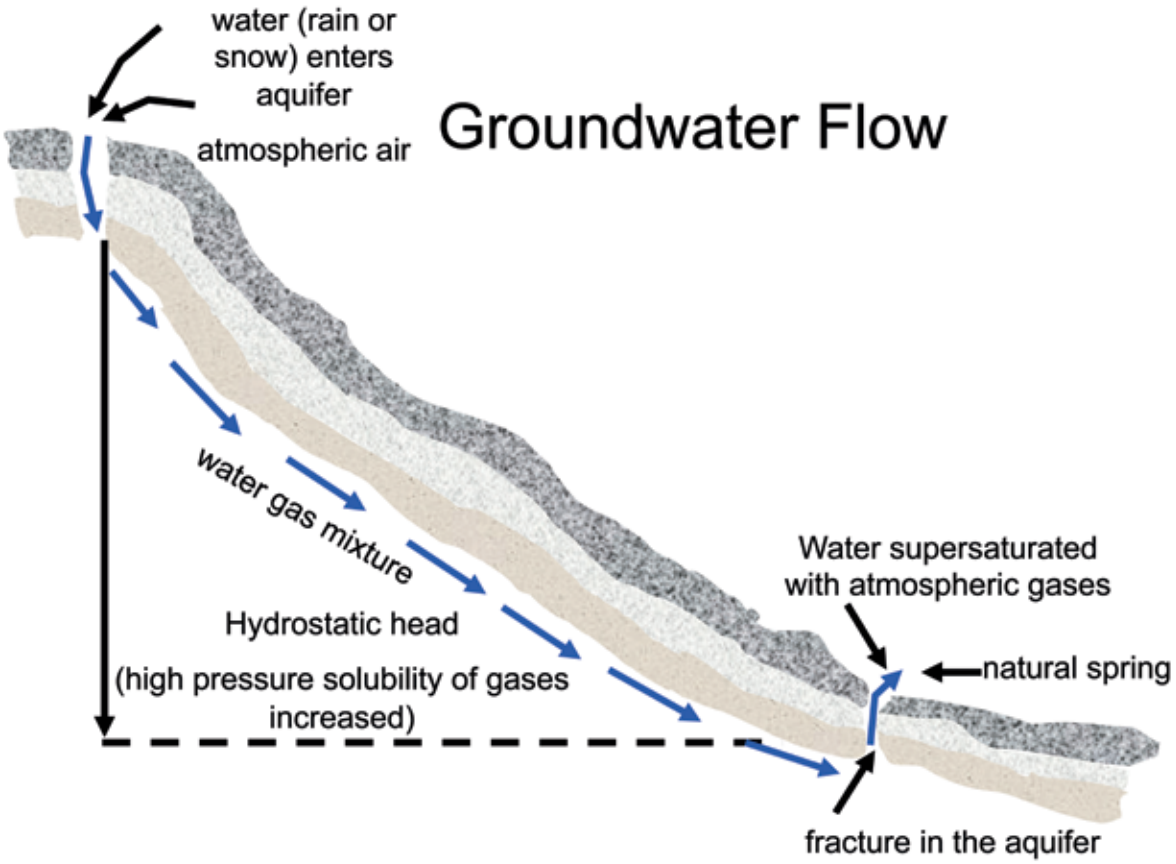


Diagram courtesy of Larry Hinzman, adapted from Post, G.W. *Textbook of Fish Health*, 1983, p. 249.

Knowing the water and sediment temperature is important for determining the presence and impact of groundwater in any given area of the river. The temperature of the groundwater and the volume entering the river influences ice development and presence of open water.

Date: *March 23, 2011*

Location: *Tanana River near Howard Luke's Camp*

Sediment temperature: *0.5 degrees Celsius (33°F)*

Water depth: *75 cm (2.5 feet)*

Date: *March 23, 2011*

Location: *Tanana River near Peirce's Island (named for Walt Peirce)*

Sediment temperature: *0 degrees Celsius (32°F)*

Water depth: *2 meters (7 feet) with a current estimated to be moving at 2 meters/second (6 mph)*

Date: *March 23, 2011*

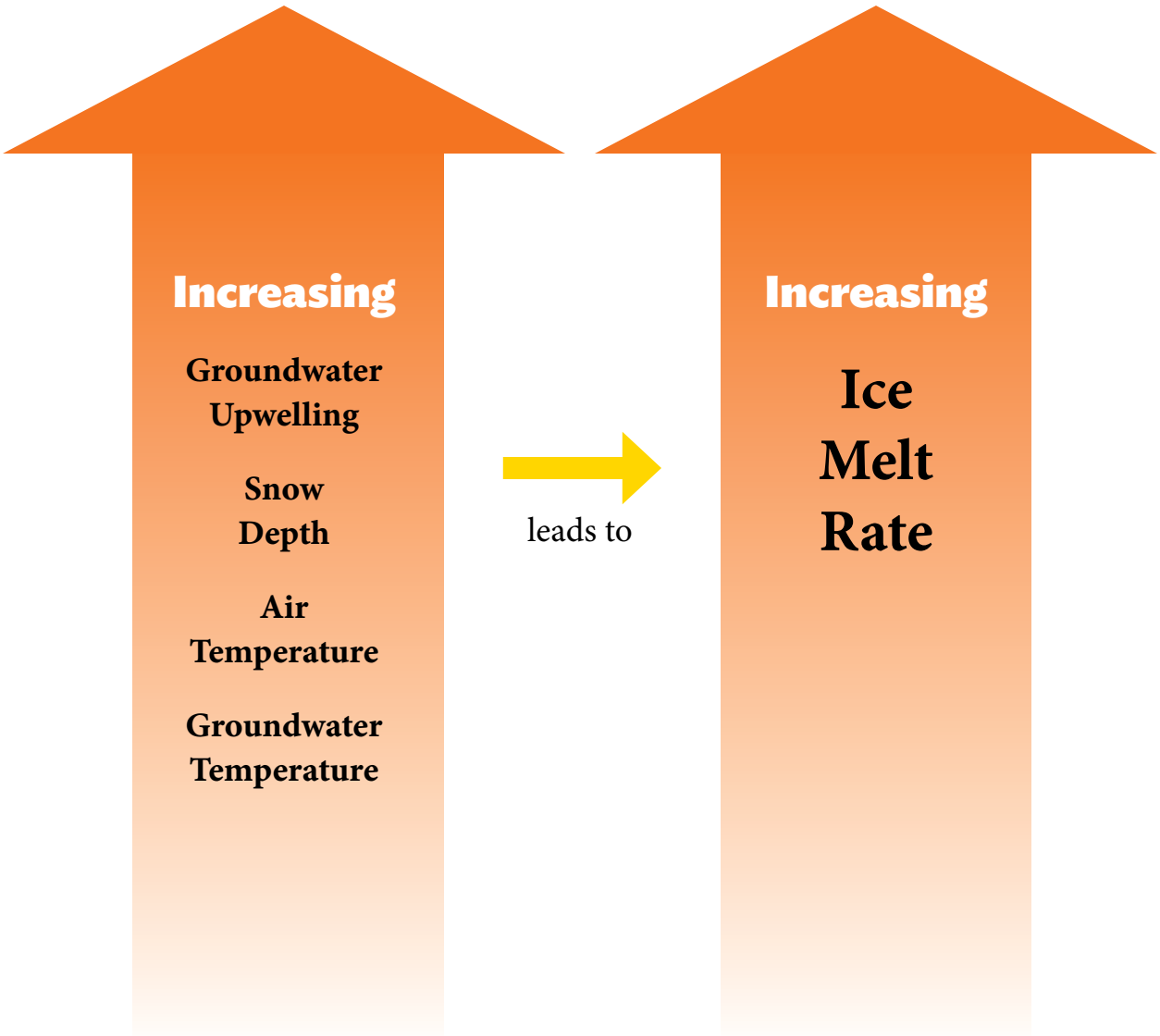
Location: *Luke's Slough*

Sediment temperature: *2.5 degrees Celsius (36.5°F)*

Water depth: *20 cm (8 inches)*

The higher temperature of the sediment in Luke's Slough compared with the sites in the main channel of the Tanana River indicates a greater presence of groundwater. The more warm groundwater that is present, the greater potential there is for ice melting.

Groundwater's Impact on Ice Thickness



Preliminary results of research by Chas Jones, UAF PhD student, March 2013

Minimizing Risks

"Dangerous is what looks safe, but isn't."

— Matthew Sturm, April 24, 2013

Observing Seasonal Changes

Observing the river during all seasons, understanding the dynamics of the river system, and talking with local, experienced travelers is the best way to be prepared.

Stacey Baldridge

Travel on Well-established Trails

Travel on existing trails may be safer, because packed snow is a poor insulator compared to undisturbed snow, allowing the ice under these packed areas to grow thicker over the course of a winter.

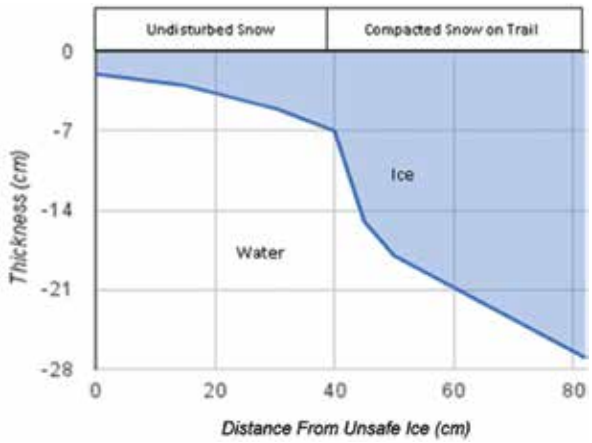
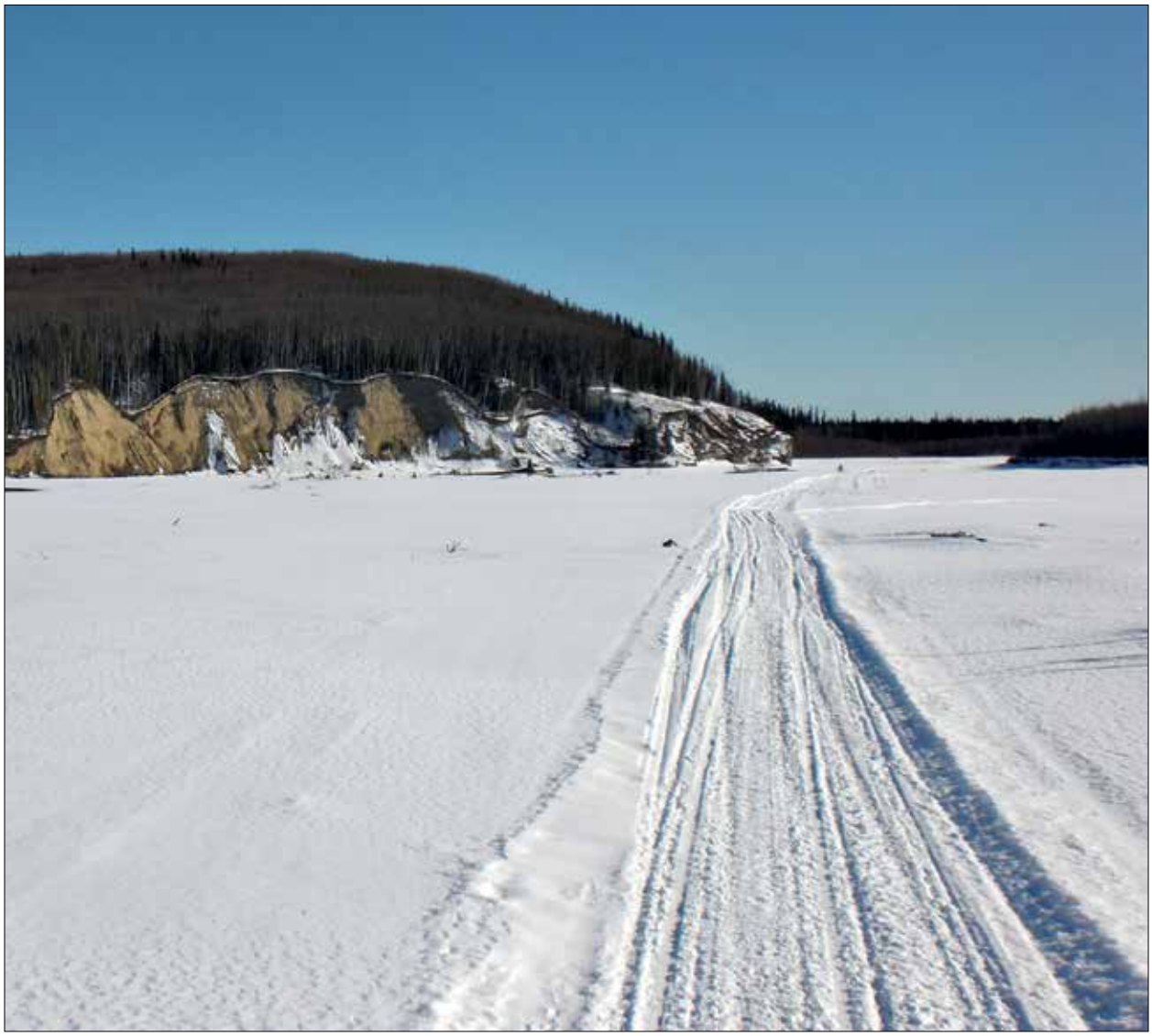
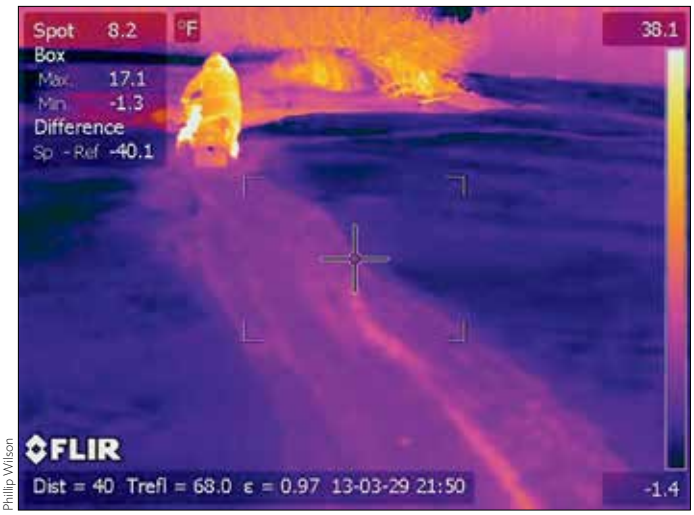


Diagram courtesy of Phillip Wilson



Karl Olson



Phillip Wilson

This infrared image shows differences in heat flux between undisturbed snow and a snowmachine trail. Because undisturbed snow insulates the ice (reduces loss of heat to the air) this results in lower freezing rates at the bottom of the ice; hence the ice will likely be thinner. The compacted (denser) snow of the trail allows more heat to escape, thereby increasing the potential for ice growth. Consequently, ice under established trails is likely to be thicker.

Tom Douglas

Ice floes with remaining snowmachine tracks floating down the Chena River after breakup show that this is thicker ice that takes longer to melt.

Knut Kielland

Even well-established, compacted trails can be unsafe. It is important to always be aware of the ice conditions and your surroundings.

The faster you are driving the shorter amount of time you have to react to unforeseen hazards on the trail.

Knut Kielland

Follow Trail Markers

Trail markers often mark a main trail, but they do not necessarily ensure a safe trail.

This is a section of the Iron Dog Snowmachine Race Trail. It appears well traveled and safe.
But, *notice the hole to the right. The water here was over six feet deep.*

Trail markers can mean several different things, including:

- Having a visible path to follow in bad weather
- Dangerous curves or dips
- Thin ice
- Open water
- Trail junctions
- Obstacles (logs, rocks, etc.)

Traveling Alone

No matter how competent you are, it is always a good idea to travel with a partner. You may unexpectedly find yourself in an emergency situation where you need help.

Traveling in the Dark

Traveling in the dark can be dangerous if you are on unfamiliar river trails or in places where you might not easily see the hazards.

Some people note that the beam of a snowmachine headlight provides an easy path to follow in the dark, sometimes creating better visibility than in flat light during the day.

However, night vision away from the narrow field of the headlight is reduced considerably.

When visibility is limited to the short and narrow distance of a headlight path, reducing your speed will give you time to react to problems ahead.

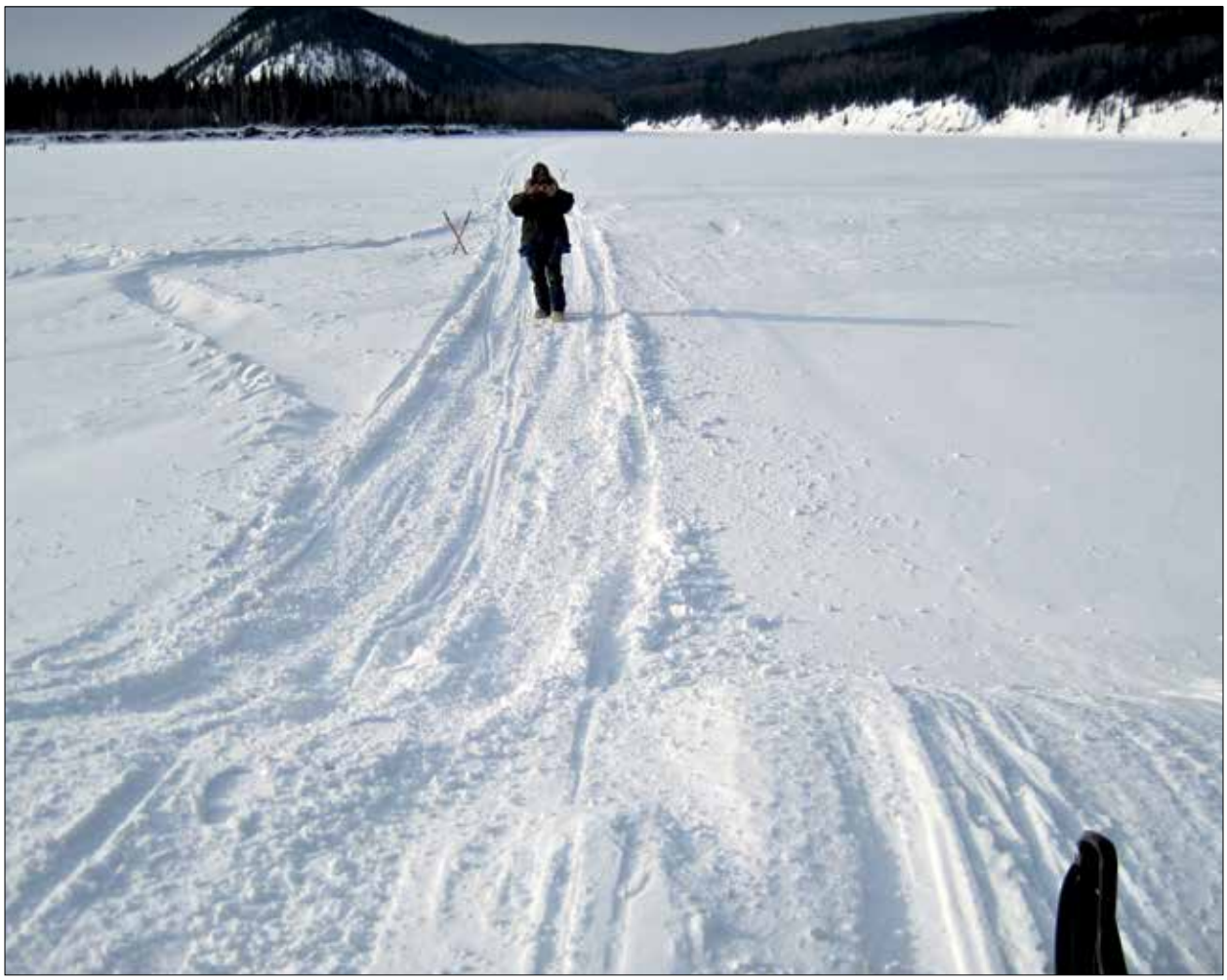
Bunching Up

When traveling as a group, if you spread out you can avoid putting too much weight on the ice at any one spot. If there is an unexpected hazard up ahead you also will have time to see what fellow travelers do and take your own evasive action.

Chas Jones

Traveling on Sandbars

Some people familiar with the river from summer travel prefer keeping to sandbars during the winter, because there is solid ground beneath them. They cross the ice between sandbars at the narrowest spots in order to minimize time on the ice. Caution is advised when approaching or leaving a sandbar because of potential hazards that can develop below their cutbanks.



"We travel the river so much we just know there's sandbars that appear at every point as you're going through the traditional S-turns in the river."
— Sam Demientieff, March 1, 2010

Traveling on Smooth Ice Versus Rough Ice

Choosing to travel on smooth ice versus rough ice varies between individuals and parts of the river.

Some people seek out the smooth ride of flat ice, and take the shortest route across when faced with jumbled ice because it is more jarring on the traveler's body and is harder on equipment.

Chas Jones

Karl Olson

Others recommend sticking to rough ice, because the ice chunks frozen together can be more stable. But, there also can be areas of open water between the blocks of ice, so care and attention are still required.

Portage Around Dangerous Spots

This is the portage on Hay Slough off the Tanana River between the communities of Manley Hot Springs and Tanana. The portage is used to avoid an area that typically has open water and is dangerous.

Test the Ice

Always test areas of questionable ice with an axe or a long pole. The pole also can be used to keep yourself from falling through the ice by creating a brace support across a hole.

Things to consider when testing the ice:

- Do you break through?
- Does the ice sound solid or hollow? Hollow sounding ice is not supported from below by water or the river bed.

All photos by Chas Jones

Listen For The Sound of Running Water

The sound of running water may indicate thin ice or areas of open water.

Use Extra Caution If You Are Pulling A Sled

Pulling a sled may cause you to bog down more quickly in overflow, and it may be more difficult to remove oneself once stuck. A toboggan-type sled distributes the cargo weight and is less likely to break through the ice or get stuck.

A quick release system for hooking the sled to the snowmachine may be helpful if you have to unhook the sled when in water or sinking in overflow.

Keep a steady speed to avoid getting bogged down, and if you feel yourself sinking, give the snowmachine more gas to try to power your way out of danger.

Use of Snowshoes on Ice

When using snowshoes to break trail on a snow-covered river or lake, leave the heel strap of your snowshoes untied, so that if the ice collapses you can easily pull your foot out from the toe strap and be free of the snowshoes. Otherwise, you may become entangled in the snowshoes and trapped in the hole.

Chas Jones

Emergency Gear

- A **saw or axe** can be used to cut poles to anchor a winch or to test the ice.
- **Shovels** are used regularly to dig snowmachines out from snow or overflow.
- A **knife** is essential if you have to cut your survival equipment lose from a sinking snowmachine or sled.

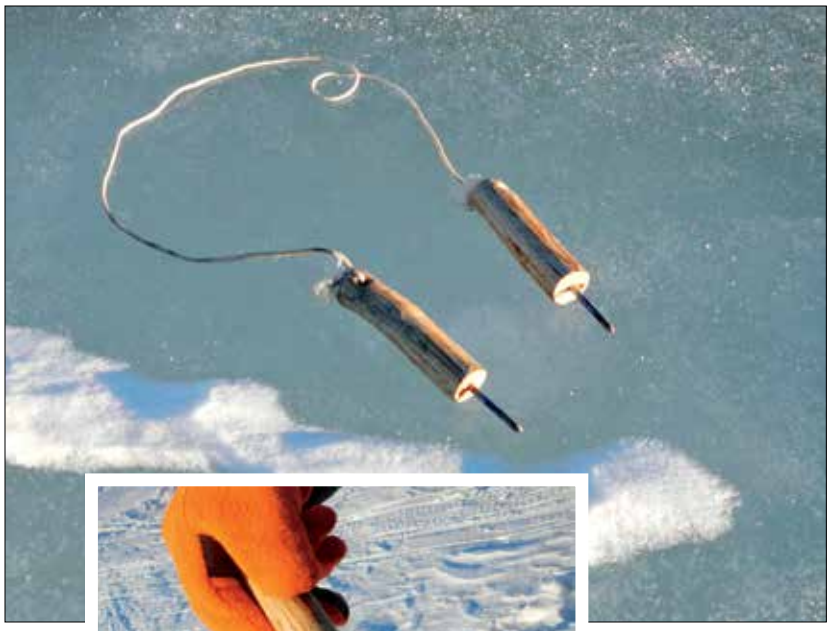
A Rope Winch or Come-along

A rope winch or come-along can be used to pull out a stuck snowmachine. At least 50 feet of heavy weight rope is recommended. Kevlar rope is extra strong and does not stretch.

Ice screws can be useful for attaching your winch line, since you may be far from any trees.

A rope with a piece of wood at the end can be used to rescue someone in the water. When throwing the line, the person in the water may be able to grab onto the floating piece of wood and more easily be pulled to safety.

Chas Jones



Ice Picks

Ice picks are used to pull yourself up and out of the water if you fall through the ice. They give you something to dig into the ice and grab onto. They should be kept in a place where you can get to them quickly, such as an outer pocket or pouch around your neck.

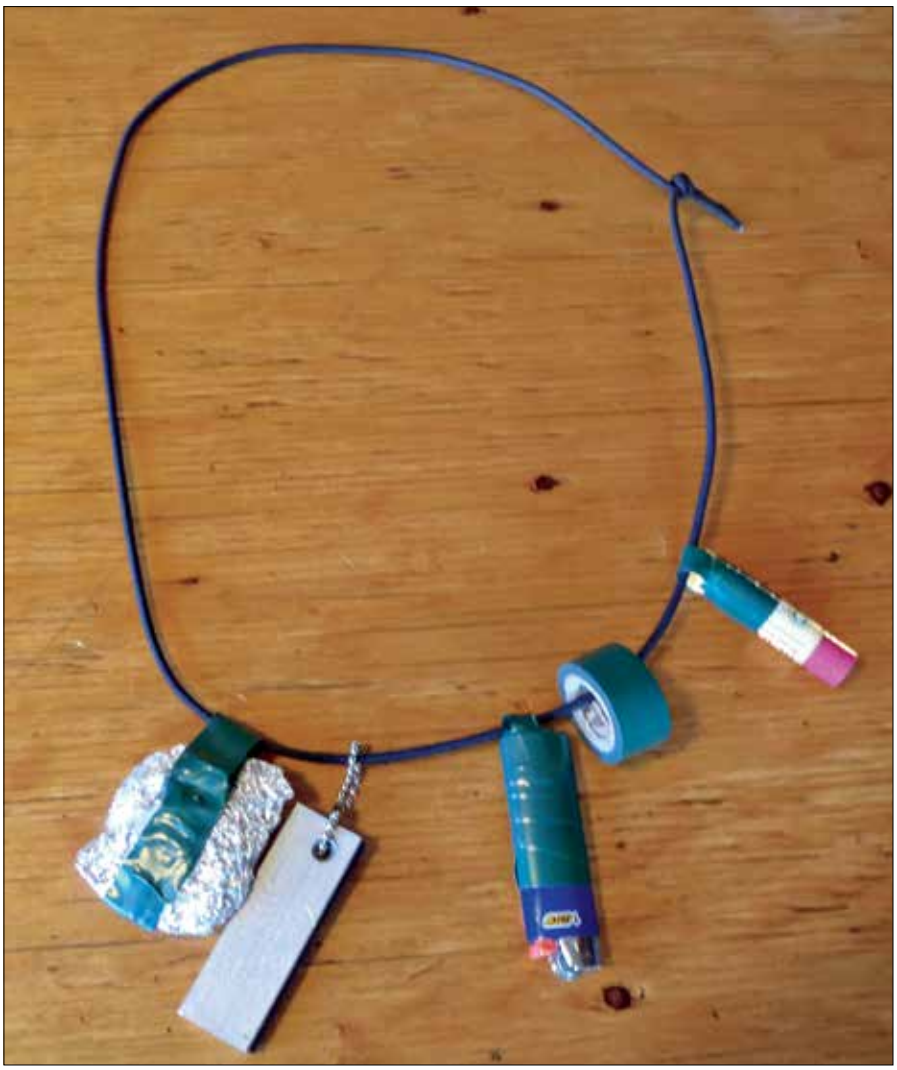
All photos by Knut Kielland

Fire Starter Kit

In case of an emergency, kerosene, matches, flint, or kindling can be used to get a fire started quickly. A waterproof container will help keep this fire starting material dry if you get wet (see photo at right).

Cotton balls or other textiles rubbed with chapstick or candle wax or soaked in kerosene are good fire starters.

Photo at right shows an emergency kit to be worn around the neck consisting of a lighter, flint, electrical tape, chapstick, and cotton wrapped in aluminum foil.



Both photos by Chas Jones

Emergency Food

Food that will not freeze or can easily be eaten cold or frozen is best. Smoked salmon, beef jerky, cheese, crackers, hard candies, chocolate, or trail mix are some preferred items. A hot drink or water is always great on the trail.

Chas Jones

Spare Parts and Extra Fuel

In case of breakdown, you may want tools and spare parts, such as a drive belt and spark plugs, for your snowmachine.

Extra fuel and oil for your snowmachine may be needed.

A Quick Link or carabiner can also be useful if you need to tow another snow machine.

Keeping Dry If You Have to Get in the Water

Waterproof fabric "waders" that fit over your boots can keep you dry if you have to wade through overflow to pull out a stuck snowmachine. But, if they are not tightly fastened at the top, water can seep in. The extra weight of this water can make it difficult to climb out of a hole.

Both photos by Chas Jones

Spare Clothing

Even on a short trip, you could end up getting wet. Extra clothing to change into may include socks, boot liners, down jacket, gloves/mittens, knit hat, long underwear, windproof or insulated overpants, fleece top, and fleece pants.

Staying Warm and Dry

In case you get wet, remove the wet clothing immediately, warm up the affected skin, and put on dry clothes. If it is extremely cold, stop and build a fire to warm up and dry off. Frostbite and hypothermia are constant threats during winter travel. Your hands, feet, and face are particularly vulnerable to frostbite. Dressing in insulating layers and a warm hat will help you stay warm.


TUNDRA

Thank You to All Our Project Participants

for joining us on the river to show us dangerous ice spots, and for their thoughtful input and insight as we try to understand Tanana River ice dynamics.

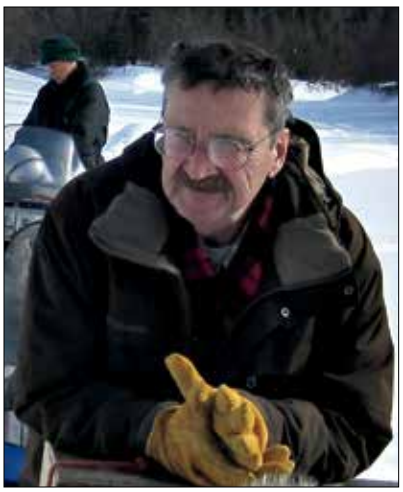
River Travelers in Fairbanks

Wally Carlo
Fairbanks

Sam Demientieff
Fairbanks

William Demoski
From Galena living in Fairbanks

Dave Norton
Scientist and river traveler



Tim "Neil" Scannell
Fairbanks

River Travelers in Tanana and Manley Hot Springs

Chas Jones

Charlie Campbell
Tanana

Ronnie Evans
Tanana

Sabrenia Jervsjo

Espen Jervsjo
Manley Hot Springs

Chas Jones

Charlie Wright
Tanana

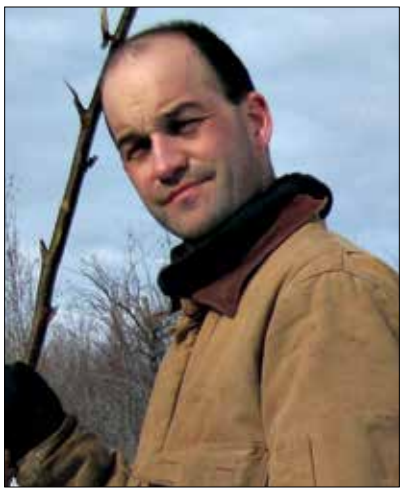
Scientists

Knut Kielland
Project Scientist & River Traveler in Fairbanks

Chas Jones

Bill Schneider
Project Anthropologist/ Oral Historian

Martin Jeffries
Consulting Freshwater Ice Scientist, Professor of Geophysics, UAF



Chas Jones
PhD Candidate, UAF Hydrology and Groundwater Studies

Glen Liston

Matthew Sturm
Consulting Snow/Ice Scientist, Geophysical Institute, UAF & U.S. Army Cold Regions Research and Engineering Laboratory (CRREL), retired

Project Management

Knut Kielland

Karen Brewster
Videographer, Project and Data Management, Website Development

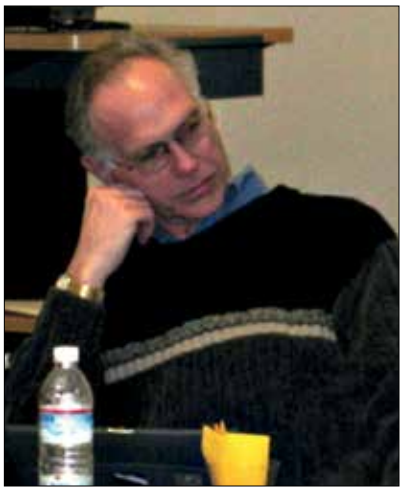
Leslie McCartney
Videographer, Project Management

Chas Jones

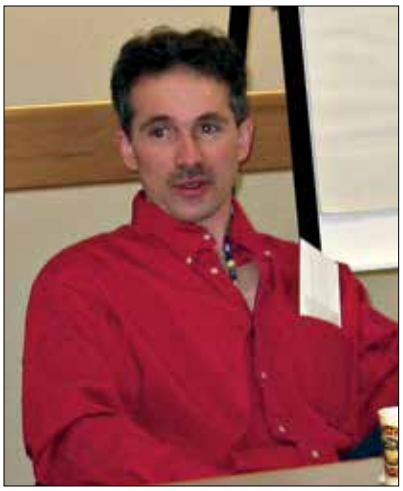
Karl Olson
Research Technician

Marla Statscewich
Website Development

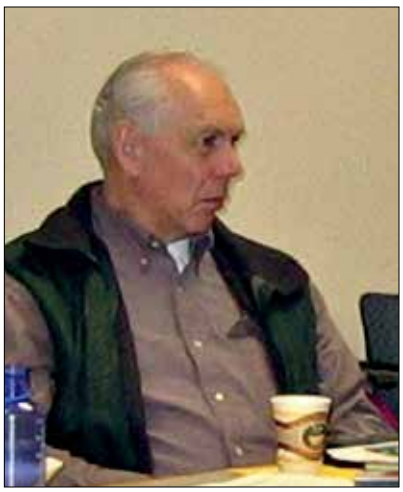
2004 Dangerous Ice Workshop Participants



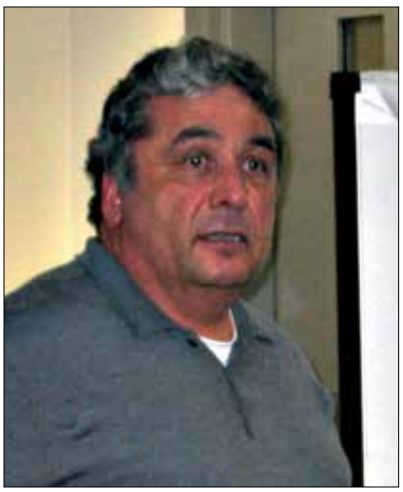
Larry Hinzman
Scientist, Water Resources and Ice Dynamics



Jack Reakoff
River Traveler, Wiseman



Charles Slaughter
Scientist, Eco-hydrology



Peter Snow
River Traveler, McGrath

"It was a great experience to be part of a science and local knowledge project that helps with safe ice travels. It's a good recommendation before venturing out on our waters. I learned many facts about river ice conditions that I never considered before."

— Samuel S. Demientieff, life-long river traveler

"The frozen rivers of Alaska are natural highways and have always been used for winter traveling. But unlike blacktop highways, ice highways are dangerous. Sadly each year a few Alaskan snowmobilers drown after breaking through the ice. Gathered in this booklet are a set of essential rules, observations, and concepts every winter traveler should know and which will help them navigate the ice more safely."

—Matthew Sturm, author, *Finding the Arctic, Apun the Arctic Snow*