¡ICE POWER!

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(Adapted for 2003)

In the Spanish language, exclamation marks are used at both ends of a sentence or declaration. The title of this article, "¡ICE POWER!", warrants this same added emphasis to draw your attention to the awesome force which ice unleashes upon Minnesota's shoreland almost every year.

Ice is a marvelous form of our most precious resource. No hockey game, cocktail, winter fishing or Minnesota winter would be complete without it. But there is a dark side to ice! It has to do with a property of ice that scientists and engineers casually identify as the **coefficient of thermal expansion**. In numerical expression this property is represented as **0.000051 inches per degree centigrade**. It is defined as the ratio of the change in length per degree centigrade to the length at 0 degrees centigrade. In layman's terms, this simply means that ice gets larger as its temperature rises. When conditions are right, this latent force will unleash havoc on shoreland and any structure man has unwisely constructed in its path.

For example, for a lake that is one mile across, when the ice's temperature rises from 14 to 32 degrees Fahrenheit (equivalent to 10 degrees Celsius), the ice sheet will expand laterally a total of approximately 32 inches, almost 3 feet! This can occur in a matter of hours when there is no snow cover on the ice sheet.

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The west shore of Big Cormorant Lake, Becker County, suffered from "ice power" . Taken on March 5, 1987, this photo demonstrates that aesthetics is not the only reason structures need proper setback.

Unfortunately, the reverse is not true. The ice sheet will not contract to its original size when the temperature goes down again. This paradox is based upon another of the inherent properties of ice. **Namely, that ice is much stronger in compression than it is in tension. To the lakeshore owner, this spells trouble!** There would be little impact if a lake's ice would expand a little when the temperatures rises … if only the ice sheet would shrink when the temperature goes down again. But it doesn't happen this way … at least not enough to matter.

What actually happens is that the ice sheet will expand a small amount during a temperature rise, with the resultant force of its compressive strength directed to its point of contact with the shoreline. But as the temperature drops, trouble starts. The ice sheet then tries to shrink back to its original shape – like a piece of steel that expands when heated and contracts when cooled. The ice tries to pull its massive weight inward in a tensile force struggle within itself. The pulling force is relentless. But since the ice's tensile strength is weak, the ice literally ruptures itself, breaking open into shrinkage cracks. Some cracks can be wide, others no more than "hairline cracks",

A good example of Ice Power! This photo was taken on Otter Tail Lake, Otter Tail County, on February 4, 1987. Bruce Winterfeldt (then DNR Waters, now DNR Trails & Waterways) is 6 ft. 6 in. tall for perspective.

but collectively their widths equal the amount that the ice sheet has contracted.

Then, as Murphy's Law would dictate, the worst that can happen, happens. The cracks don't stay open to allow room for the next expansion event of the ice sheet! Instead, the water in the cracks freezes, forming new ice and stealing the space that otherwise would have served nicely to accommodate thermal expansion.

The ice sheet couldn't care less. When its temperature rises again, its thermal expansion forces get into gear exerting its relentless force again upon the shoreline. As each successive expansion/contraction event occurs, the ice sheet creeps further, scraping, gouging and pushing as it goes. Some people call this process "ice-jacking" because of the ratcheting effect that each subsequent and cumulative push exerts upon the shore. Regardless of the name given to it, the effects of the power of ice are apparent and sometimes painfully real, as can be seen in the accompanying photos recently taken in northwestern Minnesota. Its victims are the boathouses, cabins, docks, sidewalks and retaining walls which were installed along the shoreline without regard to this phenomenon!

Ice Power! As fearsome as it can be, it does have its ups and downs and can be dealt with intelligently. First, and fortunately, there are good years and bad years for damaging ice action. During years of early snow falls and deep snow cover, the snow helps insulate the lake ice. This keeps its temperature more constant and thus minimizes "ratcheting". But in other years when snow cover is light or absent (like this past winter) and temperature extremes are great, look out! Ice power will then unleash its worst fury and maximum total expansion will occur.

There are basically four ways to deal with ice forces in shoreland areas:

1. do nothing at all;
2. do nothing, then restore damage;
3. attack its strength;
4. attach its weakness.

Any of the four approaches may be appropriate for a given situation. Taken separately, the first approach: **"do nothing at all"**, is obviously the cheapest. It could best be utilized in undeveloped shoreland areas. Surprisingly, this can be one of the most effective methods because, ironically, the lake itself builds its own protection against itself. For example, a small earth pressure ridge is pushed up one year followed by additional pushes in ensuing

Taken on Lake Lida, Otter Tail County, on January 8, 1987, this photo shows an example of "ice jacking" where the expansion force was relieved at a weak spot in the ice a safe distance from shore.

years. This not only enlarges the pressure ridge, but often fortifies it by jamming rocks into it. Roots of trees, brush and other vegetation then bind together the soil and rock. After a period of time you will have a natural retaining wall that will adequately protect personal property on its landward side. The next time you're on Minnesota lakes, look for these ridges. They're there!

The Department's shoreland rules provide for a minor setback for accessory structures from the ordinary high water level (OHWL) primarily to prevent damage from ice and wave action. Past rules unwisely allowed boathouses and tool sheds to be built right down to the OHWL.

The second alternative: **"do nothing, then restore the damage"**, is not a joke and may be the most reasonable approach along existing developed shorelines. This method basically says: stay out of wrath's path and clean up afterwards. It's a form of planned, acceptable damage. It naturally would require that all structures, landscaping, etc., be placed beyond anticipated damage limits. The allowable damage then would be to let the ice do its "push thing", shoving the earth upon the shore. Then, when spring thaw is over, man does his "push thing" and shoves the earth back again. This is a kind of unending game that some may enjoy, but most don't.

The third way to deal with ice force is to: "**attack its strength"**. This means you will acknowledge the superior strength ice has in compression and will build something strong enough to resist it. As you might expect, this would be the most costly approach. One example would be a reinforced concrete retaining wall, professionally designed to withstand the forces acting upon it. Most shoreland residents cannot afford the cost of proper

The foundation of this cabin on Big Cormorant Lake suffered damage when ice jacking jammed an unattached deck into the foundation block.

design let alone the cost of construction of such a facility. The Department discourages the installation of retaining walls, but allows them when no alternatives exist and the landowner agrees to repair and maintain them. They can only be constructed after a permit is issued by the Department.

The fourth approach: **"attack the weakness"**, is the most innovative method, but undoubtedly the most difficult. Knowing that ice is weak in tension, the problem becomes one of designing a project that will make the ice more or less self-destruct. One example may be to use sloped runners or ribs, perpendicular to the shoreline, that would cause the ice to deflect upward and then sag and break from its own weight (tension failure).

If you have a problem along your shoreline that is caused by ice, contact your nearest Area Hydrologist of DNR Waters. He/she will be able to advise you whether permits are needed and can give advice on how to solve your particular problem.