The rise and fall of the Great Lakes

For the last two years, the water levels of Lakes Michigan, Huron and Erie have been at record heights. With the resulting disappearance of protective beaches, low-lying areas now bear the brunt of any severe storms that sweep across the lakes. The combination of high water levels and storm-generated wave action has already caused considerable flooding, erosion and damage to homes, docks and other shoreline structures.

The problem isn't likely to go away soon. "Even if we had a drought," says Frank H. Quinn of the National Oceanic and Atmospheric Administration's Great Lakes Environmental Research Laboratory in Ann Arbor, Mich., "it would take Huron and Michigan three and a half years to return to the usual levels, and Lake Erie would take four years." With normal precipitation and runoff, he says, the Great Lakes system would take six to 10 years to recede to more usual levels. Several wet periods, on the other hand, could raise water levels by another foot over the next few years. Quinn made these projections last week in Chicago at an American Association for the Advancement of Science meeting.

Although water levels have been rising gradually for the last two decades, the current record heights were caused by two consecutive years of abnormally high precipitation. It was one of the few times since the 1880s that all of the lakes had periods of high rainfall at the same time. In contrast, just 22 years ago, the Great Lakes' water levels were at record lows, about five to six feet below the present high levels.

Large water-level fluctuations over periods of decades have often occurred in the past, says Quinn, and they're likely to continue. "This poses a real challenge for people living along the lakes and managing the lakes," he says. "How do you cope with this type of a range in lake levels?" Moreover, he adds, "to date, we've been able to find no well-defined cycles which can be used to predict lake levels on into the future."

The Great Lakes hold about 20 percent of the world's fresh surface water. Because of their large surface areas and restricted outlets, the lakes respond slowly to changes in precipitation, runoff and evaporation rates and to human efforts to control or divert flows. For instance, doubling the amount of water that is diverted from Lake Michigan into the Mississippi River system, says Quinn, would lower the mean water level at Chicago by merely an inch or so after about three years.

"This is one of the main reasons why diversions have not been used to regulate the water levels," he says. "By the time you make a change and . . . get the effect, times have probably changed, and the conditions that you originally set out to achieve are no longer valid." Furthermore, such projects are costly, and diverting excess water into the Mississippi or slowing the flow out of Lake Superior may just shift where flooding occurs.

The historical record also shows that the period between 1930 and 1960, a time of considerable shoreline development, was perhaps the warmest 30-year period in the last 2,000 years or so. It also happened to be a drier-than-usual period.

"If we look at the last several thousand years," says Quinn, "the climate that we have today, which is cool and wet, may very well be the normal climate for the Great Lakes region. And the period that many of us considered to be normal, which included some very warm and dry periods, may very well be the abnormal climatic base." In the same way, the geological record indicates that today's high water levels may be closer to the long-term "normal."

Meanwhile, the lack of ice on the Great Lakes this winter means that storms could drive lake water against shorelines and cause severe flooding in lakefront cities. "The potential for problems," says Quinn, "is much greater than it ever has been during the years we've been keeping water-level records." — *I. Peterson*

Keep cool with cold nuclear fusion

Cold fusion, or muon-catalyzed fusion, is an unconventional approach to nuclear-fusion power that suddenly looks promising due to recent experimental surprises. On his way to a related experiment at the Rutherford Laboratory in Oxford, England, Steven E. Jones of Brigham Young University (BYU) in Provo, Utah, last week discussed the latest results at the National Bureau of Standards in Gaithersburg, Md.

Back in the 1940s, Russian physicists Andrei Sakharov and F. C. Frank suggested that the subatomic particles called muons might be able to catalyze nuclear fusions, but it seemed at the time that the efficiency of the reaction, the number of fusions that an individual muon could accomplish, was too low to be practically interesting.

However, one of the recent surprises shows that if the hydrogen isotopes deuterium and tritium are used as fuel, a resonance occurs that greatly raises the fusion efficiency of the muons. Experiments at the Los Alamos (N.M.) National Laboratory (LANL) have confirmed the existence of the resonance, as have others at the Swiss Institute for Nuclear Research (SIN) at Villigen and at the Japanese KEK laboratory. The latest results — achieved by a group from LANL, BYU and the Idaho National Engineering Laboratory at Idaho Falls — show an average of 150 fusions of deuterium and tritium nuclei catalyzed by a single muon rather than the one-per-muon or so that earlier predictions expected. This is still some way from the 1,200 fusions per muon that Jones calls "energetically interesting."

Because atomic nuclei are all positively charged, they repel each other. To make them fuse, that repulsion has to be overcome. Conventional methods heat the nuclei to millions of degrees or crush them together by implosion.

If muons are introduced into a gaseous mixture of deuterium and tritium at room temperature (300°K), they will replace electrons in the atoms. The resonance means that the energy balance is favorable for such a muonic-tritium atom to invade a molecule consisting of two deuterium atoms and replace one of the deuteriums. This makes a molecular ion of deuterium and tritium bound together by the muon orbiting them both. The large mass of the muon makes this molecular ion so small that the deuterium and tritium nuclei encounter each other and fuse. The fusion produces a helium nucleus and a free neutron that carries away energy.

Raising the temperature and manipulating the density and proportions of the fuel mix seem to be able to enhance the efficiency, but above a certain temperature the resonance disappears, and so, says Jones, "You can't make a bomb with muon-catalyzed fusion."

Whether you can make an energy reactor with it depends on yet a second question: What fraction of the muons stick to the helium nuclei that come out of the fusions? Those that do are out of the game and can't repeat the fusion cycle. Swiss results show 0.4 percent of the muons sticking, but U.S. results give fractions as low as 0.1 percent. A U.S. experiment just completed counted both bare helium nuclei and those with muons attached, and found a lot of bare ones but almost none with muons attached. If accurate, that argues for a very low sticking fraction. The Rutherford Laboratory experiment is trying to confirm this.

If sticking proves a surmountable problem, the third, and possibly last, question is the cost of the muons. They have to be made by particle accelerators, and a questioner wanted to know whether "to light up the Texas panhandle you would have to cover New Mexico with accelerators." Probably not. In fact things look promising enough from that angle that Marshall Rosenbluth of the University of Texas at Austin has been looking at possible designs for a cold fusion reactor.

— *D. E. Thomsen*