



CRYSTAL LAKE & WATERSHED ASSOCIATION
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October 4, 2011

To: Participants of the **Crystal Lake "Walkabout"**.

Welcome to the **Crystal Lake "Walkabout"**, an unique experience of observational monitoring and environmental exploring especially designed for young adults. Anyone who is young of heart and open of mind is welcome. Of all the inland lakes of Michigan, Crystal Lake is one of the most beautiful - to look at, swim in, fish in, boat on - everything you would ever want to do and enjoy at a lake, you can do at Crystal Lake. It is there for all of us to share now, but also to protect for the future.

The **"Walkabout"** will make you look at the Crystal Lake Watershed from myriad points of view. Sometime in the future you will be making informed choices on water quality, land use, zoning, wells and septic tanks, green belts, sustainable development, education, and watershed management.

You will receive a commemorative T-shirt showing the Crystal Lake Watershed and an Interpretive Manual containing maps and facts. During the **"Walkabout"**, you will be visiting three or four of thirteen geographically and environmentally different "Sites", which will be interpreted by volunteer environmental professionals who will tell you how they relate to the Watershed.

You'll "learn about" and "talk about" our Watershed with a theme of "hydrology" - how water moves about our Watershed. You'll have chances to see and do things. Take notes and pictures. Your challenge is to learn about the myriad environments of the Crystal Lake Watershed: to help us all manage it wisely, and to keep its waters as clear and as beautiful for your children tomorrow as they are for you today. Enjoy the **Crystal Lake "Walkabout"** and learn about its unique Watershed.

Remember: act safely and respect the rights of others. Leave our Watershed as you found it. Observe, learn, and have fun!

Yours for the Crystal Lake Watershed,

2011 Fall Cosponsors:

Crystal Lake & Watershed Association; Grand Traverse Regional Land Conservancy; Benzie Conservation District; Sleeping Bear Dunes National Lakeshore (NPS).



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October 4, 2011

To: Property Owners & Visitors, **Crystal Lake Watershed**

Whether you "**Walkabout**", the Crystal Lake Watershed as a student, a property owner, or a visitor, you share the many remarkable vistas of an unique environment. The Crystal Lake Watershed is more than just a place where individuals live around or near a lake, visit for a time, or simply pass through. We are all responsible for its stewardship.

The **Crystal Lake "Walkabout"** involves observational monitoring and environmental exploring especially for students. Anyone who is young of heart and open of mind is welcome to partake in the program as a group, or ponder its philosophy as an individual. Environmental awareness is developed through "hands-on" leaning by a "walk about" environmentally significant sites, described in the Manual, or in one's own special place or mind's eye).

This "**Walkabout**" Interpretive Manual has evolved both as An Educational Primer for Students and as A Reference Handbook for Property Owners and Visitors. At various times, you are involved in making informed choices on water quality, land use, zoning, wells, wells and septic tanks, green belts, sustainable development, education, and watershed management. This Interpretive Manual will inspire you to consider the myriad environments of the Crystal Lake Watershed.

The Manual contains information and offers ideas on several environmental topics. It contains a detailed colored map of our Watershed, interpretations of thirteen geographically and environmentally different sites, a section on watershed management, and a list of concerns for Property Owners and Visitors. Supplemental publications describe the importance of living in a watershed and steps you can take to protect it.

Your challenge is to learn about the Crystal Lake Watershed, to help us all manage it wisely, and to keep its waters as clear and as beautiful for your children tomorrow as they are for you today. Enjoy the **Crystal Lake "Walkabout"** and learn about its unique Watershed.

The Crystal Lake & Watershed Association.



Crystal Lake "Walkabout" – Tues., Oct. 4, 2011; (Rainout Wed., Oct. 5, 2011).

Four concurrent ~45-min periods + ~15-min travel among Sites.

| Periods | Period I | Period II | Lunch | Period III | Period IV | Schools |
|-----------------|-------------------|-------------------|--------------|-------------------|-------------------|-----------|
| | | | | | | |
| Times | 09:45 | 10:45 | 11:45 | 12:30 | 13:30 | |
| 1st Team | A ---> | B ---> | Park | D1 ---> | D2 ---> | FE |
| 2nd Team | B ---> | A ---> | Park | D2 ---> | D1 ---> | BC |
| 3rd Team | D1 ---> | D2 ---> | Park | A ---> | B ---> | BC |
| 4th Team | D2 ---> | D1 ---> | Park | B ---> | A ---> | BC |

Lunch: Pavilion Park (Beulah); Restrooms: Trail Head. Be neat and pick up any trash.

"Walkabout" Locations:

| Date | Site | Description / Location (Interpretive Manual & T-Shirt |
|--------------------|------------|---------------------------------------------------------------------------------------------------------------------------------|
| | | |
| Fall 2011 | A. | Crystal Lake (Lake, East End). (At Beulah Public Dock, 44° 37' 57.59" N, 086° 05' 35.13" W, 183 m.) |
| Fall 2011 | B. | Cold Creek/Sediment Basin (Tributary). (In Downtown Beulah, 44° 37' 45" N, 086° 05' 36" W, 184 m.) |
| Fall 2011 | D1. | Crystal Lake Outlet (Discharge). (On Mollineaux Rd near Outlet Ck, 44° 38' 08" N, 086° 08' 46" W, 181 m.) |
| Fall 2011 | D2. | Railroad Point Natural Area (High Ridge). (On Mollineaux Rd, after Boat Launch 44° 38' 14" N, 086° 08' 35" W, 191 m.) |
| | | |
| Spring 2012 | | Three of four sites, concurrently. |
| Spring 2012 | | Including one activity. |
| | | |
| Summer 2012 | | Four Sites, sequentially, determined on demand. |

Notes:

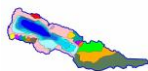
Sites A - L "Walked" over 2-yr schedule to allow 6th & 8th grades to view 6-8 Sites.

Site X is Special Activity.

Summer "Walkabout" is open to the public.

Sites D1 & D2 are both on Mollineaux Road but have separate parking areas!

Note: Start time of 9:15 A.M. changed to 9:45 A.M. to align with bus schedules!



Crystal Lake "Walkabout " - Fall 2011 – Feedback

Please tell us what you think of the "*Walkabout*".

(1) Where did you hear about the "*Walkabout*"?

(2) What did you like best about the "*Walkabout*"?

(3) What can we do to improve the "*Walkabout*"?

(4) Tell us something about yourself (and your organization).

(5) Tell us something about our Site Interpreters.

(6) What did you learn on the "*Walkabout*"?

(7) Would you like to go on another "*Walkabout*"?

(8) Any other comments?

Please return to Crystal Lake & Watershed Association, PO Box 89, Beulah, MI 49617.

THE CRYSTAL LAKE “WALKABOUT”

(Environmental Awareness Through Hands-On Education)

INTERPRETIVE MANUAL

An Educational Primer for Students;

A Reference Handbook for Property Owners and Visitors

Crystal Lake, Benzie County, Michigan

October 4, 2011 Edition

Dr. Stacy L. Daniels, “Walkabout” Coordinator
© Crystal Lake & Watershed Association

Dedication and Acknowledgements.

"Si Quaeris Lacum Effundam Circumspice." -- "If you seek a pleasant watershed, look about you."

The Lake Michigan coastline of Northwest Lower Michigan has always captivated the imagination of all who "walk about it". Beginning with explorations by Frs. Marquette and Charlevoix; land surveys by the Burt brothers, Alvin and Austin; geological surveys by Douglass Houghton and Henry Schoolcraft; environmental studies by Henry Chandler Cowles, William James Beal, Warren Gookin Waterman, Irving D. Scott, Frank Taylor, and James Lewis Calver; and the prose of William L. Case, Bruce Catton, and Earnest Hemingway, it has continued to the present day. Thoreau traveled on Lake Michigan near Crystal Lake and "botanized" at the Carp River (Leland) viewing the Manitou, Fox, and Beaver Islands.

The Crystal Lake Watershed contains a myriad of diverse, hydrologically intertwined ecologies and unique environmental niches: active sand dunes, forested heights, wetlands, tributaries, and a large deep inland lake connected to Lake Michigan. It encompasses Crystal Lake, an immense body of pristine water of exceptional clarity, with a mixed sandy and rocky nearshore, a sandy shoreline, a deep marl bottom, and a high-ridged vista. It is the responsibility of those of us in the present to respect, maintain, and preserve the integrity of our Watershed for the generations that follow us. This Interpretive Manual for the Crystal Lake "**Walkabout**" is hereby dedicated toward that goal. It is hoped that it provides both interpretation and guidance for responsible stewardship by students, visitors, and property owners.

Cosponsors of the "**Walkabout**" have included many organizations with local presence in Benzie County: the Crystal Lake & Watershed Association (**CLWA**) (prime sponsor); the Crystal Lake Watershed Fund, Inc. (founder); the Grand Traverse Regional Land Conservancy; the Grand Traverse Band of Ottawa and Chippewa Indians; Crystallaire Camp; The Nature Conservancy - MI Chapter; the Friends of the Betsie Valley Trail; the Friends of Betsie Bay; the Friends of Point Betsie Lighthouse; the U.S. Coast Guard – Station Frankfort; the Congregational Summer Assembly; the Benzie Conservation District; the MSUE Betsie Valley Trailway; the MSUE Michigan Groundwater Stewardship Program; the Inland Seas Education Association; the Tip of the Mitt Watershed Council; the Watershed Center - Grand Traverse Bay; the Michigan Land Use Institute; the Sleeping Bear Dunes National Lakeshore (NPS); the Benzie Area Historical Society; the Benzie-Leelanau District Health Department; the Mills Community House Association; Onsite Wastewater of Northwest Michigan; and the Betsie Lake Utilities Authority.

Special thanks are given to corporations, foundations, and civic organizations for their financial support. Special thanks are due to the dedicated teachers from Benzie Central Schools and Frankfort-Elberta Area Schools, who include the concepts of watershed interpretation and management into their curricula, and who provide moral support, chaperons, and bus transportation, and especially, the student participants. Most sincere thanks to all of the students, who play significant roles in contributing to the Interpretive Manual, and by their participation, make the "**Walkabout**" worthwhile for all of us.

Additional thanks to many other individuals and organizations for making the "**Walkabout**" a continued success include: Michigan Lake and Stream Associations, North American Lake Management Society, The Benzie County Record Patriot, The Traverse City Record-Eagle, The Benzie County Advisor, the Northwest Michigan Council of Governments, the Michigan Sea Grant, the Michigan Department of Environmental Quality, the U.S. Geological Survey, the U.S. Environmental Protection Agency, the Water Environment Federation, and local village and township governments within the Crystal Lake Watershed.

2011 marks the 19th year of the "**Walkabout**" conceived in 1993 and offered to ~ 4,500 participants ! The total of 13 (+1) Interpretative Sites continue from the previous edition. The Crystal Lake Outlet (**Site D1**) and the Railroad Point Natural Area (**Site D2**) have been distinguished for this edition. (The new MDNR Boat Launch may become a new site in 2012.) Pilots of curriculum targeted Geo-"Walkabout" and "Eco-"Walkabout" were tried in the Spring 2011 "**Walkabout**". Information on the Emerald Ash Borer has also been added. We encourage the use of this Interpretive Manual by others with common interests in promoting watershed educational programs. Comments are welcome. You are also cordially invited to participate/observe in the Crystal Lake "**Walkabout**"! **CLWA** 231/882-4001, info@CLWA.us

-- Dr. Stacy L. Daniels, Crystal Lake, October 4, 2011.

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Inside Back Cover: Supplemental Information (Subject to Change).

Tab 2 What to Expect of the “Walkabout”.

"I have met with but one or two persons in the course of my life who understood the art of Walking, that is, of taking walks, who had a genius, so to speak, for sauntering . . ."

- - Henry David Thoreau, *Essay on Walking*.

(2a) What about the “Walkabout”.

The concept of the **“Walkabout”** is borrowed from the Australian Aborigines. Tribal members would take brief leave from their responsibilities of daily living. They would then “walk about” their environment and renew their fundamental spiritual associations. It can be imagined that Henry David Thoreau, the noted naturalist, might have used the same approach in his extended sojourn at Walden Pond. A modern-day context of the **“Walkabout”** is applied in this innovative educational program. The Crystal Lake **“Walkabout”** is intended to instill and nurture in young people and adults a sense of awareness of their watershed environment through an interactive program of science education involving “hands-on” observational monitoring and environmental exploring.

(2b) What to do on the “Walkabout”.

As the name **“Walkabout”** suggests, you simply “walk about” your watershed environment, and think about what you see! Sounds easy? It is! In the case of Crystal Lake and its Watershed, try to see things from different points of view. Don’t look at the Lake as a just a place to swim, or boat, or fish, or watch the sunset. Think of all the water in Crystal Lake - where it comes from, what happens to it in the Lake, and where it goes. Think about the impacts of human activities and development upon the uses of the land and water. Think how Crystal Lake might have looked in the past, and how it may look in the future.

You may follow a few guidelines in observing the watershed environment about you in a group. You are also free to observe what might be of interest to you personally. You might want to think about how you and your friends use Crystal Lake. What about the fish, birds, and plants that live in, on, or near Crystal Lake? How many locations with different geography or environment can you describe around Crystal Lake? How should the Crystal Lake Watershed best be managed to preserve its unique character?

(2c) What to see on the “Walkabout”.

During the Crystal Lake **“Walkabout”** you will visit several Interpretive Sites within our Watershed. Some of these Sites you may have never seen or heard about before. These Sites are found in geographically and environmentally different locations. Each Site is associated with the other Sites within the Watershed in different ways. Listen to the Site Interpreters and watch their demonstrations. Try the activities and suggest others. Be curious! Ask questions! Keep your eyes and ears open. You may hear or read about new “words” (underlined) that describe our Watershed. You may learn about facts and figures describing our Watershed. You’re sure to finish the **“Walkabout”** with a better understanding of how water moves about our Watershed, its consequences, and your personal responsibilities.

(2d) What to do after the “Walkabout” ?

The **“Walkabout”** is more than just a single experience. Hopefully, it will make you look at the Crystal Lake Watershed from different points of view. As future citizens and voters, you will be making informed choices on issues affecting water quality, land use, zoning, wells and septic tanks, green belts, sustainable development, education, and overall watershed management. The **“Walkabout”** is designed to enhance your community awareness and social responsibility by providing “hands-on” educational experiences that will result in you helping to protect the integrity and improve the condition of our watershed environment. The Crystal Lake **“Walkabout”** is focused upon developing an environmental awareness of the Crystal Lake Watershed. While specific to the Crystal Lake Watershed, the **“Walkabout”** has borrowed ideas from other programs, and it can be extended to other watersheds. The **“Walkabout”** was originally designed for students, but its philosophy also applies to property owners and visitors. It can be practiced in a group, or by an individual.

Tab 3 Map of the Crystal Lake Watershed. (At end of Manual)

"A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature."

- - Henry David Thoreau, *Walden*, Chapter IX: The Ponds, 1854.

Crystal Lake is shaped something like a big footprint. It's a large depression in the ground filled with lots of water. The outline of the high ridge around Crystal Lake is like an even bigger footprint with a big "toe". The Crystal Lake Watershed (which makes up a "boot" with a big "toe" pointing from NW to SE) contains the Lake and all of the land around it up to the tops of the high hills. Within the Crystal Lake Watershed are seventeen smaller "sub-watersheds" with small creeks flowing into the Lake. Beyond the hills to the North is another larger watershed - the Platte River Watershed. To the South is yet another larger watershed - the Betsie River Watershed. To the West is a very large watershed - the Lake Michigan Watershed. The Crystal Lake Watershed is part of the Betsie River Watershed, which in turn is part of the Lake Michigan Watershed. (Please see the Michigan Sea Grant map in the supplemental materials.)

A watershed is like splashing water in and out of a big leaky bathtub. Water falling from the air or flowing from the land washes into the lake (the tub). Water falling on the land or lake (the faucet) as rain and snow can go many directions: (1) downhill over the ground and directly into the Lake; (2) soak into the ground and slowly flow in several different directions; (3) be taken up by plants; and (4) evaporate back into the air from the land and water surfaces. Some water that flows into the Lake can flow out again through Outlet Creek (the drain). Other water just soaks into the ground and flows slowly away from the Lake into Lake Michigan or into the Platte or Betsie River Watersheds. Water can also evaporate directly into the air or indirectly through the leaves of trees and other vegetation.

Another view of a watershed is to see how high the land rises above the lake surface on a topographic map of land contours. Looking closely at the map, you see "contour" lines for different land elevations. The closer the lines are together, the steeper the grade. The high ridges ("bluffs") rise almost 300 feet (~100 meters) above the surface of Crystal Lake (twice as high as the Lake is deep). Crystal Lake is like a bathtub with very steep sides. During the "**Walkabout**" you may visit the high ridges at Railroad Point.

Yet another view of a watershed is to look beneath the surface of a lake on a hydrographic (bathymetric) map of water contours. The closer the "contour" lines for different water depths are together, the steeper the drop-off into deeper water. There is a long deep trench down the center of Crystal Lake where water depths exceed 150 feet (~ 50 meters). The maximum depth of Crystal Lake is about 165 feet; the mean depth is about 70 feet. The hills around Crystal Lake are unique among Michigan lakes. The highest hills (ridges) around Crystal Lake are about twice as high as the Lake is deep. During the "**Walkabout**" you may visit a Site on the shoreline of Crystal Lake at the East End (Beulah) or the West End (Frankfort).

The Crystal Lake Watershed (Benzie County, NW Lower Michigan) is small compared to the two larger riverine (river) watersheds to the north and south. It contains parts of three townships around the Lake (Benzonia, Crystal Lake, and Lake); parts of three other townships (Homestead, Inland, and Weldon) are drained by Cold Creek. The Villages of Beulah and Benzonia are near the East End of Crystal Lake. The City of Frankfort and the Village of Elberta are near the West End of Crystal Lake (just over the hills), but are actually in the Betsie River Watershed. Benzie County was first surveyed in 1838-9 by Alvin and Austin Burt, who called Crystal Lake, "Cap" Lake (short for "Whitecap", for the large waves on the Lake).

Geographical Information System (GIS) uses a computer to make maps to visualize the Watershed with layers of information put together like a deli sandwich. Each layer tells us something different: Watershed and sub-Watershed shapes; villages, roads, and other place names; lake depths and ridge heights; locations of tributaries and wetlands; critical slopes; vegetation cover; land use and zoning; environmental monitoring locations, "Walkabout" sites, etc. Locations are defined by latitude & longitude (degrees, minutes, seconds). The "center" of Crystal Lake is at Latitude 44° 39' 33" N, Longitude 086° 09' 23" W. As the crow flies, Crystal Lake is about halfway between "here" and "there". It is about halfway between the Equator and the North Pole (and about ¼ away around the world from the Prime Meridian). It is also halfway between the extreme northwestern edge of the Upper Peninsula (UP) and the extreme southeastern edge of the Lower Peninsula (LP) of Michigan.

Tab 4 The Crystal Lake Watershed (All Sites).

“Earth and sky, woods and fields, lakes and rivers, the mountain and the sea, are excellent schoolmasters, and teach some of us more than we can ever learn from books.” -- John Lubbock

(4a) Watershed Facts.

There are myriad ways to view the Crystal Lake Watershed. A watershed: can be defined in two ways: (1) just the land around the Lake - the land that “sheds” runoff (rainwater and melted snow), or (2) both land and water (preferred way) (*). The total area (land plus water) making up the Crystal Lake Watershed is not especially large compared to other watersheds in MI. The Crystal Lake Watershed covers 43.67 square miles (28,145 Acres) with a perimeter of 44.65 miles based on latest computer calculations. The surface area of Crystal Lake is 15.4 square miles (9,854 Acres), making it the 9th largest inland Lake in Michigan! The Crystal Lake Watershed is unique in that the surface of the Lake is only about 35% of the total Watershed (land + water).

Crystal Lake contains a lot of “crystal” clear water - almost a quarter of a trillion gallons (242,000,000,000 gallons = 740,000 Acre-ft = 0.22 cu mi)! If all the water in Crystal Lake was spread evenly over all of Benzie County (assuming it was flat and the water didn’t soak into the ground), it would cover the land to a depth of 3’-8”, or just about head-high for a five-year-old! It would take a faucet flowing at 10 gallons per minute for 51 years to reach the volume of water contained in 1 inch at the surface of Crystal Lake! Since its original survey, Crystal Lake has changed only slightly in area, but dramatically in level - now set by law at 600 feet above mean sea level (plus or minus ¼ foot, summer to winter). For more about the Crystal Lake Watershed, see at www.CLWA.us/about_watershed.htm

(4b) Hydrologic Cycle (at end of Manual).

The science that deals with the occurrence, circulation, distribution, and properties of the waters of the earth and its atmosphere is called hydrology. A “sidewise” view of the Crystal Lake Watershed is useful to explain the hydrologic cycle, that is, how water moves about the Watershed. It passes from a vapor in the atmosphere through precipitation (rain and snow) onto the land and water surfaces, and ultimately back into the atmosphere by evaporation from water surfaces and by transpiration from trees and other plants. The total of evaporation + transpiration is called evapotranspiration.

If you dig a hole in the ground around the Lake, at some point you will reach the water table. For wells that are sources of potable (drinking) water, it is important to have enough water of good quality below the water table that can be pumped to the surface for household uses. For septic systems that are sinks for disposal of wastewater, it is important to have enough space above the water table to pump the water away and not contaminate any nearby wells. Drain fields for septic systems cannot be put below the water table because the wastewater has no place to go. Wells for drinking water must be driven below the water table and into a pervious (porous) formation (sand not clay) to get good flow. The hydrologic cycle for Crystal Lake is shown on a following page. During the “*Walkabout*” you will visit several Sites in the Crystal Lake Watershed, and learn how the Sites are related hydrologically to one another.

Another unique feature of Crystal Lake is its 21-mile perimeter (part of the annual Crystal Lake Team Marathon). This extended shoreline is due to a dramatic drop in the elevation (level) of the Lake during an “ill-fated” project to float logs back in 1873 known as the “*Tragedy*” of Crystal Lake. Instead of having sad or bad consequences, it actually was an unforeseen “*Comedy*” (happy consequence!) since a wide expanse of clean sandy beach was exposed that is now used for cottages and recreation. The surface of Crystal Lake is still slightly higher (averaging about 20 feet) than the surface of Lake Michigan (*). A drop of water falling on the down slope of the high ridges around the Lake will eventually flow into Crystal Lake, either as surface water (over the top of the ground) in tributaries such as Cold Creek, or as groundwater (underneath the ground) and emerge in the Lake from underwater springs.

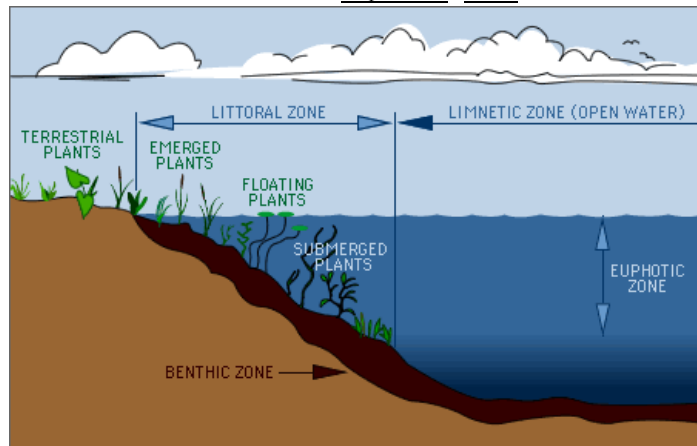
(*) The story of the Tragedy/Comedy of Crystal Lake has been greatly expanded. (See Tab 15.) For more watershed information see: “Your Lake & You”; and “Watersheds: Where We Live” (USGS).

Surface water flows much faster than groundwater. Surface runoff from cleared land or paved surfaces can transport more sediment than groundwater. Erosion control is very important around the Lake. Water can also flow from Crystal Lake into Lake Michigan either as surface water through Outlet Creek, or as groundwater beneath the surface, particularly at the West End of Crystal Lake toward Pt. Betsie. The level of Crystal Lake is controlled by the dam on Outlet Creek to be 600.25 ft in the summer (May 1 - Oct 31) to give more water for boating, and 599.75 ft in the winter (Nov 1 - Apr 30) to reduce shoreline erosion. Lake Michigan, a much larger lake, also rises and falls with season and climate. Crystal Lake, large as it is, is but a small part of the immense Great Lakes water system.

(4c) Layers of Crystal Lake.

Our Lake can be viewed as pieces of a layered “cake” in constant motion. You can “slice” it horizontally into layers (profiles) or vertically into pieces (transects). It depends on whether you nibble at the edges or the top, or cut the frosting in the center down to the bottom. You can describe a cake by its taste and flavor, frosted, with fruit and nuts, hot from the oven or at room or refrigerator temperature. The layers of the Lake are described by its light penetration and by its water temperature. While we are most familiar with the shallow nearshore waters where we swim and play, we also fish and boat in the deeper waters.

Our Lake has distinct zones of biological communities linked to its physical structure, i.e. water depth, light penetration, and temperature. The littoral zone includes the nearshore water where sunlight penetrates all the way to the bottom allowing macrophytes (plants) to grow. While it includes the shallow waters, the littoral zone extends out from shore to the bottom of the euphotic zone where it is too dark for macrophytes to grow. Because Crystal Lake is so transparent, light can penetrate much further down than in most lakes. A general rule of thumb is that the depth of the euphotic zone extends down about 2 to 3 times the limit of visibility as estimated using a Secchi disk. The measured Secchi disk depths of 20 to 30 feet for Crystal Lake would equate to effective light penetration down to 40 to 90 feet. In a survey done by the CLWF in 1996, aquatic plants were found at depths of sixty feet and more. Considerable phytoplankton activity is evidenced by supersaturated dissolved oxygen below the thermocline.



<http://lakeaccess.org/ecology/lakeecologyprim9.html>

The compensation depth is the depth at which 1% or less of surface light is measured and photosynthesis (growth) of green plants stops. This also defines the boundary between the euphotic zone (light top layer) of the lake and the profundal zone (dark bottom layer). The limnetic zone is the open water zone away from nearshore where light does not generally penetrate all the way to the bottom. The benthic zone includes the sediment at the bottom of a lake. At shallow waters, the sediment may be mixed by the action of wind and wave; at deeper depths, the sediment is relatively quiescent (still) unless disturbed by the bioturbation (crawling and burrowing of benthic macroinvertebrates, such as insect larvae or small crustaceans). The CLWF completed a biomonitoring survey of the benthic invertebrates in Cold Creek.

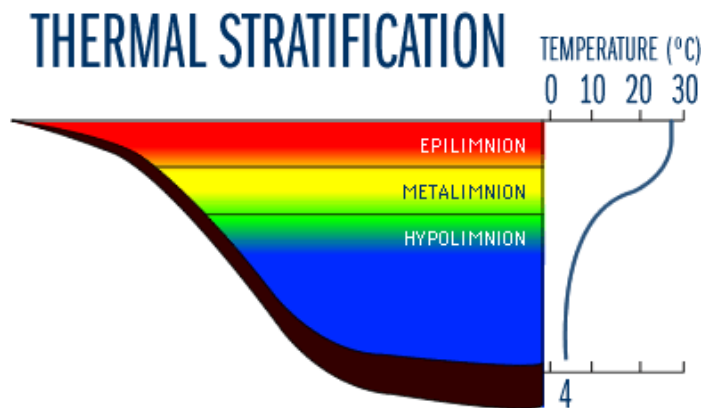
Our Lake has various layers defined by temperature. In the spring, immediately after ice-out (thaw) in temperate (warm summers, cold winters) climates, the water column is isothermal (same temperature) from the top to the bottom of the lake. Warm spring sunlight heats up both the air and the upper water layer. The lake begins to get warm at the top while still cold at the bottom. The density (weight per

volume of water) is important: water as a solid (ice) is less dense than as a liquid. Ice which forms at 0° C being more buoyant (lighter) floats, while liquid water at temperatures just above freezing sinks. Water is most dense (heaviest) at 4° C (above freezing), and becomes less dense at both higher and lower temperatures. Because of this, many lakes in temperate climates stratify (separate into distinct layers).

Imagine a bottle of salad dressing containing vegetable oil and vinegar. Oil is lighter (more buoyant) than vinegar, which is mostly water. When you shake the bottle you are supplying energy to overcome the buoyant force, so the two fluids become uniformly mixed together. After standing undisturbed, the more buoyant (less dense) oil will float to the top and the two-layer system will return.

In the spring, for most lakes in the upper Midwest, the water near a lake's bottom will usually be at 4°C just before the ice cover melts in the spring. Water above that layer will be cooler, near 0°C just under the ice. As the weather warms, the ice melts. The surface water heats up and decreases in density. When the temperature (and the density) of the surface water equals the bottom water, very little wind energy is needed to completely mix the water in the lake. After this spring turnover (complete mixing of the lake), the surface water continues to warm up and becomes lighter than the colder water down below. Winds may still continue to mix the lake from bottom to top, but eventually the upper water becomes too warm and too buoyant to mix completely with the denser deeper water. The differences in density at higher temperatures are very effective at preventing further mixing because it takes too much energy.

In the summer, the temperature (and density) differences between upper and lower water layers increase. Deep lakes become physically stratified into three layers: the epilimnion (the upper, warm layer, well mixed), the metalimnion (or the thermocline, a depth where temperature and density change most rapidly from warm to cold, and from light to heavy), and the hypolimnion (the bottom, cold layer). The thermocline acts as a physical barrier to prevent mixing of upper and lower layers for several months during the summer. Thermoclines for large lakes with strong winds, like Crystal Lake and Lake Michigan, extend down 30 to 50 feet.



<http://lakeaccess.org/ecology/lakeecologyprim4.html>

In the autumn, air temperatures cool down and so does the epilimnion of the Lake. As time passes, winds mix the Lake to greater depths, and the thermocline gradually deepens. When surface and bottom waters approach the same temperature and density, the winds mix the entire lake in the fall turnover. As the air cools, the surface water continues to cool until it freezes, most of the water under the ice becomes isothermal, and the lake water sheltered from the wind remains stratified throughout the winter. This pattern (spring turnover — summer stratification — fall turnover — winter stratification) is typical for temperate lakes. Lakes with two mixing periods are called dimictic (two turnovers per year).

In most lakes, the sunlit euphotic zone occurs within the epilimnion. In unusually transparent lakes, photosynthesis may occur well below the thermocline into the perennially cold hypolimnion. Algal growth in western Lake Superior can persist in the summertime down to depths of at least 75 feet, while the mixed layer, or epilimnion, only extends down to about 30 feet. Lake Tahoe was so transparent that algal growth historically extended down to below 300 feet even though its upper mixed layer only extended down about 30 feet in summer. Since 1960, significant loss of transparency has occurred due to increased algal growth and increased sediment inputs from stream and shoreline erosion.

The shoreline zone (where lake and land meet) is often defined as the lands 1,000 ft from the ordinary high-water level. For Crystal Lake, where the surrounding land is not flat, but consists of high hills, the shoreline zone is quite narrow around most of the Lake. The Crystal Lake Watershed Overlay District (CLWOD) is a jurisdictional area extending a minimum of 500 feet, and in some places much further as it follows the topography and the outer

perimeter of the Watershed. It imposes restrictive regulations for zoning, development, vegetation removal, and septic system installation.

Acknowledgement is given for excerpts and paraphrasing from the excellent webbook: "Understanding Lake Ecology - an Online Limnology Primer", Water on the Web, Natural Resources Res. Inst., Univ. Minn. Duluth, 2004 www.waterontheweb.org/under/lakeecology/index.html

Tab 5 **“Walkabout” Sites (A - M).**

“Forests, lakes, and rivers, clouds and winds, stars and flowers, stupendous glaciers and crystal snowflakes - every form of animate or inanimate existence, leaves its impress upon the soul of man.”
-- Orison Swett Marden

The Crystal Lake Watershed with its myriad environments can be interpreted from myriad viewpoints. It contains a myriad of diverse, hydrologically intertwined ecologies and unique environmental niches: active sand dunes, forested heights, wetlands, tributaries, and a large deep inland lake connected to Lake Michigan. It encompasses Crystal Lake, an immense body of pristine water of exceptional clarity, with a mixed sandy and rocky nearshore, a sandy shoreline, a deep marl bottom, and a high-ridged vista. Beneath the high ridges surrounding Crystal Lake and in the sediments of the Lake, remnants left by the glaciers that once covered Michigan. These sediments are made up of layers like a giant sandwich and include: large rock boulders left by the retreating glaciers; coarse sand and gravel washed up by the ancient seas which became the Great Lakes, or blown up by the prevailing winds; fine clay which settled from the melt waters; and accumulations of organic matter from plant and animal growth and decay.

The Crystal Lake **“Walkabout”** addresses diverse environmental features of a series of Interpretive Sites, each experienced in its own natural setting. The series of Interpretive Sites has evolved from a progression of interests, concerns, and demands. As the **“Walkabout”** has continued to develop, various topics have been introduced which are associated with one or more of the Interpretive Sites.

Cumulative List of Interpretive Sites (See Front Cover & T-Shirt)

The locations of the Interpretive Sites are indicated by their latitude, longitude, and elevation.

Site A. Crystal Lake (Lake, East End).

(At Beulah Public Dock, 44° 37' 57.59" N, 086° 05' 35.13" W, 183 m.)

Site B. Cold Creek/Sediment Basin (Tributary).

(In Downtown Beulah, 44° 37' 45" N, 086° 05' 36" W, 184 m.)

Site C. Trapp Farm Nature Preserve (Lake Wetlands).

(On Narrow Gauge Road, 44° 37' 56" N, 086° 05' 12" W, 184 m.)

Site D1. Crystal Lake Outlet (Discharge).

(On Molineaux Rd, near Outlet Ck, 44° 38' 08" N, 086° 08' 46" W, 181 m.)

Site D2. Railroad Point Natural Area (High Ridge).

(On Molineaux Rd, after Boat Launch 44° 38' 14" N, 086° 08' 35" W, 191 m.)

Site E. Crystal Lake (Lake, West End).

(At CSA Beach, 44° 37' 56" N, 086° 14' 42" W, 183 m.)

Site F. Betsie Valley Trail (River Wetlands).

(Near River Road & M22 Bridge, 44° 37' 47" N, 086° 14' 34" W, 178 m.)

Site G. Betsie Bay (Bay / Great Lakes / USCG).

(In Downtown Frankfort, 44° 37' N, 086° 13' W, 178 m.)

Site H. Pt. Betsie (Dunes / Lighthouse).

(On Pt. Betsie Rd. at Lake Michigan, 44° 41' 27" N, 086° 15' 19" W, 180 m.)

Site I. Benzie Area Historical Museum (Heritage)

(6941 Traverse Ave., Benzonia, 44° 37' 02" N, 086° 06' 00" W, 249 m.)

Site J. Round Lake (Bay of Crystal Lake).

(North on M22, entering SBDNL, 44° 41' 39" N, 086° 11' 11" W, 185 m.)

Site K. Hurdman's Bay/Winnetka Point (High Ridge).

(M-22, 1/2 mi North of Crystal Dr, Northshore of Crystal Lake) 44° 41' 12" N, 086° 11' 11" W, 249 m.)

Site L. Betsie Lake Utilities Authority (Wastewater Treatment).

(M-22, South of East End of Main St, Frankfort) 44° 37' 51" N, 086° 13' 22" W, 182 m.)

Site M. Personal Choice.

One's own special place or in mind's eye. The "n + 1" Interpretive Site.

For more on the philosophy, origin, evolution, and operation of the **“Walkabout”**, see **Tab 17**

The following overview shows how the Interpretive Sites interrelates about the Crystal Lake Watershed.

Site A. Crystal Lake (Lake, East End).

Most of the surface water in the Crystal Lake Watershed is contained within Crystal Lake, the 9th largest inland lake in Michigan (in area). It is internationally famous for its "crystal clear" waters (~ 1/4-trillion gallons). The Crystal Lake Watershed is unique in that 35% of the total watershed is the surface of the Lake itself. The deepwaters, nearshore regions, tributaries, and outlet of Crystal Lake have been subjects of many comprehensive studies of water quality over the past century.

Site B. Cold Creek/Sediment Basin (Tributary).

The major tributary (inflow stream) of Crystal Lake is Cold Creek. The North and Middle Branches are mostly within the Trapp Farm Nature Preserve (cf. Site C). This area was cedar swamp before the Lake was lowered in 1873. It has returned to its natural state and contains wetlands with abundant plant and animal life. The South Branch flows through mostly wooded terrain. All Branches of Cold Creek meet at the Sediment Basin (Holding Pond) near the Village of Beulah. (cf. Round Lake, Site K)

Site C. Trapp Farm Nature Preserve (Lake Wetlands).

The Trapp Farm Nature Preserve was once a farm for abundant crops of celery, cabbage, broccoli, radishes, and onions. In 1991, the farm, containing regional significant wetlands, was donated to the Grand Traverse Regional Land Conservancy. The Preserve now encompasses more than 132 Acres. A number of trails have been developed for interpretive nature hikes through the diversity of ecosystems ranging from open fields to cedar stands, and including remnant orchards and mature woodlands.

Site D1 Crystal Lake Outlet (Discharge).

The major outlet for surface water to discharge from Crystal Lake is located on the southeastern side of Crystal Lake. It is the site of the famous lowering of the Lake in 1873 by Archibald Jones.

Site D2 Railroad Point Natural Area (High Ridge) / Outlet (Discharge).

Railroad Point is an undeveloped area (~ 61+ Acres) features high-forested ridges ("bluffs") and a spectacular vista of Crystal Lake. A grant from the Michigan Natural Resources Trust Fund to the Grand Traverse Regional Land Conservancy conserved this resource. The Michigan Department of Natural Resources is currently constructing a boat launch facility nearby for fishermen and visitors.

Site E. Crystal Lake (Lake, West End).

Crystal Lake was originally a large bay (embayment) open to Lake Algonquin (prehistoric Lake Michigan). Over thousands of years, prevailing westerly winds created sand dunes closing it off from Lake Michigan. Crystal Lake is now ~ 27 feet higher in elevation than Lake Michigan. Water at the Lake's surface ("surface water") flows into Lake Michigan by way of Outlet Creek into the Betsie River, then into Betsie Bay at Frankfort and finally into Lake Michigan. Water beneath the ground ("groundwater") flows underground from Crystal Lake through the sand and into Lake Michigan near Pt. Betsie.

Site F. Betsie Valley Trail (River Wetlands).

The Crystal Lake Watershed (a "lacustrine" or lake watershed) is part of the Betsie River Watershed (a "riverine" or river watershed). Crystal Lake overflows into the Betsie River by way of Outlet Creek. The Betsie Valley Trail, a 27-mile rail-trail, stretches between Thompsonville and Elberta/Frankfort, Michigan, and runs adjacent to Crystal Lake at Railroad Point, the Outlet, and Cold Creek. Geographic Information System (GIS) and Global Positioning System (GPS) technologies have been used extensively to highlight sites of special interest along the Trail, including the extensive wetlands near Betsie Bay.

Site G. Betsie Bay (Bay / Great Lakes / USCG).

Betsie Bay (Lake) is located at the mouth of the Betsie River at Frankfort where it enters Lake Michigan. Its excellent harbor has long been used by railroad car ferries transporting goods between Michigan and Wisconsin ports, and by commercial and sport fishermen. It is an important component of the Betsie River Watershed, since all water from upstream sources flows into the Bay. Wastewaters from the communities of Frankfort and Elberta are collected in sanitary sewers and treated at the Betsie Lake Utilities Authority facility (BLUA) before discharge into the Bay. The U.S. Coast Guard - Station Frankfort, near the mouth of the Bay, provides search and rescue services, and promotes boating and water safety.

Site H. Point Betsie (Dunes / Lighthouse).

Pt. Betsie is the site of the world-famous Pt. Betsie Lighthouse, now under the stewardship of Benzie County and the Friends of Point Betsie Lighthouse. It is a prominent location mentioned in the early travels of Frs. Marquette and Charlevoix, and appears on many early maps. It is situated on the east shore of Lake Michigan with only 1-1/2 mile of sand dunes separating it from the Crystal Lake Watershed. The Point Betsie Dunes Preserve of ~ 94.5 Acres maintained by The Nature Conservancy - MI Chapter features interdunal wetlands, open dunes, cobble and sand beach, and pockets of boreal forest. Pitcher's thistle and Lake Huron locust are two species found only on Great Lakes shores. Spotted sandpiper and American redstarts are commonly seen there, as are migrating birds of prey, such as peregrine falcons.

Site I. Benzie Area Historical Museum (Heritage).

The Benzie Area Historical Museum is owned and operated by the Benzie Area Historical Society that collects, interprets, and expands knowledge about Benzie area history. This educational facility is located in an historic 1887 church, which was the center of the religious colony that founded Benzonia in 1858. The exhibits are a cross-section of life in Benzie County from early inhabitants and pioneers to modern residents and tourists, describing aspects of exploration, lumbering, farming, fishing, and recreation.

Site J. Round Lake (Bay of Crystal Lake).

Round Lake is a former bay of Crystal Lake that was left "high, but not dry" when the level of Crystal Lake was abruptly lowered in 1873. It is a small shallow lake (surface area only 15 Acres; avg. depth ~ 18 ft; max. depth ~48 ft). A small tributary flows through a marshy area into Hurdman's Bay. About 2/3 of Round Lake lies within the Sleeping Bear Dunes National Lakeshore. Its ecological features include submergent and floating vegetation in waters surrounded by forest and marsh much in their original natural states. (cf. Cold Creek, Site B)

Site K. Hurdman's Bay (Winnetka Point).

Hurdman's Bay, located along the north shore of Crystal Lake, is near Round Lake. It is named for Frank Hurdman, an early settler from Winnetka, IL. The view of much of the Crystal Lake Watershed from the high ridge overlook is spectacular. (cf. Railroad Point, Site D).

Site L. Betsie Lake Utilities Authority.

All waters entering and leaving the Crystal Lake Watershed are accounted for in an overall hydrological balance. Major inputs are precipitation (rain and snow); major outputs are surface and ground water flows, and evaporation. There are smaller amounts accounted for in wells providing drinking water and septic tanks providing wastewater treatment for individual homes. The Village of Beulah collects wastewater that is treated in lagoons before discharge to the Betsie River. The City of Frankfort collects wastewater that is treated at the Betsie Lake Utilities Authority before discharge to Betsie Bay.

Details for these Interpretive Sites are included within one or more of the following Tabs. Multiple topics may be discussed at various Sites depending upon the Site Interpreters.

Tab 6 Environmental Quality (Sites A, Site E).

"Perfect sincerity and transparency make a great part of beauty, as in dewdrops, lakes, and diamonds."
- - Henry David Thoreau, from the *Journal* (June 20, 1840).

The qualities of the waters within the Crystal Lake Watershed are very important to us for many reasons. We all use water for many purposes: swimming, boating, fishing, and other recreation; for drinking and waste disposal; and for just viewing the scenery around us. Most homes and cottages within the Crystal Lake Watershed are served by wells and by septic systems.

Environmental parameters are used to describe the existing and historical conditions within our Watershed. Baseline conditions and levels of substances that occur naturally, or that are artificially introduced into the water, land, and air, are assessed to determine effects that may be produced due to population influx, changing land uses, and other developments. Decisions are then considered in watershed management for purposes of both prevention and remediation.

The CLWF helped to establish and supported enforcement of the local ordinance to ensure that septic systems, esp. those near Crystal Lake comply with current standards. The CLWF also addressed sediment runoff from Cold Creek. The CLWF and the CLA encouraged property owners to maintain "green-belts" to slow erosion and runoff, and limit uses of fertilizers, herbicides, and pesticides. Public issues that indirectly affect water quality include: the proposed boat launch (MDNR); the resurfacing of State Highway M-22 (MDOT); the Benzie Corridor (SBDNL); and individual development on steep slopes.

The **CLWA** brings together local volunteers, resident experts, student interns, academic faculty, and governmental officials in cooperative environmental monitoring studies. The **CLWA** program has been integrated with joint programs of the Benzie-Leelanau District Health Department, the Michigan DEQ, the U.S. EPA, the Michigan Lake and Stream Associations, the US Geological Survey (with the NPS), the Grand Traverse Regional Land Conservancy, Benzie County Central & Frankfort-Elberta Area Schools, and Interlochen Arts Academy. Many studies have been done in the Crystal Lake Watershed over the past 160 years in support of watershed management. Building on these past studies, the **CLWA** has continued to monitor levels and trends of various water quality parameters. As a cosponsor of the Crystal Lake "*Walkabout*", the **CLWA** emphasizes the importance of water quality monitoring by describing the significant parameters to be measured and the equipment used for measurement and sample collection.

Environmental Monitoring.

Environmental monitoring is the measurement over time of physical, chemical, and biological parameters on samples of water and sediment, and microscopic plants and animals. Some are measured directly in the Lake; others require collection of samples and measurement in laboratories. Limnology (the study of lakes) requires special instruments to measure parameters and special tools to collect samples. The **CLWA** uses the instruments and techniques described here to assess our Watershed.

A Geographical Information System (GIS) uses a computer to make up layers of data to map our Watershed. Just like making a deli sandwich, each layer is different: watersheds, tributaries, wetlands, places, depths, heights, etc. Global Positioning System (GPS): Satellites accurately locate positions (latitude, longitude, altitude) in the Watershed and transmit the coordinates to hand-held GPS units. Locations for environmental monitoring and other points of interest are placed on maps created by GIS.

A Multiparameter Analyzer (Hydrolab H20[®] Water Quality Multiprobe) is used to measure seven parameters at once in the Lake (depth, temperature, dissolved oxygen, pH, conductivity, redox potential, and turbidity). Values for each parameter at different locations are logged into a computer and evaluated.

The Temperature of Crystal Lake is warm in Summer and cold in Winter. In the Spring, light, warm water (20°C = 68°F) at the surface forms a layer over heavy, cold water (6°C = 43°F) near the bottom. A thermocline (zone of sharp temperature change) forms between these layers at depths of 30-50 feet. All Lake water "turns over" and completely mixes twice as it warms in the Spring, and as it cools in the Fall.

Dissolved Oxygen (DO) in water is important to aquatic life. The DO of Crystal Lake may have 8-12 “ppm” (parts per million) of DO in summer, lower DO for a brief period in the fall, and 10-14 ppm in winter.

pH (Hydrogen Ion Concentration) is a measure of how much acidity or alkalinity is in water. A pH of 7 is neutral; a pH of 5 is 100 times more acidic; a pH of 9 is 100 times more alkaline. Some lakes like Crystal Lake (pH 8-9) are alkaline because of natural sediments of calcium carbonate (marl) that are very beneficial in controlling pH and phosphorus.

Conductivity is a measure of the dissolved salts (like table salt or road salt) in water. Water from Crystal Lake is like drinking water, and has much lower conductivity than seawater.

Redox Potential (reduction/oxidation) tells if Lake water can use more dissolved oxygen. Sediments that are anaerobic (little DO) have lower redox potential, are often black in color, and have unpleasant odors. Sediments that are aerobic (lots of DO) have higher redox potential and no odor. Deep water sediments from Crystal Lake have a slight seasonal demand for DO and no odor. Biochemical Oxygen Demand (BOD) is a measure of how much DO is need to treat wastewater

Turbidity (cloudiness) in water is due to suspended sediment, plankton (microscopic plants & animals), and bubbles. In a very clear lake like Crystal Lake, turbidity is and Suspended Solids (SS) are very low.

Secchi Disk is a weight circular disk painted in four black-and-white quadrants that is lowered into the water. Clarity of the water is determined as the depth at which the disk can no longer be seen. A deeper depth means clearer (less cloudy, less turbid) water. Secchi disc depths in Crystal Lake are 20-30 feet.

Phosphorus and Nitrogen are nutrients (fertilizers). A eutrophic (over-fertilized) lake has too much phosphorus, which can cause algae blooms that reduce dissolved oxygen and harm fish and other aquatic life. Phosphorus enters a watershed from “point” sources (septic tank discharges), or “nonpoint” sources (fertilizer runoff, plant and animal debris, or airborne deposition). The excellent water quality of Crystal Lake is due to its oligotrophic (under-fertilized) condition.

Chemical Analyses include other elements: calcium and magnesium cause hardness (scale); sodium adds to conductivity; iron and manganese cause slight tastes; and arsenic, copper, chromium, lead, and zinc are toxic, but usually not detected in lake water at significant levels. Other analyses include: chlorophyll a, an indicator of algal growth; and specific pesticides and herbicides that may be present.

Water Samplers are a simple bottle or bucket, or a tube with open ends and “mouse-trap” covers that is lowered by a rope into the water to the depth to be sampled. A small weight (messenger) is sent down to trigger the covers to close and capture a water sample for testing of parameters in the laboratory.

Sediment Samplers are long hollow tubes that are slowly lowered near the bottom of the Lake. When they are quickly dropped the rest of the way, they punches holes in the bottom and fill with sediment. The samples are bottled and tested later. Sediment may be sand, marl, and/or muck in different proportions.

Plankton Samplers are nets of very fine cloth that are towed behind a boat or lowered into the Lake. Very small plants (phytoplankton) and animals (zooplankton), either floating or suspended, are caught, washed into bottles, preserved, and later identified.

Hester-Dendy Samplers are series of hard wooden discs threaded on a bolt and hung in the Lake for a period of days or weeks. Plants, insects, and microorganisms that attach and grow can be studied.

Aquatic Plant Samplers are hooks, rakes, or dredges to collect plants, with and without roots and stems that may grow on the bottom or in the Lake. Samples are observed and identified.

Macroinvertebrate Samplers are nets of various sizes and shapes used to collect bottom dwelling organisms in lakes and streams.

Level Gauges monitor changing levels of Crystal Lake and its tributaries as they rise and fall when rain and melted snow enter, and surface and ground waters leave. Winds and tides also change the levels.

Biomonitoring.

Biomonitoring or biosurvey is the assessment of changes in aquatic life using biological methods. Assessments of ecological data and habitat evaluation are coupled with hydrology, chemical monitoring, and land use information. Benthic macroinvertebrates (bottom-dwelling, small organisms with no backbones) are collected in nearshore lake waters and wadeable streams, identified using taxonomic keys, and recorded on survey sheets. Streams are classified by Stream Order or Valley Segment Types (VSTs), using various parameters, e.g. channel characteristics, riparian zone features, total catchment area, hydrogeomorphic features (depth, velocity, flow, hydraulic gradient, erosive power), habitat (substrate, wetness), and water quality (temperature, dissolved oxygen, turbidity, nutrients).

The vegetative cover, bottom substrate (sediment), and stream morphology (shape) are determined for each sampling site. Benthic macroinvertebrates are collected by disturbing the bottom and washing the released sediment into a fine-mesh net. Samples are placed in flat trays to sort the macroinvertebrates from the sediment and detritus. Specimens are identified by taxonomy (size, shape, and unique anatomical features, e.g. legs, tails, antenna, mouth parts, etc.). Benthic microinvertebrates are assigned into sensitive, somewhat sensitive, and tolerant groups depending upon their resistance to adverse environmental conditions (temperature, pH, dissolved oxygen, trace pollutants, etc.). The Total Stream Quality Score (TSQS) is a comparative score of the diversity and numbers of benthic macroinvertebrates.

Benthic Invertebrate Families.

| Group 1: Sensitive | | Group 2: Somewhat-Sensitive | | Group 3: Tolerant | |
|---------------------------|----------------------|------------------------------------|--------------------|--------------------------|--------------------|
| Common Name | Scientific Name | Common Name | Scientific Name | Common Name | Scientific Name |
| Beetle adults | <i>Coleoptera</i> | Beetle larvae | <i>Coleoptera</i> | Aquatic worms | <i>Oligochaeta</i> |
| Caddisfly larvae | <i>Trichoptera</i> | Clams | <i>Pelecypoda</i> | Leeches | <i>Hirudina</i> |
| Hellgrammites | <i>Megaloptera</i> | Cranefly larvae | <i>Diptera</i> | Midge larvae | <i>Diptera</i> |
| Mayfly nymphs | <i>Ephemeroptera</i> | Crayfish | <i>Decapoda</i> | Pouch snails | <i>Gastropoda</i> |
| Gilled Snails | <i>Gastropoda</i> | Damselfly nymphs | <i>Odonata</i> | Sowbugs | <i>Isopoda</i> |
| Stonefly nymphs | <i>Plecoptera</i> | Dragonfly nymphs | <i>Odonata</i> | True bugs | <i>Hemiptera</i> |
| Water penny | <i>Coleoptera</i> | Scuds | <i>Amphipoda</i> | Other | <i>Diptera</i> |
| Blackfly larvae | <i>Diptera</i> | Alderfly larvae | <i>Megaloptera</i> | | |

The question is, “What are the water quality goals for a watershed?” Physical and chemical parameters may indicate good water quality. Environmental conditions may suggest “improvements” in stream habitat for greater diversity and numbers of benthic invertebrates. Greater productivity through the food chain from plankton to benthic invertebrates to fish to humans, however, may run counter to high water quality expected for an extreme oligotrophic lake like Crystal Lake. Nutrient and sediment controls and good water flow management within reasonable limits are laudable goals. Water quality in Cold Creek and Crystal Lake are being addressed from the standpoint of use – fishable, swimmable, drinkable, etc., but the “solution” of one “problem” may create a new ecological outcome that is unforeseen.

For further information:

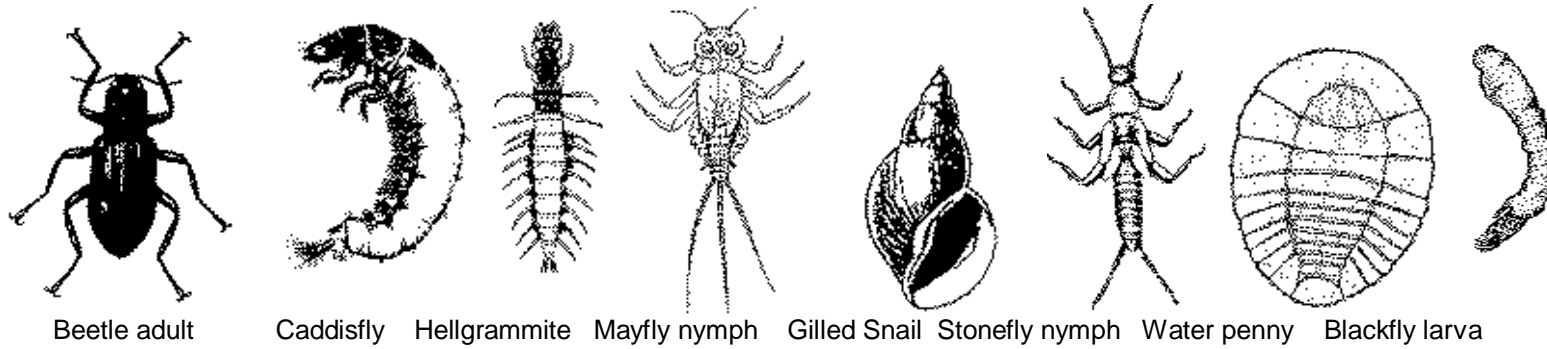
Larkin, Loren Kellogg, Monitor's Guide to Aquatic Macroinvertebrates, Izaak Walton League of America, 1994, 60pp, www.people.virginia.edu/~sos-iwla

Daniels, Stacy L., and Murphy, Paul C., Biomonitoring of the Cold Creek Watershed - Three Subwatersheds of the Crystal Lake Watershed, Benzie County, Michigan, Final Report, Michigan Department of Environmental Quality, Volunteer Monitoring Program, Clean Water Fund, Clean Michigan Initiative, July 15, 2003, 40pp + 100 pp appendices.

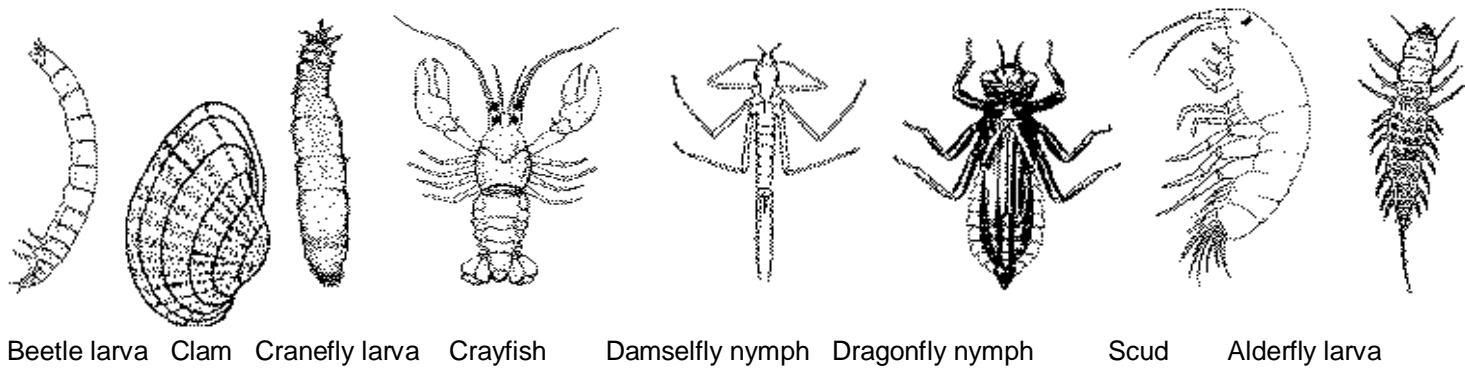
http://www.clwa.us/references.htm#Biomonitoring_of_Cold_Creek

Freshwater Benthic Macroinvertebrates (IWLA, 1994).

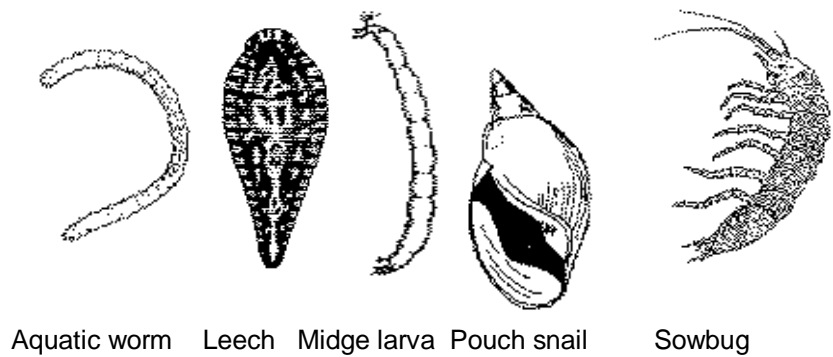
Sensitive Benthos



Somewhat-Sensitive Benthos



Tolerant Benthos



Tab 7 Environmental Health (Site L).

“Crystal Lake is a noble body of water, ... It was properly named, because it is so crystal-clear that you can count pebbles on the bottom where it is twenty feet deep. It is surrounded by low green hills, and when the sun is out its color is a breathtaking, incredible, picture-postcard blue; spring-fed, it is deep and cold, ... but when the weather is warm to go into this water is like dipping into the fountain of youth.”
-- Bruce Catton, *Waiting for the Morning Train*, 1972.

The environmental health of the human occupants of the Crystal Lake Watershed is also important in insuring the availability of safe drinking water, the treatment of wastewater, and disposal of solid wastes. In most homes in Benzie County outside of the incorporated villages and towns, drinking water is provided by individual wells, and nearly 90% of the wastewater is treated by individual onsite septic systems. Inspection and permitting for wells and septic systems is done by the Benzie-Leelanau District Health Department (BLDHD). Testing of drinking water quality is done by the State of Michigan. Testing of bathing beaches is done by the (BLDHD). The On-Site Wastewater of Northwest Michigan was formed in 2002 to engage and educate the various stakeholders in our region (which contains five of the states ten largest inland lakes, including Crystal Lake) as to potential alternatives in wastewater treatment and management. www.michigan-onsitewastewater.org

Drinking waters for the Village of Beulah and Benzonia, and the City of Frankfort, are provided by central wells. Wastewater from the Village of Beulah is collected by sewers and piped out of the Crystal Lake Watershed to lagoons for treatment before discharge into the Betsie River. Wastewater from the City of Frankfort is collected by sewers and piped to the Betsie Lake Utilities Authority (BLUA) for treatment before discharge into Betsie Bay. Septage, the concentrated solid waste from septic tanks, and holding tank wastes are transported to approved facilities for treatment. Challenges in Northwest Lower Michigan in resolving local wastewater issues and management are being addressed thru regional collaboration.

Environmental Health Regulations.

In 1989, Benzie County became one of the first counties in the U.S. to adopt a precedent-setting ordinance to require upgrading of onsite wastewater treatment systems comprised of septic tanks with drain fields, or holding tanks subject to periodic collection and disposal. Upgrading is now required prior to sale of any properties. Priority of enforcement was placed on upgrading those failed or poorly operating systems located near water bodies. To date, several hundred individual systems, within the Crystal Lake Watershed and elsewhere in Benzie County, have been upgraded.

Alternative Treatments Units (ATU's) use "innovative" or "advanced" technologies to provide a higher degree of wastewater treatment to protect the water quality of lakes and groundwater. They provide an alternative to holding tanks without outlets that must be pumped periodically and the contents properly disposed of in an approved treatment facility. Benzie and Leelanau Counties have adopted new standards allowing septic systems to be constructed on properties having soils that do not "perc" (do not allow partially treated wastewater to trickle through the soil for further treatment). An advisory group supports the Benzie-Leelanau District Health Department in implementing these regulations.

Onsite Wastewater Treatment Demonstration Project.

Conventional septic systems for wastewater treatment consist of settling out solids and satisfying the oxygen demand of soluble compounds that would otherwise lower the dissolved oxygen level in lakes and streams. The U.S. EPA created the National Onsite Demonstration Project (NODP) to demonstrate alternative wastewater treatment technologies in communities with environmental and site constraints. Water quality considerations included: close proximity to lakes; shallow water table; highly permeable, sandy soils; and small lot sizes. The main concern was to remove pathogens and nutrient phosphorus. The Benzie-Leelanau District Health Department (BLDHD) received a grant to demonstrate seven alternative systems: iron-oxide phosphorus removal horizontal barrier; recirculating sand filter with upflow phosphorus (P) removal filter; packed-bed filter; intermittent sand filter; open-cell foam biofilter; low-

pressure shallow trenches; and low-pressure contour trenches. These systems have performed according to expectations with the upflow P-removal filter showing much promise.

Bacteria.

Bacteria are microscopic organisms that are widespread in our environment: in soil and water, and in and on living plants and animals. Certain species (kinds) are found in the colon and intestines of all warm-blooded animals. They are necessary for proper digestion of food, and are always found in feces (excreted wastes). *Escherichia coli* (*E. coli*), one of the main species of coliform (from the colon) bacteria is a common indicator of fecal contamination of water. Fecal streptococci are another group of bacteria found in feces. "Enteric" organisms live in the intestines; "fecal" organisms live in feces. One human may pass an average of 10^{11} to 10^{13} (= one with eleven to thirteen zeroes after it) bacteria per day!

Coliform bacteria live in the colons of animals, and in the ground on soil or decaying plants. Sources of coliform bacteria are birds and farm animals; failed septic systems; inadequate wastewater treatment; and combined sewer overflow and surface runoff, which may increase during heavy rains or snow melts. The presence of high numbers of fecal coliform bacteria in a water sample means that the water may have been in contact with fecal matter and may be a potential risk to human health. Fecal coliform bacteria are not necessarily agents of disease, but may indicate the potential presence of other pathogenic (disease-causing) bacteria, virus, and protozoa that also live in human and animal digestive systems. *E. coli* O157:H7, an uncommon but virulent strain of *E. coli*, is found in isolated cases in undercooked meat.

Most states set strict standards for fecal coliform bacteria to protect public health. Standards for drinking water are more stringent than standards for swimming areas. Fecal coliform bacteria are measured by growing cultures in a laboratory and reporting the number of "colonies" per 100 milliliters (mL) of water. Bacteria like to attach to small particulate of soil or sand and may be present in the environment even though the overlying waters are relatively clean.

For further information: What are fecal bacteria and why are they important?

www.epa.gov/OWOW/monitoring/volunteer/stream/vms511.html

Swimmer's Itch.

Swimmer's itch (SI) is a nuisance skin condition that humans get after swimming, wading, playing, or working in the water. Also known as "water itch" or "cercarial dermatitis", it is a long-time reoccurring problem in northern freshwater lakes, and worldwide in freshwater and marine settings. Tiny parasitic cercariae ("sur-care-ee-aye") released into water by bottom-living snails infect ducks. Duck feces released back into the water repeats the life cycle by reinfesting snails. Ducks and snails are not bothered, but humans, not being part of the normal life cycle, become inadvertent targets. The cercariae penetrate human skin, and then die realizing the human is not a duck. The resulting inflammatory reaction (large red papules and itching) is quite different from poison ivy, heat rashes, or insect bites.

There are two approaches to reduce the problem: (1) Break the life cycle in a lake by controlling ducks and/or snails. Some lake associations have tried duck control, but success is difficult because the major species, the common merganser (the saw-bill duck, the Benzie County namesake), is swift and wily, has large broods, and returns to the same lake year after year, and (2) Use caution when entering the lake and take preventive action upon leaving the lake. Chemical control of snails is ineffective in large lakes.

Exposure is increased by being in shallow waters in early morning during onshore winds. Children can get swimmer's itch because they play in shallow water for many hours, where SI cercariae



are most dense. Application of lotions, insect repellents, or rubbing alcohol, and showering after use, are partial remedies. The **CLWA** is continuing studies of snail/duck populations and SI incidences, and assessments of both control measures and availabilities of topical applications to prevent SI.

Tab 8 Tributaries (Cold Creek and Round Lake) (Site B, Site C, Site J).

“To trace the history of a river or a raindrop . . . is also to trace the history of the soul, the history of the mind descending and arising in the body. In both, we constantly seek and stumble upon divinity, which like feeding the lake, and the spring becoming a waterfall, feeds, spills, falls, and feeds itself all over again.” -- Gretel Ehrlich, *Islands, The Universe, Home*.

Sediment in water running off the surface of a watershed can reach a lake and degrade its water quality. Wetlands filling and vegetation clearing within a watershed can increase sediment and nutrient loadings to Crystal Lake. Cold Creek includes three tributary subwatersheds to Crystal Lake – North, Middle, and South Branches, covering 16.54 square miles, slightly bigger than the area of Crystal Lake of 15.4 square miles. Assuming uniform distribution of a precipitation (rain or snow) event over the entire Crystal Lake Watershed, Cold Creek would make up 58.5% of the total hydraulic (water) loading due to surface runoff. This loading is subdivided among the North Branch, 18%; Middle Branch, 25%; and South Branch, 57%. The North Branch consists of three sub-branches. The sediment loading to the Cold Creek Sediment Basin from the North Branch, however, is much greater than the loadings from the Middle and South Branches combined. Sediment from the North Branch also has a higher content of nutrient phosphorus.

The Cold Creek Sediment Basin (Holding Pond) intercepts the combined flows of the three branches of Cold Creek, the major tributary at the SE end of Crystal Lake. The Basin was built in 1975 as a USDA Resource Conservation & Development (RC&D) measure for Flood Prevention & Land Stabilization in Northwest Michigan. The project was sponsored by the Village of Beulah and Benzonia Township, who are jointly responsible for its operation, and the Benzie Soil Conservation District, with the assistance of the USDA Soil Conservation Service. The facility is intended to remove sediment from upstream erosion. Cold Creek is responsible for about 1/3 of the sediment and nutrient loadings to Crystal Lake. The three subwatersheds of Cold Creek are the largest of the 17 sub-watersheds of the Crystal Lake Watershed. The South Branch flows through undeveloped woodlands; the North and Middle Branches flow through fallow farmlands. The Trapp Farm Nature Preserve, administered by the Grand Traverse Regional Land Conservancy, contains regionally significant wetlands. The combined North/Middle and South Branches have their confluence (meeting of streams) at the Sediment Basin.

The Basin collects sediment discharged from a former onion/celery farm (now part of the Trapp Farm Nature Preserve) through drainage ditches that significantly increased soil erosion and sediment runoff by altering the natural pre-1910 stream hydrology. Natural revegetation has reduced wind erosion to the Lake, but concerns remain for water-created soil erosion. If not intercepted and removed, this sediment, with associated nutrients from 50 years of farming, flows directly into Crystal Lake, where growths of aquatic weeds are stimulated. Deposits of sediment have been noted near the mouth of Cold Creek. After major storm events, plumes of sediment follow the shore of the Lake for several miles before dispersing. Water quality monitoring has been done at several locations on the Cold Creek subwatersheds, and biomonitoring is about to begin.

The Basin (W 90 ft, L 390 ft, D 15 ft) intercepts ~ 9,750 yd³ of sediment over 6 - 10 yr. During dredging, the Basin is isolated by closure of upstream and downstream stop-logs, and the entire flow is bypassed through a 30" conduit. Sediment is drag-lined to an adjacent spoil basin for natural dewatering and trucked to land disposal being too friable for use as a soil supplement. Basin performance is limited by 50-fold variations from dry weather (< 2 cfs) to stormwater (> 100 cfs) flows corresponding to velocities of 0.17 - 8.8 fpm, overflow rates of 36 – 1,840 gal/day/ft², and detentions of 36 hr - 44 min (empty). Loadings are 220 - 11,000 lb/day assuming total suspended solids (TSS) of 20 mg/L. While these solids loadings are low, the short detention times and high overflow rates are not conducive to good sedimentation of fine organic particles containing insoluble phosphates.

The CLWF completed a project, “Biomonitoring of the Cold Creek Watershed”, in 2003 supported by a grant from MDEQ. This project surveyed benthic invertebrates and stream habitats within the Cold Creek subwatersheds that are indicative of biological health of this major tributary to Crystal Lake. The results are being used to assist in determining the feasibilities of management options for improved operation of the Cold Creek Sediment Basin to reduce sediment and nutrient loadings from nonpoint sources. They are also available to assess the impact of new land development in the upper portions of the Watershed.

Tab 9 Native, Nonindigenous, or Nuisance Species (Site A, Site E).

“And what is a weed? A plant whose virtues have not been discovered.” -- Ralph Waldo Emerson

“But a weed is simply a plant that wants to grow where people want something else. In blaming nature, people mistake the culprit. Weeds are people's idea, not nature's. -- Author Unknown

What Are Native, Nonindigenous, or Nuisance Species?

Plants, animals, and microorganisms, and their human counterparts, like tourists and retirees, all tend to move around on their own, and naturally "invade" new territories. They find their way across or around significant natural barriers (such as oceans and mountains), but at slow natural rates. We humans help to speed up this movement by moving ourselves, and our possessions around the planet. Multiple routes and means of transport greatly increase opportunities for new species to enter new habitats, with unpredictable and possibly costly results.

Many factors have shaped our attitudes towards introduction of new species into new locations. For centuries, humans have transported plants and animals to new habitats around the world by accident and on purpose. Concerns for invasive species are not new. America in the mid-19th century was awash in immigrant flora and fauna, with fear of starlings, English sparrows, Hessian flies, gypsy moths, and the eucalyptus tree. Construction of shipping canals in the late 1800's and early 1900's breached the natural barriers to species movement between adjacent watersheds. Niagara Falls blocked passage of the sea lamprey (an invasive species predatory on native trout) between the Atlantic Ocean and the upper Great Lakes until the construction of the Welland Canal in 1829.

Ballast tanks of international cargo ships are the major contributor to the global movement of invasive aquatic species. Large quantities of "ballast water" (used to stabilize empty ships) must be discharged when the ships take on cargo. The potential for simultaneous release of invasive species is significant. Water quality in coastal zones and harbors also has improved, making it easier for new species to survive. Another source of invasive species is the garden, aquaria, and bait trades, and the increased movements of boats from lake to lake. The Zebra mussel came to Crystal Lake most probably from transient boaters (since ZMs cannot fly). Increasing rates of new invasions of aquatic species also reflects wider recognition and attention to the problem -- we are simply looking harder.

The terms, exotic, invasive, alien, nonindigenous, and nuisance, generally refer to living species of plants, animals, or microorganisms growing where they don't belong, or are not wanted, and competing with native plants and animals for food and space. They may be intentionally introduced to improve fishing, to introduce new crops, or for ornamental landscaping.

A "weed" to a gardener or a farmer is a flower or vegetable growing in the wrong place. This concept can be applied to many species. Deer and turkey, usually thought of as "wild", are now common sights in rural and urban environments. *E. coli*, a bacterium found in digestive tracts of all mammals including humans, usually causes no harm other than occasional mild digestive disturbances. A rare variety, *E. coli* O157:H7, produces large quantities of potent toxins that cause severe damage to the intestinal lining. *Saccharomyces cerevisiae*, commonly known as baker's yeast or brewer's yeast, is beneficial in making bread or fermenting sugar to alcohol. Molds are very common in wooded areas where they are part of the process of natural decay. Undesirable molds grow indoors on bathroom fixtures, and on walls that have been damaged by water.

An invasive species is non-native (non-indigenous or exotic or alien or foreign) to an ecosystem. It can be a nuisance at the least, and a threat at the most, by potentially causing harm to the environment or human health. Nonindigenous and exotic describe where a species comes from. Invasive describes how a species lives and reproduces. An invasive species successfully reproduces and forms a sustainable population in a new territory. Invasive species have high reproductive rates, good means of dispersal (like the wind-borne seeds of the milkweed or the "tumbling" of the baby's breath), and ability to survive adverse conditions (like cold winters). Some native species are invasive, but since they evolved within the same ecosystem in which they are found, usually have natural predators (enemies), or other factors

to keep them in check. Nuisance species cause problems from a human perspective. Poison ivy is indigenous (native) to North America, but is both an invasive and a nuisance plant. Swimmer's Itch is indigenous in most temperate lakes where its incidence is a function of water temperature, waves, exposure time, and sensitivity. An "invasive" differs from a native species in that it originates from "somewhere else". Since the 1800s, more than 140 exotic plants, fish, algae, and mollusks, have entered the Great Lakes and Lake Michigan. www.glerl.noaa.gov/res/Programs/ncrais/great_lakes_list.html Nonindigenous or exotic species are not necessarily "bad", and many are actually "good". Salmon and smelt are not nuisances but both are nonindigenous to the Great Lakes.

Nonindigenous Species in the Crystal Lake Watershed.

Within the Crystal Lake Watershed, we humans coexist with many other living species of plants and animals. We, as natives, welcome visitors to share and enjoy our Watershed. Together we all impact the wetlands, the nearshore waters, and deepwaters of Crystal Lake, the forests of the surrounding high ridges, the underlying soils, and the air around us. Our environment is a balance of many different living species. Some, like our pets and plants in our gardens, live happily with us humans. Others, like house mites, insects, rats, and other pests, cause allergies, produce odors, destroy food, and carry disease.

Specific invasive species found within the Crystal Lake Watershed include: baby's breath, garlic mustard, purple loosestrife, spotted knapweed, Eurasian WaterMilfoil (EWM), and the Zebra Mussel (ZM). The Emerald Ash Borer (EAB) and Beech Bark Disease (BBD) have recently infested some areas of Benzie Co. Efforts toward control range from hand weeding of Garlic Mustard (GM), Baby's Breath (BB), and Autumn Olive (AO), to protecting the habitat of the Pitcher's Thistle (PT), to selective herbicide spraying to control the Gypsy Moth (GM), or to banning transport of infested firewood and invasive plants. Attempts at control, however, are not always feasible because of limited effect on the target or adverse effect on the ecosystem. Others are either too costly or largely ineffective as permanent solutions.

In lakes with high levels of nutrients, algae and certain aquatic macrophytes are of concern. The very low levels of plant nutrients in Crystal Lake are not conducive for excessive plant growth, except in some nearshore areas. A healthy balance of common phytoplankton was found in a survey of Crystal Lake in 1995-6. Limited growths of EWM were found in another survey of aquatic plants in 1996, reevaluated in 2008, and again in 2011. The presence of ZMs in Crystal Lake was confirmed in 1998, and by 2002 ZMs had been found in 230 lakes in Michigan, including Bass, Crystal, Herring, Little Platte, Platte, and Loon Lakes in Benzie Co., and all the large lakes in NW lower MI. From small localized infestations, ZMs have dispersed throughout the nearshore waters of Crystal Lake. They are also found off the dropoff clinging to strands of *Chara*, a common green algae found in hardwater lakes. Numbers of ZMs vary depending upon the substrate (sand or rock) and local nutrients (from excessively fertilized lawns and poorly functioning septic systems). The exceptional water clarity of Crystal Lake has actually improved over the past several decades, but this is not directly attributed to the ZMs.

Whether "Invasive" or "Native" Species ?

The litany of invasive species include: emerald ash borer, chestnut blight, house sparrow, sea lamprey, Zebra mussel, quagga mussel, alewife, round goby, spiny water flea, purple loosestrife, garlic mustard, Eurasian WaterMilfoil, viral hemorrhagic septicemia (VHS, a fish disease), and bloody red shrimp. Natives include: lake trout, whitefish, and lake sturgeon. Some non-native species, however, are environmentally and/or commercially important: Atlantic smelt, rainbow & brown trout, and Coho & Chinook salmon. There are native species, like swimmer's itch, poison ivy, periwinkle (myrtle), baby's breath, and the common reed (*Phragmites*), that can become nuisance species.

Salmon and smelt are nonindigenous (not native) to the Great Lakes, but have been in our lakes for decades, and are not exotic (foreign). Crystal Lake is the source of all the smelt in the Great Lakes, except Lake Ontario! In 1912, smelt eggs from Green Lake, MN, were planted in Crystal Lake as a food source for the native lake trout. Some escaped into Lake Michigan by way of Outlet Creek. By 1918, smelt "runs" were seen in Cold Creek where "smelt dipping" was very popular until closed to "protect" this lake trout food. Smelt are still caught through the ice of Crystal Lake for eating or as bait for lake trout.

The Atlantic smelt was planted in Crystal Lake in 1912 and later spread throughout all of the Great Lakes! The Lake Sturgeon is a "glacial relic" that has inhabited Crystal Lake since the last ice age.



Atlantic Smelt (6-8") and Lake Sturgeon (3-5 ft) (<http://fish.dnr.cornell.edu/>) (Not to scale.)

Fortunately, most undesirable invasive species are not found in Crystal Lake. The **CLWA** is concerned, however, about future prevention and control of invasive species where feasible. Once present, invasives are very difficult to eradicate in a large body of water like Crystal Lake, since chemical and biological controls are not feasible. The sea lamprey is not found in Crystal Lake because of the barrier of the Outlet Dam, which restricts the direct entry of exotic species from Lake Michigan. Sea lampreys are controlled in the Great lakes by periodic treatment of tributaries with a selective chemical.

Garlic Mustard

Garlic mustard (GM) is an invasive plant that degrades wildlife habitat, displaces rare plants, and causes long-term degradation of forests by shading out tree and shrub seedlings. 1st-year plants form attractive clumps of round shaped, slightly wrinkled leaves, that when crushed smell like garlic. 2nd-year plants flower in spring, producing cross-shaped white flowers in dense clusters, blooming on an elongated spiked stem. Dispersed seeds can lie dormant in the ground for several years.

A garlic mustard "pull" was part of a past spring "*Walkabout*". The first "annual" GM harvest by the **CLWA** in early Summer of 2008 was very successful - volunteers collected more than 70 large garbage bags of GM. We look forward to seeing the difference in the cleared sites next spring. The **CLWA** recommends property owners remove GM wherever possible before it spreads uncontrollably. We support the efforts by other local organizations to pull plants with roots intact in spring and early summer and place in black bags for disposal at approved collection sites. Call the **CLWA** for further information.



1st- and 2nd-year GM plants, and seed heads http://www.ipaw.org/invasders/garlic_mustard/gm.htm

Impacts on the Crystal Lake Ecosystem

A particular invasive species may not be a nuisance to humans, but have direct or indirect impacts on native plants and animals that share the same habitat (home), and an indirect effect on fishermen, farmers, and tourists who rely on those resources. Zebra mussels nearly eliminated native clam populations in Lake St. Clair and western Lake Erie, affected crawfish populations in Lake Michigan, and disrupted the balance of phytoplankton in other lakes. The spiny waterflea and the freshwater jellyfish also change the food web that is important to young fish. The alewife, a nonindigenous fish found in the Great Lakes, was once considered a costly nuisance in the early 1960's. It is now considered the primary food for trout and salmon (several are also nonindigenous) supporting a multi-billion dollar sport fishery.

Unlike Crystal Lake, with visibility of 20 to 30 feet, in Saginaw Bay, Lake St. Clair, and western Lake Erie in 1986, it was difficult to see down more than a few feet prior to the entry of the ZMs in 1986. Now one can see the bottom (!) - a benefit for recreational boaters and divers, but also a benefit for bottom-rooted plants, which improve fish habitat, if growth is not excessive. Because ZMs prefer to eat green algae, nuisance blooms (excessive growths) of less desirable blue-green algae have been reported in summer months in these same areas. In excess, blue-green algae cause taste and odor problems, increased treatment costs for municipal water supplies, and detract from recreational use.

For further information: Invasive Species http://en.wikipedia.org/wiki/Invasive_species ; Invasive Species in the Great Lakes Area <http://www.great-lakes.net/envt/flora-fauna/invasive/invasive.html> ; Jude, D., et al., Non-Indigenous Species in the Great Lakes: Ecology, Interactions, Impacts, and Future Research Directions, UM Initiative in Great Lakes Research, 2002. www.miseagrant.umich.edu/symposium/papers/AQUATI.pdf

American Chestnut Tree

The American Chestnut (sweet chestnut), the largest single living organism east of the Mississippi River, is a large, deciduous tree of the beech family that grows up to 30–45 meters (100–150 ft) tall, and 3 meters (10 ft) in diameter. It is related to the Chinese Chestnut, but not the Horse Chestnut (Buckeye). It is well known for its natural ecological sustainability and urban landscaping. Its reputation as a best-loved native American tree is associated with its beautiful and stately form, fast growth, pleasing rich wood grain, bright foliage, attractively-shaped leaves, odorous, cream-colored blossoms, and toothsome nuts. Its many historical uses include: food for wildlife, livestock, and humans; fine woodwork, furniture, musical instruments; charcoal for blacksmiths; construction, fencing, boxes, barrels, railroad ties, telegraph poles, mine timbers (resistance to rot); and tannins leather tanning industry. An estimated four billion trees once covered more than two million acres from Maine to Florida and the Carolinas to Ohio. Its range extended into SE Michigan but it was not native to NW Lower Michigan. It was planted by early settlers along the Lake Michigan coastline and several thousand trees survived at 271 sites into the 1970's.



A grove was planted ~ 1910 on the old Rogers farm at Chimney Corners on the shores of Crystal Lake.

In what was considered the worst disaster in forest history, most of the American Chestnut forest was annihilated by the chestnut blight beginning in New York in 1904 and reaching Michigan by 1916. The blight caused by a bark fungus, produced bark cankers, wilting of foliage, death of the main stem, with subsequent periodic re-sprouting. There have been major attempts to restore the American chestnut tree to its native range within the woodlands of the eastern United States, using scientific research and breeding programs to encourage the establishment of blight-free and blight-resistant trees. Michigan growers are now actively producing, harvesting, and processing sweet chestnuts. During the Spring 2009 "*Walkabout*" students participants engaged in a special activity by planting seedlings of American Chestnut trees at several public locations within or near the Crystal Lake Watershed.

Reference: Freinkel, Susan, American Chestnut: The Life, Death, and Rebirth of a Perfect Tree, Univ. Cal. Press, 2007, 284pp. <http://books.google.com/books?id=0doVW63nytAC>

Emerald Ash Borer

The emerald ash borer (EAB), an invasive species, is becoming a major threat to local ash trees (*Fraxinus spp*). The magnitude of its potential impact is being compared to the Chestnut Blight and Dutch Elm Disease http://en.wikipedia.org/wiki/Emerald_ash_borer It was accidentally introduced into the U.S. and first sighted in 2002 in the Detroit area, and reached Benzie County in 2005 according to the Cooperative Emerald Ash Borer Project. www.emeraldashborer.info/files/MultiState_EABpos.pdf

The EAB beetle lays its eggs on the outside of the bark in late summer. The nearly microscopic larvae hatch and bore in S-shaped patterns to feed on the inside bark (phloem) used to transport sugars photosynthesized in the leaves to the roots. As this transport is cut off, the branches begin to lose their leaves and eventually the tree dies. The larvae remain within the tree for 1-3 years feeding on the inner bark. In the late spring, the larvae emerge as mature beetles leaving a distinctive “D-Shaped” exit hole.



EAB Larva, Adult, and Exit Hole.

This insect has likely to have only been in our area for a short time and in some trees without showing any obvious signs of entry. Its presence can be evidenced by woodpecker damage and die-off of upper branches. Sometimes ash will begin to develop excessive branching from lower parts of their trunks sending out shoots to capture sunlight with leaves in the lower parts of the tree where it can still send sugars to its roots. However this (epicormic) branching can be the result of other factors affecting its health. It is important not to transport firewood harvested from diseased trees into uninfested areas! Ash trees can be protected from EAB by circumferential injection of insecticides into their trunks but the economics are complicated. For further reading: http://en.wikipedia.org/wiki/Emerald_ash_borer ; details <http://www.emeraldashborer.info/>

Tab 10 Atmospheric and Sediment Effects (All Sites).

“Nothing so fair, so pure, and at the same time so large, as a lake, perchance, lies on the surface of the earth. Sky water. It needs no fence.” -- Henry David Thoreau, *Walden*, Chapter IX: The Ponds (1854).

Atmospheric chemistry (what reacts in the air and falls from the air) and sediment chemistry (what settles to the bottom of the lake and stays there) affect the distribution of materials within the Crystal Lake Watershed. Whatever falls from the air and/or washes in from the land, eventually settles in the Lake.

Atmospheric Effects over Crystal Lake.

Various components enter the Crystal Lake Watershed from the air. These range from liquid droplets of rain and snow, to fine particulate matter, to volatile organic compounds, to inorganic chemicals like ozone and carbon monoxide. While many of major components are from natural sources, some minor but significant components come from anthropogenic (manmade) sources.

The conservation of mass means that the total mass of a system remains unchanged. A mass balance sums the amounts of any component entering, leaving, remaining, or reacting in a system like the Crystal Lake Watershed. Crystal Lake and Lake Michigan acts as "sinks" for all components because they are enclosed systems where some components accumulate. A single drop of water could remain in Crystal Lake for 32 years before it escapes; sediment in the lake remains much longer. Because of this confined system, components deposited in the past and in the present can potentially cause ecological problems. Solid particles increase turbidity; semivolatile components bioaccumulate in the food chain, water-soluble components increase the acidity of lake water.

Certain components accumulate or persist in the Great Lakes because, unlike rivers that are constantly flushed with cleaner waters, lakes act as "pollutant sinks" where they stick around for long periods of time. The Lake Michigan Mass Balance Study (LMMB) is a multidisciplinary multi-institutional study designed to measure distribution, fate, and toxicity of potential toxic components, such as polychlorinated biphenyls (PCBs), atrazine (an agricultural herbicide), *trans*-nonachlor (a pesticide), and mercury, that are present in the atmosphere, sediments, lake and river waters, and the food chain. A mathematical model was developed to predict the effects of reducing these components on water quality and aquatic species. Effects upon nearby inland lakes with contiguous watersheds like Crystal Lake are also important.

A network of sampling locations was established as part of the Great Lakes Integrated Atmospheric Deposition Network (IADN), a joint effort between Canada and the United States to measure atmospheric deposition of precipitation and toxic materials into the Great Lakes. The network of sampling locations included the Sleeping Bear Dunes National Lakeshore. Because of its proximity, it can be considered as representative of atmospheric deposition on the Crystal Lake Watershed. There are no local sources of PCBs entering the Crystal Lake Watershed and the sole source is atmospheric deposition. A consequence is the imposition of a fish advisory that recommends the limited ingestion of brown trout, lake trout, and white suckers taken from Crystal Lake because of their potential content of PCBs. Fish from Crystal Lake were analyzed to be at the low end of the "radar screen" in 1987, but a subsequent lowering of the standard resulted in continued inclusion within the fish advisory.

In the upper atmosphere, O₃ is beneficial to life by shielding the earth from harmful UV (ultraviolet) radiation from the sun. O₃ at ground level, however, is a major health and environmental concern since it is a photochemical oxidant and the major component of smog. Benzie County was removed from the U.S. EPA list as an ozone (O₃) nonattainment area. The 8-hour average level occasionally exceeded the National Ambient Air Quality Standard of 80 parts per billion. O₃ is not emitted directly into the air, but is formed locally through complex chemical reactions between volatile organic compounds (VOC) and oxides of nitrogen (NO_x). The prevailing winds over Lake Michigan carry O₃ precursors toward Crystal Lake from large metropolitan areas to the south. Peak O₃ levels occur during the summer months since these reactions are stimulated by sunlight and temperature. NO_x are emitted by transportation and industrial sources. VOCs are emitted from autos, chemical manufacturing, dry cleaning, painting, and other sources. O₃ causes health problems by damaging lung tissue, reducing lung function, and sensitizing the lungs to other irritants. www.CLWA.us/watershed_concerns.htm#Ozone_Nonattainment

Sediment Effects in Crystal Lake.

As vacationers or riparian owners of cottages and homes within the Crystal Lake Watershed, we have little control over weather - winds and waves; rain, snow, and runoff; evaporation from the lake and soil; or transpiration from the trees and plants. We can maintain greenbelts and trees along the ridge lines to reduce evaporation and sediment runoff, and to keep the water of Crystal Lake in its pristine quality. The ultimate repository of all that enters the Crystal Lake Watershed is the Lake and the bottom of the Lake. Water is deposited as rain or snow directly on the Lake or indirectly on the land that flows over the land or under the land surface into the Lake. Any sediment (solid particulate) or soluble components in this water also end up in the Lake. Just how the individual components are distributed depends upon their physical properties. Certain components will volatilize from the Lake surface and enter the atmosphere. Other components will be transformed if they are biologically degraded or chemically precipitated (converted from soluble to insoluble forms). Any solid particulate matter, be it inorganic precipitates, like calcium carbonate, or organic particulates, like phytoplankton (algae), eventually, slowly but surely, settles to the bottom of the Lake and becomes part of the overlying sediment.

The MI Department of Environmental Quality has embarked on a program to monitor sediment chemistry with several specific objectives: (1) Determine the chemical character of sediments in waters of the state, and whether sediment contaminant levels are changing over time, (2) Identify priority locations for sediment remediation activities in Michigan, (3) Determine background sediment chemical character of waters of the state, (4) Determine whether new chemicals are accumulating in sediments, and (5) Evaluate the overall effectiveness of the NPDES permit program in reducing contaminant levels in sediments. The sediment chemistry element consists of two components in combination to provide data necessary to achieve these objectives. These include: inland lake trends, and watershed surveys.

Approximately 30 lakes are being assessed over several years. Crystal Lake in Montcalm Co. and Crystal Lake in Benzie Co. were among the lakes selected. Sediment samples are being analyzed for total mercury, trace metals (cadmium, chromium, copper, lead, nickel, zinc), total PCBs, and organochlorine pesticides, such as DDT. Inland lake trend data are summarized in annual reports by researchers at Michigan State University, reviewed and approved by DEQ-SWQD, and entered into the U.S. EPA [STORET](#) database. Sediment samples collected as part of the watershed surveys are analyzed for a variety of parameters, based on local conditions and known/suspected sources.

During the summer of 2001, samples of sediment were collected from the bottom of Crystal Lake at the central deepwater region. A chronological history of Crystal Lake over several centuries was contained in this sediment core. Recent sediments are deposited in the top layers, while older sediments are buried in the deeper layers. Different layers of sediment are dated by the decay rate of Pb-210, a radioactive isotope. The dramatic event of the lowering of Crystal Lake in 1873 (the Tragedy of Crystal Lake) was very evident even 130 years after the fact! A significant layer of sand reflecting the historical influx of a considerable amount of sand at the time when the Lake was abruptly lowered by twenty feet as a result of an ill-conceived plan to float saw logs to Lake Michigan. Sediment cores were analyzed in more detail for various chemical elements. Pore water (the free water between the sediment particles) and the solid sediment itself were analyzed for some twenty chemical elements (As, Al, Ba, Ca, Cd, Cu, Fe, K, Mg, Mn, Mo, Pb, Sr, Ti, V, U, Zn) and selected pesticides. Different elements are indicative of either natural and/or anthropogenic (manmade) influences.

Results of the Crystal Lake component of the MSU Inland Lakes Project were summarized at the 2003 Annual Meeting of the CLWF by Sharon Yohn, who received her PhD at MSU in 2004. Overall, the chemical elements in the sediments of Crystal Lake are at or below levels of other NW MI lakes. They are also well below levels of concern for environmental or human health effects. The slow, but inevitable natural aging of the Lake and the impact of the population are determined by analysis of these cores.

For further information: the Lake Michigan Mass Balance www.epa.gov/glnpo/lmmb/; the Integrated Atmospheric Deposition Network www.msc-smc.ec.gc.ca/iadn/index_e.html and the Michigan Fish Advisory www.ichigan.gov/documents/FishAdvisory03_67354_7.pdf For further information on sediment: www.michigan.gov/deq/0,1607,7-135-3313_3686_3728-32365--,00.html; for detailed analyses and illustrations: www.cevl.msu.edu/~long/projects/inlakes.htm

Tab 11 Lake Level (Crystal Lake Outlet) (Site D1).

"You must live in the present, launch yourself on every wave, find your eternity in each moment."
--Henry David Thoreau

The Changing Levels of Crystal Lake

Everyone considers freshwater to be one of our most valuable resources for drinking, fishing, and boating. It's hard to believe that sometimes we have too much water in Crystal Lake and too little water in other places. In the Spring of 2001 the Great Lakes were falling toward 30-year lows, while the level of Crystal Lake was being affected by heavy spring rainfall and high winds were causing shoreline erosion by waves. In the fall of 2007, Crystal lake reached a 37-year low that recovered to normal by the Spring of 2008. These are not new occurrence but only the latest in a long history of events.

The original name of Crystal Lake was "Cap" Lake named after the large "whitecap" waves. A large inland lake like Crystal Lake can expect occasional high winds and shoreline movement of sand due to waves and ice. In fact, the historical scientific literature on sand dune movement and ice push goes back more than 100 years. It's a delicate balance in any large lake, however, between having enough water for boating, but not too much water as to cause shoreline erosion. This article is intended to provide a brief explanation of how the level of Crystal Lake is defined, monitored, interpreted, and controlled.

Levels of Lake Michigan and Crystal Lake

Lake level changes in the Great Lakes region are subject to natural hydrologic variability. The level of Lake Michigan has risen and fallen as much as 17 feet over the recent period of record (1819-1999), which is similar to the geologic record for the past 3,400 years. The level of Lake Michigan (577.5 ft as of October 2007) is about 22.5 feet below the level of Crystal Lake (600 ± 0.25 ft). A drop of water falling on the high ridges defining the Watershed eventually flows into Crystal Lake, either as surface runoff in tributaries, such as Cold Creek, or as groundwater beneath the surface. The water from Crystal Lake then flows toward Lake Michigan, either on the surface by way of Outlet Creek and the Betsie River, or underground beneath the dunes toward Pt. Betsie.

Lake Level Control

While we can't do much about controlling the level of Lake Michigan, local government officials have the ability to directly control the level of Crystal Lake. This is accomplished by adjusting the amount of water that is spilled over the Outlet control dam during the course of each year. A series of five stoplogs (heavy wooden timbers that are added or removed) act as gates. This allows more water or less water to flow over the Outlet Dam, thus maintaining the Lake level as close as possible within the legally prescribed limits. It should be emphasized that the amounts of water involved are very large. Control of lake level is not as simple as turning a faucet on and off, but takes considerable foresight and patience. (Note: as of Sep. 2011, a new engineered structure to facilitate lake level control has been installed at the Outlet.)

Lake Level Records

A level of 595 ft was reported back in 1906. The first dam was constructed at the Outlet in 1909, when the first legal limit was set at 600.48 feet above mean sea level. Before this time, the Lake level rose and fell seasonally by as much as 2 ½ feet! Monitoring done by the Geological Survey in 1942 showed rises and falls of more than 6 inches - twice the present-day changes. The single legal level of 600.48 feet remained in effect for 70 years until it was changed in 1980. Because of concerns for shoreline erosion, the present-day seasonal limits of 600 feet plus-or-minus 0.25 feet (+/- 3 inches) were established by court order after considerable public debate. This two-tiered limit requires a summer level of 600.25 feet from May 1 to Oct. 31, and a winter level of 599.75 feet from Nov. 1 to Apr. 30. This compromise allows higher water for recreation in the summer, and lower water to limit shoreline erosion in the winter. Curiously, the Federal Emergency Management Agency (FEMA) has set a 100-year flood level for Crystal Lake at 601.5 feet that is above the ordinary high water level and well above the crest of the Outlet Dam!

The Benzie County Road Commission monitored water levels of Crystal Lake from 1970 through 1999; the Benzie County Drain Commission has continued monitoring after 1999. Weekly readings have been taken weather permitting, except when the Lake was frozen. Since 1970, the level has rarely exceeded the higher limit for any appreciable time. There have been longer periods when the level has dropped below the lower limit. The Outlet dam sometimes is left "high-and-dry" with only a small trickle of water, while at other times can discharge a raging torrent. On October 30, 2000, the Lake was 5.5 inches below the summer level. This is in contrast to the "full-and-overflowing" condition due to the unusually wet Spring of 2001. On May 1, 2001, the Lake was only 1.68 inches above the summer level, but by May 30, 2001, it had risen to 6.24 inches above the summer level. Citizens were concerned about high water levels and damage to shoreline and structures by both ice and waves. Considerable water was spilled until the summer level was reached in early July. By September 7, 2001, the level had dropped by evaporation to six inches below the summer level, and rose again with the early Fall rains. Over several decades of record, repeating patterns of rise and fall show somewhat less severe fluctuations.

Continuous Monitoring of Lake Level

The **CLWA** has continued the pursuit of scientific water quality monitoring throughout the Crystal Lake Watershed. Two state-of-the-art probes were acquired by the CLWF in 2000 for continuous monitoring of changes in water level and temperature in Crystal Lake and its tributaries. Each of these intelligent probes (Troll 4000[®] (In-Situ, Inc.) contains a computer, memory, sensors, and internal power source allowing remote deployment. The units are programmed for automatic recording of lake level data that can be periodically downloaded to a personal computer for processing and referencing to a surveyed benchmark. Water levels can be measured to within 5.5 mm (0.21 in or 0.018 ft), and changes as small as 1 mm (0.039 in or 0.003 ft) can be observed to define glassy, rippled, and white-capped lake surfaces.

Continuous long-term monitoring, automatic readings of the water level of Crystal Lake have been taken at 30-second intervals and averaged every ten minutes from late May until December 2001. Each week, 1,008 values were collected and compared with weekly values compiled by the Benzie Co. Drain Commission. Various events affecting water level, such as rain, waves, and control of the Outlet dam, were observed. Periods of relative calm were often followed by heavy winds and waves. The highest water level recorded by CLWF in 2001 was 600.82 feet (1 PM, 06/02) and the lowest was 599.77 (6 AM, 09/07). The highest water level recorded over the past 30 years by local government officials was 600.96 feet in 1976. A level of 601.13 was recorded by the Geological Survey in 1942. The total rainfall for May 2001 at Beulah was 8.34 in (about four times the average of the past 30 years), including 3.76 in that fell on May 16th! No wonder that, in May, Crystal Lake rose 4.56 in! An even more dramatic event occurred on August 21, 2002, when a heavy rainfall caused Crystal Lake to rise ~ 5 inches in a four-hour period!

A one-inch rain over the entire Crystal Lake Watershed would amount to more than 100,000,000 cubic feet (or 760,000,000 gallons) of water. At a discharge rate of 100 cubic feet per second (cfs), it would take almost 12 days to discharge this much water. Since much of the water falling on the land soaks in, or slowly flows in the tributaries, it is more realistic to consider only a one-inch rain directly on the lake. This amounts to 36,000,000 cubic feet (or 268,000,000 gallons). Discharging this much water at 100 cfs would require about 4 days. Crystal Lake contains almost a quarter of a trillion gallons (242,000,000,000 gallons)! It would take about 1,000 inches of rain falling directly on an empty Lake to refill it to capacity! Too much rain in too short a time can be a concern since high flows carry more sediment. A four-inch rain in a two-hour period on August 19, 2005, caused the nearby Platte River to rise 1.7 feet, and stressed the importance of slowing stormwater flows through culverts under M-22 into Crystal Lake. Longer term weather conditions, such as the dry summer of 2007, has resulted in the Lake being several inches below its winter level.

For further reference:

Great Lakes Water Levels Home Page, maintained by the U.S. Army Corps of Engineers, Detroit District, www.huron.lre.usace.army.mil/levels/hmpglv.html

For a summary of Crystal Lake levels, please see www.CLWA.us/water_quality.htm#Physical

Tab 12 Wetlands (Trapp Farm, Betsie Valley Trail (Site C, Site D1, Site F, Site J)).

“Do not go where the path may lead; go instead where there is no path and leave a trail.”
-- Ralph Waldo Emerson

The riverine and lake wetlands are found in many variations, esp. at the Trapp Farm, the Betsie Valley Trail, Round Lake, and the Outlet, where they play important roles (See Tab 13). The Betsie Valley Trail is constructed on the former Ann Arbor Railroad corridor from Elberta and Frankfort past Crystal Lake through Beulah and Benzonia to Thompsonville. It offers recreation for walkers, runners, bikers, fishermen, wheelchairs, skiers, skaters, and in some areas, snowmobiles. It passes around Betsie Bay, over and along the Betsie River, beside Crystal Lake, and through a total of 27 miles of forested terrain. It links the 5 communities and 13 existing recreational areas. Remote from homes and roads in most areas, it is one of the most beautiful rail trails in the country. The Frankfort-Elberta Beach-to-Beach Waterfront Trailway and the link from the Frankfort and Elberta Lake Michigan beaches to Crystal Lake were opened in 2003. The trail near Crystal Lake was improved in 2004 and reconstruction from the old Train Station in Beulah to Thompsonville in 2005.

Trail Surface

The Ann Arbor Rail corridor is raised above grade and covered with a layer of ballast stones to allow drainage during inclement weather. Two surface options were considered. From Thompsonville to Beulah, limestone fines (crushed limestone with dust left in the mix) were used to make a surface 6 inches thick by 10 feet wide that looks and feels like "Diamond Dust" on a baseball field. The second surface is an asphalt surface 10-12 feet wide extending 7 miles from Mollineaux road to the communities of Frankfort and Elberta. The 1-1/2 inch asphalt surface is placed over a sub-base of gravel above a 6-inch layer of ballast stones similar to a nice dirt driveway.

Permitting for Trail Surface

Several miles of the Betsie Valley Trail lie within 400 feet of the Betsie River making the Trail subject to Natural Rivers zoning. The Natural Rivers program exists to preserve the natural quality, health, life, and appearance of river systems. Part of Natural Rivers permitting for the Betsie Valley Trailway considers the surfaces used on the trail and how they impact the water quality of the Betsie River. A surface of limestone fines if not consolidated could add sediment load to the river. This sediment load of limestone also could increase the pH of the river water. A surface of heat-absorbing asphalt could increase the water temperature of the river. The pH level created by the limestone and the temperature increases from asphalt in the river could change the environment for plants and animals.

Pedestrian Bridge

A new pedestrian bridge has been constructed over the Betsie River between Frankfort and Elberta. A boardwalk raised above the water by wood pilings every 10 feet provides wetlands viewing, a safe crossing with handrails, and fishing access over the river after it flows under the M-22 Bridge. Before building the boardwalk, the Army Corp of Engineers and the Michigan Department of Environmental Quality reviewed and permitted the project. The MDEQ was provided with a hydraulic analysis of the pilings in the river flow. A professional engineer certified that the structure would not fail during a 100-year flood. Restriction of water flow by the pilings, restriction of water flow by pilings with flood debris trapped against the pilings, strength of structure to withstand the forces generated during flood conditions, and negative effects of restricted water flow upstream of structure were also reviewed.

Michigan Groundwater Stewardship Program

Protection of groundwater from contaminants is important since it is the primary water supply for many individuals in the rural areas of Benzie County. In the Villages of Beulah, Benzonia, Frankfort, and Elberta, water is supplied from wells maintained by local government. Many individuals in the County and around Crystal Lake have individual wells. The Michigan Groundwater Stewardship Program provides information and assessment tools to help them identify risks to groundwater associated with pesticide and nitrogen fertilizer uses and to coordinate local, state, and federal resources to help individuals reduce those risks. The Program is voluntary and locally driven. It is implemented through local programs and commodity programs. A series of Groundwater Stewardship Practice Manuals have been developed.

Tab 13 Great Lakes (Site G).

“Many drops make a bucket, many buckets make a pond, many ponds make a lake, and many lakes make an ocean.” -- Percy Ross

“The Great Lakes - An Environmental Atlas and Resource Book”, Government of Canada and U.S. EPA, Great Lakes National Program Office, Chicago, IL, Third Edition, 1995, is an excellent source of information on the Great Lakes: characteristics, natural processes, people, environmental concerns, joint management, and new directions. Emphasis is on understanding and managing the Great Lakes watershed as a sustainable basin ecosystem. www.epa.gov/glnpo/atlas/index.html

Physical Characteristics describing the sheer magnitude of the Great Lakes water system are difficult to comprehend, even for those who live within the basin. They contain 23,000 km³ (5,500 cu. mi.) of water and cover an area of 244,000 km² (94,000 sq. mi.). The Great Lakes are the largest system of fresh, surface water on earth (18 % of the world supply). Only the polar ice caps contain more fresh water. In spite of their large size, the Great Lakes are sensitive to effects of a wide range of pollutants, including: runoff of soils and farm chemicals, waste from cities, discharges from industrial areas and leachate from disposal sites. The Lakes are also vulnerable to direct atmospheric deposition of pollutants.

Climate describes the average meteorological conditions prevailing over time while weather is the state of the atmosphere at a given time and place. The Great Lakes Basin is affected by air masses from other regions, the location of the basin within a large continental landmass, and the moderating influence of the Lakes themselves. The prevailing movement of air is from the west. The characteristically changeable weather of the region is the result of alternating flows of warm, humid air from the Gulf of Mexico and cold, dry air from the Arctic. Increased summer sunshine warms the surface layers of water in the Lakes, making them lighter than the colder waters below. In the fall and winter months, release of the heat stored in the lakes moderates the climate near the shores of the Lakes. Parts of Southern Ontario, Michigan and western New York enjoy milder winters than similar mid-continental areas at lower latitudes.

Surface Runoff from thousands of tributaries feed the Great Lakes, replenishing the vast supply of stored fresh water. Surface runoff is a major factor in the character of the Great Lakes basin. Rain falling on exposed soil tilled for agriculture or cleared for construction accelerates erosion and the transport of soil particles and pollutants into tributaries. Suspended soil particles in water are deposited as sediment in the lakes and often collect near the mouths of tributaries and connecting channels. Much of the sediment deposited in nearshore areas is resuspended and carried farther into the lake during storms. Before settlement of the basin, streams typically ran clear year-round because natural vegetation prevented soil loss. Clearing of the original forest for agriculture and logging has resulted in both more erosion and runoff into the streams and lakes. This accelerated runoff aggravates flooding problems.

Wetlands are areas where the water table occurs above or near the land surface for at least part of the year. Swamps, marshes, bogs, and fens are basic types of wetlands in the Great Lakes Basin. Swamps are areas where trees and shrubs live on wet, organically-rich mineral soils that are flooded for part or all of the year. Marshes develop in shallow standing water, such as ponds and protected bays. Aquatic plants form thick stands rooted in sediments, or floating mats where the water is deeper. Swamps and marshes occur in the southern and eastern portions of the Basin. Bogs form in shallow stagnant water.

The most characteristic plants are the sphagnum mosses, which tolerate conditions that are too acidic for other organisms. Dead sphagnum decomposes very slowly, accumulating in mats that may become many feet thick forming a dome well above the surface of the water. This material is excavated and sold as peat moss. Peat also accumulates in fens, which develop in shallow, slowly moving water. They are less acidic than bogs and are usually fed by groundwater. Fens and bogs are referred to as 'peatlands' and occur in the cooler northern and northwestern portions of the basin. Wetlands are important ecologically, economically, and socially to the overall health and maintenance of the Great Lakes ecosystem. They provide habitats for plants and animals, some of which are found nowhere else. Wetlands are an important part of the migratory cycle for ducks, geese, and other birds, by providing food, resting places and seasonal habitats. Wetlands also provide desirable habitats for aquatic life, and prevent damage from erosion and flooding by controlling point and nonpoint source pollution.

Groundwater is important to the Great Lakes ecosystem because it provides a reservoir for storing water and slowly replenishing the lakes in the form of base flow in their tributaries. It is also a source of drinking water for many communities. Shallow groundwater also provides moisture to plants. As water passes through the subsurface, some materials are filtered out, but others in the soil are dissolved or suspended in the water. Salts and minerals in the soil and bedrock are sources of 'hard' water, a common feature of well water. Groundwater can also pick up materials of human origin that have been buried in dumps and landfill sites. Groundwater may discharge directly to the lakes or indirectly as base flow to the tributaries.

Lake Levels of the Great Lakes are part of the global hydrologic system. Prevailing westerly winds continuously carry moisture into the basin in air masses from other parts of the continent. At the same time, the basin loses moisture in departing air masses by evaporation and transpiration, and through the outflow of the St. Lawrence River. Over time, the quantity lost equals what is gained, but lake levels can vary substantially over short-term, seasonal, and long-term periods. Day-to-day changes are caused by winds that push water on shore. This is called 'wind set-up' and is usually associated with a major lake storm, which may last for hours or days. Another extreme form of oscillation, known as a 'seiche', occurs with rapid changes in winds and barometric pressure. Annual or seasonal variations in water levels are mainly due to changes in precipitation and runoff. Generally, the lowest levels occur in winter when much of the precipitation is locked up in ice and snow on land, and dry winter air masses pass over the lakes enhancing evaporation. Levels are highest in summer after the spring thaw when runoff increases. Highest levels occur during periods of abundant precipitation and lower temperatures that decrease evaporation. During periods of high lake levels, storms cause considerable flooding and shoreline erosion, which often result in property damage. Much of the damage is attributable to intensive shore development, which alters protective dunes and wetlands, removes stabilizing vegetation, and generally reduces the ability of the shoreline to withstand the damaging effects of wind and waves.

Lake Processes, such as stratification and turnover, occur because the Great Lakes are not simply large containers of uniformly mixed water. They are highly dynamic systems with complex processes and a variety of subsystems that change seasonally and on longer cycles. Stratification or layering of water in lakes is due to density changes caused by changes in temperature. The density of water increases as temperature decreases until it reaches its maximum density at about 4° C (39° F). This causes thermal stratification, or the tendency of deep lakes to form distinct layers in the summer. Deep water is insulated from the sun and stays cool and more dense, forming a lower layer called the 'hypolimnion'. Surface and nearshore waters are warmed by the sun, making them less dense so that they form a surface layer called the 'epilimnion'. As the summer progresses, temperature differences increase between the layers. A thin middle layer, or 'thermocline', develops in which a rapid transition in temperature occurs. The warm epilimnion supports most of the life in the lake.

Algal growth is greatest near the surface where sunlight readily penetrates. The surface layer is also rich in oxygen, which is mixed into the water from the atmosphere. A second zone of high productivity exists just above the hypolimnion, due to upward diffusion of nutrients. The hypolimnion is less productive because it receives less sunlight. In late fall, surface waters cool, become denser and descend, displacing deep waters and causing a mixing or turnover of the entire lake. In winter, the temperature of the lower parts of the lake approaches 4° C (39° F), while surface waters are cooled to the freezing point and ice can form. As temperatures and densities of deep and shallow waters change with the warming of spring, another turnover may occur. The lakes usually remain mixed throughout the winter.

Ecosystems like the Great Lakes basin are units of nature in which living organisms and nonliving things interact and adapt. The sun provides energy as light and heat to ecosystems. This energy warms earth, water and air, causing winds, currents, evaporation, and precipitation. Light is essential for photosynthesis by green plants in water and on land. Plants of all sizes grow when essential nutrients, such as phosphorus and nitrogen, are present with oxygen, inorganic carbon and adequate water. Microscopic algae are consumed by zooplankton in water. Macroscopic plants are consumed by plant-eating animals (herbivores) on land. Energy transfer continues through levels of the ecosystem with organisms that feed on other animals (carnivores) and those that feed on both animals and plants (omnivores). These levels of consumption constitute the food chain, or web, a system of energy transfers through which all the species in an ecological community are sustained. In ecosystems, including the Great Lakes basin, everything depends on everything else and nothing is ever really wasted.

U.S. Coast Guard - Station Frankfort History

U.S. Coast Guard Station Frankfort is located in the town of Frankfort on picturesque Lake Michigan, where dedicated crews have stood watch for over 100 years. The long history of the Coast Guard in Frankfort began in 1887 with the U. S. Lifesaving Service establishing a Station in Elberta, Michigan. This Lifesaving Station is still standing approx. one half of a mile from where our current station sits today and has been fully restored to its original condition. In 1934, a new 14,000 square foot station was built in Frankfort that contained wooden lifeboats mounted on rails inside the station boathouse directly underneath the living quarters. As technology progressed and lifeboats became larger and more sophisticated, the boats were kept at the docks near the station. For a brief two-year period at the turn of the century, Station Frankfort became a Station (small) under the parent command of Station Manistee. It was soon obvious, though, that the need for a larger independent crew in Frankfort was in the public's best interest and in July of 2003, Frankfort once again stood on her own as one of Group Grand Haven's units. During that same year, construction began on a brand new modern facility located next to the 1934 building and the Coast Guard took possession of the building in June of 2004. The summer of 2005 brought even further changes with the restructuring of command within the Coast Guard community. Sector Lake Michigan, located in Milwaukee, became the new parent unit for all Lake Michigan units and Group Grand Haven became a Sector Field Office. These changes marked a new beginning and in many ways, reaffirmed the Coast Guard's continued service and commitment to the boating public well into the 21st century!

<http://www.uscg.mil/d9/sectLakeMichigan/history.asp>

Crystal Lake Watershed: Maps and Models

Maps put the Crystal Lake Watershed and its 17 subwatersheds in perspective. A series of maps are available from the **CLWA**: (1) the Crystal Lake Watershed map, with all "**Walkabout**" Interpretive Sites; (2) an outline map, showing the extent of the watershed and bathymetry of Crystal Lake; (3) a digital elevation map (DEM), showing topography of the land; and (4) an historical map of the "Frankfort Colony Lands" (1860. A map of the Lake Michigan Watershed (part of the "**Walkabout**" Interpretive Manual) shows how the Crystal Lake Watershed relates to the Great Lakes region.

A model of the Crystal Lake Watershed is to be shown during the "**Walkabout**" to illustrate land and water features created by glaciers, water, and wind. (The surrounding land is about twice as high as the Lake is deep!) It was designed by the **CLWA** and sculpted by Corey Becker, Art Teacher, Benzie Central Intermediate School, and patterned after a generalized watershed model created by Mark Walton, NOAA NWS, and David Chapman, Earth Science Teacher, Okemos High School. It will be on display at Point Betsie (summer) and the Benzie Area Historical Museum (winter).



www.miseagrant.umich.edu/store/images/products/159.jpg Crystal Lake & Lake Michigan Watersheds

Tab 14 Dunes (Point Betsie) (Site H).

“Every time we walk along a beach some ancient urge disturbs us so that we find ourselves shedding shoes and garments or scavenging among seaweed and whitened timbers like the homesick refugees of a long war.” -- Loren Eiseley

Geology of the Crystal Lake Watershed

Geology tells the story of the birth of Crystal Lake. The glaciers that traveled across Michigan scoured out large areas of earth as they moved southward. When the final (Wisconsinian) glacier that covered northwest Lower Michigan retreated between 8,000 and 13,000 years ago, it had carried and deposited large quantities of sand, gravel, and rock in large ridges called moraines. Crystal Lake lies in a depression between two east-west trending glacial moraines. Before Crystal was a Lake, it was actually a bay that sat between these moraines while still being open to Lake Nipissing, the name given to Lakes Michigan, Huron, and Superior at this stage - 4,000 years ago. Movement and deposition of sand along the shoreline eventually built a sandbar across the mouth of the bay forming what is known as an embayment lake. As Lake levels dropped, the sandbar at Point Betsie was exposed and permanently isolated the “Crystal Bay” from Lake Michigan, forming Crystal Lake.

Dune Formation

Crystal Lake owes its existence to the process of sand movement that also expresses itself in the formation of dunes. Three factors led to the formation of Michigan’s dunes: a sufficient supply of sand, a persistent west wind, and trapping mechanisms. As the beach sand dries, it is carried by the prevailing winds until either the wind slows or it encounters an obstruction. An obstruction can be anything: a rock, a log, or a clump of grass that has established itself. At this point, the sand being carried is dropped. During the fall and winter, heavy winds and waves can carry sand even further inland.

Dune Zones

A dune ecosystem contains different zones or communities. These can be categorized as:

- (1) Wet beach (swash zone) - constantly bombarded by waves, no vegetation.
- (2) Dry beach (backshore) - can support some vegetation, such as sea rocket.
- (3) Foredune - the first ridge behind the beach, can support a wide variety of life.
- (4) Interdunal wetlands - shallow pools and ponds between dunes.
- (5) Back dunes (dune forests) - Northern dunes are dominated by beech and maple, boreal pockets of northern white cedar, and white spruce may be found.
- (6) Blowouts - Areas eroded by wind, causing a lack of vegetation in that area.

Dune Vegetation

An ecological process called succession takes place on the dunes. This refers to the different communities of animals and plants from the shoreline to the back dunes. The numbers and kinds of organisms gradually change over time in an ordered sequence. The first organisms that are found on the dunes are grasses, such as marram grass. This grass is referred to as a pioneer species. It helps to build the dunes and allows for the initial stabilization of the dune system.

There are many other plants that are native to the dunes that also help to stabilize the dune system. Some examples are: cottonwood, sand cherry, wormwood, common milkweed, hairy puccoon, beach pea, starry false Solomon’s seal, harebell, red osier dogwood, bearberry. How many of these do you recognize?

Many dune plants have special adaptations that allow them to live in the hot and dry dune environment. A long taproot allows the plants to reach deep into the dunes for water. Light colored leaves enable the plant to keep cool. Hairs on the surface of the leaves ensure that the plant loses as little water by evaporation as possible.

Threats to the Dune Ecosystem

Humans can negatively impact a dune in many ways. Habitat can be lost when development occurs on the sensitive dune system. Individuals can cause local disturbances with foot or vehicle traffic. Native vegetation can be killed opening an area to erosion. Non-indigenous (non-native) plants, imported for ornamental or other uses, can invade and crowd out and threaten the existence of native vegetation.

The Preserve

The Nature Conservancy (TNC) is an international non-profit organization that has protected over 7.3 million Acres of land worldwide, and manages over 1,300 private nature preserves - the largest collection on Earth. The Michigan Chapter of TNC maintains the Zetterburg Preserve in the dunes near the Pt. Betsie Lighthouse. These dunes provide habitat for the threatened Pitcher's thistle and Lake Huron locust. The Pitcher's thistle occurs only along the shorelines of the Great Lakes. TNC hopes that one day these beaches might also provide a home for the endangered piping plover, a bird that nests only in northern Michigan on the beaches of Lake Michigan and Lake Superior.

The Project

TNC is working to protect the Pt. Betsie Dunes Preserve from being permanently altered by the encroachment of invasive species. Dunes are naturally dynamic ecosystems, with open sandy areas continually being moved by wind. Two non-native (exotic) species, baby's breath and spotted knapweed, have established themselves at Pt. Betsie and are altering the ecosystem due to their density. They actually cause "overstabilization" by reducing species diversity and preventing sand movement of this dynamic ecosystem. TNC, along with volunteers, are working to reduce the number of these exotic species at the Preserve. TNC is also working in cooperation with Sleeping Bear Dunes National Lakeshore toward the same goal.

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For information: The Nature Conservancy MI Chapter
www.nature.org/wherework/northamerica/states/michigan/preserves/art17122.html

Point Betsie Lighthouse

The Point Betsie Lighthouse is the most famous landmark in Benzie County. It is located on the eastern shore of Lake Michigan just south of the Sleeping Bear Dunes National Lakeshore and just north of Frankfort, MI. Point Betsie marks the southern entrance to the Manitou Passage, a major shipping channel. Pt. Betsie was originally known by the French as "*Point Aux Bec Scies*", meaning "point of the sawed-beak (duck)", which is known locally as the Common Merganser, *Mergus merganser*. Construction of the Lighthouse was completed in 1858 and the light has continued to guide passing ships to the present. An adjacent life saving station was operated from 1877 through 1938. The light sits 52 feet above Lake Michigan and has a range of 27.5 miles.

The Friends of Point Betsie, seeks to preserve this noble Benzie County landmark so that its significance and varied meanings will remain vivid for everyone who comes upon it for decades to come. Benzie County, in full partnership with the Friends, acts as the official caretaker of the Lighthouse grounds via a historical lease granted by the Coast Guard. While today Point Betsie is most often thought of as a site for observing the splendor of sunsets or simply enjoying the Lake Michigan beach, the Lighthouse and its beautiful setting hold an important place in the Great Lakes' rich maritime history.

For information: The Friends of Pt. Betsie Lighthouse, 231/352-4915, www.pointbetsie.org

Tab 15 Benzie Area Heritage (Site I).

“Do not go where the path may lead; go instead where there is no path and leave a trail.”

-- Ralph Waldo Emerson

The history of Northwest Lower Michigan encompasses Benzie County and the Crystal Lake Watershed. It is a culmination natural events: the advance and retreat of large glaciers, the rise and fall of great lakes, the creation of majestic sand dunes, and the growth of virgin forests. Settlement of the area was started by the explorers, fur traders, and pioneer settlers; was exploited by the logging industry; was expanded by the fruit growing industry, and was developed by the tourist industry. An event unique to the Watershed was the abrupt lowering of the level of Crystal Lake 130 years ago that exposed a shoreline expanse that defines our Watershed (Walter F. Case, *The Tragedy of Crystal Lake / By a Survivor*, 1922).

“In 1873 an ambitious but ill-advised project was put through in an effort to connect Crystal Lake and Lake Michigan with a navigable channel. The original level of Crystal Lake was, at that time, much higher than its present level. The project was a complete failure in respect to its accomplishing its proposed purpose. The result was the lowering of the lake and exposing a wide stretch of beach around the entire lake and making possible the development of Crystal Lake as a resort and residential area as well as the site of the village of Beulah. This monument, erected by the people of Benzie County, stands at the original level of Crystal Lake. 1978.” (Inscription on three permanent markers placed at the original level of Crystal Lake as located by the County Surveyor, the Soil Conservation Department, and the Benzie Area Historical Society.)

It Takes A Watershed (Are You Ready to Be a “Shedie” ?)

There’s a small village of Welsh heritage upnorth in Minnesota, named “Lake Crystal”. Unlike Garrison Keillor’s Lake Wobegon, where “all the women are strong, all the men are good-looking, and all the children are above average”, a lot of folks in Lake Crystal are named “Jones”. When you were born, you were delivered by Doctor Jones, you were schooled by Teacher Jones, you bought things from Butcher Jones or Furniture Jones, you gave your money to Cashier Jones, and you got mail from Postmistress Jones. Besides dozens of John Jones and a host of “Farmer” Jones, there were nicknames, like “Big” and “Little” Jones, “Young” and “Old” Jones, etc. And if you died there, Undertaker Jones buried you, and Reverend Jones preached the sermon.

The Crystal Lake Watershed has similarities with Lake Crystal, but it is defined by much more than political boundaries or personal names. Geographically, it encompasses parts of six townships, two villages, and a very large Lake. Our relatively small Watershed area consists of all the land that “sheds” water downhill and the Lake itself. Water leaves our Watershed by evaporation, by transpiration from trees and vegetation, by discharge at the Outlet → to the Betsie River → to Betsie Bay → to Lake Michigan, or by groundwater flow to Lake Michigan.

Within the Crystal Lake Watershed, we’re all “Shedies” (“*Lakie*” + “*Townie*” + “*Fudgie*” = “*Shedie*”). We may be permanent or summer residents somewhere within the Watershed – around the lakeshore, in the neighboring villages, or the surrounding countryside, - or we may be visitors from somewhere else. Regardless of who we are, and where we’re from, we all share a love for our Watershed, and wish to preserve it for future generations. We may think our own lives as ordinary, but we are remembered for what we do with them. As individuals and as families, we are all integral to a mutually supportive community where we impact each other in many ways for the betterment of our watershed environment. It indeed takes a watershed to raise our children and to mold them into responsible adults able to make informed decisions on watershed issues. –SLD, 091007

For over 40 years, the Benzie Area Historical Society has collected, interpreted, and expanded knowledge of the Benzie area. The Museum, located in an historic 1887 church building, once the center of the religious colony that founded Benzonia in 1858, contains a cross-section Benzie County life from early inhabitants and pioneers to modern residents and tourists describing exploration, lumbering, farming, fishing, and recreation.

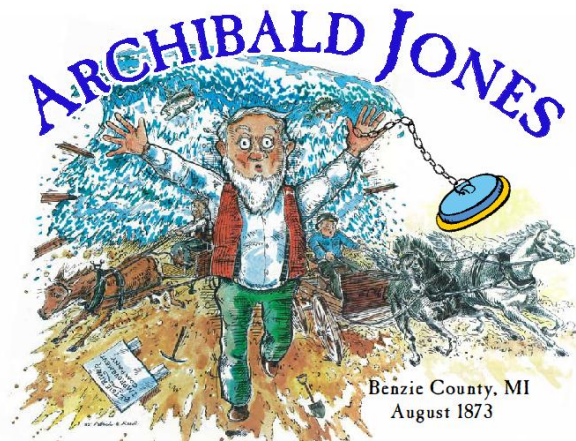
The “Tragedy” and the “Comedy” of Crystal Lake and The Role of Archibald Jones¹

The “Tragedy of Crystal Lake is a well-known story of the artificial lowering of Crystal Lake in Benzie County, and how it came to be an unique event among large inland lakes in northwest Lower Michigan. William L. Case masterfully told what was believed to be the authentic story based upon his recollections made fifty years after witnessing the event as a 17-year old. His account was serialized in the Benzie Record and printed as a small pamphlet in 1922.²

There is much to wonder about the uniqueness of Crystal Lake: What was the cause of the “Tragedy”?

Who was Archibald Jones? Should he be credited or blamed for the lowering of Crystal Lake? Since the “Tragedy” of Crystal Lake figures so prominently in Benzie County history, there was more to the story. A review of contemporary accounts, recorded legend, and scientific evidence, has pinpointed the actual date for the Tragedy/Comedy. A biography was created for the travels of Archibald Jones.

The actual event occurred early the morning of Saturday, August 23, 1873, when whitecaps of Crystal Lake washed out a temporary dam intended to be part of a slack-water canal with locks. In a seemingly ill-fated attempt to create a navigable channel between Crystal Lake and Lake Michigan, the Betsie River Improvement Co. caused the level of Crystal Lake to be lowered by 20 feet. This tumultuous event resulted in Crystal Lake losing 25% of its water volume (76,000,000,000 gallons), and reducing its surface area by 25% (3,093 Acres)! Crystal Lake is still the 9th largest inland lake in Michigan with a surface area of 9,854 A and a volume of 242,000,000,000 gallons of water!



The Man Who Pulled the Plug at Crystal Lake

The drawdown was unsuccessful from a navigational standpoint, but created a 21-mile sandy beach and prime recreational area around Crystal Lake where ~ 1,100 cottages and the Village of Beulah are now located. The “Tragedy” of Crystal Lake is forever preserved in the exposed terrace of sandy beach, the perimeter roads and trails, the deep water sediments, and the outwash plain along the Outlet. *“The event was so epochal in its nature and has such a permanent bearing on the subsequent development of Benzie County that it is rightly considered as one of the major incidents of the county’s early history.”³*

Western expansion by settlers from the Eastern States to the Great Lakes region occurred during the 1830’s – 1890’s. Particular to Michigan were the unlimited opportunities to create harbors of refuge for shipping along the eastern shoreline of Lake Michigan, and the creation of accessible waterways to inland regions of the State for logging and farming. The saga of Archibald Jones is both typical and unique.

Early Years – New York: Archibald Jones “Jr.” was born in Petersburg, NY, on 14 Sep 1811, the 4th of 8 children of Archibald Jones “Sr.” and wife Prudence. This locale is close to the Hudson River and the eastern terminus of the Erie Canal, which was the first rapid transportation system between the eastern seaboard and the Great Lakes that did not require portage or arduous overland travel through wilderness on primitive roads. Archibald worked on the Canal as a young man. His great(5) grandfather, Christopher Jones Jr., was owner and captain of the Mayflower.

¹ Abstracted from a chapter of a book being written by Dr. Stacy L. Daniels on the environmental history of the Crystal Lake Watershed; published in the Benzie County Record Patriot, Jul. 21, 2010, and Aug. 4, 2010; Benzonia Academy Lecture, Aug. 12, 2010; Darcy Library, Archibald Jones Day, Aug. 28, 2010.

² William L. Case, *The Tragedy of Crystal Lake / By a Survivor*, J.W. Saunders, Beulah, MI, 1922, 17pp.; Reprinted 1978, 22pp, sponsored by the Benzie Area Historical Society.

³ Leonard Case, *Benzie County, A Bicentennial Reader*, 1976.

Marriage and Family – New York: Archibald married Sophia Needham, of Brattleboro, VT, 15 Apr 1835. The first five of eight children, Ai, George W., Anna, Olive C., and Frank A., were born in small towns in upper middle NY straddling the Erie Canal. Archibald was a “carriage maker” in Urbana, NY, in 1850, before embarking on his adventures to the west.

Migration to the Mid-West – Ohio: The growing Jones family followed the wave of immigrants west to Ohio. In 1851, Archibald and son Ai, drove teams of horses from Whitesville, NY, to Sandusky, OH, a distance of 310 miles through wilderness and along the shores of Lake Erie. The family first lived on a farm east of Sandusky, then on Put-in-Bay Island, where Archibald was overseer of the estate of Judge Ogden Edwards. Archibald was the foreman of the property until 1854. Archibald learned fruit culturing as grapes were cultured and the wine industry began on the island.

Opportunity on the Frontier – Michigan: The Jones’ family grew with Archibald (III), Charles H., and Sophia. By 1860, Archibald, along with six of his eight children, was a “lumberman” in Sanilac Co., MI, where he was befriended by Truman Moss, a prominent businessman, during which time he learned much about the lumbering industry in Michigan.

Moving On – Illinois: In the early 1860’s, several family members moved to Irving Park, IL. Archibald, Sophia, and the younger children may have moved on to Marengo, IL. Following the Great Chicago Fire of 1871, Archibald and Sophia, and family moved to Benzonia, MI, to fulfill their destiny at Crystal Lake.

The “Tragedy” of Crystal Lake – Michigan: Archibald formed the Betsie River Improvement Co. in early 1873, intending to create a navigable waterway between Crystal Lake and Lake Michigan. Timber could then be transported to the sawmills and cordwood to the iron foundry downriver in Frankfort, and finished goods shipped upriver to Benzonia and points inland. An engineered slack-water canal never materialized, but the wide sandy beach has become a prime recreational area. Archibald, a shrewd business man and bootstrap engineer, may not have actually “pulled the plug”, rather the whitecaps of Crystal Lake, washed out the temporary dam before permanent locks could be constructed.

Archibald Jones - “He Buildded Better Than He Knew”: The lowering of Crystal Lake was unique in the histories of Michigan inland lakes, and one of the most spectacular and long-lasting of river improvement projects anywhere in the U.S. Following the “Tragedy” and the failure of his Company, Archibald was sued by John Torrans, the builder of a paddleboat commissioned to ply the Betsie River. In the ensuing court testimony, Archibald, when asked why the boat failed to perform replied with a famous anecdote, “Well, the real reason was because the bottom of the river was too close to the top of the water.”

Further Adventure – Illinois & Kansas: Archibald and Sophia returned to Marengo, IL, in late 1877, where he was a horse dealer and a miller, and sometime before 1885, moved to Emporia, KS, living on a 900-A cattle ranch. They celebrated 50 years of married life 1885. Sophia died in 1887 and Archibald moved to Davenport, IA, to live with a widowed daughter. Archibald died on 15 May 1890, and was buried in Emporia, KS, next to Sophia. He was survived by Julia F. Jones, whom he married in 1889.

Descendants: Some Jones’ children married and settled in Ohio, but family members shared in joint ventures. Son George assisted in his father’s Company, and later ran a livery stable and stage stop. Grandson Irving Park Jones was a cashier in the Central State Bank in Benzonia. Great grandson, Milton Irving Jones, an osteopathic physician retired to Benzonia. Great granddaughter, Mildred M. (Jones) lived the “Archibald Jones House” in Benzonia. Many of Jones’ are buried in Benzonia Twp. Cemetery.

The following verse of Burton Rensselaer Jones, a namesake Jones, is aptly applied to Archibald Jones:

| | |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| "The smallest bark on life's tumultuous ocean Will leave a track behind for evermore; The lightest waves of influence set in motion, Extend and widen to the eternal shore: We should be wary, then, who go before | A myriad yet to be; and we should take Our bearing carefully, where breakers roar And fearful tempests gather; one mistake May wreck unnumbered barks that follow in our wake." |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

Significant Events in Crystal Lake Watershed History.

| Year | Event |
|-----------------------|------------------------------------------------------------------|
| 2,000,000 - 10,000 BP | Pleistocene Epoch (extensive glaciations) |
| 10,000 BP - Present | Holocene Period (post-glacial) |
| 11,000 - 9,000 BP | Glacial Lake Algonquin |
| 6,000 - 4,000 BP | Glacial Lake Nipissing |
| 2,000 BP | Final embayment of Crystal Lake |
| 1675 | Exploration of Lake MI (Fr. Marquette) |
| 1721 | Exploration of Lake MI (Fr. Charlevoix) |
| 1787 | Northwest Territory est. |
| 1805 | Territory of Michigan est. |
| 1820 | Exploration of Lake MI (Lewis Cass) |
| 1837 | State of Michigan est. |
| 1838 | Geology of Lake MI (Douglass Houghton) |
| 1838-39 | Land survey of Benzie Co. |
| 1854 | "Discovery" of Betsie Bay |
| 1858 | Beulah/Benzonia est. |
| 1858 | Construction of Pt. Betsie Light |
| 1859 | Crystal Lake Township est. |
| 1859 | Village of Frankfort est. |
| 1863 | Benzie County est. |
| 1863 | Benzonia College & Benzonia Academy est. |
| 1863 | Roads from Benzonia to Manistee and Traverse City |
| 1867 | Frankfort Iron Works est. |
| 1873 | The "Tragedy" / "Comedy" of Crystal Lake |
| 1873 | Lake Township est. |
| 1874 | Western Union Telegraph from Frankfort to Traverse City |
| 1887 | U.S. Coast Guard - Station Frankfort |
| 1890 | Plat of Crystal City & Beulah View Resort |
| 1892 | First RR Car Ferry bet. Frankfort and Kewaunee |
| 1896 | Railroad Cut at "Bay" Point on Crystal Lake |
| 1901 | Congregational Summer Assembly |
| 1909 | First legal lake level est. (600.48 ft) |
| 1912 | Smelt planted in Crystal Lake |
| 1922 | Cherry Hut Restaurant |
| 1927 | Crystal Downs Country Club |
| 1931 | Crystal Lake Yacht Club |
| 1935 | Chimney Corners Resort |
| 1935 | Crystal Lake bathymetry (Robert S. McNamee) |
| 1970 | First Earth Day |
| 1970 | Sleeping Bear Dunes National Lakeshore |
| 1980 | Environmental Impact Statement (EIS) (U.S. EPA) |
| 1980 | Summer/winter lake levels est. (600 +/- 0.25 ft) |
| 1989 | Septic system ordinance (Benzie Leelanau District Health Dept.) |
| 1987-93 | Water quality monitoring (Crystal Lake Clean Water Committee) |
| 1994 | Crystal Lake Watershed Overlay District (CLWOD) |
| 1993-10 | Water quality monitoring (CLWA and others) |
| 1993-10 | Crystal Lake "Walkabout" (CLWA and others) |
| 1994 | Crystal Lake Watershed Overlay District (CLWOD) |
| 2000 | Benzie Co. 2020 Comprehensive Plan (BCCAC) |
| 2004 | Crystal Lake & Watershed Association (CLWF + CLA = CLWA) |

A century of environmental studies of exploratory, scientific, and historical significance illustrate the diversity of subjects and dedication of many individuals whose studies have defined the unique environmental history and significance of the Crystal Lake Watershed. (The following were selected from an annotated bibliography of ~ 1,900 references by Daniels, Stacy L., "Crystal Lake: An Environmental History of Myriad Environments, The Crystal Lake Watershed, Benzie County, Michigan, Being Summary Descriptions of Its Creation, Transformation, and Destiny from Myriad Viewpoints", manuscript in preparation, The University of Michigan Press, 2011.)

A Century of Environmental Studies of the Crystal Lake Watershed.

| Year | Personnel | Description of Study |
|------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| 1888 | William James Beal | Across Michigan by Covered Wagon: A Botanical Expedition |
| 1899 | Henry Chandler Cowles | Ecological Relations of Vegetation on Sand Dunes of Lake MI |
| 1903 | David J. Hale | Marl and Manufacture of Portland Cement |
| 1904 | Frank Leverett | (A geological circumnavigation of Crystal Lake.) |
| 1906 | Frank Leverett | Water supplies of Benzie County |
| 1914 | Irving Day Scott | (Geology notes of Crystal Lake) |
| 1915 | George Damon Fuller | Department of Botany Field Ecology class at Crystal Lake |
| 1915 | Frank Leverett & Frank B. Taylor | Pleistocene of IN and MI; History of the Great Lakes |
| 1917 | Warren G. Waterman | Ecology of Northern Michigan Dunes: Crystal Lake Bar |
| 1919 | Warren G. Waterman | Development of Root Systems under Dune Conditions |
| 1921 | Irving Day Scott | "Inland Lakes of Michigan" (Crystal Lake) |
| 1922 | Warren G. Waterman | Forests and Dunes from Point Betsie to Sleeping Bear |
| 1922 | Warren G. Waterman | Plant Communities of a Sand Ridge Region in Michigan |
| 1922 | William L. Case | "The Tragedy of Crystal Lake" / By A Survivor |
| 1923 | David E. Davis | A Natural History of Crystal Lake |
| 1925 | Charles W. Creaser | Establishment of Smelt in the Great Lakes |
| 1926 | Irving D. Scott | Ice-Push on Lake Shores |
| 1930 | Jan Metzlar & T.H. Langlois | Smelt of Crystal Lake, Benzie County |
| 1931 | Wilbert B. Hinsdale | Archaeological Atlas of Michigan |
| 1932 | Florence Wolfe | Tree Rings, Climatic Conditions, and Movement of Sand |
| 1935 | Robert L. McNamee | Map of Crystal Lake Benzie County Michigan |
| 1937 | Irving D. Scott & Kenneth W. Dow | Dunes of the Herring Lake Embayment |
| 1937 | John Van Oosten | The dispersal of smelt in the Great Lakes (from Crystal Lake) |
| 1937 | Oren F. Evans | Waves, currents, sediments, and shorelines |
| 1940 | C.J.D. Brown/ & John Funk | Fisheries survey of Crystal Lake |
| 1946 | Hathaway J. Hanes | Crystal Lake Level Control |
| 1942 | David S. Shetter & Dexter Reynolds | Operation of the Crystal Lake Outlet Weir |
| 1947 | James Lewis Calver | Glacial/Post-Glacial History of Platte and Crystal Lakes |
| 1958 | Alfred M. Beeton | Vertical migration of <i>Mysis relicta</i> in Lakes Huron and MI |
| 1970 | John A. Dorr & Donald F. Eschman | "Geology of Michigan" (Crystal Lake) |
| 1970 | John J. Gannon | Crystal Lake Water Quality Investigation |
| 1970 | MI Water Res. Com. | Water quality in the Grand Traverse Region |
| 1972 | Bruce Catton | "Waiting for the Morning Train, An American Boyhood" |
| 1974 | William M. Marsh & Thomas E. Borton | Michigan Inland Lakes and Their Watersheds: An Atlas |
| 1978 | John E. Gannon, Daniel J., Mazur, Alfred M. Beeton | Glacial Relic Crustacea in Michigan Waters |
| 1978 | Fred J. Tanis | Crystal Lake Water Quality Study |
| 1980 | U.S. EPA | EIS: Alternative Wastewater Treatment Systems |
| 1980 | William B. Kerfoot | Septic Leachate Discharges into Crystal Lake, Michigan |
| 1984 | Fred J. Tanis | Crystal Lake Shoreline Aerial Survey |
| 1985 | William R. Overlease & Edith Overlease | Flora of Benzie County |
| 1987 | R. William Decker | "Crystal Lake - Life or Death" (A Lake Owners' Manual) |
| 1987 | John Gehring et al. | Crystal Lake Water Quality Monitoring |
| 1987 | Helen Hornbeck Tanner | Atlas of Great Lakes Indian History |
| 1990 | Lawrence B. Taylor | Glacial-Lake Levels in the Northeastern Lake Michigan Basin |
| 1992 | Julie A. Wolin | Paleoclimatic Implications of Late Holocene Lake-Levels |
| 1994 | Paul C. Murphy | Crystal Lake Water Quality Monitoring |
| 1995 | Stacy L. Daniels & Thomas R. Osborn | Crystal Lake Water Quality Monitoring |
| 1998 | Alfred M. Beeton & R. Stephen Schneider | Century of Great Lakes Research at University of MI |
| 1998 | Wallace Fusilier | Water Quality Study |
| 1999 | Raymond Canale, McCool, Blecker | A Comprehensive Water Quality Study of Crystal Lake |
| 2000 | Jesse J. Granet | Growth and Survival of Yellow Perch |
| 2002 | Crystal Lake Association | Crystal Lake Handbook |
| 2002 | Richard L. Whitman et al. | Inland Lakes of the Great Lakes Cluster National Parks |
| 2002 | Richard L. Whitman et al. | Zooplankton as a Bioassessment Tool for Lakes |
| 2002 | Sharon S. Yohn et al. | Factors Influencing Metal Accumulation in Inland Lakes |
| 2002 | Wallace Fusilier | Crystal Lake Water Quality Study |
| 2003 | Stacy L. Daniels & Paul C. Murphy | Biomonitoring of the Cold Creek Watershed |
| 2004 | Bruce Knapp | Landforms of Northern Lower Michigan |
| 2004 | Lois M. Verbrugge et al. | Swimmer's Itch Incidence and Severity |
| 2005 | Scott McNaught | Nutrient Sources and Biological Production |
| 2005 | Thomas A. Edsall & W.E. Philips | Mayflies as Indicators of Aquatic Ecosystem Health |
| 2007 | Jane Limmer (Summer Intern) | Benthic Invertebrates |
| 2008 | Emily Baker, Molly Walton (Summer Interns) | Aquatic Macrophytes (CLWA) |
| 2009 | Hadley Boehm (Summer Intern) | Swimmer's Itch Vector Analysis (CLWA) |
| 2010 | Tiffany Moore, Chelsea Spaulding (Summer Interns) | Roadside Survey of Environmental Conditions (CLWA) |
| 2011 | Paul Gerhart (Summer Intern); Laura Bailey; Jessica Schaub (Summer Interns) | Emerald Ash Borer (CLWA); Swimmer's Itch Control Evaluation (CLWA) |

Tab 16 Watershed Management (Site D2, Site K).

"In every walk with nature one receives far more than he seeks." -- John Muir

(16a) Definition of Watershed Management

Watershed Management requires decision-making regarding uses and modifications of lands and waters within a watershed. The Michigan Department of Environmental Quality has developed a process of watershed management to allow stakeholders to balance diverse goals and uses for environmental resources, and to consider how their cumulative actions may affect long-term sustainability of these resources. The Guiding Principles of the process are Partnerships, Geographic Focus, & Sound Management (strong science & data). Human modifications of lands and waters alter delivery of water, sediments, and nutrients that alter aquatic systems. There are varying goals and values relative to uses of local land and water resources. Watershed management provides a framework for decision-making to: (1) assess the nature and status of the watershed ecosystem; (2) define short-term and long-term goals for the system; (3) determine objectives and actions needed to achieve selected goals; (4) assess both benefits and costs of each action; (5) implement desired actions; (6) evaluate the effects actions and progress toward goals; and (7) re-evaluate goals and objectives as part of an iterative process.

As a form of ecosystem management, watershed management encompasses the entire watershed, from uplands and headwaters, to floodplain wetlands and river channels. It focuses on the processing of energy and materials (water, sediments, nutrients, and toxics) downslope through this system. The management of the basin's water budget that is the routing of precipitation through the pathways of evaporation, infiltration, and overland flow is of prime concern. Routing of groundwater and overland flow defines the delivery patterns to streams, lakes, and wetlands; and shapes the nature of aquatic systems. Watershed management requires use of the social, ecological, and economic sciences. Common goals for land and water resources must be developed among people of diverse social backgrounds and values. An understanding of the structure and function--historical and current--of the watershed system is required, so that the ecological effects of various alternative actions can be considered. The decision-making process also must weigh the economic benefits and costs of alternative actions, and blend current market dynamics with considerations of long-term sustainability of the ecosystem.

(*) See www.CLWA.us/watershed_concerns.htm#Concerns

(16b) Crystal Lake Watershed Management Plan.

The Crystal Lake Watershed is a valuable natural resource. Protecting the integrity of its high quality waters and unique environment is a worthy objective. Watershed management includes three items:

(1) determining what we know about it from the past, (2) planning to use it in an environmentally sustainable manner today, and (3) implementing projects to protect it for the future. Watershed management is not a new undertaking for the Crystal Lake Watershed. Its importance was confirmed in the draft Benzie County Comprehensive Plan. Scientific studies of geology (soil), hydrology (water), ichthyology (fish), limnology (lakes), biology (plants and animals), and ecology (relationships of organisms with their environment), done over the past 160 years form a database for decision-making. Definitive reports and resource plans already have been developed by citizen and governmental committees. (As of 2011, the **CLWA** and other partnering organizations is in the process of reapplying for a grant to develop a comprehensive watershed management plan for the Crystal Lake / Betsie River Watershed. http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3714_4012-9595--,00.html)

An overlay district is a geographical area subject to special zoning that crosses political boundaries. The Crystal Lake Watershed Overlay District (CLWOD) was created in 1994 to protect and manage the valuable natural resources of the Crystal Lake Watershed. The CLWOD contains certain provisions for planning and zoning more restrictive than conventional zoning. Contributions to the CLWOD have been made by a number of stakeholders with presence or interest in the Watershed. These have included individual citizens; nonprofit organizations; local, state, and federal governments; and academic institutions. Establishment of the CLWOD has led to consideration of broader overlay district ordinances for other streams and lakes within Benzie County. www.CLWA.us/zoning_landuse.htm#CLWOD

(16c) Concerns for Property Owners and Visitors to the Watershed.

"The lakes are something which you are unprepared for; they lie up so high, exposed to the light, and the forest is diminished to a fine fringe on their edges, with here and there a blue mountain, like amethyst jewels set around some jewel of the first water, - so anterior, so superior, to all the changes that are to take place on their shores, even now civil and refined, and fair as they can ever be."

-- Henry David Thoreau

Site M, the "n + 1" Interpretive Site of the Crystal Lake **"Walkabout"** is left to the readers' choice. Perhaps almost unspoken for each of us is that special "place near the Lake" where we live, work, play, and think. Lake and Watershed properties might seem to be the prime responsibilities of government, institutions, or individual property owners. These properties, however, are also the responsibilities of visitors and summer renters to insure that they are used wisely and maintained appropriately. There are myriad ways that we may look at the Crystal Lake Watershed - as a student, a visitor, an owner of watershed property (a "lakie", a "townie", a "fudgie", etc.). All of us together ("shedies") have slightly different perspectives, but we all share the benefits - the use and enjoyment of our Watershed for fishing, boating, swimming, recreation, working, and living. We also share the same concerns for maintaining a proper balance between reasonable environmental protection and sustainable development. Together, we are all stewards of the environment that makes up Crystal Lake and its surrounding Watershed.

Supplemental materials which have accompanied this **"Walkabout"** Interpretive Manual, describe concerns that are common to all watershed property owners and users. "Watersheds: Where We Live" (U.S. Geological Survey) describes the importance of living in a watershed. "Your Lake and You" (North American Lake Management Society, Michigan Lake and Stream Associations, and Michigan Department of Environmental Quality) describes steps to take to protect a watershed. Much of this advice is just good "common sense" in recognizing that a pristine watershed is different from an urban streetscape. Many of the best management practices (BMPs) are directed at protecting a watershed, i.e. preventing "pollution" from whatever source that might despoil the environment and adversely affect aquatic ecosystems. It is much more difficult to repair damage to the environment from unknowing or uncaring activities.

The Crystal Lake "Walkabout" Interpretive Manual is designed specifically for the Crystal Lake Watershed. Unique features of the Watershed make it alternately very resistant or potentially vulnerable to environmental impacts. Concerns (*) that all of us as stewards of our Watershed should consider range from those affecting the entire Watershed to those within individual properties.

Education & Communications

- Scenic Vista – Viewshed
- Land Cover – Trees & Vegetation
- Boating, Swimming, & Fishing
- Lawns, Gardens, & Greenbelts
- Land Conservation
- Aesthetics & Noise
- Natural, Economic, & Social Challenges
- Litter, Trash, & Hazardous Materials

Land Use & Development

- Land Use
- Planning & Zoning
- Water Access
- Construction & Development
- Critical Slopes, Wetlands, & Dunes
- Wells & Septic Systems

Water Quality

- Soil, Sediment, & Nutrients
- Erosion & Shoreline Protection
- Atmospheric Deposition & Ozone
- Algae, Bacteria, and Molds
- Aquatic Vegetation, Fish, & Waterfowl
- Nonindigenous Species – Plants & Animals

(*) As evolved from **"Crystal Lake - Life or Death"**, A Lake Owners' Manual, Benzie County, Michigan, 1987, 32 pp+ 8 figures, and as modified from a presentation to the 2006 Annual Meeting of the **CLWA**.

For Further Reading:

Decker, R. William, Chair, Ad Hoc Committee, Benzie County Board of Public Works, **“Crystal Lake - Life or Death”**, A Lake Owners’ Manual, Benzie County, Michigan, 1987, 32 pp + 8 figures.

Note to current readers of the annotated version:

As a prototypical Lake Owners' Manual, **Crystal Lake - Life or Death (CLLD)** is a significant book. It resulted from discussions by local citizens who formed an Ad Hoc Committee to the Benzie County Public Works Department. This Committee raised concerns about two issues: (1) present and future water quality problems of the Crystal Lake Watershed, and (2) absence of an equitable and effective plan for watershed management. At the time of its original printing in 1987, **CLLD** was one of the first Lake Owners' Manuals developed for riparian owners and visitors in Northwest Lower Michigan. It specifically addressed environmental issues facing the Crystal Lake Watershed (Benzie County, MI). **CLLD** has served well as a model for other Lake Owners' Manuals throughout Michigan. Its basic messages remain timely and are shared by many other riparian communities. Written in plain, non-technical language, the original text touched upon many issues: the water quality of Crystal Lake and Cold Creek, the impact of nutrients on the Watershed, the often opposing forces of government and development, the requirements of good septic systems, and the need for continued public education.

Crystal Lake, the 9th largest inland lake in Michigan, appears unchanged to the passing eye of history. Its long-time attraction as a major recreational resource has continued unabated for more than a century. Land and water use and development within the Watershed continue to intensify, however, and the needs for environmental sustainability and watershed management are very relevant. In the intervening 20 years (as of 2007) since **CLLD** first appeared, new issues have arisen, such as intensified shoreline development and invasions by exotic species. These issues have been addressed in several collaborative monitoring studies conducted by local environmental organizations.

The original intent of **CLLD** was the education of property owners and visitors. A series of annual "Updates" have been provided to the public, first by the Ad Hoc Committee, then by its immediate successor, the Crystal Lake Clean Water Committee, and now by its current successor, The Crystal Lake Watershed Fund, Inc. This tradition of public education has continued to date through fourteen "Updates". Since 1994 they have appeared as "Crystal Shorelines", the newsletter of the Crystal Lake Watershed Fund, Inc. www.CLWA.us/references.htm#Newsletters, and subsequently as "Crystal Whitecaps", the newsletter of the Crystal Lake & Watershed Association www.CLWA.us.

The original edition of **Crystal Lake - Life or Death** is for reflection by previous readers, and for discovery and contemplation by new readers. It is reproduced online in its entirety (with minor editing and annotations) www.CLWA.us/PDF/CLWFCLLDTextPicsPDF.pdf. The Crystal Lake Handbook, A publication jointly sponsored by the Crystal Lake Association and MSU Extension, Betsy Youngblood, Ed., Beulah, MI, 2002, 64pp, is at [www.CLWA.us/references.htm#Crystal %20Lake Handbook](http://www.CLWA.us/references.htm#Crystal%20Lake%20Handbook).

Mission Statements of Crystal Lake & Watershed Association and its Science Review Panel:

- “Protect and promote the natural qualities of Crystal Lake and its surrounding Watershed.
- Preserve for future generations the beauty and recreational resources of Crystal Lake and its watershed.
- Engage in water-quality monitoring, educational programs, promotion of harmonious land development, and promotion of the safe use of Crystal Lake.
- Advocate and ensure the continued aesthetic beauty and environmental integrity of the Lake and its watershed.”

"The Science Review Panel (SRP) of the Crystal Lake & Watershed Association is proactive in developing consensus viewpoints by reviewing environmental issues of particular local interest and by providing scientifically sound recommendations where appropriate to the public. This will involve continued review of sponsored studies, and assessment of studies conducted by other responsible organizations that have demonstrated performance in related areas."

Tab 17 The Philosophy of “Walkabout” (All Sites).

“I think that I cannot preserve my health and spirits, unless I spend four hours a day at least - and it is commonly more than that - sauntering through the woods and over the hills and fields, absolutely free from all worldly engagements.” -- Henry David Thoreau, Walking.

(17a) History of the Crystal Lake “Walkabout”.

The Crystal Lake Watershed contains diverse, hydrologically intertwined ecologies and unique environmental niches: active sand dunes, forested heights, wetlands, tributaries, and a large deep inland lake connected to Lake Michigan. It encompasses an immense body of pristine water of exceptional clarity, a mixed sandy and rocky nearshore, a sandy shoreline, a deep marl bottom, and a high-ridged vista. It is the responsibility of those of us in the present to respect, maintain, and preserve the integrity of our Watershed for the generations that follow us. The extended glacial history of the Crystal Lake Watershed coupled with its incredible diversity of ecological and environmental niches, it ideal for both recreation and education.

The **Crystal Lake “Walkabout”** is designed to educate students, property owners, and visitors about the Crystal Lake Watershed using a “hands-on” approach of observational monitoring and environmental exploring. Participants “walk about” a series of Interpretive Sites that represent differing environmental niches within the Watershed. At each site, “Site Interpreters”, who are knowledgeable individuals and/or environmental professionals, interact with the participants and conduct group activities. The cumulative listings of cosponsoring organizations with environmental interests at the local or regional level now exceed 24 as of 2009.

A common theme linking the Interpretive Sites has been: “How does a single drop of water enter, linger, and then pass through the Watershed”? While the program focuses on hydrology, it also addresses water quality, ecology, land use, zoning, wells and septic tanks, green belts, sustainable development, and watershed management. The unique qualities of life as experienced by students, property owners, and visitors are related to physical features, environmental issues, public concerns, and educational aspects of the Watershed.

The Crystal Lake **“Walkabout”** is the interpretation of the myriad environments of a series of Interpretive Sites experienced in natural settings. The series of Interpretive Sites has evolved from a progression of interests, concerns, and demands. The first three Sites (**A, B, C**) were the subjects of EcoExplorations, an innovative educational program for young adults initiated in 1993 by the CLWF. Site **D1/D2** was added in 1997 to emphasize both the Outlet from Crystal Lake and the high ridge boundary of the Watershed. The first four Sites (**A, B, C, D1/D2**) are all in the East End of the Watershed. Four new Sites (**E, F, G, H**), all in the West End of the Watershed, were added in 2000 to show connections to neighboring riverine (river) and lacustrine (lake) “downstream” watersheds, i.e. the Betsie River Watershed, and the Lake Michigan Watershed. The Benzie Area Historical Museum Site (**I**) added in 2007 provides historical perspectives of logging, agriculture, and tourism. New Sites (**J, K, L**) added to the West End series in 2009 add further diversity. The final Interpretive Site (**M**) is the walker's choice. Unspoken for each of us is that special “place near the Lake” where we live, work, play, and think. “Lakies”, “townies”, and “fudgies” share benefits and responsibilities of natural resources.

As the **“Walkabout”** program has grown, logistics have expanded. Initially, one small group visited a few sites in sequence. To better serve more participants, and to provide a greater variety, the number of sites was expanded. The Summer event (public) still consists of a single small group traveling among four sites with four, one-hour periods. Spring and Fall events (schools) consist of four large groups traveling to 3 or 4 sites operated concurrently with 3 or 4 one-hour periods (45 min interpretation at each site; 15 min of transit among sites). Groups of up to 200 students are bussed among Interpretive Sites where they are subdivided into 2-3 subgroups of 15-20. East End (Sites **A, B, C, D1/D2, I**) and West End (Sites **E, F, G, H, J, K, L**) sites are visited biennially allowing all 6th and 8th grade students in Benzie County to view 6 to 8 Sites over a two-year period.

The **“Walkabout”** Interpretive Manual has evolved into “An Educational Primer for Students” and “A Reference Handbook for Property Owners and Visitors”. Its contents features the Crystal Lake Watershed but can be extrapolated to other watersheds. It is not a textbook, but introduces simple terms and concepts. It is revised as new Interpretive Sites are added and new concerns emerge. The **“Walkabout”** T-shirt has a colorful map of the Watershed on the front and logos of cosponsors on the back. This year (2011) marks the 19th year of the program, which has been presented to more than 4,500 students, residents, and visitors since 1993.

(17b) The Origins of "Walkabout".

Walkabout refers to the belief of non-indigenous Australians that Aborigines were prone to "go walkabout" - meaning to stop working and wander in the bush for long periods. It is interpreted as "a journey undertaken without notice or warning, of no fixed duration, with no particular destination in mind, and undertaken for reasons of spiritual well-being". Most Aboriginal cultures required their peoples to visit certain sites at certain times to engage in age-old ceremonies. This has led to a jocular modern usage, whereby someone (or their mind) has wandered off or has 'gone walkabout', or a misplaced item has 'gone walkabout'. The Ojibwe traditionally sought personal relations with guardian spirits whom they encountered as adolescents seeking status as adults in vision quests, i.e. rites of passage blending practical and ritual elements in seeking a meaning in life.

Translations (Disambiguations) for "Walkabout":

Ojibwe - Giiwitaayaazhagaame - he walks around the lake

Nederlands (Dutch) - gelegenheid waarbij een beroemdheid zich onder de mensen begeeft

Esperanto - promeni - antaŭ spektantaro

Français (French) - bain de foule

Deutsch (German) - Bad in der Menge, Buschwanderung

Ελληνική (Greek) - (Βρετ., καθομ.) περίπατος επισήμου ανάμεσα στο πλήθος

Italiano (Italian) - passeggiata

Português (Portuguese) - viagem a pé (f), retorno temporário à vida simples (m)

Русский (Russian) - пеший туризм, прогулка высокого лица среди толпы с целью неофициального общения

Español (Spanish) - paseo de políticos, realeza, etc. entre el público

Svenska (Swedish) – vandringstur

Turkish - dolaşma, (insanlarla karşılaşmak için) yaya dolaşmak.

中国话 (Simplified Chinese) - 徒步旅行, 短期丛林流浪, 长期旅行

中國話 (Traditional Chinese) - 徒步旅行, 短期叢林流浪, 長期旅行

日本語 (Japanese) - 徒步旅行

(الاسم) فترة قصيرة يتشرد فيها العبد من أصل أستراليا - العربية (Arabic)

מסע אל הטבע (של ילידי אוסטרליה), סיור רגלי בקרב ההמון של אישיות שבאה לביקור, תקופת נדודים, טיול - עברית`

"A Parable of Sauntering" by Albert W. Palmer, Excerpted from "*The Mountain Trail and Its Message*", Pilgrim Press, Boston, 1st Ed., 1911; reprinted by Sixth Street Press, Fresno, 1997.
www.sierraclub.org/john_muir_exhibit/frameindex.html?http://www.sierraclub.org/john_muir_exhibit/life/palmer_sauntering.html

There are always some people in the mountains who are known as "hikers". They rush over the trail at high speed and take great delight in being the first to reach camp and in covering the greatest number of miles in the least possible time. They measure the trail in terms of speed and distance.

One day as I was resting in the shade Mr. Muir overtook me on the trail and began to chat in that friendly way in which he delights to talk with everyone he meets. I said to him: "Mr. Muir, someone told me you did not approve of the word 'hike.' Is that so?" His blue eyes flashed, and with his Scotch accent he replied: "I don't like either the word or the thing. People ought to saunter in the mountains - not hike!

"Do you know the origin of that word 'saunter?' It's a beautiful word. Away back in the Middle Ages people used to go on pilgrimages to the Holy Land, and when people in the villages through which they passed asked where they were going, they would reply, '*A la sainte terre,*' '*To the Holy Land.*' And so they became known as *sainte-terre-ers* or *saunterers*. Now these mountains are our Holy Land, and we ought to saunter through them reverently, not 'hike' through them."

John Muir lived up to his doctrine. He was usually the last man to reach camp. He never hurried. He stopped to get acquainted with individual trees along the way. He would hail people passing by and make them get down on hands and knees if necessary to see the beauty of some little bed of almost microscopic flowers. Usually he appeared at camp with some new flowers in his hat and a little piece of fir bough in his buttonhole.

Now, whether the derivation of saunter Muir gave me is scientific or fanciful, is there not in it another parable? There are people who "hike" through life. They measure life in terms of money and amusement; they rush along the trail of life feverishly seeking to make a dollar or gratify an appetite. How much better to "saunter" along this trail of life, to measure it in terms of beauty and love and friendship! How much finer to take time to know and understand the men and women along the way, to stop a while and let the beauty of the sunset possess the soul, to listen to what the trees are saying and the songs of the birds, and to gather the fragrant little flowers that bloom all along the trail of life for those who have eyes to see!

You can't do these things if you rush through life in a big red automobile at high speed; you can't know these things if you "hike" along the trail in a speed competition. These are the peculiar rewards of the man who has learned the secret of the saunterer!

Various definitions of "*saunter*":

- a careless leisurely gait; "he walked with a kind of saunter as if he hadn't a care in the world"
- amble: a leisurely walk (usually in some public place)
- to loiter, linger, stroll, wander: walk leisurely and with no apparent aim
- [Probably Fr. *s'aventurer* to adventure (one's self), shortened form *s'auntrer*.

Thoreau on color of water (especially descriptive of blue and green reminiscent of Crystal Lake):

"Some consider blue 'to be the color of pure water, whether liquid or solid'. But, looking directly down into our waters from a boat, they are seen to be of very different colors. "Walden is blue at one time and green at another, even from the same point of view. Lying between the earth and the heavens it partakes of the color of both. Viewed from a hilltop it reflects the color of the sky; but near at hand it is of a yellowish tint next the shore where you can see the sand, then a light green, which gradually deepens to a uniform dark green in the body of the pond." -- Henry David Thoreau, *Walden*, Chapter IX: The Ponds, 1854.

www.vcu.edu/engweb/transcendentalism/authors/thoreau/walden/chapter09.html

(17c) Physiographical Geology.

Physiographical geology focuses on understanding the natural environment, vs. the cultural or built environment of human geography. Hydrology, a subfield, is the focus of the **“Walkabout”**. Excerpts from *“Inland Lakes of Michigan”*, by I.D. Scott, Lansing, MI, 1921, 383pp (emphases added). Dr. Scott, who taught physiographical geology at the University of Michigan, visited Crystal Lake in the summer of 1914 and examined the topography to determine the geological origin of the basin, and traversed the shores by boat and on foot to study water levels and geological features.

“Among the functions performed by lakes ... natural reservoirs. ... lessen the flooded conditions of streams and hinder the stripping of the land. ... power, irrigation, logging operations, city water supply, ... a source of food supply, as highways of commerce, and as a tempering effect on climate ... But the most important function of lakes is, ... their unique advantages for the recreation of man. ... The pure air, cool temperatures and simple conditions of life stimulate renewed physical and mental vigor.”

“Lakes are attractive not alone for their beauty but to a large extent because they portray so faithfully our own emotions and intensify the condition of our physical environment. During periods of calm, winter’s solitude is accentuated by the ice-bound expanse and, in summer, tranquility is reflected from the unbroken surface. At times its leaden waters appear sullen, foretelling impending storms, at others boisterous and jubilant, and again, whipped to a state of fury.”

“From a physiographic standpoint, one may study the entire life history of such bodies of water. ... the origin of the basin, its development by the various agencies active upon it, and finally its extinction or death. ... From a practical standpoint the physiographic study of a lake gives a more intimate knowledge of ... the conditions not only of the shores but the surrounding country. ... It would seem axiomatic that the shores and surrounding country should be well drained, if the lake is to be useful for summer homes ... An ideal site ... is to be found on lakes which have stood for a considerable time at an appreciably higher level ... (where) ... a sandy terrace is now exposed high and dry above the level, surmounted by a cliff of varying height from the base of which springs of cool, pure water often flow (!).”

“... lakes have served a useful purpose in the storing of water ... (which) ... necessitates the building of a dam, thereby interfering with the natural level of the lake ... (by) ... a raising or lowering of the level, or both at different times of the year, and results in serious inconvenience and often damage to property along the shores. A lowering of the level means stranded docks and boat houses ... A raising of the level is more serious and results in flooded shores and an increased activity of the waves.”

“Physical Geography ... is not primarily a text book subject. Illustrative material is a necessity. Pictures may partially supply the need, but by far the best illustrations are those obtained by direct observation (!). ... or field study ... and ... should be a most valuable asset to the teachers of the State. ... excellent lakes of considerable size. ... Walloon, Pine (= Charlevoix), Torchlight, Elk, and Crystal – are typical for the region and are all attenuated in form ... An ill-fated attempt was made to make a navigable waterway from Crystal Lake to Frankfort but the result was merely (!) to lower the level of the lake. This proved so serious that a dam was built at the outlet to hold the water at somewhere near its natural level.”

“Crystal Lake ... A well-developed submerged terrace is uniformly present about all shores, and the drop into deep water is clearly marked by a sudden change in color from the light yellow (green) of the shallow water to a deep blue where the depths are greater. ... due in part to the clearness of the water, and the name of the lake has appropriately been changed from Cap, as found on the old maps, to Crystal. ... The striking physiographic characters are the predominating high cliffs from whose base the sandy terrace ... extends to the water’s edge. The first surmise is that this lake has stood at a higher level ... Crystal Lake existed as a fjord-like bay of early Lake Algonquin. ... Wave and current action were excessive in the Crystal Lake depression, after its separation from the main lake, and resulted in the carving of prominent cliffs in the morainic borders, the formation of a broad terrace, and the development of strong bars in front of the depressions and at the west end. ... The waters receded from the Algonquin level ... a drop of twelve to fifteen feet (!), and left a broad exposed terrace, the sands of which have been heaped into low dunes. This level persisted until ... the lake was (further) lowered artificially (1873).”

(17d) Derivations of Local Place Names.

Native American Heritage

According to legend, an Ojibwe chief drowned in Crystal Lake, and mysteriously reappeared in Lake Michigan. According to Kenny Neganigwane Pheasant at www.anishinaabemdaa.com, the Anishinaabe name for Crystal Lake was **Digmegonbiz** (White Fish Lake). Dr. Margaret Noori, Lecturer in Ojibwe Language and Literature at the University of Michigan, has suggested the name of **Nishiime** (Younger Sibling) of the Gichigami (Great Lakes). This heart-felt name is simple and direct, and does not overly personify nature, as fast-talking old men might have done standing on the shore calling Crystal Lake: **Giiwitaayaazha-mangi-waashegaminaaboo-zhaaboonde-naazibiiyaamadinaa-waasaa-ishpadin-anzigwag-bijjimaagzehns-gamaa**" (105 letters) approximated in Anishinaabemowin translates as: "He walks around - big - clear water - open from one end to the other - with hills coming down - waves frothing white - ice freezes thick - (with) saw-bill ducks - (and) shining little fishes - lake."

Benzie County, Betsie River, Point Betsie

By most accounts, the word "Benzie" derives from the French, *La Rivere aux Bec Scies*, for the Betsie (var. Betsey, Betsy) River, meaning, river of the saw-bills (ducks). The Native American name, *Uns-zig-o-ze-bee*, has the same meaning. *Mergus merganser* (*L. mergere* dive + *anser* goose), the common merganser (alt. Goosander, sawbill, Shelldrake, Grand harle, grande bec-scie), found on lakes and rivers in Europe, northern Asia, and North America, is a large, crested, fish-eating duck, whose bills have serrated edges (saw-bills) to help them grip and swallow prey. They nest in tree cavities, from which the young emerge shortly after hatching. Common mergansers have rather shaggy crests, large broods of young, raucous cries, inedible flesh, hunting restrictions, and can carry the vector for swimmers' itch. . The male merganser has a dark green head, while the female has a reddish-brown head.

Henry Rowe Schoolcraft (1793-1864), in his "Personal Memoirs of a Residence of Thirty Years with the Indian Tribes", Chap. XXXVII, page 356, 1851, <http://books.google.com/books?id=X-wNAAAAIAAJ> spoke of "unfledged ducks" thusly: "The men had rare and very exciting sport, in coasting around the peninsula, in catching the young of the onzig - which is the sawbill. In the early part of the month of July, the wings of the young are not sufficiently developed to enable them to fly. They will run on the water, flapping their unfledged wings, with great speed, but the gay Frenchmen, shouting at the top of their lungs, would propel their canoes so as to overtake them whenever the little fugitives could not find some nook in the rock to hide in. They chased down one day thirteen in this way, which were found a most tender and delicate dish. The excitement in these chases was extreme."

"In the early spring, when live fish are difficult to obtain, they seem to enjoy frozen, rotten fish with the same gusto as fresh, picking them out of the floating ice. They also feed to some extent on frogs, small eels, aquatic salamanders, crawfish, and other small crustaceans, various bivalve mollusks and snails, leeches, worms, water insects and larvae, and the stems and roots of aquatic plants." -- Bent, Arthur Cleveland, Common Merganser, Smithsonian Institution United States National Museum Bulletin 126 (Part 1), 1-13, 1923. <http://www.birdsbybent.com/ch61-70/merganser.html> Nevertheless, these ducks are part of our local Benzie heritage, so we have to appreciate them!

Crystal Lake

Crystal Lake was originally named Cap Lake because of its propensity for generating "white caps", i.e. large rolling waves with broken and foaming crests, which are ever present on its surface during periods of strong winds. The name Cap Lake originally appeared on the first surveys by Alvin and Austin Burt dated 1838-9. Prior to about 1860, Crystal Lake was sometimes shown on maps with no name, or incorrectly identified as the nearby Lake aux Becs Scies or Betsie Lake (Betsie Bay) at the mouth of the Betsie River at Frankfort. The names of other large inland lakes in NW Lower Michigan neighboring Crystal Lake, such as Platte Lake, Glen Lake, Torch Lake, Lake Charlevoix, and Lake Leelanau, have also had other names. The original surveyors considered Crystal Lake waters as "very transparent". The name "Crystal Lake" first appeared on a "Map of the Harbor Town of Frankfort, Lelanau (sic) County Mich., with adjoining lands", Sage, J., & Sons, Buffalo, N.Y., 1860.

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Please see the many webpages at www.CLWA.us to learn more about the Crystal Lake Watershed.

(17f) Participants/Sponsors/Supporters/Contributors: (1993-2011).

Participants.

The general public, riparians, visitors, and guests to the Crystal Lake Watershed.
Benzie County Central Schools www.benzieschools.net/
Frankfort - Elberta Area Schools www.frankfort.k12.mi.us/
Interlochen Arts Academy www.interlochen.org

Sponsors.

Crystal Lake & Watershed Association www.CLWA.us (Crystal Lake Watershed Fund (now CLWA) (Founder)
Grand Traverse Regional Land Conservancy www.gtrlc.org
Grand Traverse Band of Ottawa and Chippewa Indians www.gtb.nsn.us/index.asp
Crystalaire Camp www.crystalairecamp.com
The Nature Conservancy MI Chapter www.nature.org/wherework/northamerica/states/Michigan
Friends of the Betsie Valley Trail www.betsievalleytrail.org/
Friends of Betsie Bay www.friendsofbetsiebay.info/
Friends of Pt. Betsie Lighthouse www.pointbetsie.org
U.S. Coast Guard - Station Frankfort www.uscg.mil/d9/sfoGrandHaven/stafrankfort.asp
The Congregational Summer Assembly www.summerassembly.org/
Benzie Conservation District www.benziecd.org/
MSUE MI Groundwater Stewardship
www.portal.msue.msu.edu/portal/default.cfm?page_id=106067&pageset_id=27320
Inland Seas Education Association www.schoolship.org
Tip of the Mitt Watershed Council www.watershedcouncil.org
The Watershed Center - Grand Traverse Bay www.gtbay.org
Michigan Land Use Institute www.mlui.org
Sleeping Bear Dunes National Lakeshore (National Park Service) www.nps.gov/slbe/
Benzie Area Historical Society www.benziemuseum.org
Benzie-Leelanau District Health Department www.bldhd.org/
Mills Community House Association www.millscommunityhouse.org/aboutus.html
Wastewater Education www.wastewatereducation.org/
Betsie Lake Utilities Authority

Supporters/Contributors.

Bayside Printing Company www.baysideprintinginc.com
Benzie County www.benzieco.net/
John N. Barnes Environmental Education Fund www.gtrcf.org/funds/?fuseaction=record&FundID=525
Benzie Area Youth Council (BAYCO) www.gtrcf.org
Benzie-Leelanau District Health Department www.bldhd.org
Chimney Corners Resort www.chimneycornersresort.com
City of Frankfort www.frankfortmich.com
The Dow Chemical Company www.dow.com/Homepage/index.html
Bookwear by Field Crafts, Inc. www.bookwear.com
Grand Traverse Regional Community Foundation www.gtrcf.org
Great Lakes Water Quality Laboratory www.greatlakeswaterlab.com/
Ingenuity IEQ, Inc. www.ingenuityieq.com
L'Chayim Delicatessen
MacDonald Marine www.macdonaldmarineinc.com
Michigan Department of Environmental Quality www.michigan.gov/deq
Michigan Lake & Stream Associations (ML&SA) www.mlswa.org
Michigan Sea Grant www.miseagrant.umich.edu/research/index.html
Michigan Water Research Center, CMU www.cst.cmich.edu/centers/mwrc
Northwest Michigan Council of Governments (NWMCOG) www.nwm.org
Rotary Club of Frankfort www.frankfort-rotary.org/
Century 21 Sleeping Bear Realty www.c21sleepingbearrealty.com/
The Benzie County Record Patriot www.pioneergroup.net/publications/weeklies/recpat.shtml
The Land Use and Conservation Planning Fund
US Geological Survey (USGS) www.mi.water.usgs.gov/
US Environmental Protection Agency (US EPA OWOW) www.epa.gov/owow
Village of Beulah www.villageofbeulah.org/
Water Quality Investigators (WQI)
Water Environment Federation (WEF) www.wef.org

Volunteers/Interpreters.

We will walk on our own feet, we will work with our own hands, we will speak our own minds."
-- Ralph Waldo Emerson, "The American Scholar" (1837)

Special thanks are in order to all of the individuals who, since the inception of the **"Walkabout"** in 1993, have served as willing volunteers in many capacities, as Site Interpreters, coordinators, consultants, moral supporters, and general "go-fers". Without YOU, the **"Walkabout"** would not continue to flourish and evolve! Please contact the **CLWA** if you enjoy working with young people and sharing your experiences. We are interested in learning of willing volunteers with sincere interests in environmental education. 231/352-7043, info@CLWA.us

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Amy Ferris & FPBL
Shauna Fite
AnneMarie Fleming
Tom Fountain
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Jane Gary
Don Gatz

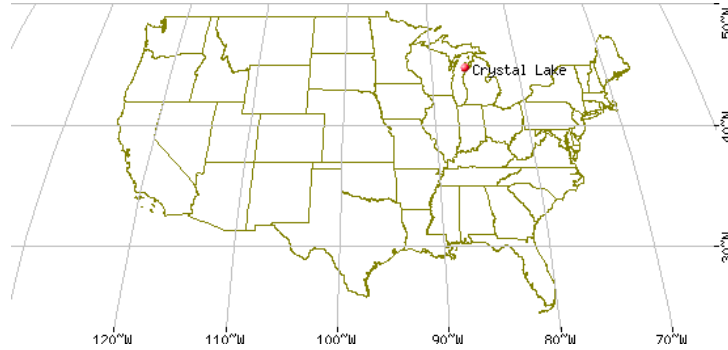
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Keith Schneider
Marie Scott
Virginia Sorenson
Carolyn Thayer
Toby Tull
Jeff Vitton
Keith Westphal
USCG – Station Frankfort
Lou Yock

Dedicated to "Winnie" (An awful good dog!), the unofficial **"Walkabout"** mascot (1989-2004).



CRYSTAL LAKE IN THE UNITED STATES (44° 39' 33" N; 086° 09' 23" W)



CRYSTAL LAKE IN NORTHWEST LOWER MICHIGAN



If you no longer have need of this Interpretive Manual, please return to your school, or to the address below, so it can be recycled, updated, and used again.

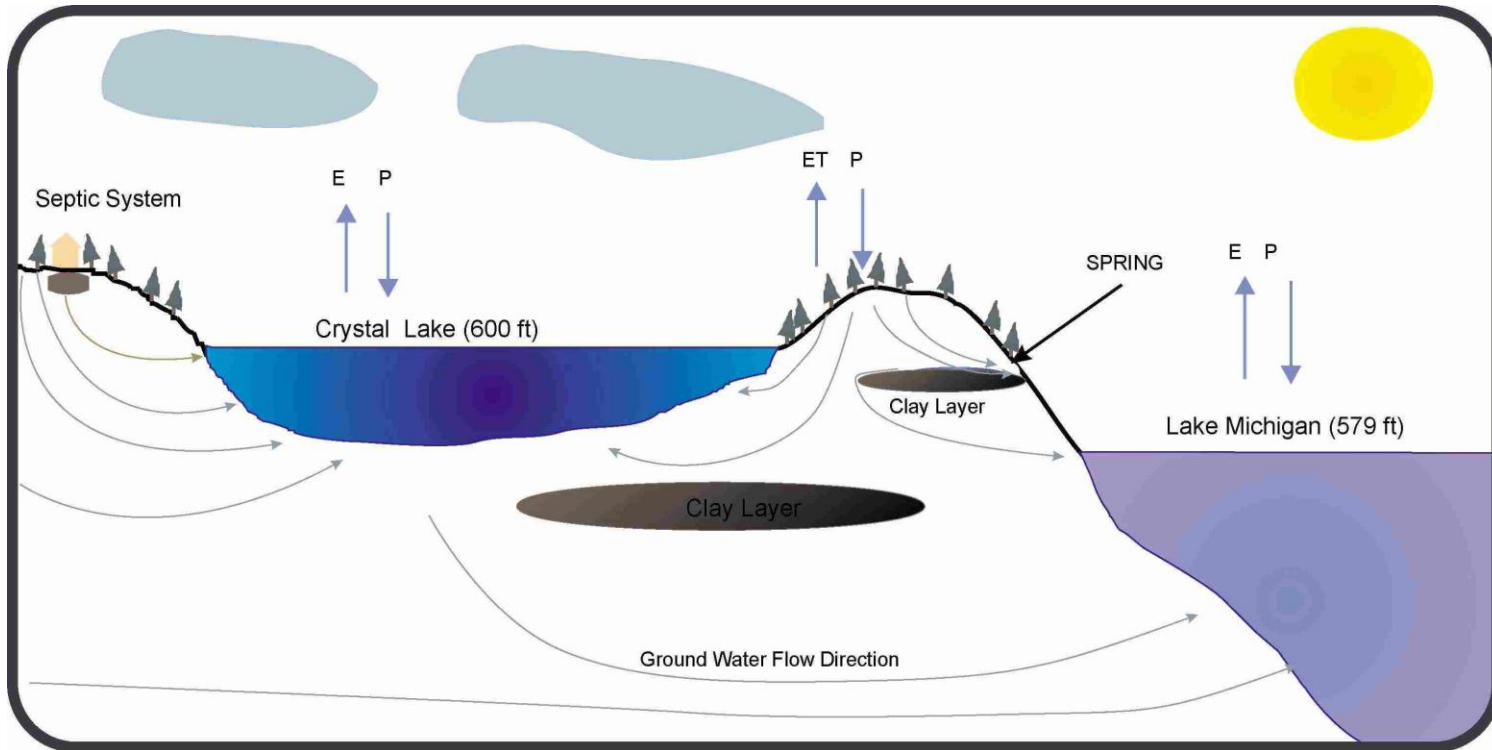


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(*) The GIS map of the Crystal Lake Watershed represents cumulative efforts by the **CLWA**, GLEC, NWMCOG, MDEQ, RSGIS – MSU, Tetra Tech MPS, and USGS. It is consistent with governmental usages of the Michigan Resource Information System (MIRIS). The diagram of the Hydrologic Cycles of Crystal Lake & Lake Michigan was prepared by Dr. John Walton, UTEP.

Hydrologic Cycles of Crystal Lake & Lake Michigan (Idealized: E <----> W , looking South)



Water Table - The level at which the water fills up below the ground surface. If you dig a hole in the ground, at some point you will reach water, this point is on the water table.

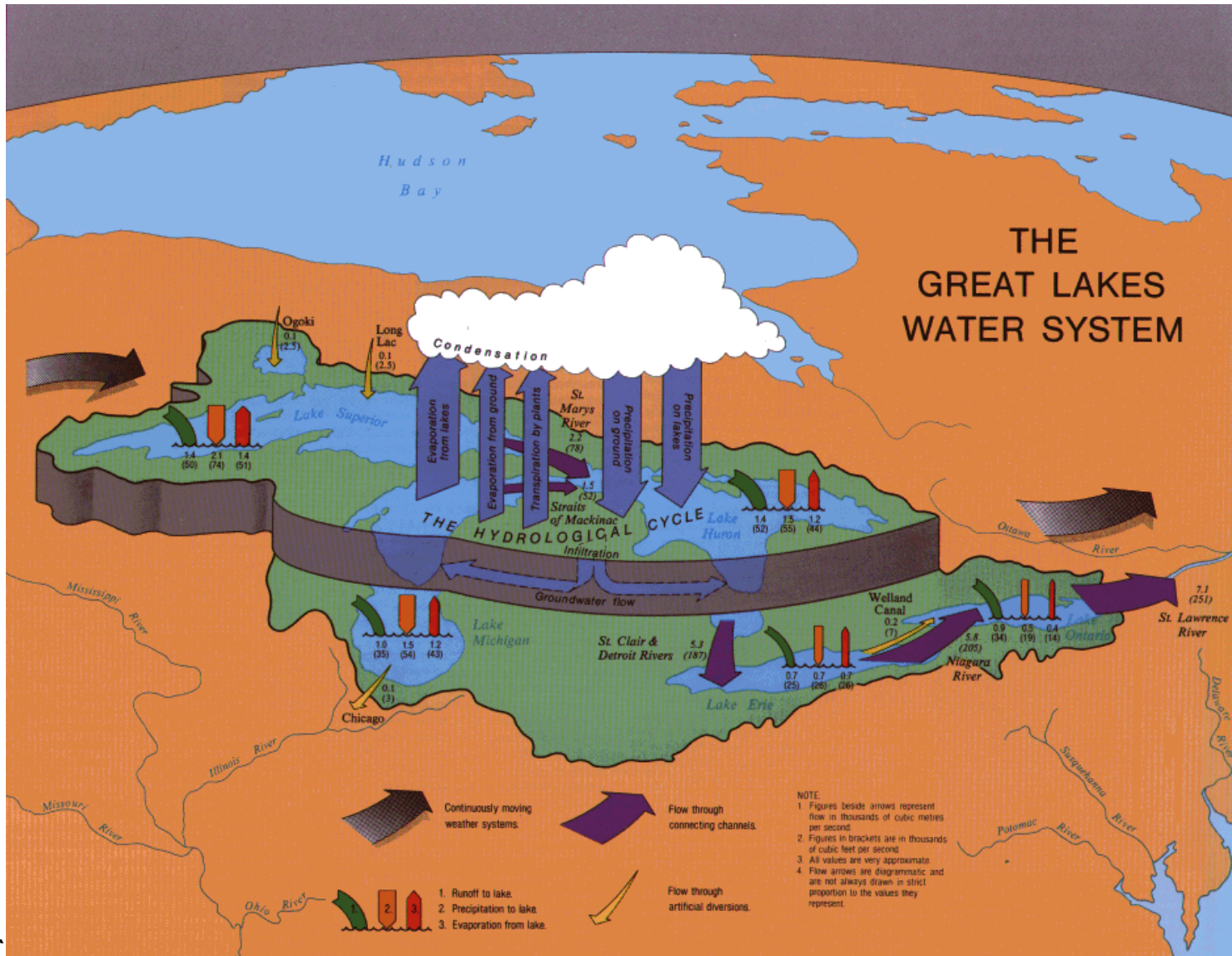
Precipitation (P) - The amount of rainfall and snow on the drainage basin.

Evaporation (E) - The amount of water that changes to water vapor and is lost to the atmosphere.

Evapotranspiration (ET) - Sum of water lost to the atmosphere from evaporation and transpiration (water lost through plant leaves).

Clay layers - Water cannot pass easily through clay layers and thus tends to flow around them. Water may build up or perch on the top of clay layers. Sometimes this leads to the formation of a spring.

Flow lines - The direction of ground water flow is shown by the arrows. Ground water may transport pollutants from septic tanks and fertilizers placed on lawns into Crystal Lake. The ground water flows in different directions depending upon location and time of year. Ground water always flows down an energy gradient but can sometimes flow uphill as shown.



Source: "The Great Lakes - An Environmental Atlas and Resource Book", Government of Canada and U.S. EPA, Great Lakes National Program office, Chicago, IL, Third Edition, 1995, www.epa.gov/glnpo/atlas

Crystal Lake Watershed

Benzie County, Michigan

