As we learned in Part 2, bathymetric maps are essential tools for anyone interested in learning about a lake system. The following is a continuation of this discussion, as we will now introduce the various lake features that are commonly associated with bathymetric maps. Note: These terms and concepts are not listed alphabetically but are instead presented in the order of their significance to the lake management process.

**Surface area** — refers to the size of a lake and is generally expressed in units of acres or hectares (abbreviated ha). Note: One hectare equals 2.47 acres. A square that is 100 meters on a side would have an area of 1 hectare.

In Florida, the majority of lakes have small surface areas. About 80% of the named lakes have surface areas less than 100 acres (40 ha) and only 31 lakes have surface areas greater than 5,000 acres (2,024 ha). Florida’s largest lake is Lake Okeechobee, with a surface area of 450,000 acres (183,000 ha).

It’s important to remember that the water level and surface area of many Florida lakes can change dramatically with drought and/or flood conditions. This can be a shocking realization for homeowners who bought lakefront property during a lake’s high water stage, and later find themselves living hundreds of feet from the water’s edge due to drought-induced shrinkage of the lake.

Surface area is one of the most important morphometric parameters of a lake because it not only describes the size of a lake, but also plays a major role in a lake system in the following ways:

Lake surface area can be used to help predict the potential effects of wind on a lake.

In general, lakes with more surface area are subject to larger waves during windy conditions. This is significant because larger waves have the ability to mix water at greater depths, in some instances reaching all the way to the bottom of the
Lake Eloise at Cypress Gardens, Florida. Lakes with more surface area are generally subject to larger waves during windy conditions.

...
Hypsographic curves — are graphs used to provide a visual representation of the relationship between the surface area of a lake basin and its depth. With these graphs, we can be more accurate in predicting how a lake’s surface area could change based on changes in water depth. *See Figure 3-2 on page 13.*

To help explain this concept, let’s refer a LAKEWATCH bathymetric map: When looking at the bathymetric map in Figure 3-1, we have a “bird’s eye” view of Lake Denton. From this perspective, it’s easy to picture how the lake would look if it were full of water, right up to its outermost contour line. It’s also relatively easy to picture what the lake would look like if water levels were to shrink down to the 6-, 11- or 16-foot depth contours. Notice that if the lake were to shrink down to the 21–foot depth contour line, its surface area would be reduced to about half its original size.

But this approach gives us a visual estimation only. If we were to calculate the surface area within each one of the contour lines in Figure 3-1 and then plot them on a graph, we’d have a hypsographic curve — a visual image that can give us accurate information at a glance.

*See Drawing Hypsographic Curves on page 13 for more about how we make these graphs.*

Interpreting hypsographic curves

Using the “gauge” provided in the vertical y-axis of Figure 3-2, we can choose a hypothetical change in lake level and then compare it with the horizontal x-axis for an estimate of what the lake’s surface area would be under those circumstances. For example, let’s say that we want to know what the surface area of Lake Denton would be if the water level were to drop 10 feet.

To do this, we would draw a horizontal imaginary line across the graph in Figure 3-2 from the 10 unit mark. As you can see, it would intersect the hypsographic curve at about the 45 unit mark along the x-axis. This means that if the lake level were to drop 10 feet, the lake’s surface area would be reduced to approximately 45 acres.

Notice that a larger drop in the water level would have an even more profound effect. For instance, if the lake level were to drop 30 feet, the surface area of the lake would be reduced to 25 acres.
One way to explain hypsographic curves is to describe the steps that were taken to draw one. To do this, we’ll need to revisit what we know about bathymetric maps. Why? Because hypsographic curves are based on lake bathymetry and it works like this:

1. While looking at the bathymetric map in Figure 3-1, we can see that the outermost contour line of the map is used to represent the lake’s shoreline at its high water level.

2. Using any one of the techniques from Appendix A on page 29 (i.e., Measuring Surface Area), the area within that outermost shoreline contour can be measured and calculated. In this instance, the surface area of Lake Denton in Figure 3-1 was found to be 60 acres.

   Depending on whether you are using the English or Metric system, the unit of measure may be represented in square feet, square yards, acres, square miles OR square meters, hectares, or square kilometers.

3. Lake Denton’s surface area measurement of 60 units was then plotted on the x-axis of the graph in Figure 3-2. Notice that it was plotted to correspond with a “0” value on the y-axis (i.e., depth). In other words, the surface area of the lake, at 0 units below the surface, is 60 acres.

   Notice the value for the lake’s maximum depth (i.e., 51 units) is plotted on the y-axis. If lake levels were to ever drop to this depth, the surface area would be a value of 0 on the x-axis.

4. By calculating and plotting surface area measurements for the remaining contour lines in Figure 3-1, we were able to complete the hypsographic curve for Lake Denton as shown in Figure 3-2 above.
Why are hypsographic curves important?

- Hypsographic curves are used for predicting the best time to implement various lake management strategies such as aquatic plant management, habitat restoration, muck removal activities, etc. From a lake resident’s standpoint, being able to visualize and/or predict a lake’s surface area during high, medium, or low water levels can certainly be helpful in planning the location for a new lakefront home or dock.

- Hypsographic curves are also useful for comparing lakes and explaining why some lakes are more susceptible to changes in lake surface area while others of similar size (i.e., surface area) may show very little change. For example, during dry weather conditions, property owners on a shallow lake basin often see a dramatic recession of water from what they considered to be the original shoreline. In contrast, those living on a deeper lake basin would probably notice very little change in lake surface area when lake levels drop.

If both the shallow and deep lakes happen to be located near one another, it can be quite confusing to the shallow lake property owners who are trying to figure out why their lake has so little water, while a neighboring lake seems unaffected. This scenario occurs on a regular basis in Florida and is cause for much concern to some lake residents.

Most of the time, such discrepancies can be explained simply by differences in lake morphometry (i.e., size, depth and shape).

Scientists use hypsographic curves for predicting two lake dynamics in particular:

1. A lake’s ability to dilute incoming materials,
   See Surface Area on pages 10-11 and Volume on page 15 for more about dilution capacity.

2. The potential for lake water mixing.
   See Part 4 Wind, Waves and Water Mixing on pages 20-27 for more about this dynamic.

Deeper lakes, with steep bottom slopes, are often less affected by periods of low rainfall.

Both of these dynamics are particularly important because they have much to do with the concentration of nutrients in a lake and a lake’s ability to support life — its biological productivity. For instance, it’s been found that, in Florida shallow lakes tend to be more productive than deep lakes, meaning that shallow lakes often have greater concentrations of nutrients and also produce more fish and wildlife.
**Volume**

is the total amount of water in a lake basin, and it is usually expressed in units of acre-feet or cubic meters depending on which measurement system being used (i.e., English or Metric).

*Volume is often represented in scientific literature with the symbol \( V \).*

Lake volume data are available for only a limited number of lakes in Florida. As a whole, Florida lakes tend to have less volume than deeper lakes in the northern United States. It is also important to remember that lake volume can fluctuate dramatically depending on rainfall.

Lake **volume is an important consideration to lake management, as it can influence a lake’s dilution capacity.**

As mentioned earlier in the Surface Area segment on pages 10-11, the ability of a lake to dilute materials, whether they be naturally occurring from the watershed or from human activity, is known as a lake’s dilution capacity. Lakes with larger volumes of water have a greater ability to dilute materials coming into the lake basin.

♦ Dilution capacity is an important consideration when applying some herbicides to algae or aquatic plants in a lake. Extra care must be taken to apply the correct concentration of chemical based on the lake’s volume as herbicides are absorbed by plants from the water column. If concentrations are too weak, they would be less effective and if the dosage is too strong, the herbicide application would cost more than it should. (Herbicide treatment for submersed aquatic weeds can cost as much as $300 – $400 per acre.)

♦ Scientists also consider lake volume when estimating nutrient loads or flushing rates, as both can impact algal populations in a lake.

**There are several ways to measure the volume of a lake.**

♦ Hypsographic curves are used to determine lake volume. In the graphs in Figure 3-3, the area between the x-axis, the y-axis and the curve itself is proportional to the lake’s volume. Based on this knowledge, we can use several techniques to calculate volume.

*See Appendix B Measuring Lake Volume on pages 31-32 for details.*

♦ If you happen to know the mean depth of a lake and also its surface area, volume can be found by multiplying the two:

\[
\text{Volume (V)} = \text{mean depth (Z)} \times \text{surface area (A)}
\]

*See surface area on pages 10-11 and mean depth on page 16.*

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**Figure 3-3**

Hypsographic curves can be used to make comparisons between deep lakes and shallow lakes.
Maximum length —
is the distance, in a straight line, between the two farthest points on a lake. The distance must be measured without intersecting a land mass. See Figure 3-5 on page 19.

Maximum length is important because it can influence the depth at which waves can mix water and/or bottom sediments in a lake.

For example, if a lake should happen to have a sizable maximum length, with no landform to disrupt the wind, waves have the potential to grow quite large under windy conditions, influencing boating safety and shoreline erosion.

In contrast, when a lake has a small maximum length, waves are prevented from becoming very large and lake water mixing is reduced.

As a general rule, the larger the maximum length, the larger the waves, and the greater potential there is for mixing or disruption of bottom sediments. Of course, there are exceptions. For instance, deep lakes are less likely to experience disruption of bottom sediments and oxbow lakes are usually less affected by wind-induced wave action due to their narrow shape. A lake’s orientation to prevailing winds is another consideration.

Mean width —
is calculated by dividing a lake’s surface area by its maximum length. This measurement is also used to predict the amount of water mixing that can occur in a lake during strong winds. See definition of maximum length.

Maximum width —
is the maximum distance between the two widest points of a lake, that can be measured without crossing land, and at a right angle to the maximum length. In other words, the lake’s maximum width must be measured at a 90° angle to the lake’s “axis.” See Figure 3-5 on page 19.

Maximum width is also important to consider when determining the potential for waves to mix water and/or sediments at the bottom of a lake.

Mean depth —
is the average water depth of a lake.

Mean depth is important because early studies of algae, aquatic invertebrates, and fish populations have shown that shallow lakes are generally more productive than deep lakes.

Mean depth also has much to do with the potential for waves to disrupt bottom sediments. For example, lakes with greater mean depths usually don’t experience as much mixing of bottom sediments, as wave action is less likely to reach the bottom.

Maximum depth —
is the greatest depth of a lake. The location of a lake’s maximum depth is sometimes (but not always) indicated in bathymetric maps with an “X.” See Figure 3-5 on page 19.

Maximum depth is often represented in scientific literature by the symbol $z_{max}$.

Maximum depth cannot be estimated, and can only be obtained by locating and actually measuring the deepest point in a lake.
Maximum depth is important because it can influence the movement of fine organic sediments found on the bottom of a lake.

For example, water currents or waves can move sediments along the bottom of a lake or resuspend them into the water column. If a lake has deep areas or holes, the sediments usually find their way into these areas first. However, if the holes were to eventually become filled-in with sediments, there is no place for new and/or remaining sediments to go except back and forth across the lake bottom or into the water column.

See *A Lake Mystery* on page 17.

**Shoreline** —

is the area where a body of water meets the land. On a bathymetric map, it is represented by the outermost contour line of the map. See Figure 2-1 on page 7.

*A lake’s shoreline is important because it defines the area where a waterbody interfaces with the land.*

In Florida, this area of interface can change considerably depending on rainfall and lake levels. Lakefront property owners also need to be aware of the fact that, in Florida, land below the high water mark typically belongs to the state. This is important for planning various activities such as aquatic plant removal, muck removal, or dock construction, as some of these activities require permits.

Changes in a lake shoreline can also be significant to aquatic plant management. For instance, at high water levels, and depending on the slope of the land, a lake may have small amounts of aquatic vegetation along its shoreline. However, if water levels were to fall, the reduction in water depth along the lake’s shoreline could result in a dramatic increase in aquatic plant growth. Why?

Because when the water becomes shallow, sunlight may be able to reach larger areas of the lake bottom, providing the necessary energy for plants to grow.

**Shoreline length** —

is the linear measurement of a waterbody’s entire perimeter, at a given water level. In Florida, shoreline lengths fluctuate considerably, depending on rainfall and lake levels.

*Shoreline length is important because it provides a measurement of the actual amount of interface between a waterbody and the surrounding land.*

There are several approaches one can use to measure shoreline length:

♦ Using an aerial or topographic map of the waterbody, trace around the image of the lake with a cartometer (a mapmaker’s device that...
measures distances as drawn on a map). If you don’t have a cartometer, trace around the waterbody using a piece of string. Compare the cartometer measurement or the length of string with the map’s scale to convert the measurement to the actual shoreline length.

- If the lake has a perimeter road that is in close proximity to the lakeshore, it might be possible to drive the perimeter in a car and measure the distance with an odometer, and then estimate shoreline length using that distance.

- Using electronic navigation instrumentation, such as a GPS, measure the distance while traveling close to the shoreline in a boat.

- If the waterbody is small enough, the distance can be manually paced off by walking the perimeter. (One average stride is generally equal to about three feet.)

Shoreline development refers to the length of a lake’s shoreline relative to a circle of the same area. In other words, lakes with longer, irregularly shaped shorelines are considered to have more shoreline development, while circular lakes are considered to have less shoreline development. See the following explanation:

Shoreline development is often represented in scientific literature by the symbol SLD.

Consider Lakes A and B above. Both lakes have the same surface area. Notice how Lake B on the right has an irregularly shaped shoreline and Lake A on the left is more circular in shape. If you were to trace the entire perimeter of each lake with a piece of string, you would find that the string used to trace Lake B would be longer than that of Lake A.

**Determining a lake’s shoreline development is important because it helps us assess the amount of potential wildlife habitat available for a lake.**

For example, if Lake B has a greater amount of shoreline development, there is more of an interface between the water and surrounding land (i.e., coves and peninsulas). This interface often translates into more habitat for fish, birds, and other wildlife to raise their young.

**How does one determine a lake’s shoreline development?**

The mathematical equation provided below can be used to calculate the shoreline development of a lake. The higher the number, the greater the shoreline development.

*Note: a lake in the shape of a perfect circle will always have a shoreline development value of 1.*

\[
\text{Shoreline development (SLD)} = \frac{L}{2\sqrt{\pi A}}
\]

\[
L = \text{Shoreline length} \quad A = \text{surface area of the lake}
\]

11 *GPS is an acronym for Global Positioning System — a navigation device that utilizes satellite technology for determining one’s geographic location.*
Fetch —
is the distance that wind can travel over water before intersecting a landmass. We can use fetch distances to predict the depth at which wave energy extends below the water’s surface.

These predictions are made based on the relationship between wind velocity and the amount of fetch distance that a lake may have.

Fetch is also an important consideration when boating, as wind exerts the greatest amount of energy when there is no landmass in the way to “break” its effect. The greater the fetch distance, the greater potential there is for large waves — and increasingly dangerous boating conditions.

Figure 3-4 Using the map’s scale, fetch distances can be calculated from any direction. Both the depth contour lines and the scale in this map are recorded in feet.

Lake Brooklyn

Both the depth contour lines and the scale used in this map are recorded in feet.

Figure 3-5