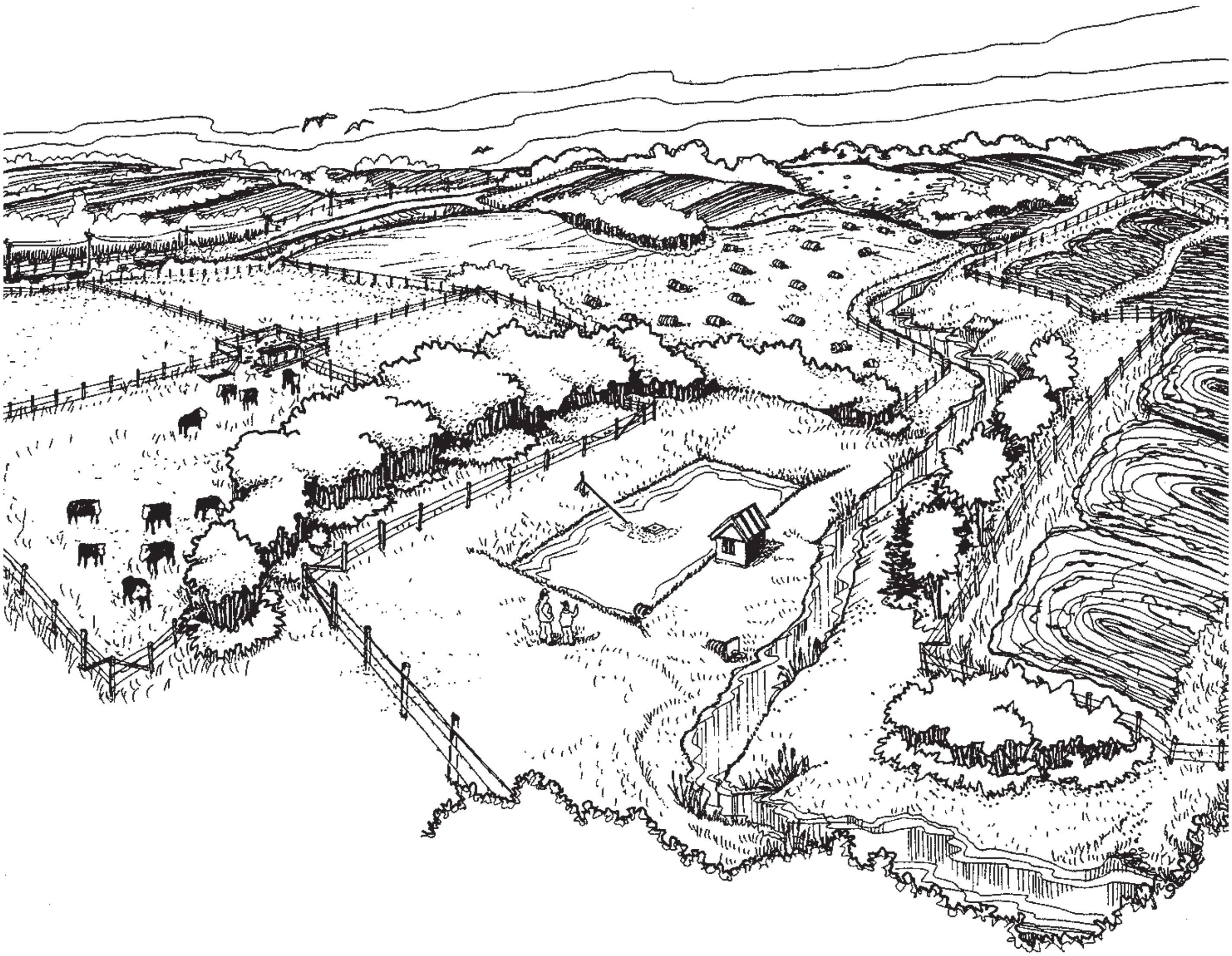
Understanding Prairie Dugouts



It is much easier to design, operate, and maintain high quality dugouts if you understand the natural processes that control them. This module explains some of these processes. Climate and landscape determine how much runoff will be captured by a dugout. Once the runoff is stored, the dugout provides an environment for a wide variety of plants, animals, and micro-organisms that can have a huge impact on water quality.

The Prairie Climate

Climate has an over-riding effect on water supplies. Three broad climate zones, as shown in Figure 2-1 Climate Zones, characterize the Prairie region:

The Prairie region is comprised of three broad climate zones.

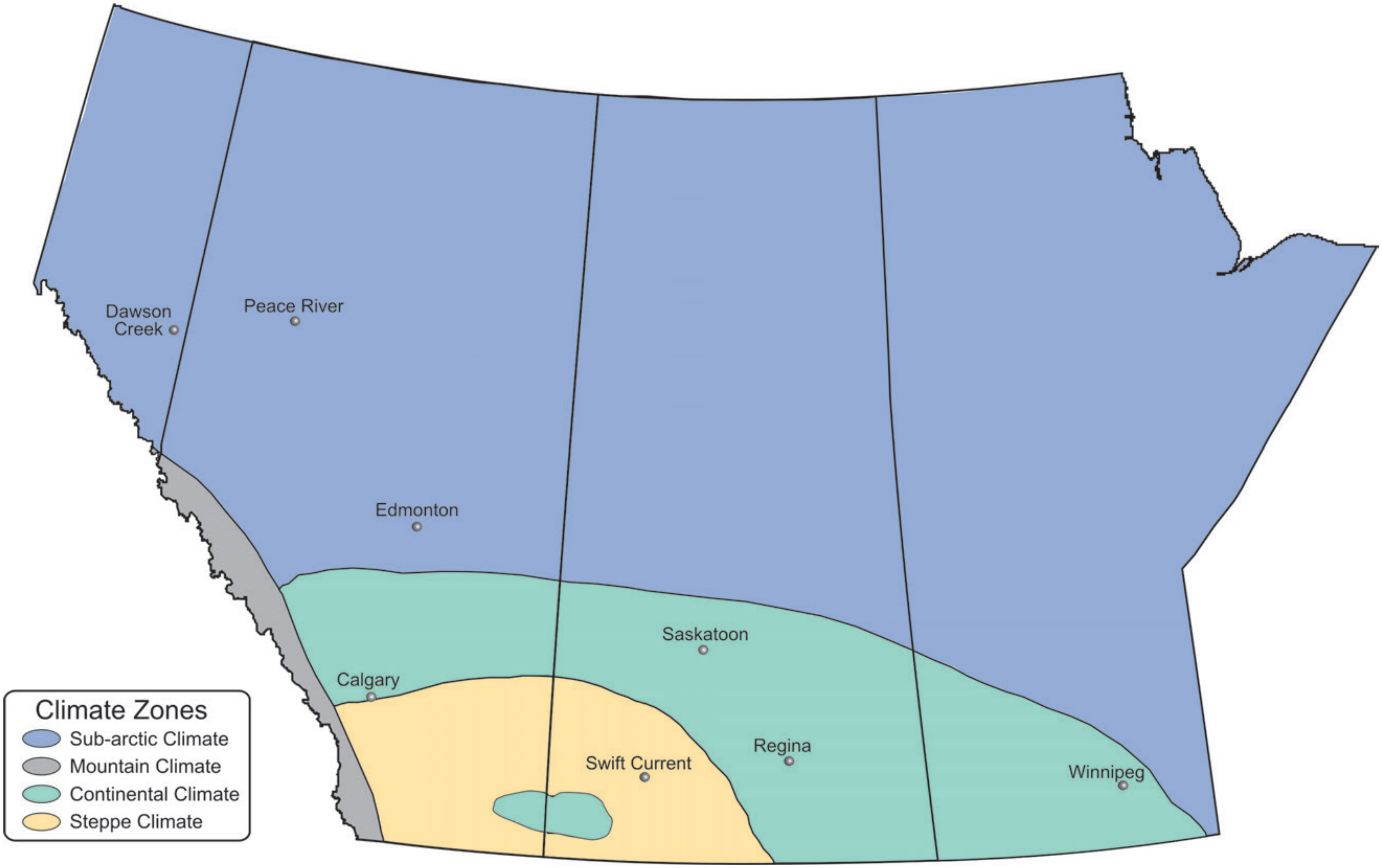
- steppe
- continental
- sub-arctic.

The steppe climate is dry year-round, with cold winters and warm summers. The continental climate is wetter, with cold winters and cool summers. The sub-arctic climate is characteristic of the boreal forest. Winters are long and cold. Summers are short and cool. The majority of the Prairie grain belt is in the continental region. Southwestern Saskatchewan and southern Alberta, with the exception of the Cypress uplands, are within the steppe region. Very little agricultural land is contained in the sub-arctic region.

With the exception of the Alberta foothills, average annual precipitation across the Prairies increases from 300 mm in the southwest to 500 mm in the northeast. Most of this precipitation occurs as late spring and summer rains. Often storm events produce floods. Winter precipitation occurs as snowfall, which usually remains all winter, melts rapidly in early spring, and creates a runoff event.

Mean annual temperature generally decreases from southwest to northeast. Southern Alberta and southwestern Saskatchewan often experience warm winter winds, called Chinooks, which produce melting and evaporation of snow during winter months. The entire Prairie region experiences an annual water deficit whereby evapo-transpiration exceeds precipitation. Because of low precipitation and Chinooks, deficits are severe in the southwest. Large fluctuations in temperature and precipitation from year to year may produce periods of drought or extreme wet conditions.

Figure 2-1 Climate Zones



The Prairie Dugout

Quality Farm Dugouts focuses on the typical family farm dugout filled from runoff.

Dugouts are earthen excavations designed to collect runoff and store it for use during drier times. Typically, dugout capacity ranges from a few hundred thousand to several million imperial gallons. **Dugouts are water sources of necessity, not of choice** because of the uncertainty of filling caused by annual variations in precipitation and the problem of maintaining water quality. More reliable, superior quality, water can usually be provided by flowing surface water and many groundwater formations. However, for some Prairie families and agri-food operations, dugouts are the only practical water source and are relied upon for all uses. For others, dugouts may provide water for specific purposes only, such as watering livestock. Although this publication provides information about the "typical" family farm dugout, the material may also be useful to managers of very large dugouts used for irrigation or watering animals in large livestock operations.

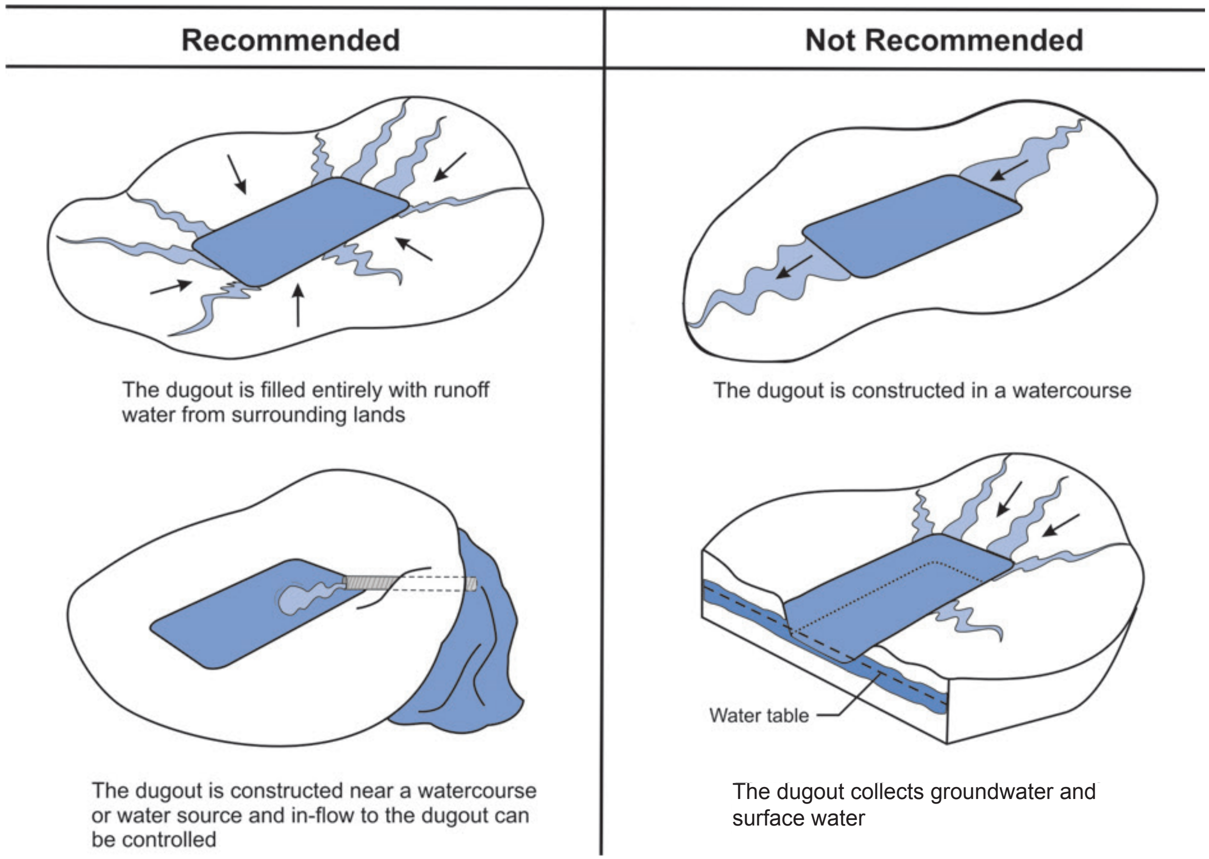
There are four major types of dugouts as illustrated in Figure 2-2 Dugout Types. The most common type is filled completely by runoff from surrounding fields. The second most common type is located adjacent to a flowing watercourse and is filled by either pumping or diverting water from the watercourse. For the purposes of this publication, a watercourse is defined as a creek, ditch, or other permanent or intermittent stream that has a well-defined channel with a streambed and banks.

Two other types of dugouts exist. One is an excavation made directly in a watercourse so that the stream fills the dugout and the overflow continues down the watercourse. This type of construction requires provincial approval and is **not** generally permitted because of downstream interests. With this type of construction, an accumulation of nutrients and organic matter can result in poor water quality as inflow cannot be controlled. The remaining type of dugout is one in contact with shallow groundwater. This is also **not** recommended because it mixes surface water and groundwater. Surface water is highly susceptible to microbial contamination and groundwater is typically highly mineralized. Most often, this mixture produces water that is of lower quality and more costly to treat than either surface or groundwater alone. Dugout owners often mistakenly assume that water entering a newly excavated dugout from a shallow aquifer provides insurance against drought. Although water levels may rise in times of high groundwater recharge, in times of falling groundwater levels, valuable runoff that has collected in the dugout may actually drain into the aquifer. In addition to emptying the dugout, this may introduce surface contaminants to the aquifer.

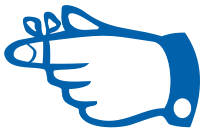
If you want to collect surface water, dig a dugout. If you want to use groundwater, dig a well.

For dugouts located on uneven ground, berms can be constructed on the lower sides of the dugout using the excavated earth to enable more water to be stored. To do this, strip the topsoil down to the subsoil where the berm is to be located, and then build up the bermed area with compacted subsoil to a level two feet higher than water level. This will prevent seepage loss under the berm and overtopping of the berm from wave action.

Figure 2-2 Dugout Types



Do not construct a dugout in a watercourse or construct a dugout that mixes groundwater and surface water.



Dugout Water Quality

As previously noted, wells are generally preferred to dugouts because water quality in most dugouts is poor. Runoff water often brings dissolved and suspended materials that are detrimental to water quality, including:

- disease-causing organisms
- plant nutrients/dissolved fertilizers
- pesticides
- decomposed plant and algae material
- suspended sediment
- fuels, solvents, and paints
- soil minerals.

A single litre of motor oil can make two million litres of water unfit for human drinking water.

The net result of contaminant-loaded runoff is poor quality, dugout water. However, dugout water quality can be managed, improved, and treated to meet most farm needs. Attempts to manage or enhance dugout water quality must recognize and work with the natural biological and chemical processes occurring in the dugout. Good dugout management starts with the dugout watershed and extends right through to the final use.

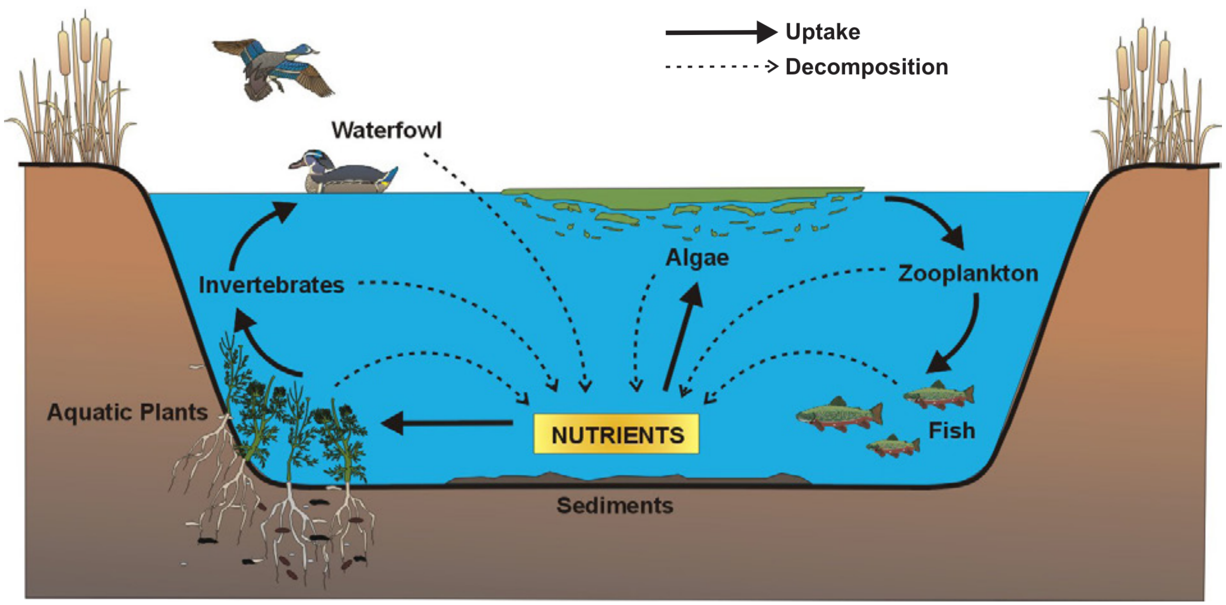
Biology of a Dugout

Many people see a dugout as a stagnant, lifeless body of water. Nothing could be further from the truth. As a newly constructed dugout fills for the first time, it is quickly invaded by a variety of organisms, including plants, microbes, insects, and animals, and develops its own unique ecosystem. The fertile soils in which most dugouts are located contribute nutrients for plant growth. The rooted plants and algae represent an important food source for tiny animals called zooplankton. Through the food chain, the zooplankton become a source of food for insects that ultimately become a source of food for amphibians and fish. In fact, a dugout is a living ecosystem driven by natural cycles and processes.

The biology of a dugout is similar to the cycle within any other small body of water. Each summer, warm temperatures and long sunny days produce an explosion of plant and animal growth. In daylight, plants consume nutrients and pump oxygen into the water; at night, oxygen production stops and respiration consumes dissolved oxygen which can result in low dissolved oxygen levels. When they die, microorganisms decompose their tissues. This decomposition process consumes oxygen. On hot, still days biological activity is high and there is little oxygen added by wind-driven mixing of the water. In winter when the surface is sealed by ice, oxygen levels can also become very low. When this occurs, anaerobic organisms that do not use oxygen take over the decomposition process. Anaerobic activity releases many unwanted compounds into water. These include forms of iron and manganese that produce coloured water and unpleasant smelling swamp gases and substances such as hydrogen sulfide and geosmin. Odourless gases such as methane and carbon dioxide may also be released. As these microorganisms die, their decomposition also adds nutrients to the water body that become available to plants to begin the cycle again.

A dugout is a living ecosystem subject to natural cycles and processes.

Figure 2-3 Simplified Nutrient Cycle



Many forms of plant life thrive in dugouts as shown in Figure 2-3 Simplified Nutrient Cycle. Some species are rooted in the dugout but are totally submerged, such as Northern Watermilfoil and White Waterbuttercup. Others inhabit the margins where they are rooted in the sediments but hold their vegetation above the water. Cattails and reeds are examples of this type of plant. Although only one of the many forms of plant life in a dugout, algae get a lot of attention. This is primarily due to the problems they cause in a water supply. Algae can be present in dugouts but go unnoticed most of the time. When conditions are favourable, however, they can reproduce very rapidly and cause a “bloom”. Algae blooms cause a variety of problems:

Algae in dugouts are of particular concern with algae blooms causing several problems.

- toxins in the water
- water turbidity
- tastes and odours
- clogging of filters
- ineffective disinfection treatment
- formation of toxic chlorination by-products
- fluctuating oxygen levels between day and night, resulting in fish kills.

DANGER

Cyanobacteria are often incorrectly referred to as blue-green algae. It is bacteria, not algae. The formation of toxins by **cyanobacteria** is of the greatest concern. Some are capable of producing toxins that can damage the liver, nerves, lungs, and hearts of livestock. Cyanobacteria float near the water surface and wind action blows them to the side of the dugout. When livestock water directly at the edge of a dugout, they may be exposed to high concentrations of cyanobacteria in the water. Cases of livestock deaths due to cyanobacteria have occurred in all the Prairie Provinces.

Growth of cyanobacteria is greatest when the water is warm and concentrations of nutrients, especially phosphorus, are high. It is not easy to distinguish between cyanobacteria and harmless green algae as shown in Figures 2-4, 2-5, 2-6, and 2-7. Positive identification requires training and use of a microscope. When an algae bloom occurs in water used for livestock, it is best to exercise extreme caution. Little corrective action is possible once a cyanobacteria bloom has occurred. The most effective strategy for reducing the risk is to manage a dugout so the conditions that induce large populations do not develop. Much of this manual is devoted to this topic.

Ron Zurawell

Figure 2-4 Green (Filamentous) Algae
There are many types of green algae. Shown here is a filamentous type which is characterized by long threads or filaments of cells attached together and found floating as a mat on the surface. It is commonly called pond scum.

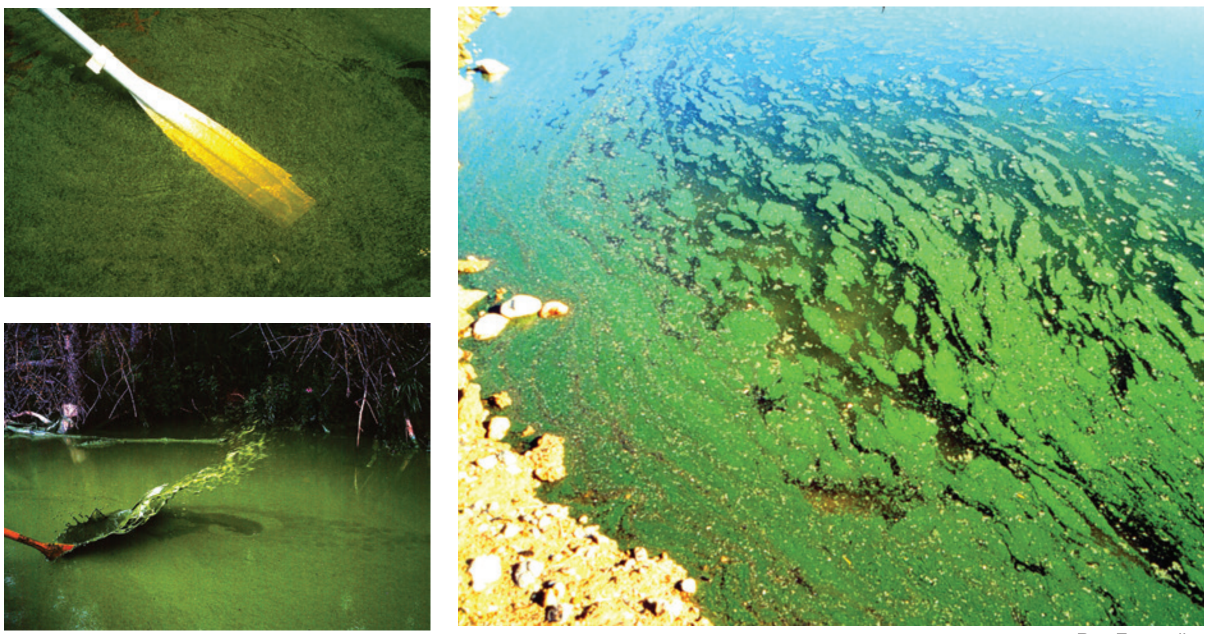


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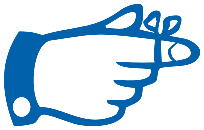
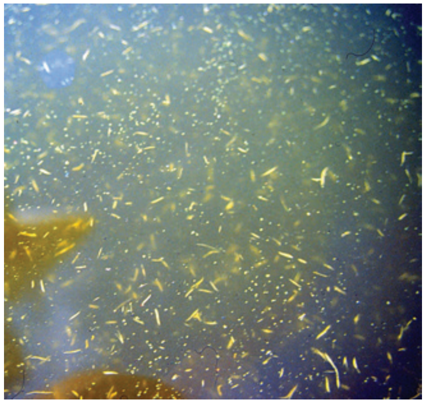
Figure 2-5 Cyanobacteria
There are many types of cyanobacteria. They are microscopic in size but become visible when large populations develop forming what is termed a “bloom”. Some types are extremely toxic to humans and animals.

Figure 2-6 Cyanobacteria
One type of cyanobacteria is highly visible due to its "grass clipping" appearance with pieces measuring from 1/2 to 3/4 inch (13-19 mm) in length.

***Cyanobacteria** are often incorrectly referred to as blue-green algae. It is bacteria, not algae.*





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Figures 2-7 Duckweed
Duckweed is a readily identified oval shaped plant that floats on the water surface and forms a mat that can cover the entire dugout.

Ron Zurawell

A much-maligned, but harmless plant called duckweed is sometimes confused with algae. It can be readily identified upon close inspection. Duckweed is an oval shaped plant that floats on the water surface as shown in Figure 2-7 Duckweed. It can cover an entire water body with a green mat composed of millions of small plants. Duckweed can be beneficial in a dugout by preventing light penetration of the water and thereby shading out algae. It also takes up nitrogen and phosphorus from the water. Long-lasting benefit from duckweed is only realized, however, if plants are removed before they die and the nutrients are released back into the water. To be successful, the duckweed must be removed as often as once a month.

The Life Span of a Dugout

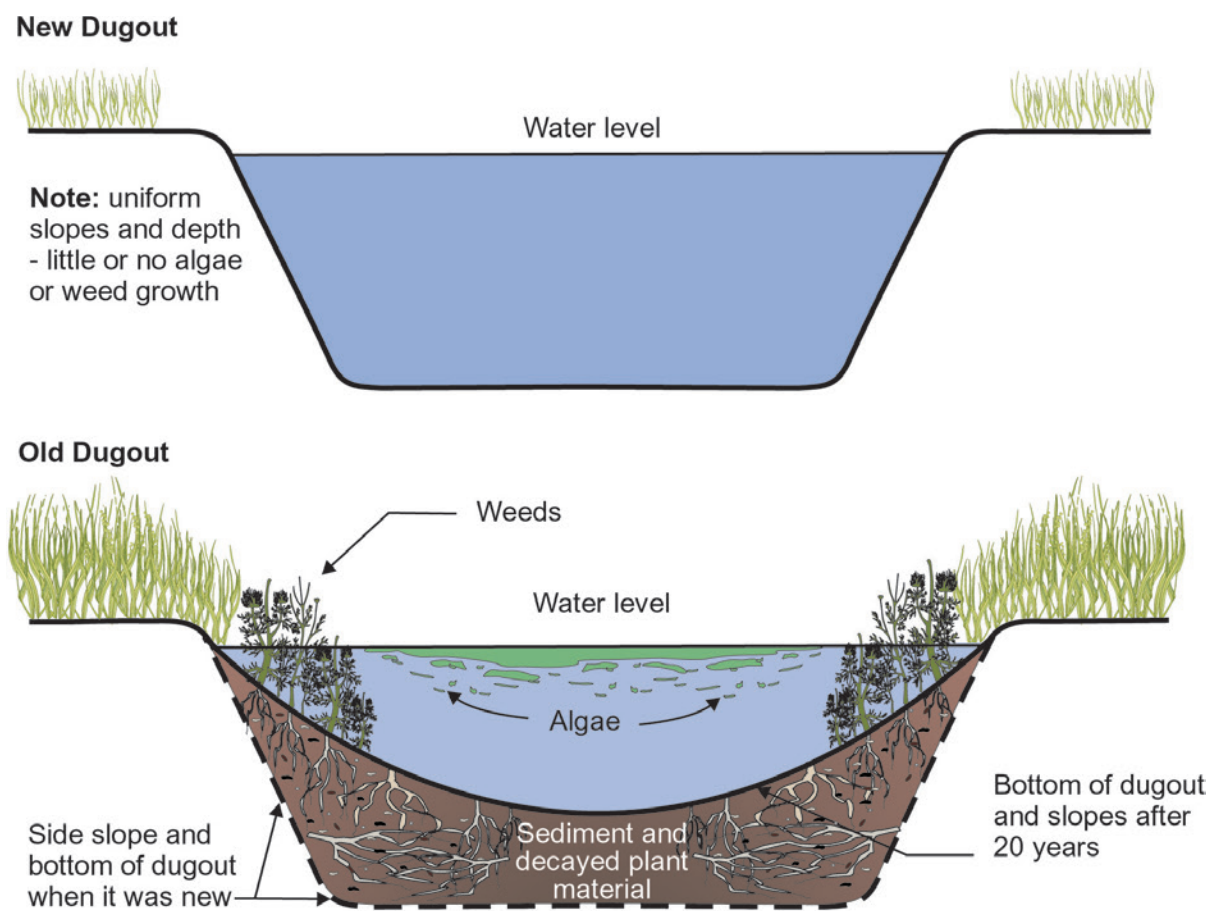
Like all man-made things, a farm dugout does not last forever as shown in Figure 2-8 New vs. Old Dugout Cross-sections. All bodies of water, including farm dugouts, undergo a natural aging process. As the years go by, the dugout accumulates sediment from wind and water erosion. In some circumstances, an average-sized dugout can collect more than 15 inches of sediment each year. This can total 50 tons or more. As the excavation fills with sediment, the holding capacity becomes greatly reduced. Some of the rehabilitation work on dugouts has shown that from 1 to 10 per cent of water volume can be lost in a single year. Sediment also contributes nutrients that rapidly accelerate the natural aging process by increasing plant growth and lowering water quality.

Ten per cent of dugout capacity can be lost in a single year due to sediment inflow from adjacent land.

As a dugout fills with sediment, water quality deteriorates. In addition to collecting water and sediment, dugouts are very efficient at trapping the nutrients deposited from runoff to the dugout. Year after year, the accumulation of these nutrients from runoff events, plus their continual re-cycling within a dugout, cause a steady increase in plant and algae growth. This leads to an ongoing deterioration in dugout water quality. A shallow dugout also warms more quickly in the summer and cools more rapidly in the winter. Warm water encourages algae growth in summer. The winter ice layer leaves even less water available and concentrates salts and nutrients in a smaller volume of water.

The actual life span of a dugout depends on the quality of water that is required for different uses. Raw water must have low biological activity in order to be suitable for treatment to drinking water standards. Irrigation water must have low levels of soluble salts. The length of time that a dugout can sustain the required quality is dependent on land-use practices in the watershed and the actual management of the dugout. As dugouts age, you can expect inferior water quality.

Figure 2-8 New vs. Old Dugout Cross-sections



As a dugout fills with sediment, water quality deteriorates.

In general, a farm dugout provides good water quality for about the first five years. Over the next 10 years, storage capacity and water quality deteriorate. After 20 years, storage capacity and water quality have usually been reduced to the point where the dugout no longer meets the needs of the landowner. Regardless of its uses, the life span of a dugout can be extended significantly through effective management.