Water Quality in the Cypress Creek

A summary of findings from CRP monitoring in the Wimberley Valley

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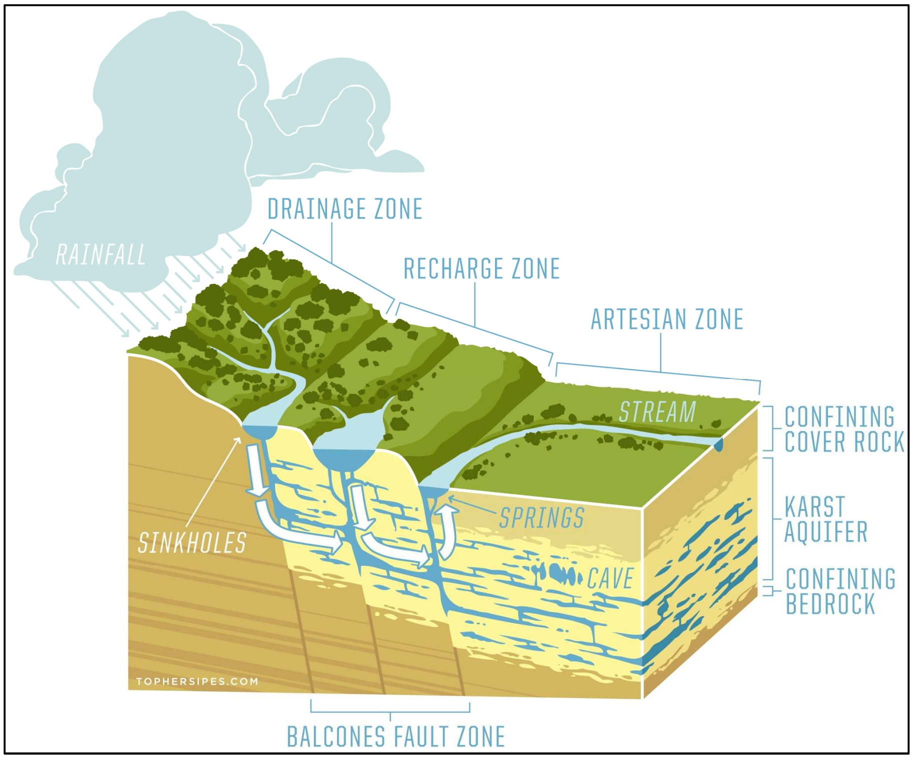
Introduction

Fairly rugged terrain, narrow canyons, and springs dominate the landscape around Cypress Creek and contribute to its natural beauty. The terrain also reflects the underlying karstic, faulted, and fractured limestone geology of central Texas. The limestone geology creates fissures and fractures that store vast amounts of water underground. The Wimberley Valley is entirely dependent on the Trinity Aquifer for its water supply, which is pumped out from underground through wells and delivered to homes and businesses. Rivers and streams, like the Cypress Creek and Blanco River, are almost entirely dependent on water from the aquifer, too. The flow of these streams will swell during wet periods, but recede again when there is no rain. The water that remains during dry periods comes directly out of the Trinity Aquifer through springs and at places where the base of the river intersects the level of the aquifer, or water table. The picture below illustrates how the groundwater and surface water are intricately connected here.



Water quality in the Wimberley Valley is very dependent on these two factors: water running over the surface after rainfall, and water coming out of the aquifer to feed seeps and springs. Water quality is a concern because adequate temperature and enough oxygen in the water are essential to maintain fish and other aquatic life, low bacteria levels are important for people to swim and recreate safely in the creeks, and nutrients need to be in balance to keep aquatic life healthy and to prevent too much algae from destroying the beauty and health of the water. In general, good water quality in the Cypress and Blanco Rivers near Wimberley is very dependent on a continuous supply of clean, clear base flow from its many seeps and springs.

Water in streams can also directly affect water quality in the aquifer because of rapid recharge through fractures and sinkholes in streambeds. Nonpoint source (NPS) pollution is a term that describes diffuse nutrients, bacteria, and other pollutants that can be part of infiltration or surface water runoff from development, animal waste, failing septic systems, treated effluent irrigation systems, spills or dumping of chemical pollutants, fertilizer or pesticide applications.

Watershed protection, or water catchment protection, is critical to reduce nonpoint source pollution and to maintain the health of the Wimberley Valley and the streams and springs that give it life. Protection of the entire area that contributes to the stream (the water catchment) is important because of the direct and well-established connection between what happens on the land and what ultimately ends up in the water.

Water Quality Summary

The Cypress Creek's excellent water quality has historically been seen in the diverse and high-quality aquatic ecosystem that it supports. The creek offers habitat to a diverse number of species, including fishes, water fowl, reptiles and amphibians, mammals, and insects. In 2000, however, the lower 5.5 miles of the Cypress Creek made the U.S. Environmental Protection Agency (USEPA) impaired stream segment list (also known as the 303(d) list) because of a quantity of dissolved oxygen lower than needed to support aquatic life. The degraded water quality correlated with what was, at the time, the lowest flow ever recorded (0.33 cubic feet per second) in July of 2000. Low flow is often correlated with degraded water quality in the Cypress, because the aquatic ecosystem evolved in a spring-fed environment, and when there is little water there is greater chance for pollutants to become concentrated at dangerous levels.

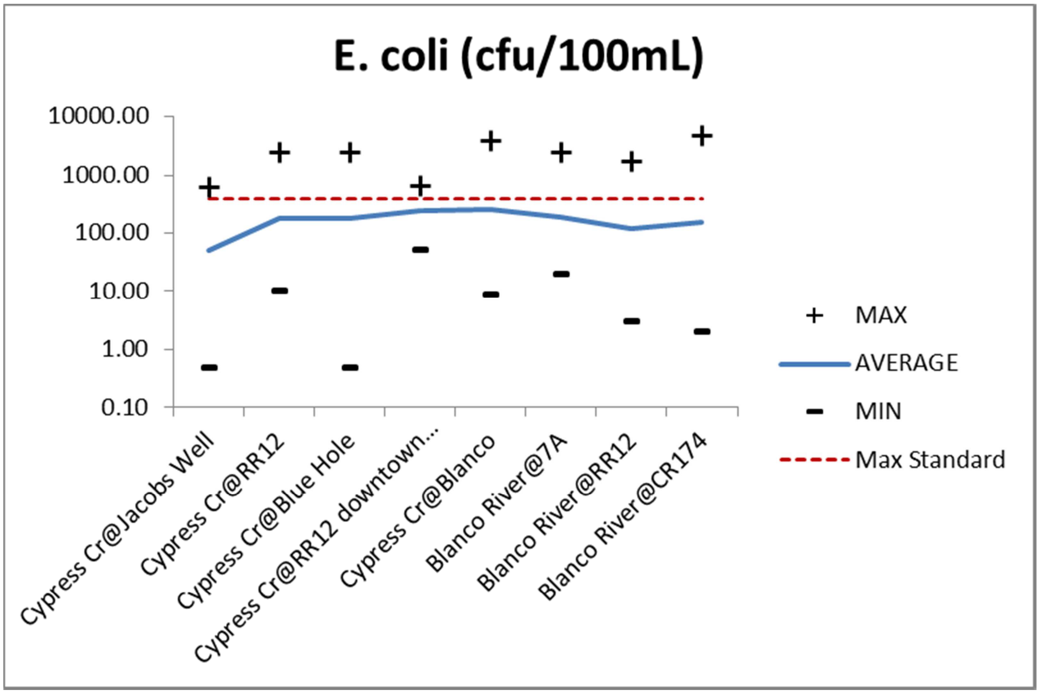
The Clean Rivers Program, through the Texas Commission on Environmental Quality, and supported also by Hays County and the Wimberley Valley Watershed Association, monitors five sites along the Cypress Creek, and three sites along the Blanco River in the Wimberley Valley. Most sites have been monitored since 2005.

Overall, there are seasonal fluctuations in water quality, and there are differences from the Cypress Creek to the Blanco River, that reflect their different sizes, flow patterns, and catchment areas. Water quality parameters vary considerably from site to site throughout the perennial part of the Cypress Creek. In general, Jacob's Well and Blue Hole are probably more influenced by groundwater interactions, as conditions there are more closely related to one another than the other sites. Other sites tend to cluster closer together and their water quality shows more of an influence of local stream conditions and runoff from contributing watersheds. Temperature is relatively steady, rising on average as you travel downstream. pH is fairly steady along the length of perennial Cypress Creek, rising only slightly as you go downstream.

Issues of concern in the Cypress Creek and Blanco River include excess sediment, high bacteria concentrations and occasionally very high nutrient levels. These indicate potential nonpoint sources of pollution including pet and animal waste, excess fertilizer application, and poorly performing septic systems. Stormflow monitoring of the Dry Cypress watershed shows that the upper watershed has a tendency toward high bacteria and sediment concentrations washing down through the channel after a storm, with occasionally high nitrogen levels as well.

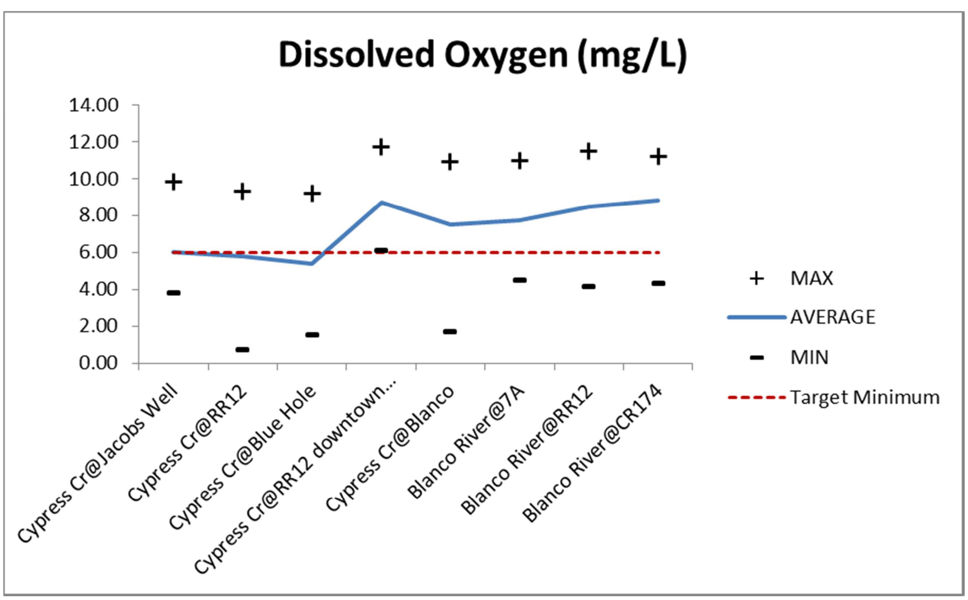
Bacteria

Average bacteria level rises as you travel downstream in the Cypress Creek, from 51 cfu/100mL at Jacob's Well to 262 cfu/100mL at the Blanco confluence. Bacteria levels in the Blanco River are slightly lower on average, but all sites have had E. coli measured above the 394 cfu/100mL standard, with maximum readings in the thousands: the highest readings are 3830 cfu/100mL in the Cypress Creek-Blanco confluence (Aug 2011), and 4800 cfu/100m in the Blanco River downstream from Wimberley (Mar 2006).

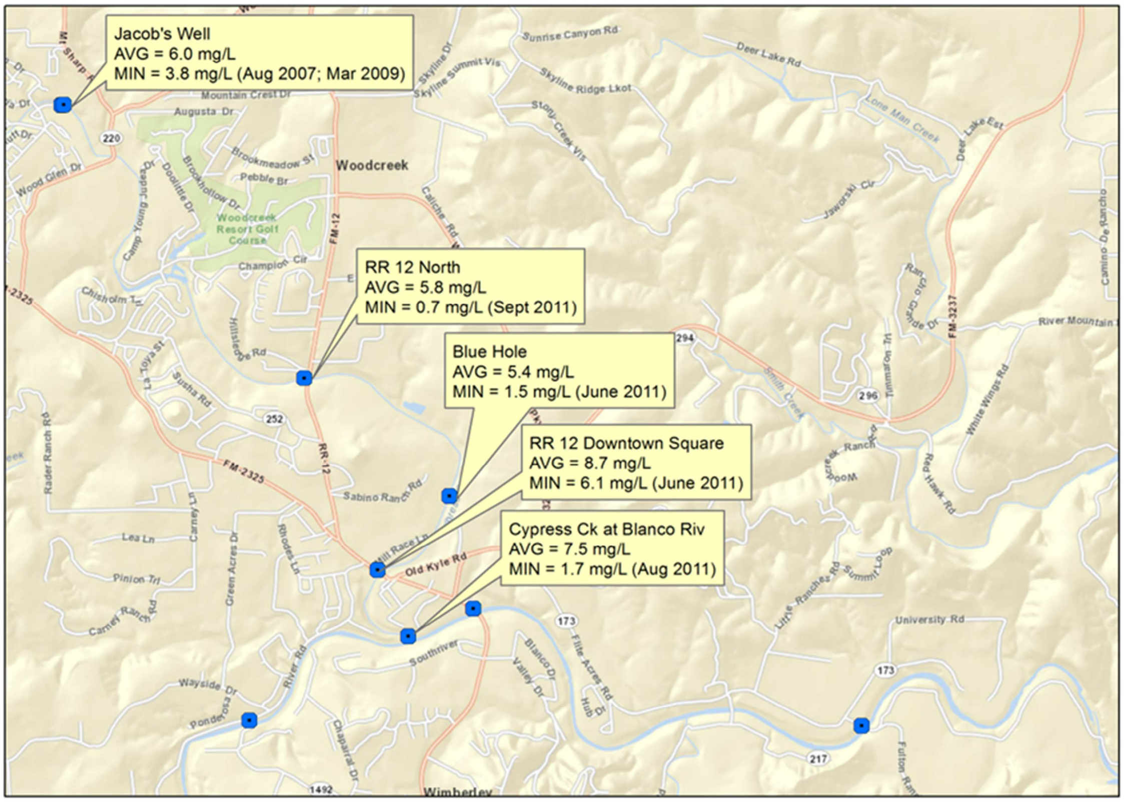


Dissolved Oxygen

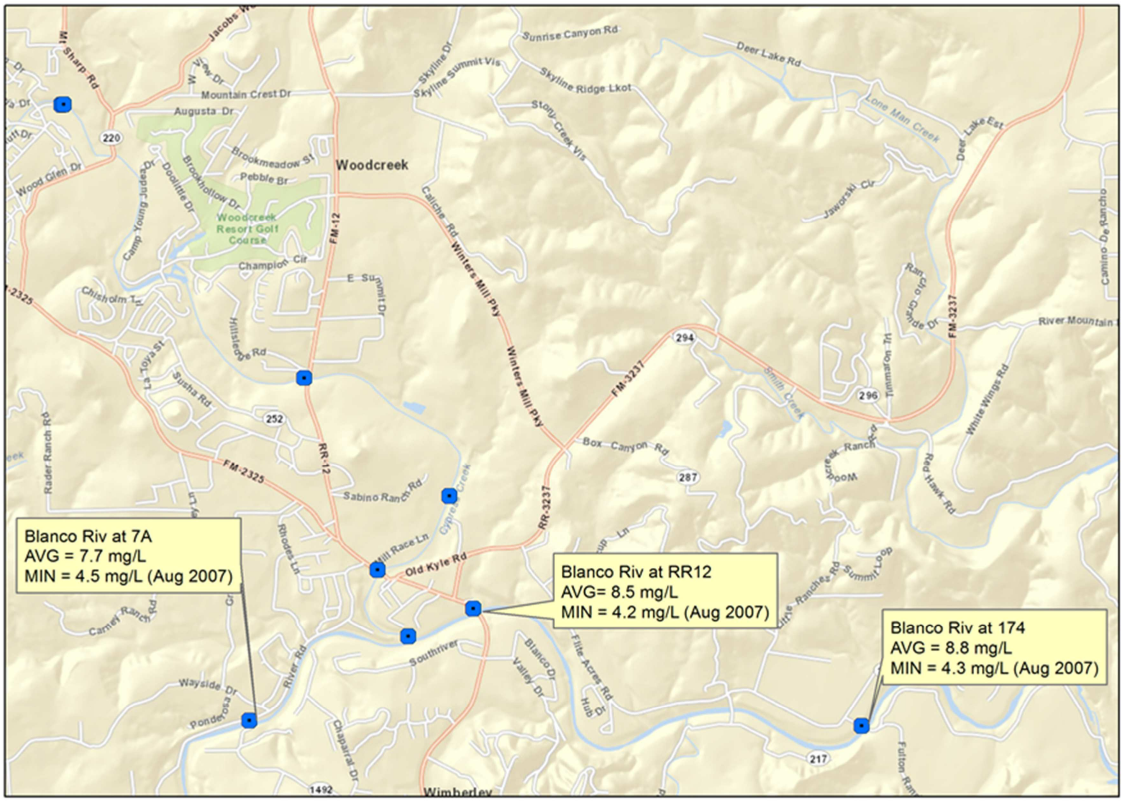
Dissolved Oxygen is relatively constant at Jacob's Well, 6.0 mg/L on average. Cypress Creek gains oxygen as it flows and tumbles over the rocky creek bed downstream. When the flow is too low, however, the water cannot get oxygenated enough and aquatic life suffers. A steady stream of oxygenated water typically flows out of the spring at Jacob's Well, oxygen is reduced at Blue Hole, and then is very high as the creek flows through the downtown square. A level of 6.0 mg/L is an indicator of healthy aquatic habitat. Dissolved oxygen that stays below 4.0 mg/L for an extended length of time is considered impaired under Texas water quality standards.



Trends in Dissolved Oxygen
Cypress Creek

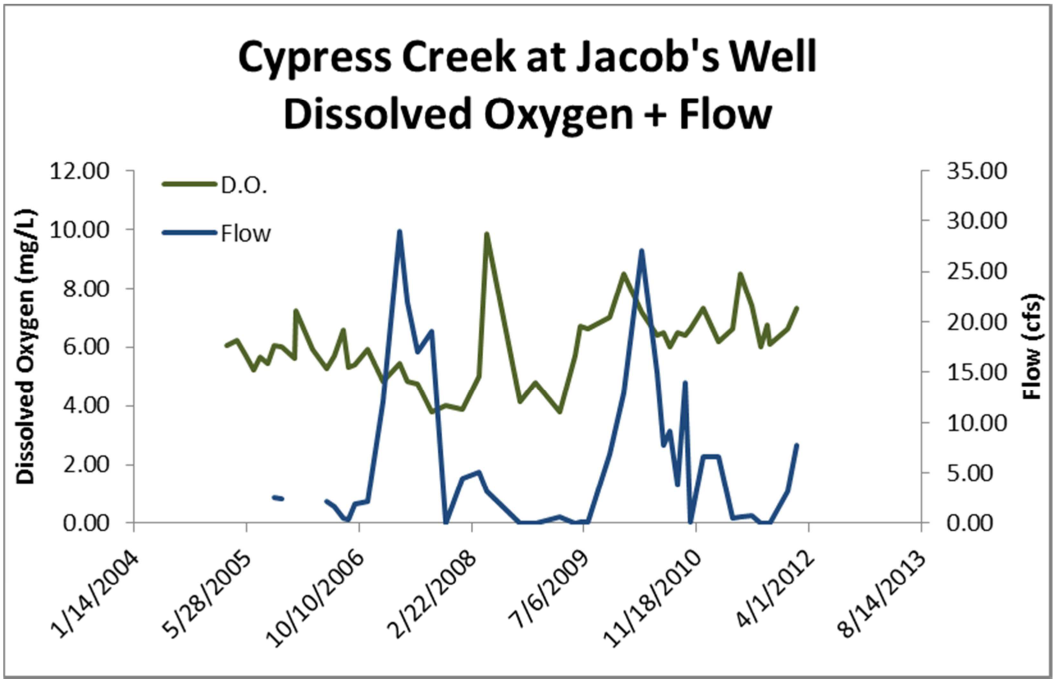


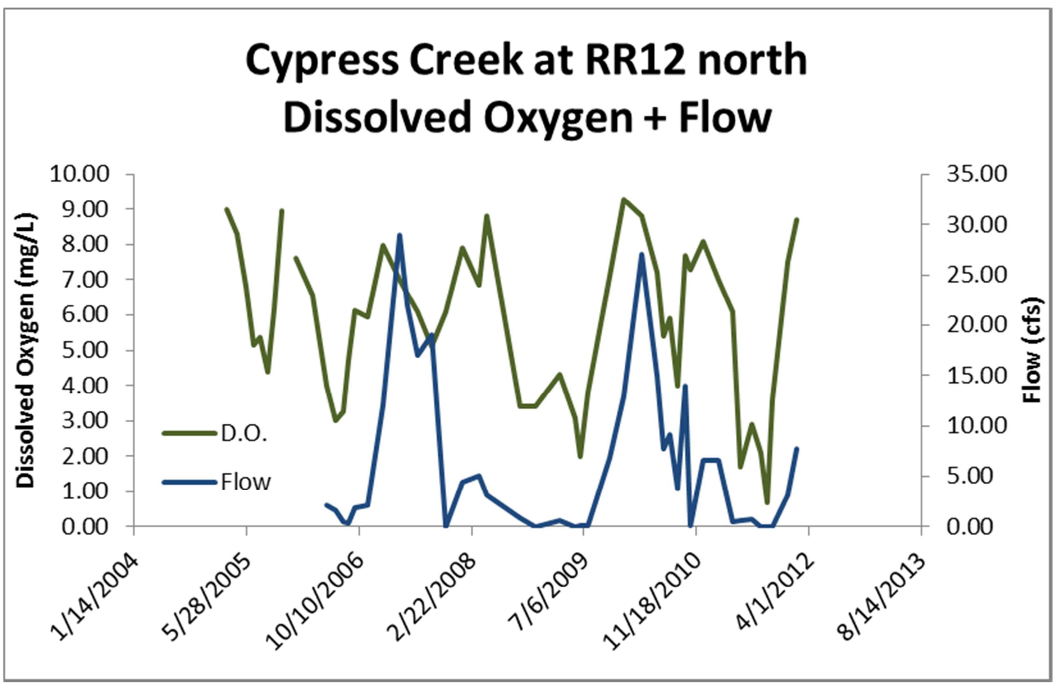
Trends in Dissolved Oxygen
Blanco River

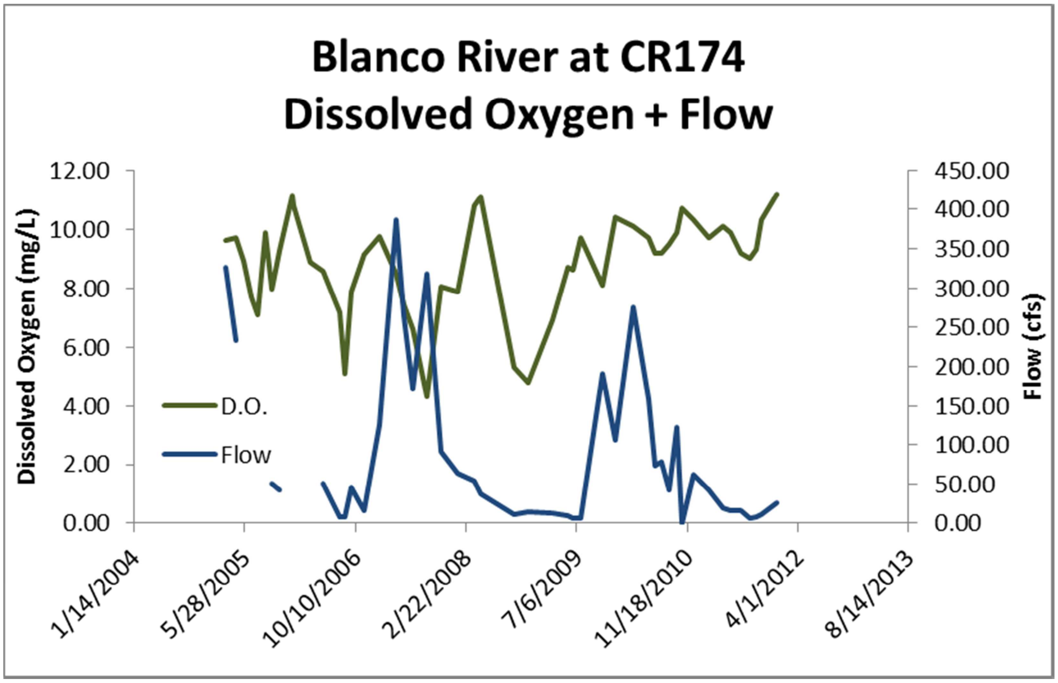


The droughts in 2008-2009 and 2010-2011 had a significant impact on the dissolved oxygen at several sites in the creek. The lowest dissolved oxygen levels ever recorded at the four downstream sites occurred in the summer of 2011, during the single worst year of drought in recorded history. In the Blanco River, on the other hand, dissolved oxygen was very high in the summer of 2011, and the lowest values were recorded at all three sites in August 2007. Typically, aquatic life depends on oxygen levels within a certain range. There are daily fluctuations as aquatic plants grow and produce oxygen during the day (so levels peak), and then the plants respire at night and devour oxygen, causing levels to plummet. So very high oxygen measurements during the day does not necessarily mean good water quality, which is why standards are usually based on a 24-hour maximum.

The graphs below show clearly that when flow is severely reduced, DO begins to drop at many sites along the Cypress Creek and Blanco River. At Jacob's Well, dissolved oxygen is less influenced by flow, as most water at that site is flowing directly out of the Trinity Aquifer. Higher dissolved oxygen during these extended periods are generally associated with rain events, when flow is increased. Even small changes in flow are correlated with large fluctuations in DO.


Cypress Creek at Jacob's Well
Dissolved Oxygen + Flow
D.O.
Flow
Dissolved Oxygen (mg/L)
Flow (cfs)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013


Cypress Creek at RR12 north
Dissolved Oxygen + Flow
D.O.
Flow
Dissolved Oxygen (mg/L)
Flow (cfs)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1/14/2004
5/28/2005
10/10/2006
2/22/2008
7/6/2009
11/18/2010
4/1/2012
8/14/2013



Future development in the Wimberley catchment is unavoidable. It is likely that development, if not properly managed, could result in negative consequences for the creek. Cypress Creek is generally within the water quality standards established by the State, but the stream does show signs of degradation, particularly when flow from the aquifer is reduced during times of drought or high pumping for domestic use. Due to its location in one of the fastest growing counties in the nation, substantial growth and development is imminent. Stakeholders and experts throughout the Wimberley Valley have agreed that simply meeting State water quality standards would be insufficient to maintain the desired health and historical nature of the creek as a spring-run stream.

It is important to acknowledge the critical importance of properly managed groundwater and its impact on the water quality in Cypress Creek. Efforts to maintain good water quality conditions are constrained by the need for base flow from Cypress Creek's artesian headwaters at Jacob's Well spring. Spring flow, in turn, depends on having the aquifer (water table) above a certain level. Aquifer level is dependent on many factors, some of which we cannot control (such as rainfall, temperature, and natural recharge), and some of which we can control (such as the amount of water pumped from wells, the location of wells in relation to major springs like Jacob's Well, and whether construction is done in such a way that it covers permeable areas and inhibits natural recharge).

Learn More:

Point and Nonpoint Source Pollution

Point source pollution is a single, identifiable source of pollution such as a discharge from a municipal or industrial wastewater treatment plant. Point sources are regulated under the Clean Water Act and Texas state law and are subject to permit requirements that focus on water quality protection. These permits specify effluent limits, monitoring requirements, and enforcement mechanisms. To date, there are no identifiable point sources of pollution in the Cypress Creek watershed.

Nonpoint source (NPS) pollution is caused by wind, rainfall, and snowmelt carrying pollutants to surface water and groundwater systems. Because moving water is the most common driving force of nonpoint source pollutant movement into a waterway, the amount of pollution from nonpoint sources varies over time and location. In a rural-to-urbanizing system such as the Cypress Creek watershed, nonpoint source pollution threats arise from a variety of human-based activities, including but not limited to increased intensity of land use, construction, alteration of natural drainage densities, and soil compaction. Fortunately, NPS pollution can be minimized through careful planning and land management practices, and public education to prevent negative impacts.

NPS pollution and detection does not lend itself directly to the traditional discharge control method that involves routine sampling from a treatment facility's permitted outfall pipe, testing for likely contaminants, and comparison to ensure permitted pollution standards are met. Rather, the nonpoint sources are widely dispersed across a landscape, making it difficult to define each source location and the impact of its contributing load to the concentration of oxygen or pollutants in the creek. Years of NPS pollution research have instead shown the most applicable solutions to come from workable land management practices, education about nonpoint source concerns, and changes through social and economic actions.

Urban NPS pollution typically moves via surface runoff and generally includes suspended and dissolved solids, bacteria, metals, oxygen demanding substances, nutrients, oil and grease, and pesticides. NPS pollution sources include vehicles, construction activities, fertilizer and pesticide application, erosion, animal wastes, and atmospheric deposition. NPS pollutants associated with agricultural areas include nutrients, pesticides, organic matter, and animal wastes, any of which can be transported in solution, suspended in surface runoff, or adsorbed onto eroded soil particles (Baird et al., 1996). Browne (1989) provides an overview of NPS pollution that stresses the following:

- Nonpoint sources are diffuse, cover substantial areas, and act either in response to human activity or as "background pollution" from natural lands.
- NPS pollution is related to land management, geologic, and hydrologic variables which may vary over time. Only the land management factors may be controlled by society.
- NPS pollutants are generated and transported as part of the hydrologic cycle. Surface runoff transports eroded soil particles from pervious areas, and picks up and transports pollutants deposited on impervious areas. Groundwater transports pollutants from septic tanks and landfills.
- Urban runoff includes suspended solids, bacteria, metals, oxygen-demanding substances, nutrients, and oil and grease. Sources of these pollutants include vehicles, fertilizer and

pesticide application, animal wastes, spills or dumping of chemical waste, construction activities, and road salting.

- Non-urban pollutants are often related to agricultural activities. Agricultural pollutants include pesticides, sediments, nutrients, and organic materials. NPS loading from agricultural areas tends to be seasonal with higher loading associated with planting and harvesting activities.

Water Quality Parameters

Water Temperature

Many aquatic organisms are cold-blooded and therefore depend on the temperature of water to be able to carry out processes such as metabolism and reproduction. Sources of warm water include power plants' effluent after it has been used for cooling, or hydroelectric plants which release warmer or cooler water (depending on the time of year) near the point of release. Water temperature can also increase due to a combination of low flow (shallow water) coupled with high air temperature or lots of sunshine on the water surface, a common occurrence in the summer. The amount of oxygen dissolved in water is also very sensitive to the water's temperature. On a yearly scale, the amount of dissolved oxygen in the water decreases as temperatures increase, and vice versa, because warmer, less dense water can hold less oxygen molecules than cooler, more dense water. However, on a daily scale, the amount of dissolved oxygen in the water increases as temperatures increase, and vice versa, because of photosynthesis adding oxygen to the water body. Water temperature variations are most detrimental when they occur rapidly, leaving the biotic community no time to adjust. However, volunteer monitoring occurs at a particular time of day, so daily variations are not covered in this report.

Dissolved Oxygen

Oxygen is necessary for the survival of most organisms. Too little oxygen will lead to asphyxiation of aquatic organisms. Too much oxygen (supersaturation) can cause bubbles to develop in cardiovascular systems, which can be fatal. Dissolved oxygen (DO) levels below 2 milligrams per liter (mg/L) can lead to asphyxiation, and levels above 20 mg/L can lead to supersaturation. The most suitable aquatic environment exhibits levels above 5 mg/L. High concentrations of nutrients can lead to excessive surface vegetation growth, which may starve subsurface vegetation of sunlight, and therefore limit the amount of dissolved oxygen in a water body due to limited photosynthesis. This process is enhanced when the subsurface vegetation dies and consumes oxygen when decomposing. Low dissolved oxygen levels may also result from high groundwater inflows (as groundwater is typically low in dissolved oxygen due to minimal aeration) or from high temperatures which reduce oxygen solubility. Supersaturation typically only occurs underneath waterfalls or dams with water flowing over the top.

Specific Conductivity

Specific conductivity is a measure of the ability of a body of water to conduct electricity. It is measured in microSiemens per centimeter (µS/cm). A body of water is more conductive if it has more dissolved materials such as nutrients and salts, which indicate poor water quality if they are abundant. High concentrations of nutrients lower dissolved oxygen, as described in the previous section. High concentrations of salt can inhibit water absorption and limit root growth for vegetation, lead to an abundance of more drought tolerant plants, and cause dehydration of fish and amphibians. Sources of total dissolved solids (TDS) leading to high conductivity can include agricultural runoff, domestic runoff, or discharges from wastewater treatment plants.

pH

pH is a measure of acidity or alkalinity. The scale measures the concentration of hydrogen ions on a range of 0 to 14 and is reported in standard units (SU). The range is logarithmic. Therefore, every 1 unit change means the acidity increased or decreased 10-fold. Sources of low pH (acidic) can include acid rain and runoff from acid-laden soils. Acid rain is mostly caused by coal power plants with minimal contributions from the burning of other fossil fuels and other processes such as volcanic emissions. Soil-acidity can be caused by excessive rainfall leaching alkaline materials out of soils, acidic parent material, crop decomposition creating hydrogen ions, or high-yielding fields which have drained the soil of all alkalinity. Sources of high pH (alkaline) include geologic composition, as in the case of limestone increasing alkalinity, and the dissolving of carbon dioxide in water. Carbon dioxide is water soluble, and as it dissolves it forms carbonic acid, an alkaline molecule. The most suitable pH range for healthy organisms is 6.5 to 9.0.

Secchi Disk Depth and Total Depth

The Secchi Disk is used to determine the clarity of the water, a condition known as turbidity. The disk shown on the next page is lowered into the water until it is no longer visible, and the depth is recorded. Highly turbid waters pose a risk to wildlife by clogging the gills of fish, reducing visibility, and carrying contaminants. Reduced visibility can harm predatory fish or birds that depend on good visibility to find their prey. Turbid waters allow very little light to penetrate deep into the water, which in turn decreases the density of phytoplankton, algae, and other aquatic plants. This reduces the dissolved oxygen in the water due to reduced photosynthesis. Contaminants are most commonly transported in sediment rather than in the water. Turbid waters can results from sediment washing away from construction sites, erosion of farms, or mining operations. Average Secchi Disk depth readings that are less than total depth readings indicate turbid water. Readings that are equal to total depth indicate clear water. Low total depth observations can indicate low flow conditions, and when there is little flow there is the potential for contaminants to be concentrated.

Flow

Flow is measured to provide a context for the water quality condition of the stream. Higher concentrations of pollutants may occur at higher flows, as water travels over land and picks up contaminants along the way. High concentrations of some contaminants are more common at low flows, when there is not enough water moving through to carry the pollutants away. Knowing the flow at the time of measurement helps scientists to understand the source of the contamination, how far is is likely to have traveled, and the possible mechanisms for how it got there.

E. coli Bacteria

E. coli bacteria originate in the digestive tract of warm-blooded organisms. The US Environmental Protection Agency (EPA) has determined *E. coli* to be the best indicator of the concentration of pathogens in a water body, which are far too numerous to be tested cost-effectively. A pathogen is a biological agent that causes disease. Sources include livestock, pets, failing septic systems and wastewater treatment plants, or wildlife around the water body. The single-sample standard is currently set at 394 colony forming units per 100 milliliters (cfu/100mL). At this level, 8 in 1,000 people might become ill if recreating in the water body. 25% of 7 samples with the same reasonable amount of time between them within the last 10 years and ranging at least two years must exhibit counts higher than 394 cfu/100 mL for a water body to be considered impaired. There is also a standard for a geometric mean, a type of average which is not heavily weighted by zeros. That standard is 126 cfu/100mL. A water body is also considered impaired if the geometric mean is higher than this standard.

Nitrogen

Nitrite and Nitrate are forms of the element Nitrogen, which makes up about 80 percent of the air we breathe. As an essential component of life, nitrogen is recycled continually by plants and animals, and is found in the cells of all living things. Nitrites are relatively short-lived because they're quickly converted to nitrates by bacteria. Nitrites produce a serious illness (brown blood disease) in fish, even though they don't exist for very long in the environment. Nitrate is a major ingredient of farm fertilizer and is necessary for crop production. When it rains, varying nitrate amounts wash from uplands into nearby waterways. Nitrates also get into waterways from lawn fertilizer run-off, leaking septic tanks and cesspools, manure from farm livestock, animal wastes (including fish and birds), and discharges from car exhausts. Nitrates stimulate the growth of plankton and water weeds that provide food for fish. This may increase the fish population. However, if algae grow too wildly, oxygen levels will be reduced and fish will die.

Ammonia

In nature, ammonia is formed by the action of bacteria on proteins and urea. Ammonia is rich in nitrogen so it makes an excellent fertilizer. In fact, ammonium salts are a major source of nitrogen for fertilizers. Like nitrates, ammonia may speed the process of eutrophication in waterways. Ammonia is toxic to fish and aquatic organisms, even in very low concentrations. When levels reach 0.06 mg/L, fish can suffer gill damage. When levels reach 0.2 mg/L, sensitive fish like trout and salmon begin to die. As levels near 2.0 mg/L, even ammonia-tolerant fish like carp begin to die. Ammonia levels greater than approximately 0.1 mg/L usually indicate polluted waters. The danger ammonia poses for fish depends on the water's temperature and pH, along with the dissolved oxygen and carbon dioxide levels. The higher the pH and the warmer the temperature, the more toxic the ammonia. Also, ammonia is much more toxic to fish and aquatic life when water contains very little dissolved oxygen and carbon dioxide.

Phosphorus

The element phosphorus is necessary for plant and animal growth. Phosphates come from fertilizers, pesticides, industry, and cleaning compounds. Natural sources include phosphate-containing rocks and solid or liquid wastes. Nearly all fertilizers contain phosphates (chemical compounds containing the element, phosphorous). When it rains, varying amounts of phosphates can wash into nearby waterways. Phosphates can also come from human and animal wastes (the human body releases about a pound of phosphorus per year), phosphate-rich rocks, wastes from laundries, cleaning and industrial processes, and farm fertilizers. Phosphates stimulate the growth of plankton and water plants that provide food for fish. This may increase the fish population and improve the waterway's quality of life. If too much phosphate is present, however, algae and water weeds grow wildly, choke the waterway, and use up large amounts of oxygen. Many fish and aquatic organisms may die.

Sediment

Total Suspended Solids is the measurement that determines how much sediment or other particulates (organic materials, leaf litter, etc.) are carried in the water. In simple terms, total suspended solids will affect how cloudy the water is, because light's ability to pass through water depends on how much suspended material is present. Muddy water is caused when light is blocked by large amounts of silt, microorganisms, plant fibers, sawdust, wood ashes, chemicals and coal dust. Any substance that makes water cloudy will cause turbidity. The most frequent causes of high suspended solids in lakes and rivers are plankton and soil erosion from construction, mining, dirt roads, and dredging operations.