Pristine to Polluted

Sewage Problems & Solutions in the Texas Hill Country

Save Barton Creek Association

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"During most of my life I have cherished the Hill Country, as have large numbers of my fellow Texans. Since well over a century ago, the region has been a sort of reference point for natives of other parts of the state, and mention of it usually brings smiles and nods. Not much of it is spectacular in the manner of high mountains and craggy seacoasts and such places, but we care about it — the dissected, elevated landscapes unlike the areas where most of us live, the un-Texas cool spring-fed streams, the fishing and hunting if we're inclined that way, the people and their towns and farms and ranches and their rather distinctive history."

— John Graves,
Texas writer

"If it were anywhere else in the country,
[the Hill Country] would be a national park."
— Frederick Steiner,
former dean of architecture, UT/Austin

INTRODUCTION

Executive Summary

The Hill Country has always been one of the most treasured parts of our state, both by the residents who live there and by the Texans who visit it for recreation. The region's allure lies not just in its unique terrain, but in its waterways. From the Colorado River to the San Antonio River, from Cypress Creek to Cibolo Creek, from Barton Springs to Comal Springs, these water bodies are some of the Hill Country's most popular features. In addition, the region is the location of two major underground reservoirs — the Edwards Aquifers, which supplies drinking water to 1.7 million people in the San Antonio area, and the Trinity Aquifer, which supplies water to many other Hill Country residents.

However, the Hill Country's streams and aquifers are facing a growing threat: sewage pollution. Some people may think that the treated sewage that comes out of a wastewater treatment plant is clean water. But only some pollutants are removed during treatment, while others are left in. Because the Hill Country's rivers and creeks often have low or sporadic flow, treated wastewater often makes up a large part of the stream volume below a treatment plant. This can harm both the streams, and the aquifers they replenish.

Dumping treated sewage into streams is regulated by direct discharge permits issued by the Texas Commission on Environmental Quality (TCEQ). Wastewater discharge caused fewer problems when the Hill County was lightly populated. But the number of people living in the region's 17 counties has been steadily increasing, from approximately 800,000 in 1950 to 3.4 million in 2015. By 2050 the area's population is projected to double, to 6.8 million.

A larger population means more wastewater. Several new or expanded permits have been approved in recent years — some for direct discharge (dumping treated wastewater into streams and lakes), others for land application (irrigating treated wastewater on fields). TCEQ is currently considering applications for a new discharge permit on a tributary of Barton Creek below Austin, an expanded discharge permit on the Blanco River, and a land application permit on Honey Creek near Guadalupe River State Park.

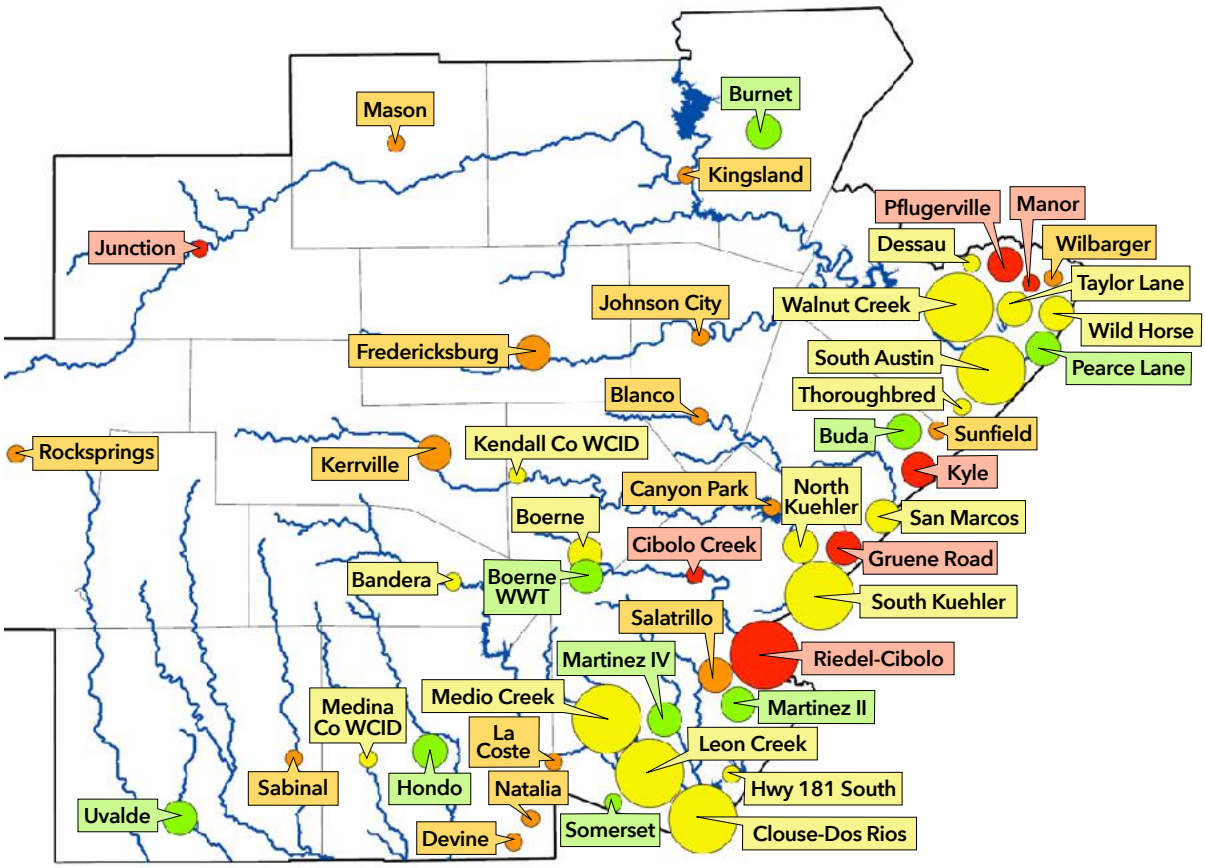
For our Hill Country Sewage Scorecard, we examined pollutant monitoring data that was self-reported by the 48 municipal sewage treatment plants with discharge permits in the region's 17 counties. We found that during the past three-and-a-half years, 39 facilities exceeded at least one of the pollutant limits set by TCEQ in their operating permits. In other words, 81 percent of Hill Country sewage plants dumped something into a stream that wasn't allowed by their permit at least once since 2017.

The most common failures were for oxygen depletion and excess suspended solids (both of which can harm aquatic life), and E. coli bacteria (which can harm people). The key measurement used for this report was the total number of days with reported pollutant exceedances from January 2017 to 2020. During this period, 6 plants had 1-50 days with exceedances, 15 plants had 51-500 days, and 6 plants had more than 500 days. Only 6 plants had no exceedances.

And this was just for the sewage pollution that's regulated and reported. Because most discharge permits only contain monthly average limits for pollutants, some plants may have had high daily levels of pollutants that they didn't have to report.

Plus, only some pollutants are removed during sewage treatment, while others remain. Two of those pollutants, phosphorus and nitrogen, do the same thing in the water that they do on land: they help plants grow. Dumping inadequately treated sewage into streams can lead to large growths of algae. Known as blooms, these growths can cause oxygen depletion, which harms fish and other aquatic life. Some forms of algae also produce toxins that can poison people and

Hill Country **Sewage Scorecard**



Days With Effluent Exceedances

A 0 days B 1-50 days C 51-500 days F 500+ days

Maximum Permitted Discharge

0.1-1 mgd 1-10 mgd 10+ mgd

their pets. Algae has recently blanketed central Texas streams at locations below sewage facilities, including plants in Blanco and Liberty Hill.

Because existing plants are already problem-plagued, it's essential that new permits should be issued sparingly and with tight restrictions. Recommendations for policy changes and other actions are included in Chapter 5 of this report. Fewer discharge permits should be issued, pollutant limits should be lowered, and all wastewater permits should be required to use better treatment methods.

In lower-density developments, modern septic tanks and community-scale systems can provide decentralized wastewater treatment. In higher-density developments, dispersing treated sewage into the soil may be a better alternative than dumping it into streams. Treated wastewater is already being used to irrigate parks, golf courses, farms, and undeveloped fields in the Hill Country. All new developments should be designed to reuse treated wastewater for non-potable purposes such as watering lawns and flushing toilets. Reuse is key to implementing the One Water approach, which manages natural water, stormwater, and wastewater as different forms of the same resource in an integrated approach.

The Hill Country's population won't stop growing, which is why we need to prepare now for future growth. Better sewage treatment methods and more protective permits mean that wastewater can be transformed from a problem that pollutes our rivers and streams into a resource that helps conserve our best water for more important uses.

CHAPTER 1

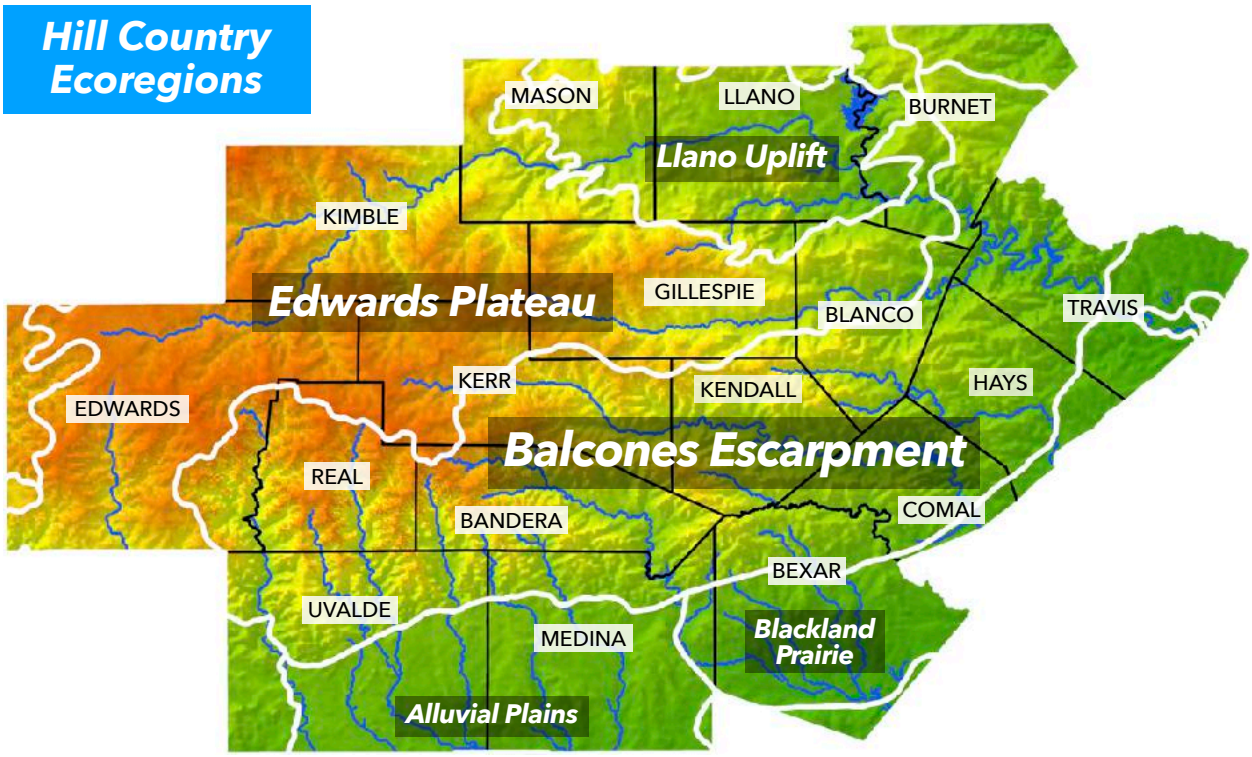
Land, Water & People in the Hill Country

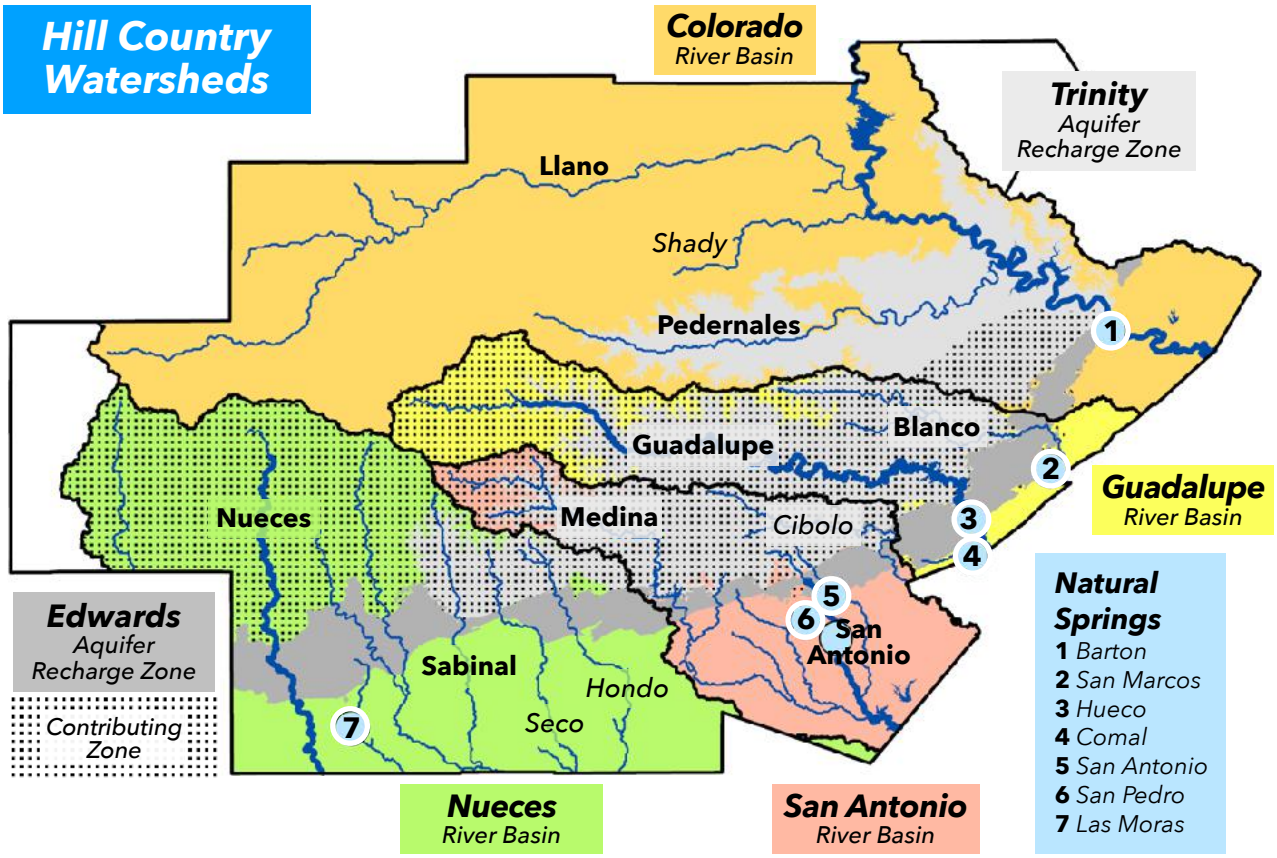
1.1 A Special Place

While our state has many places of great natural beauty, the Hill Country is the one spot that's truly special for many Texans. Views extend for miles from peaks and ridges, while valleys and canyons offer shade and seclusion in forests of oak and Ashe juniper. Roads in the region twist and turn, rise and fall as they connect small towns with rich immigrant histories. The Hill Country's allure lies not just in its unique landscape, but in its streams, lakes, and springs, which are some of the state's most popular recreation spots. In addition, the region is the location for two major aquifers which are important sources of drinking water.

However, the natural beauty and pristine waters of the Hill Country are being steadily eroded by new development. Population growth has changed the region in many ways, but one of the most worrying effects has been the increase of sewage pollution in Hill Country streams and aquifers. In order to explain why sewage is a greater problem here, it's necessary to explain what makes this area's geology, hydrology, and history different from the rest of Texas.

For this report, we're using the Hill Country Alliance's definition of the region as encompassing 17 counties, covering 17,760 square miles. Bexar, Comal, Hays, and Travis counties form the area's populous eastern border along Interstate 35. Gillespie, Blanco, Kerr, and Kendall counties make up what most people





think of as the heart of the Hill Country. Kimble, Mason, Llano, and Burnet counties form the region's drier and higher northern edge, while Edwards, Real, Bandera, Uvalde, and Medina counties on the southern edge have some of the area's most striking landscapes.

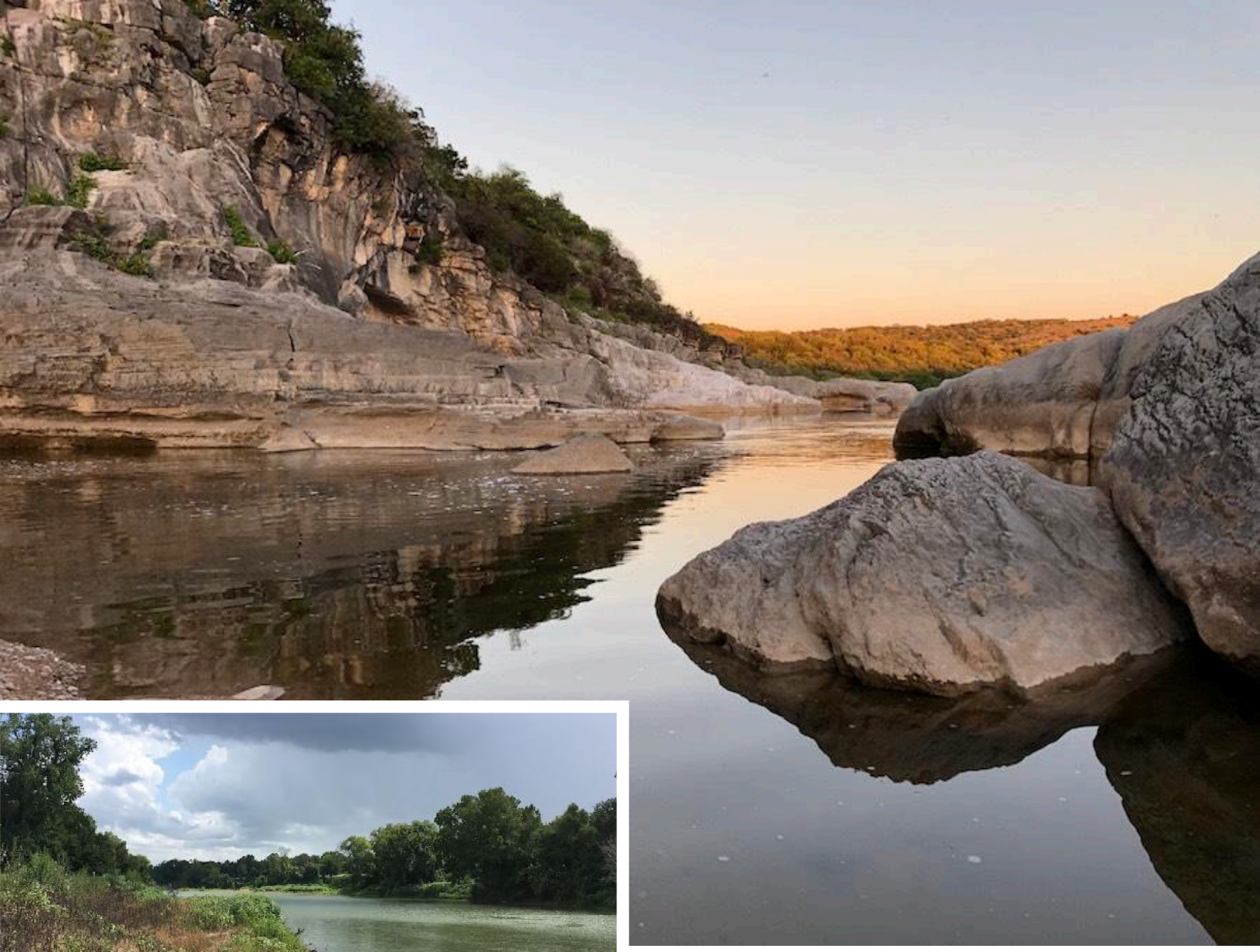
1.2 Geology & Hydrology

The region's unique nature starts with its geology. While most of Texas consists of flat plains, the Hill Country is a transition zone from a higher plain to lower ones — from the Edwards Plateau in the northwest, to the Blackland Prairie and Southern Texas Plains in the southeast. Elevations start at more than 2,400 feet in parts of the Edwards and drop down to 300 feet in some areas east of Interstate 35. Much of the decline takes place in the Balcones Escarpment, a wide geologic fault zone that's several miles wide and that curves along the southern and eastern edges of the Hill Country.

The Hill Country's terrain has in turn shaped its hydrology. Because of the region's elevation drop, water travels faster here than in the rest of the state. Erosion carved the region's valleys and canyons, and limited the build-up of topsoil on the limestone that forms the Edwards Plateau and Balcones Escarpment. While most streams in the rest of Texas meander through dirt channels covered with heavy vegetation, many Hill Country streams flow quickly through rocky banks that retain little or no water during dry months.

The rocky streams and thin soils have also contributed to the exceptional clarity of Hill Country creeks and rivers, which naturally have low levels of the nutrients (nitrogen and phosphorus) that can cause algae growths. But if treated sewage that has high levels of nutrients is dumped into the region's streams, algae growths can easily explode. The streams' clarity allows sunlight to penetrate to the bottom, fueling algae photosynthesis. The streams' rocky bottoms provide an ideal surface for algae strands to attach themselves. And because the streams naturally have low levels of algae, they also have low numbers of herbivores that can eat it when it starts growing.

Three major river systems dominate the Hill Country. The **Colorado River**, the longest to flow entirely in Texas, starts in the Panhandle and is enlarged by the Llano and Pedernales rivers in the Hill Country, as well as by several streams in the Austin area, including Barton, Onion, and Williamson creeks. The **Guadalupe River** and its tributary, the Blanco River, flow through the center of the Hill Country. The **San Antonio River** starts at the eastern edge of the Hill Country but is fed



The Pedernales River (above, shown in Pedernales Falls State Park) offers a dramatic example of the limestone rock channels common to many Hill Country streams. By contrast, the Colorado River (left, shown at Columbus) has heavily vegetated soil banks, like many streams in the rest of Texas.

by streams that start higher up, including the Medina River and Cibolo, Leon, and Salado creeks. The Hill Country is also home to the headwaters of the **Nueces River** and several of its tributaries, including the Frio River and Hondo and Sabinal creeks.

1.3 Edwards Aquifer

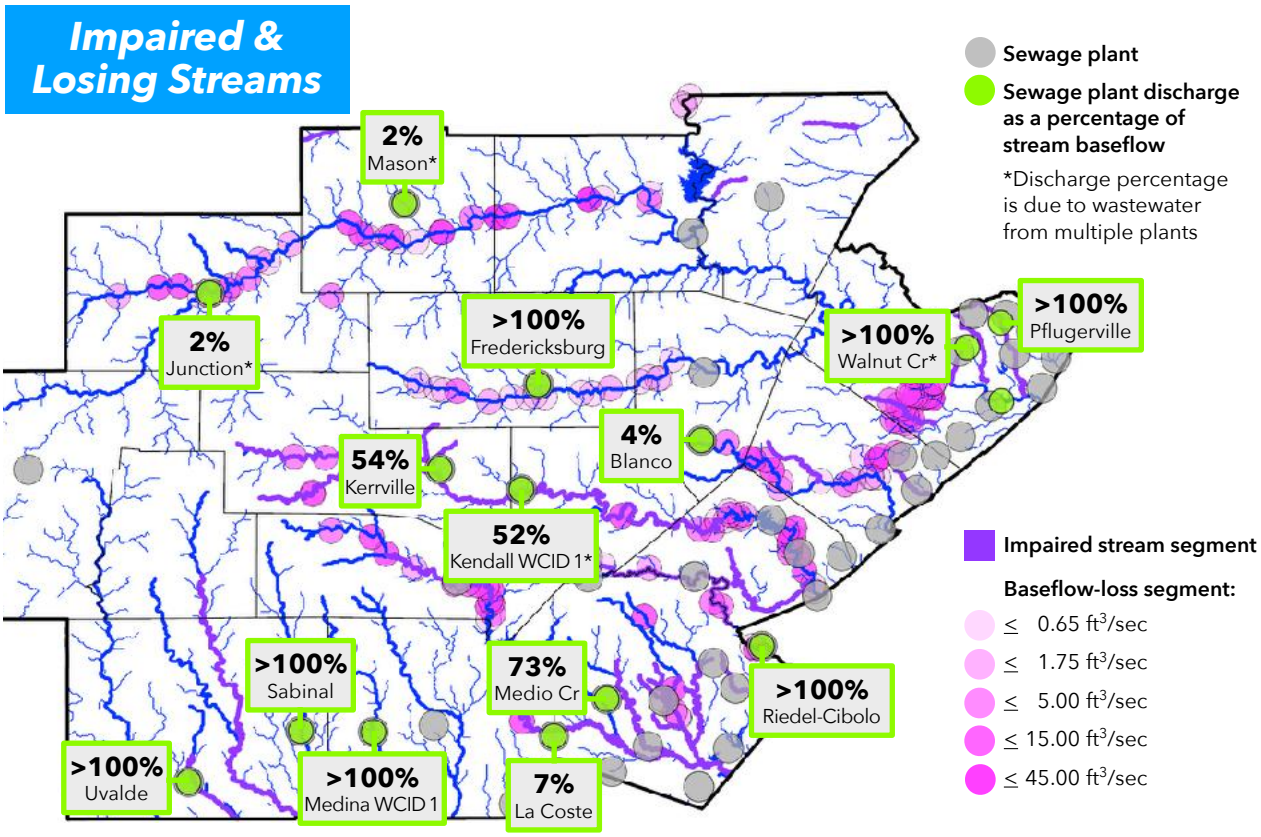
Geology has also created one of the Hill Country's most distinctive water features — the Edwards Aquifer, a vast underground reservoir located roughly along the Balcones Escarpment that supplies drinking water for more than 1.7 million people. Most aquifers, such as the Carrizo-Wilcox to the east of the Edwards, hold water in buried layers of sand or clay. The Edwards, however, is made of karst — a unique form of limestone honeycombed with countless cracks, conduits, and cavities of all sizes, including several caverns.

The limestone that forms the Edwards Aquifer is buried under other geologic layers in the northwestern part of the Hill Country, but it comes to the surface along the Balcones Escarpment. In this section, known as the Recharge Zone, surface water is able to seep directly into the Edwards Aquifer's capillary network of fissures and openings. (Recharge is the word used to describe how aquifers are refilled with water.) Streams will lose some or all of their water as they cross the Recharge Zone. For example, Helotes Creek in Bexar County disappears into a series of fractures in its stream bed, while Seco Creek is swallowed by a sinkhole in Medina County.

The limestone bed of Barton Creek near Austin (top) is typical of many Hill Country streams. Camp Creek (bottom), located in the Blackland Prairie east of Temple, has the soil banks common to many Texas streams. Soft banks with heavy vegetation can more easily assimilate water-borne pollutants than rocky channels.

Water pressure within the Edwards Aquifer forces water out of the ground in a series of artesian springs located downslope of the Recharge Zone, including Barton Springs in Austin, San Marcos Springs, and Comal Springs in New Braunfels. The aquifer has also been tapped by thousands of wells for drinking water — mostly by domestic wells in the region's rural areas that serve a single property, but also by municipal water supply wells. For decades, San Antonio was the largest city in the world to get all of its drinking water from an aquifer, and even today, it still gets 90 percent of its supply from the Edwards.

Water from the Edwards Aquifer is of remarkably high quality, but easily contaminated. Karst limestone doesn't filter out pollutants, unlike the sand and clay layers in most aquifers, and the conduits in karst may transmit contaminated water quickly to wells and springs. Pollution from sewage and other sources isn't just a threat in the Recharge Zone, but in the Edwards Aquifer Contributing Zone too. This is a much larger



Hill Country streams are especially susceptible to pollution because many water along their routes. In the western part of the region, this is usually due to surface evaporation. Over the Edwards Aquifer, it's generally due to water seeping into the Recharge Zone. The amount of water that's lost from the baseflow volume is measured by gauges at some locations. Gauges that show a drop in baseflow are shown in magenta on this map. In some places, the amount of treated wastewater discharged by a sewage plant may comprise a significant percentage of the baseflow at that location. The percentage can be caluculated for the locations shown on the map in green. In addition, some stream segments have been designated as "impaired" by TCEQ because regular water quality testing has shown that the level of some pollutants is higher than the limits set for that stream. Impairments are often caused by pollution from multiple sources, including stormwater runoff, industrial and agricultural wastewater, and municipal wastewater. Impaired segments are shown in purple on the map. (Data analysis by Raymond Slade)

area including all of the streams that drain into the Recharge Zone.

The quality of water that flows from the Contributing Zone to the Recharge Zone can substantially impact water quality the aquifer. Lauren Ross, an Austin-based engineer, explained this process in a 2011 report commissioned by Save Our Springs Alliance and Greater Edwards Aquifer Alliance: "A significant portion of the Edwards groundwater enters the aquifer through openings in the bottom of streams. Water to these stream bottoms is provided from their entire watersheds, which may stretch as far as 50 miles beyond the recharge zone boundary. These relatively large contributing watersheds gather rainfall runoff and then funnel it across stream bottom recharge features where the Edwards Limestone crops out."

In addition to the Edwards Aquifer, the Hill Country also contains part of the Trinity Aquifer, which extends north to the Red River. Hundreds of wells in the Trinity, many of them private, provide drinking water for thousands of Hill Country residents. The Hill Country portion of the Trinity Aquifer is also contained in karst limestone, meaning that it faces the same dangers from water pollution as the Edwards Aquifer.

1.4 History & Population

The Hill Country's rough and rocky terrain, combined with its general lack of reliable water sources, meant that it was sparsely populated for centuries. While Native Americans established communities elsewhere in what would later become Texas, the Hill Country was mainly a way-station for nomadic peoples, including the Apache, Comanche, and Tonkawa tribes. The first European settlements were all established in

the flatlands east of the Balcones Escarpment, and at locations with rivers and natural springs. San Antonio was founded in 1718 by Spanish colonists, Austin in 1837 by Anglo immigrants, and New Braunfels in 1845 by German immigrants.

After Texas became a state in 1845, more immigrants followed into the rest of the Hill Country, hoping to make a living from farming and ranching. The land, covered with thick carpets of native grass, looked promising at first. But the grass had taken root in the thin topsoil only over time. After settlers brought large herds of livestock into the Hill Country, most of the grass was grazed away within a matter of years. Soon much of the soil was gone too, washed away since it was no longer held in place by the grass.

The settlers remained, but the Hill Country remained a hard place to make a living, which discouraged further settlement. The region's population remained relatively stable for decades. But by the middle of the twentieth century, most Hill Country residents finally had access to paved roads, electricity, and reliable water. During this time, the rest of Texas was transitioning from a primarily rural and agricultural state to a more urbanized one. Since more Texans didn't have to make their living from the land, they could think about living in other places, and the beauty of the Hill Country made it a top draw.

As a result, the population of the 17-county Hill Country region has soared from approximately 800,000 in 1950 to 3.4 million in 2015. By 2020 the area's population is projected to double, to 6.8 million. The vast majority of this growth is taking place in the Austin and San Antonio metropolitan areas along the I-35 corridor. However, new development is expanding further west into the heart of the Hill Country. From Boerne and Bulverde in the south to Buda and Burnet in the north, small towns are turning into urban centers.

The Hill Country has historically never had to support a population this large, and the environmental damage is showing up in many ways. This report focuses on the growing problem of sewage pollution in the region. According to our review of the monitoring reports for Hill Country sewage plants, most facilities have been exceeding their pollution limits on a regular basis. In addition, the pollution limits that the state's environmental agency sets for Hill Country plants are generally the same as limits for facilities in the rest of Texas. Later in this report, we'll explain how sewage can be treated in better ways to protect the water in Hill Country streams and lakes.

CHAPTER 2

Hill Country Sewage Scorecard

2.1 Methodology & Results

As required by the federal Clean Water Act and the Texas Water Code, all sewage plants in the state that want to dump treated wastewater into natural water bodies must have a **discharge permit** approved by the Texas Commission on Environmental Quality (TCEQ). Permit enforcement starts with the plants themselves, which are required to regularly test the quality of treated sewage. Texas plants must include the test results in the monthly **discharge monitoring reports** that they have to file with the TCEQ, which forwards the data to the U.S. Environmental Protection Agency. The EPA then makes this information available to the public on its Enforcement and Compliance History Online (ECHO) website.

There are two main categories of discharge permits: Publicly Owned Treatment Works (POTW) and Non-POTW. The POTW category includes all sewage plants that are operated by cities, counties, and districts such as municipal utility districts (MUDs) and water control and improvement districts (WCIDs). The Non-POTW category includes plants that have been created for individual subdivisions, as well as a few for individual businesses.

Permits contain both a discharge limit and pollutant limits. The **discharge limit** is the maximum amount of treated sewage — called **effluent** — that a plant can dump into a stream, and is measured in million gallons per day (mgd). **Pollutant limits** define the maximum amount of specified pollutants that can remain in treated wastewater. In Texas, pollutant limits are usually set for oxygen levels, suspended solids, E. coli bacteria, ammonia nitrogen, pH level, and chlorine. Some permits also have total nitrogen and phosphorus limits. All permits have monthly average limits for pollutants, which are based on multiple tests of treated wastewater; some permits also have single-sample limits. If a test shows that the amount of a specific pollutant remaining in treated wastewater exceeds either a single-sample or monthly average limit, that is referred to as an **effluent exceedance**.

Highlights

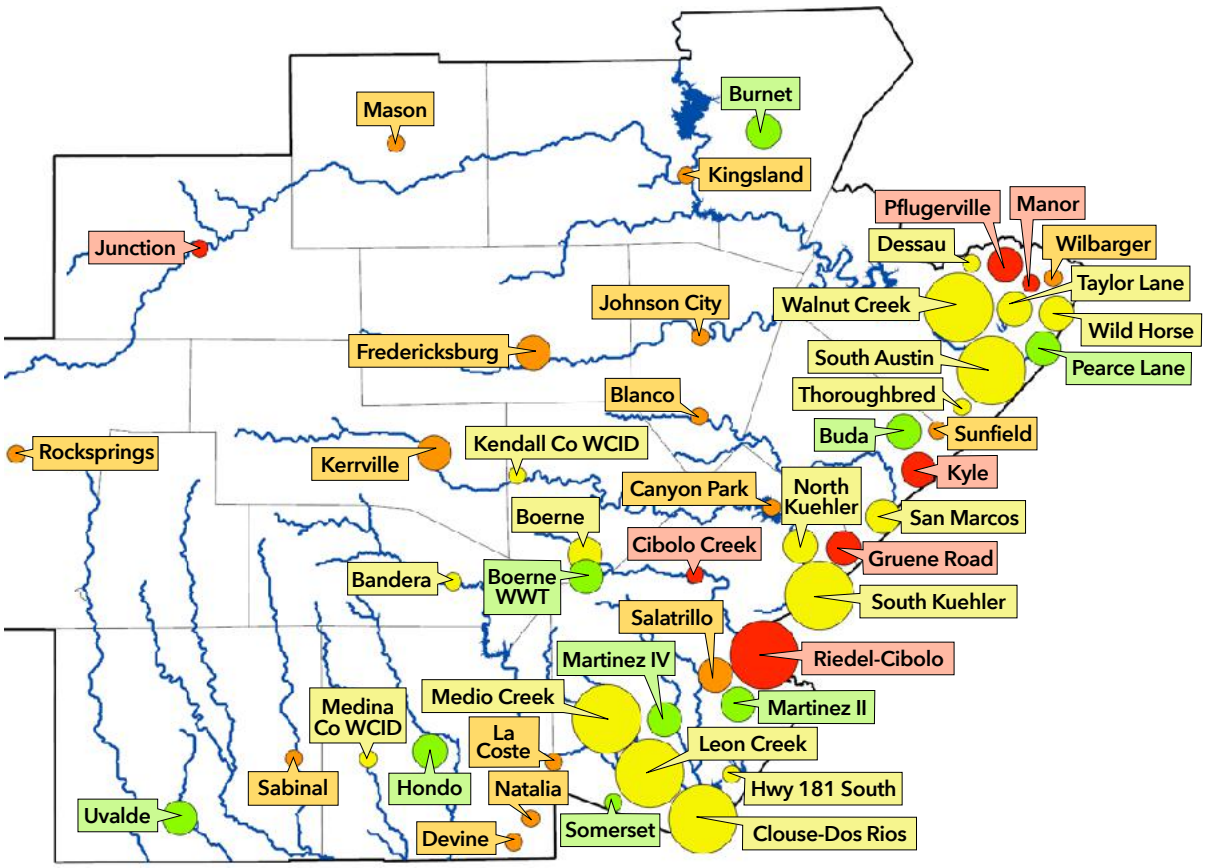
In the Hill Country, **48** municipal sewage plants have discharge permits.

81% have exceeded at least one pollutant limit since 2017.

The average number of exceedances at all plants was **8.6**

All plants averaged **188** days with exceedances.

Hill Country **Sewage Scorecard**



Days With Effluent Exceedances

A 0 days B 1-50 days C 51-500 days F 500+ days

Maximum Permitted Discharge

0.1-1 mgd 1-10 mgd 10+ mgd

For this report, we analyzed data for all of the publicly owned sewage treatment facilities in the Hill Country Alliance's 17-county region that are permitted to discharge 0.1 mgd or more of treated sewage into a creek, river, or lake. In this report, we also refer to these facilities as **municipal sewage plants**. This report does not include publicly owned plants with discharge limits smaller than 0.1 mgd. Nor does it include privately owned plants, all of which have discharge limits below 0.5 mgd. While there has been a noticeable increase in new discharge permits issued for the Hill Country since 2000, the available online data for many smaller plants are incomplete or missing, making a reliable analysis impossible.

For the 48 municipal sewage discharge facilities in the Hill Country, we examined their self-reported data for the past three-and-a-half years, from January 2017 to June 2020. We looked at two key statistics: the **number of effluent exceedances** that plants reported during this period, and the **number of days with exceedances**. We found that publicly owned sewage plants in the Hill Country exceed their pollutant limits with disturbing frequency. Overall, 39 municipal plants out of 48 had at least one effluent exceedance since 2017. In other words, 81 percent of the region's sewage facilities have dumped something into Hill Country streams that they weren't supposed to on at least one occasion in the past three and a half years.

Not all plants are exceeding their permit limits at the same level, however. In order to make this easier to understand, we assigned grades to plants based on their number of days with effluent exceedances during

Hill Country ***Sewage Scorecard***

COUNTY FACILITY	EFFLUENT EXCEEDANCES GRADE	DAYS	NUMBER
BANDERA			
Bandera	**B**	28	2
BEXAR			
Martinez II	**A**	0	0
Martinez IV	**A**	0	0
Somerset	**A**	0	0
Clouse-Dos Rios	**B**	4	4
Hwy 181 S	**B**	33	5
Leon Creek	**B**	3	3
Medio Creek	**B**	4	4
Salatrillo Creek	**C**	71	13
Cibolo Valley	**F**	575	26
Riedel-Cibolo Creek	**F**	731	3
BLANCO			
Blanco	**C**	121	5
Johnson City	**C**	91	4
BURNET			
Burnet	**A**	0	0
COMAL			
North Kuehler	**B**	1	1
South Kuehler	**B**	1	1
Canyon Park Estates	**C**	91	4
Gruene Road	**F**	1,150	51
EDWARDS			
Rocksprings	**C**	122	4
GILLESPIE			
Fredericksburg	**C**	121	5
HAYS			
Buda	**A**	0	0
San Marcos	**B**	3	3
Sunfield MUD 4	**C**	60	3
Kyle	**F**	833	65

COUNTY FACILITY	EFFLUENT EXCEEDANCES GRADE	DAYS	NUMBER
KENDALL			
Boerne WWT	**A**	0	0
Boerne	**B**	1	1
Kendall Co WCID 1	**B**	30	1
KERR			
Kerrville	**C**	93	8
KIMBLE			
Junction	**F**	1,119	52
LLANO			
Kingsland MUD	**C**	155	11
MASON			
Mason	**C**	303	19
MEDINA			
Hondo	**A**	0	0
Medina Co WCID 2	**B**	30	2
Devine	**C**	243	14
La Coste	**C**	120	4
Natalia	**C**	120	4
TRAVIS			
Pearce Lane	**A**	0	0
Dessau	**B**	29	2
S Austin Regional	**B**	2	2
Taylor Lane	**B**	30	1
Thoroughbred Farms	**B**	1	1
Walnut Creek	**B**	4	4
Wild Horse Ranch	**B**	32	3
Wilbarger Creek MUD 2	**C**	391	17
Manor	**F**	846	35
Pflugerville	**F**	1,372	22
UVALDE			
Uvalde	**A**	0	0
Sabinal	**C**	62	5

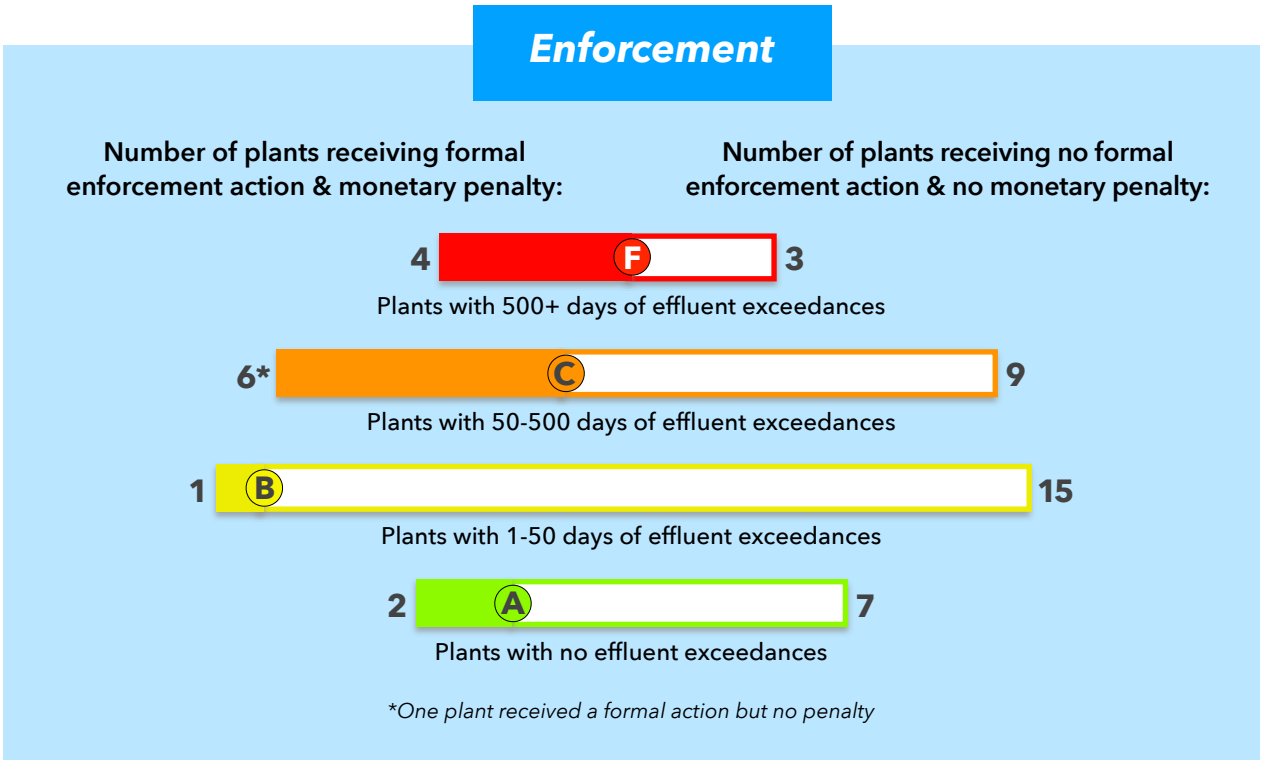
(No municipal sewage discharge plants are located in Real County)

the three-and-a-half-year study period: A = 0 days;B = 1-50 days; C = 51-500 days; F = more than 500 days

We also categorized plants by size based on their maximum permitted discharge, expressed in million gallons per day (mgd): Large: more than 10 mgd; Medium: 1-10 mgd; Small: 0.1-1 mgd.

Only 6 plants earned a grade of A on our chart — Boerne WWT (Wastewater Treatment & Recycling), Buda, Burnet, Hondo, Somerset, and Uvalde. These are small plants, with discharge limits ranging from 0.32 mgd to 2.44 mgd.

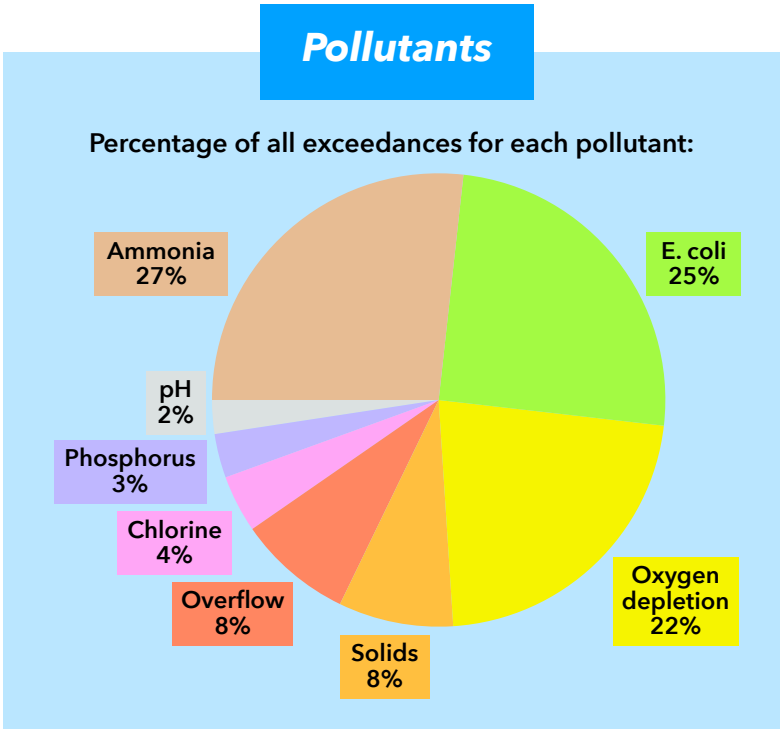
A total of 16 plants received a grade of B. This group includes the largest plants in our survey. South Austin Regional and Walnut Creek (Austin) have limits of 75



mgd and 100 mgd, respectively, while the Clouse (Dos Rios) and Leon Creek plants in San Antonio each have limits of 46 mgd.

A grade of C was given to 15 plants, mostly located in smaller towns. Several of the Hill Country's best-known towns received a C, including Blanco, Canyon Park Estates, Fredericksburg, Johnson City, and Kerrville.

Finally, 6 plants received a grade of F. This group includes two plants in the Austin suburbs of Manor and Pflugerville, one of New Braunfels' plants, and the Cibolo Creek plant north of San Antonio. The other two plants receiving an F, Junction and Mason, are on the northwestern edge of the Hill Country.



2.2 Enforcement Patterns

While sewage plants are required to do their own monitoring and reporting, TCEQ is still responsible for enforcing permits and making sure that plants comply with all regulations. The agency does this through on-site inspections, informal enforcement actions (phone calls and emails to discuss a problem), formal enforcement actions (official orders issued by the agency), and monetary penalties.

A review of enforcement statistics for Hill Country sewage plants shows that enforcement isn't always connected with effluent exceedances. In addition to the pollutant limits in their permits, plants must also com-

Enforcement & Pollutants

Publicly Owned Sewage Plant	Days With Exceedances	Penalities	Formal Actions	Informal Actions	On-Site Inspections	Ammonia	E.coli	Oxygen Depletion	Solids, flow, phosphorus, chlorine, pH
Pflugerville	1,372	$29,450	1	135	2		7		10 s, 4 f, 2 c
Gruene	1,150				4	9	4	38 c	1 s
Junction	1,119	$16,713	2	53	1		28	23 b	4 s
Manor	846			2	2	9	3	3 d	18 f, 7 p
Kyle	833	$184,013	2		2	32	18	4 c, 1 d	2 s, 9 c, 2 pH
Riedel-Cibolo Creek	731				2	1			2 f
Cibolo Valley	575	$14,500	1		1	8	1		17 p
Wilbarger Creek MUD 2	391				2	6	2	3 c	2 p, 4 c
Mason	303				1	17	1	1 c	
Devine	243		2	6	1	8	3		3 s
Kingsland	155						1	1	2 s, 3 p, 4 pH
Rocksprings	122	$4,500	1	1				4 d	
Blanco	121				1	2	1	1 d	1 f
Fredericksburg	121			9	2		4		1 s
La Coste	120	$12,375	1		1				4 f
Natalia	120			4	1	2		1	1 f
Kerrville	93	$6,375	2	25	2	4		4	1 pH
Canyon Park Estates	91	$1,073	1		2			1 d	2 s, 1 f, 1 pH
Johnson City	91	$6,250	1	16	2	2	2		
Salatrillo Creek	71				1	4	6		1 s, 2 f
Sabinal	62				1				4 s, 1 pH
Sunfield MUD 4	60				1			1	2 s
Hwy 181 South	33				1		2	6 c	
Wild Horse Ranch	32				1		2		1 f

ply with requirements in the federal Clean Water Act (CWA) and Safe Drinking Water Act (SDWA). In instances in which TCEQ faulted plants for CWA or SWDA compliance, it was often for filing delayed or incomplete monitoring reports. In other words, plants may be just as likely to get in trouble for paperwork problems as they are for releasing too much pollution into streams and lakes.

2.3 Common Pollutants

How are Hill Country municipal sewage plants exceeding the pollutant limits in their permits? Most exceedances were for **oxygen depletion**, which can be measured in three different ways. The first two measurements are for oxygen demand, which means how much oxygen will be consumed by substances remaining in treated sewage when it is discharged. High levels of organic matter will lead to the growth of aerobic bacteria in natural waters, which will consume more of the dissolved oxygen in those waters, leaving less for fish and other aquatic life. Oxygen demand can also be created by ammonia nitrogen, which is a byproduct of the sewage treatment process. Ammonia nitrogen is unstable and will react with dissolved oxygen in water to form another nitrogen compound, nitrite.

Biochemical oxygen demand (BOD) tests are used to measure the amount of oxygen that's consumed by both ammonia and by the aerobic bacteria which decompose organic matter. **Carbonaceous biochemical oxygen demand (CBOD)** tests are used to measure only oxygen consumed by the bacterial decomposition of carbon-based organic matter. Some Hill Country sewage permits require testing for BOD, while others specify CBOD. Some permits also require testing for the

Enforcement & Pollutants

Publicly Owned Sewage Plant	Days With Exceedances	Penalities	Formal Actions	Informal Actions	On-Site Inspections	Ammonia	E.coli	Oxygen Depletion	Solids, flow, phosphorus, chlorine, pH
Kendall County WCID 1	30								1 p
Medina County WCID 2	30				1	2			
Taylor Lane	30								1 s
Dessau	29						1		1 c
Bandera	28			4	1		2		
Clouse-Dos Rios	4				4	4			
Medio Creek	4				3		5		
Walnut Creek	4				2		3		1 s
Leon Creek	3				3		3		
San Marcos	3				1	1	2		
South Austin Regional	2	$52,187	3		2		1		1 c
Boerne	1				3				1 f
North Kuehler	1				1		1		
South Kuehler	1				1		1		
Boerne WWT		$17,601	1		2				
Buda				1	2				
Burnet									
Hondo					2				
Martinez II									
Martinez IV									
Pearce Lane					1				
Somerset									
Uvalde		$15,187	1		2				

amount of **dissolved oxygen (DO)** in effluent water.

It's important to remember that while these tests measure oxygen levels, the true pollutant that's being measured is organic matter — the amount of poop, food scraps, and other waste that still remains in sewage even after treatment. While some organic matter is always present in natural waters, adding too much of it to natural waters will trigger a destructive growth spiral of bacteria and algae that can disrupt a stream or lake's biology. (The harmful effects of organic-rich sewage on aquatic bacteria, algae, and oxygen levels is discussed in greater detail in Chapter 3.)

After oxygen levels, the next most common exceedances by Hill Country municipal sewage plants were for **total suspended solids (TSS)** and **E. coli** bacteria. High levels of suspended solids in treated sewage can make the natural water in streams and lakes less clear, which can harm aquatic life. Only a few strains of E. coli are harmful to humans, but its presence in water indicates that other disease-causing fecal bacteria, viruses, and microbes are likely present too.

Hill Country sewage plants also reported exceedances for chlorine, ammonia nitrogen, phosphorus, pH, and flow. Chlorine is used in the disinfectant stage at some treatment plants to eliminate bacteria, but if the chemical remains in the treated sewage that's released into streams, it can harm aquatic life. Only a few plants have limits for nitrogen or phosphorus, nutrients that can cause algae blooms. Aquatic life can be harmed by changes in a stream's pH level.

A **flow exceedance** means that a plant released a greater total volume of sewage than its permit allows. This sometimes happens when a plant is overwhelmed with water from storms or floods. In the worst-case scenario, a plant may release raw sewage that hasn't been treated.

CHAPTER 3

The Evolution of Sewage Treatment

3.1 Natural Stream Biology

Some people may think that treated sewage is "clean enough" to be dumped into natural waters. In order to understand how even treated sewage can still harm streams, we need to know what rivers and creeks are like in their natural state.

When we see a stream that looks pristine and untouched by human activity, we may say that the water is "pure." But stream water isn't just composed of H2O and nothing else. It's full of life, and equally important, it's full of the compounds necessary to sustain life. The life that we most associate with streams are fish, but they're only the top level of an aquatic food pyramid that starts with bacteria and algae at the base. **Bacteria** break down plant and animal matter into compounds that fuel the growth of **algae**, which produce plant matter consumed by many animals.

Bacterial decomposition is the essential process by which old life becomes new life. In streams, bacteria break down plant matter, from algae and grasses to leaves and branches, as well as animal matter, usually from wildlife poop washed into the water by rain runoff. All plant and animal matter is referred to as organic matter, which means that it's made of carbon-based compounds. The organisms that break down organic matter are called aerobic bacteria, be-

The clear waters of Hill Country streams like the Frio River teem with aquatic life, both seen and unseen. (Photo: T.L. Langford)

cause they use oxygen as fuel.

Aerobic bacteria are present in both the soil, where they use atmospheric oxygen, and in natural waters, where they use dissolved oxygen. Some dissolved oxygen comes from aquatic plants, and some of it comes from oxygen in the air that comes into contact with the surface of a stream or lake and is absorbed into the water. Dissolved oxygen is used not just by aerobic bacteria, but by all of the animals that live in the water, from worms to crustaceans to fish. Aerobic bacteria break down organic matter into carbon dioxide, nitrogen, and phosphorus — the building-block chemicals that help all plants grow, including algae.

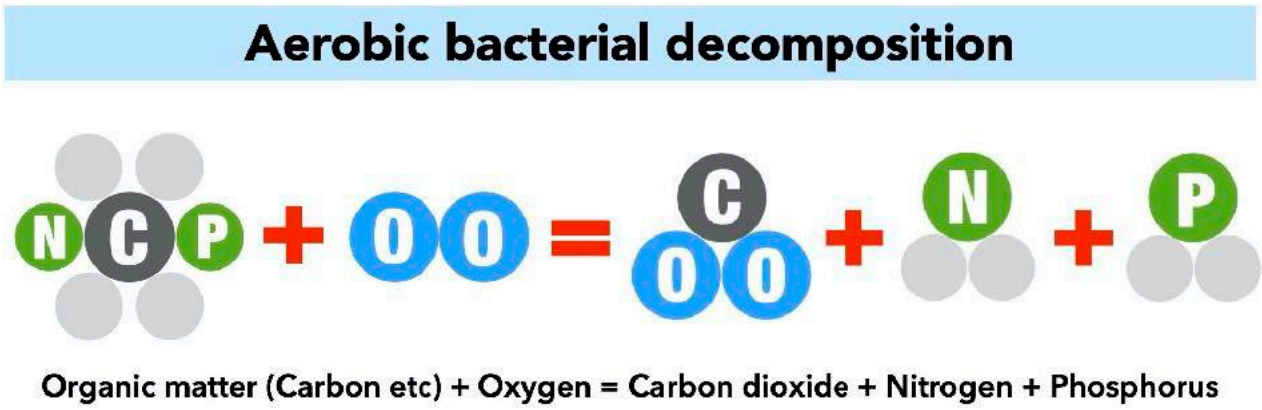
We generally only notice algae when it's grown into thick mats on the surface of streams and lakes, but microscopic algae particles are always present in natural waters. Like land-based plants, algae consume carbon dioxide, using the carbon to make new plant matter and releasing the oxygen as a byproduct. (Some studies estimate that up to half of the oxygen in our atmosphere comes from algae.) And like plants, algae consume **nitrogen** and **phosphorus**, which are also two of the main components of the fertilizers we use for lawns, gardens, and farms. Nitrogen and phosphorus are often referred to as **nutrients**, since they nurture the growth of plants.

The problem with dumping treated sewage into streams and lakes is that it contains the same components as natural water, but in very different proportions. Sewage with high levels of organic matter and nutrients can throw a stream's life cycle out of balance. The growth of bacteria and algae can go into overdrive, while other forms of aquatic life suffer.

The basic way to treat sewage is to use bacterial decomposition in a controlled setting, which can take place either in water or on land. In sewage treatment plants, aerobic bacteria is used to break down organic matter in treatment tanks before the wastewater is released into streams and lakes. In contrast to this water-based method, land-based methods such as septic tanks and irrigation fields will release treated sewage into the soil, where bacteria, plants, and sunlight can break down more waste.

3.2 Water-Based Sewage Treatment

The history of how sewage treatment has evolved is a history of how our knowledge of sewage pollution has evolved. The first problem to be recognized was the one that could most easily be seen and smelled — sewage was dirty and stinky. For most of human history, the amount of sewage that people produced was comparatively small. In rural areas, it could be dumped onto the ground or into streams with little problem. In urban areas, sewage was collected in cesspits that allowed



Dumping raw sewage – or even treated sewage with high levels of organic matter – into streams can deplete dissolved oxygen in the water, which can lead in the worst-case scenario to fish kills.

solid waste to settle to the bottom as sludge. Several cultures, from the Indus Valley and Roman Empire to the Islamic Caliphate and the Aztecs, constructed early systems that relied on water to wash away waste.

The amount of sewage that people produced increased dramatically with the construction of the first large-scale water supply systems in the 1700s. People could now use much more water in their homes, and one of the new uses was for the modern flush toilet, also developed around the same time. Because very large amounts of water were being mixed with small amounts of poop and other waste, more contaminated water had to be dumped somewhere. Flush toilets were the game-changer that created a problem we've been trying to solve ever since.

London was the first city to install water supply systems and household toilets on a widespread scale, which was also why it was one of the first cities to experience severe wastewater problems. Sewage with disease-causing microbes seeped into wells and other sources of drinking water. After a wave of cholera outbreaks in the mid-1800s, London constructed the first modern sewer system to pipe wastewater away from homes and discharge it into streams and rivers.

But dumping large quantities of raw sewage into streams created a new problem. Almost all of the solids in sewage — especially poop and food scraps — are organic matter. If this waste is dumped directly into streams, aerobic bacteria suddenly have a lot more food. And like any species with a bigger food supply, they reproduce more. More bacteria also consume more dissolved oxygen, leaving less for other aquatic animals. Fish kills next to sewage outlets were one of the first signs that something was wrong — the fish were dying of suffocation.

In the late 1800s, scientists began developing tests to measure **biochemical oxygen demand (BOD)** — how much oxygen is "demanded," or consumed, by substances in the water sample. Water with high levels of organic matter will also lead to high levels of aerobic bacteria growth, leading to high BOD levels. In 1912, an English commission set maximum allowable amounts for oxygen demand and suspended solids in sewage before it could be dumped into streams. These standards, the first to be internationally adopted, reinforced the need for sewage to be treated in order to remove some of its pollutants.

The first modern sewage treatment plants used the same basic principle as cesspits – sewage was collected in a chamber so that solid waste could sink to the bottom. The sludge at the bottom can be removed to be used as fertilizer, while the oil and grease that collects on top can be skimmed off for soap-making. This stage of sewage treatment is now referred to as **primary treatment**. Sewage that's gone through this basic process may look and smell cleaner. But while primary treatment can remove up to 90 percent of suspended solids in wastewater, it generally only reduces oxygen demand by around 50 percent. That's because the treated sewage still contains a lot of dissolved organic material that isn't visible to the naked eye.

During the late 1800s, engineers worked on ways to improve sewage treatment and reduce oxygen demand. The solution was to use aerobic bacteria, which can decompose organic matter anywhere with the right conditions — not just in streams. Engineers found that if they took sewage that had already gone through primary treatment and passed it through another stage

to encourage the growth of aerobic bacteria, they could break down more organic matter. This process, now known as **secondary treatment**, has been refined and can reduce the levels of oxygen demand in treated wastewater by 85-90 percent.

An additional benefit of secondary treatment is that it can reduce the amount of **E. coli bacteria** and other forms of fecal microbes in sewage. These organisms live in the lower intestines of humans and other mammals, where they perform useful roles in the digestive process. But if people drink water from sources contaminated with fecal microbes — or if they accidentally swallow contaminated water while swimming or wading in polluted streams and lakes — they can develop gastrointestinal illnesses.

E. coli bacteria was first identified in 1885, and the first test for the presence of E. coli in water was developed six years later. Subsequent variations of this test have become a standard feature of water quality testing, since the presence of E. coli may indicate that other disease-causing fecal microbes are also present in the water. Primary and secondary treatment combined can reduce the amount of E. coli in sewage by 90-99 percent.

While bacteria is useful in secondary treatment, it can be harmful if it's still in treated sewage that's dumped into streams used for recreation. That's why all sewage plants use a **disinfection treatment** at the end to kill off all bacteria, both the bad kind and the good kind. The most common disinfectant has been chlorine, but too much chlorine in discharged sewage can harm aquatic life, which is why it's also necessary to reduce chlorine levels prior to discharge for larger wastewater treatment plants. Some newer treatment plants use alternative disinfection treatments such as ultraviolet light or ozone to eliminate bacteria.

3.3 Contaminants of Emerging Concern

Oxygen levels, suspended solids, and E. coli were established as indicators of sewage pollution only after many years of observation and research. In recent decades, we've learned about other pollutants that can remain present even in sewage that's gone through primary and secondary treatment. The problem that's received the most attention recently in central Texas is nutrient pollution, which refers to high amounts of nitrogen and phosphorus that remain in treated sewage. Nutrient pollution is discussed at greater length in Chapter 5.

Recent studies have also exposed the effects of pharmaceuticals, endocrine-disrupting chemicals, and other **contaminants of emerging concern** in sewage. According to the Water Quality Association, up to 90 percent of oral drugs will pass through the body (meaning that the body doesn't absorb most of the dosage), and end up in sewage. Some people also flush unused medication down the toilet. Multiple research studies have shown that anti-depressant medication in natural waters can affect aquatic life, often reported in news stories as "fish on Prozac." Personal care products such as soaps, cosmetics, and shampoo that are rinsed down the drain while show-

Sewage treatment plants use aerobic bacteria to decompose the organic matter in wastewater – the same process that takes place in natural water bodies.

ering and bathing can also be harmful.

Research has additionally been conducted on the effects of endocrine disruptors in natural waters. This term refers to chemicals that can interfere with an organism's endocrine system and affect normal hormonal functions, which can lead to developmental, reproductive, neurological, or immune system damage. Endocrine disruptors include both natural and artificial hormones, as well as industrial chemicals such as bisphenol-A, better known as BPA. Several studies have found intersex fish (having both female and male characteristics) in locations near sewage outlets.

In 2019, researchers with the U.S. Geological Survey (USGS) published the first nationwide study to assess how often emerging contaminants show up in water from underground aquifers. Overall, the study found that contamination by pharmaceuticals and hormones wasn't widespread, and when they did show up, they generally weren't at levels that could harm human health. While the study tested for the presence of hundreds of substances, only 34 compounds were detected. The most frequently detected compounds were BPA, three pharmaceuticals (carbamazepine, sulfamethoxazole, and meprobamate), and a caffeine byproduct.

However, the USGS researchers also reported that emerging contaminants were more likely to be found in some locations than others. Detection frequencies were higher for water drawn from domestic wells (15 percent) than for public-supply wells, and for wells on aquifers with faster recharge (9 percent) than slower recharge (4 percent). Detection frequency was highest for sites located in areas with mixed land use (11 percent) followed by urban land use (6 percent), undeveloped (5 percent), and agricultural (3 percent). The study also analyzed detection frequency according to types of aquifers. Water from aquifers in crystalline rock formations with fractures had detection frequencies that were twice as high (16 percent) as aquifers in other formations such as sand and clay (0-8 percent).

All of these characteristics — domestic wells that pump drinking water from a quickly recharging aquifer in a fractured rock formation, and located in a region dominated by mixed land use — are true of the Hill Country. This suggests that the Edwards Aquifer could be especially susceptible to pollution by pharmaceuticals, hormones, and other emerging contaminants. In 2010, the US Geological Survey tested Barton Springs and the creeks feeding Barton Springs for wastewater indicator compounds. Twelve of the 59 compounds tested were found in at least one sample, although the concentrations were low. The insect repellent DEET was found in 42 percent of samples, and caffeine was found in 21 percent of samples. Even without discharge, these wastewater indicator compounds are being detected in creeks and in groundwater.

3.4 Land-Based Sewage Treatment

Municipal sewage plants serve approximately 80 percent of all Texas households. The remainder of the population is served by a variety of sewage management options, most of which disperse sewage onto the land rather than into water. In each of these options, sewage still goes through treatment to remove solids and organic matter before being discharged into the soil, where bacteria, plants, and sunlight can break down remaining waste. Land dispersal methods differ in scale and size, as well as the type of land that receives the treated wastewater.

Septic tanks and other decentralized treatment methods are known as **on-site sewage facilities (OSSFs)**. Most homes in rural areas use septic tanks. Modern systems have two chambers — the first lets solids sink to the bottom, while the second lets bacteria decompose organic matter. Wastewater then flows out of the tank and into a perforated pipe buried in a drain field composed of sand or gravel and overlaid with soil and grass. A **clustered on-site system** will serve several homes or businesses, each with their own septic tank for primary treatment. Wastewater is then pipe to a small shared facility for secondary treatment before being dispersed into a drain field.

Using wastewater for **irrigation** (also called **land application**) is increasingly common for subdivisions located in regions with strict rules against dumping treated sewage into streams or lakes. Sewage from multiple houses is piped to a central treatment facility and then sprayed or dripped onto parks, athletic fields, golf courses, agricultural fields, or undeveloped lots that only received wastewater.

3.5 Wastewater Reuse

Wastewater reuse is one of the newest sewage management options, as well as the one with the most potential for expansion in the future. It's based on the fact that water is used in homes and buildings for different purposes. The highest-quality water (called potable water) is needed for drinking and bathing, but isn't necessary for flushing toilets or irrigating lawns. Wastewater that's been treated to a lower standard than is needed for drinking or potable water uses can often be sufficient for these lower-priority, non-potable uses. Some reuse facilities are on-site, serving a single house or subdivision like greywater systems. A number of cities have begun building large-scale reuse systems in which wastewater is treated at a central plant and then piped back to homes and buildings through a dif-

Reclaimed water is used for a wide variety of purposes in Austin, including landscape irrigation at Mueller Lake Park.

ferent set of plumping. Centralized reuse systems are sometimes referred to as **recycled water** or **reclaimed water systems**. Purple pipes and fixtures are often used to prevent accidentally cross-connecting potable water systems to reclaimed water systems.

The final frontier for wastewater is to treat it so thoroughly that it can be reused for drinking water. This isn't hypothetical — it's already being done, and in Texas. The town of Big Spring in west Texas was the first community in the United States to install equipment for what's called **direct potable reuse (DPR)**. Wichita Falls temporarily operated a similar facility, while El Paso, Brownsville, and San Angelo are in the planning phase. DPR facilities use extremely fine membranes and filters to trap virtually all pollutants, producing purified water that's as clean as drinking water drawn from natural sources.

In addition to being a better way to manage wastewater, reuse also helps with water conservation, since it reduces demand for high-quality raw water to be withdrawn from rivers or aquifers and can keep treated, potable water from being used for non-potable uses like landscape irrigation. Reuse is a key component of **One Water**, an integrated approach that manages drinking water, natural water, stormwater runoff, and wastewater as different forms of the same resource, rather than as separate problems requiring separate approaches.

CHAPTER 4

The Evolution of Sewage Regulation

4.1 Role of the EPA & TCEQ

The evolution of sewage treatment has been accompanied by an evolution of the laws and regulations for sewage treatment. The federal Clean Water Act, which became law in 1972, established a regulatory framework for water pollution from all sources — not just municipal wastewater, but also industrial and agricultural wastewater. The key goal of the act is that all major water bodies in the U.S. should be safe for swimming and fishing and that no new discharges could occur without a permit.

The federal Environmental Protection Agency, also established in 1972, has implemented the Clean Water Act in part through the National Pollutant Discharge Elimination System (NPDES). The EPA first sets water quality standards, which are maximum limits for the amount of selected pollutants that can be present in natural water bodies. Only three measurements are applied in all places nationwide — dissolved oxygen (DO), suspended solids, and E. coli bacteria.

The EPA is also in charge of implementing the federal Safe Drinking Water Act, which became law in 1974. The agency issues drinking water standards, which set maximum limits for more than 90 contaminants, including microorganisms, disinfectants, inorganic and organic chemicals, and radioactive substances.

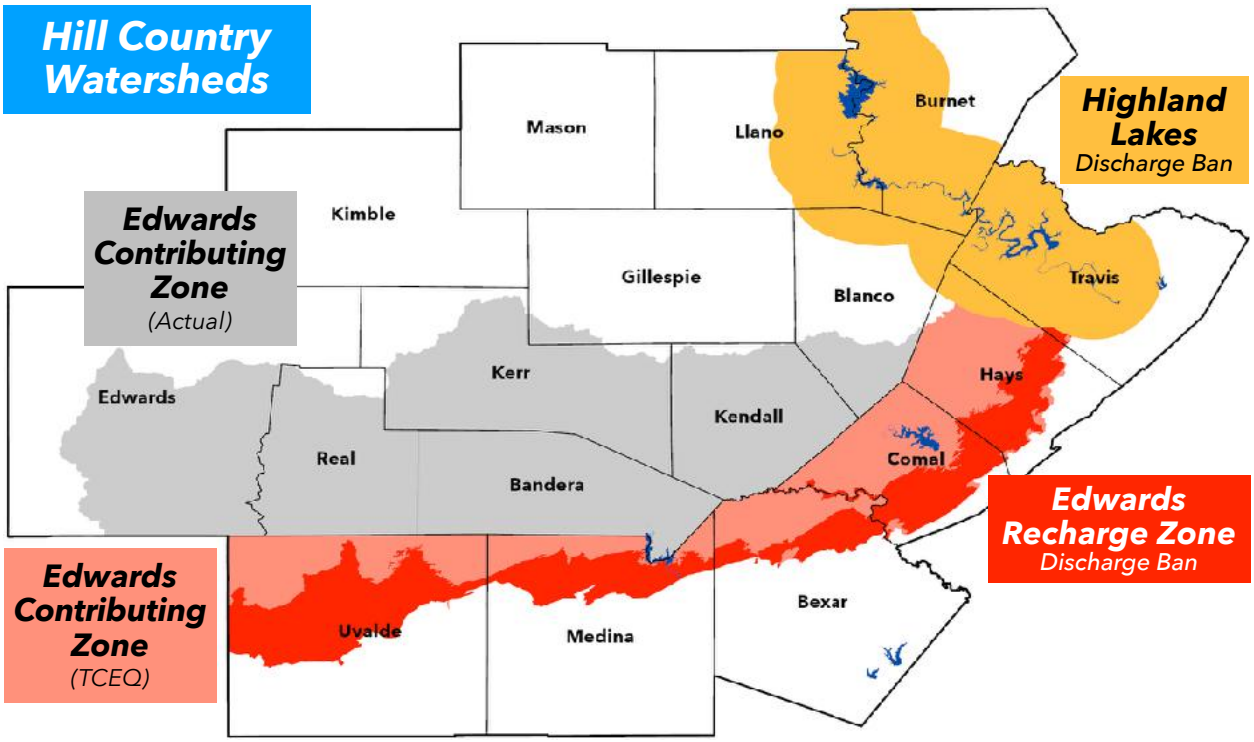
The EPA delegates the administration of the NPDES program to state environmental agencies, including the Texas Environmental Quality Commission (TCEQ). The regulation of water in our state begins with the Texas Surface Water Quality Standards, which TCEQ now updates every three years. The agency first classifies some natural water bodies based on how they're used, how well they support aquatic life, and how often they have natural flow. The classification with the strictest requirements are public drinking water supply, aquifer protection, exceptional aquatic life use, and primary contact recreation, a label that is applied to streams and lakes where people engage in swimming, wading, tubing, or other activities in which they could potentially swallow water.

After limits for the amount of dissolved oxygen, suspended solids, and E. coli that can be present in natural water bodies are set by TCEQ, these streams, lakes, and bays are regularly tested for water quality. If the amount of a pollutant in a natural water body is over the allowed limit, TCEQ will designate that water body as impaired. The agency will then require local governments (and sometimes other entities) to create a plan to reduce pollution to acceptable levels. Pollutant limits for natural water bodies are referred to as Total Maximum Daily Loads (TMDL), and the associated pollution-reduction plans are referred to as Implementation Plans.

TCEQ regulates all cities, industries, and other entities that want to dump wastewater into streams, lakes, and bays, whether a water body is designated as impaired or not. The permitting process ensures that any pollutants added to a natural water body won't cause pollution that exceeds what's allowed for that body.

All existing and proposed sewage plants that want to dump treatment effluent into natural water bodies must apply for a discharge permit through the Texas Pollutant Discharge Elimination System (TPDES). As previously discussed in Chapter 2, permits include pollutant limits that regulate the amount of pollutants that can remain in treated sewage. Pollutant limits are set in relation to water quality limits — the amount of pollutants in sewage shouldn't cause an exceedance in the amount of pollutants in streams or lakes.

Permits for the vast majority of sewage treatment plans in Texas only contain pollutant limits for biochemical oxygen demand (BOD), suspended solids, and E. coli. TCEQ has set limits for nitrogen and phosphorus in a few areas. In addition, TCEQ follows EPA policy in designating sewage plants as major or minor de-



TCEQ banned new wastewater discharge permits in a 10-mile buffer around the Highland Lakes in 1986, and over the Edwards Aquifer Recharge Zone in 1996. The agency also imposed limited restrictions on discharge permits in part of the Edwards Aquifer Contributing Zone.

pending on how much treated sewage they're allowed to dump. Permits for major plants have stricter limits for more pollutants than permits for minor plants, as well as more extensive monitoring requirements.

This regulatory framework only applies to sewage dumped into streams and lakes by treatment plants with a discharge permit. In Texas, on-site sewage facilities are classified as systems that treat less than 5,000 gallons per day of wastewater. OSSFs may be permitted directly by TCEQ, or the agency may delegate its authority to review and approve OSSFs to qualified cities and counties. Land application facilities treating over 5,000 gallons per day are permitted by the Texas Commission on Environmental Quality under the Texas Land Application Permit program, or TLAP.

The reuse of treated wastewater, or reclaimed water, may occur in Texas in connection with either a facility permitted for discharge or a TLAP. Rules for reclaimed water use are found in 30 Texas Administrative Code Chapter 210, and authorization for the use of reclaimed water is approved by TCEQ. Uses for reclaimed water are dependent upon the level of treatment of the wastewater. Type II reclaimed water is treated to a less protective standard but uses for Type II reclaimed water are restricted to those where human contact is unlikely, such as for dust suppression and cooling tower makeup water. Type I reclaimed water is treated to a more protective standard and may be used for outdoor irrigation in public areas as well as indoors for fire suppression systems or toilet flushing.

The beneficial use of effluent in association with either a discharge or TLAP permit allows permittees to use or sell their treated effluent as reclaimed water at another location. Instead of discharging or irrigating the effluent at the plant site, the reclaimed water can be otherwise used or irrigated elsewhere, such as parks or landscaped areas, that would otherwise use treated drinking water.

In response to a rule petition from the City of Austin, TCEQ has also established a beneficial reuse credit program for TLAP wastewater facilities. TLAP facilities that utilize a reclaimed water program may be able to reduce the area required for their dedicated irrigation fields based on the amount of reclaimed water that is reliably used elsewhere. This credit program reduces the cost of expanding TLAP facilities by reducing the amount of additional irrigation land needed to be acquired, and encourages water conservation by promoting the expansion of wastewater reuse.

Hill Country streams, as previously explained, are

very different from streams in the rest of Texas. Pollutant limits for discharge permits are generally based on the assumption that the pollutants in treated sewage will be diluted by the high volume of water in a stream, and that pollutants will additionally be filtered out of the stream because they will be absorbed by the soil or by vegetation. Hill Country streams usually have rocky channels with little vegetation, naturally low concentrations of nutrients and algae, exceptionally clear water that allows sunlight to penetrate throughout the stream creating ideal conditions for the growth of algae, and frequently have little or no water volume during dry months. Yet for the most part, TCEQ has continued to impose statewide pollutant limits on this very different region.

The major exceptions are bans on discharge permits in two areas that are vital sources for drinking water. Austin gets all of its drinking water from the Highland Lakes on the Colorado River, and San Antonio gets most of its water from the Edwards Aquifer. As a result, no sewage discharge permits are allowed within 10 miles of the six Highland Lakes, or on the Edwards Aquifer Recharge Zone, which is where the aquifer is exposed at the surface of the earth and surface water seeps into the underground reservoir. TCEQ has also established some limited restrictions on discharge permits that are located within 10 miles upslope from the Recharge Zone, but these restrictions are inadequate to protect the streams that replenish the Edwards Aquifer.

CHAPTER 5

Nutrients & Algae Pollution

5.1 Algae's Harmful Impact

It took many years to establish that organic matter and fecal bacteria were pollutants in sewage that could be measured through tests and removed through treatment. Similarly, the effort to classify excess nutrients as pollutants that should be removed from sewage has gone on for many years, even though the basic science about their effect on streams has long been well-known. TCEQ still has not developed quantitative standards for nutrients in freshwater streams that are protective of existing uses.

As we saw earlier, the introduction of nitrogen and phosphorus — collectively referred to as nutrients, since they nurture the growth of plants — to streams is a byproduct of current sewage treatment technology. When organic matter such as poop and food waste is decomposed by aquatic bacteria, it's broken down into compounds of carbon, nitrogen, and phosphorus. While some of the carbon dioxide produced by decomposition escapes into the atmosphere, the nitrogen and phosphorus compounds remain in the wastewater that's dumped into streams and lakes. Sewage also picks up extra phosphorus from urine and poop, which contain high levels of the substance.

Recurring summertime blooms of toxic blue-green algae led Austin to place permanent warning signs around Lady Bird Lake , including this one on Barton Creek.

Small amounts of algae are always present in natural water, but usually so little that they're not visible to the human eye. However, when sewage containing high levels of nitrogen and phosphorus is dumped into streams and lakes, it can fertilize the growth of algae. If the circumstances are right, algae can explode into huge blooms that blanket a water body. While the EPA refers to this as nutrient pollution, to most people it looks like algae pollution.

While there are thousands of species of algae, one that commonly grows into masses attached to the rocky bottoms of central Texas streams with elevated levels of nutrients is called Cladophora glomerata. Large Cladophora growths, which look like thick mats of green yarn or cotton, can make it impossible for people to use a stream or lake for swimming, fishing, or other recreation. In worst-case scenarios, algae blooms can also include a variety called blue-green algae, which can produce toxins that are harmful to humans and pets that accidentally swallow water in which it's present. Also known as cyanobacteria, this form of algae generally looks like a thin paint-like scum on the surface of the water. While both forms of algae grow in many places, Cladophora tends to be more common in streams with at least some flowing water, while cyanobacteria tends to be more common in lakes with still water.

As previously explained, algae pollution can have a devastating effect on aquatic life. Algae itself is organic matter, and when it dies, it's decomposed by the oxygen-consuming bacteria that also live in natural waters. If these bacteria have more to eat, they'll reproduce more, and in the process they'll consume even more of the dissolved oxygen in a stream or lake. That leaves less for all of the aquatic animals that also de-

Dead algae in the Reflecting Pool at Vic Mathias Shores in Austin.

pend on the same supply of oxygen, from worms and insects to fish and amphibians. In extreme cases, the cycle of algae growth and bacterial decomposition can use up so much oxygen that the water becomes a dead zone, unable to support any other life.

Sewage with high levels of nitrogen and phosphorus doesn't always cause algae pollution in streams with enough natural water volume to dilute the additional nutrients. Excess nutrients are also less likely to cause problems in streams with lower water clarity and heavily vegetated soil banks, because the dirt and plants will absorb some of the nitrogen and phosphorus. None of these features — consistently high volume, soil banks, low clarity, or heavy vegetation — are characteristic of most Hill Country streams. Instead, the region's creeks and rivers usually have clear water flowing through rocky channels of exposed limestone, with little plant growth on the banks. These streams also have less water volume, since they originate in the western part of the Hill Country, where average annual precipitation is significantly lower. In fact, water volume in some of the region's streams can drop to little or nothing during the dry months of summer and fall.

These factors make Hill Country streams especially vulnerable to nutrient pollution. A 2006 study by the U.S. Geologic Service examined nutrient and biological conditions in 15 small streams in the Hill Country. Streams that did not receive treated sewage had lower levels of nutrients and algae, while streams that did receive wastewater had higher levels of each. The USGS study found that nitrogen levels were 5 times greater in streams with wastewater than in streams without it, and phosphorus levels were 183 times higher.

5.2 Nutrient Regulation

Officials at both the EPA and TCEQ have discussed adopting numeric nutrient standards for years, but with little progress. Texas has adopted some nutrient criteria, but they are qualitative (i.e., defined with descriptions instead of numbers), nearly unenforceable, and don't protect water bodies with naturally low levels of algae and nutrients. The EPA first established a Nutrient Task Force in 1993. In 2001, the agency sent a memo to state environmental regulators in which it outlined its expectations for when states should add nutrient criteria into their water quality standards.

In 2012, the EPA rejected a petition from the Natural Resources Defense Council and 12 other organizations that called on the agency to adopt national numeric nutrient limits for sewage treatment. The EPA said that existing sewage plants faced financial and technical obstacles to installing more advanced technology. Instead, the agency said that it would work to control nutrient levels in treated sewage "by means of

site-specific, water quality–based permitting." Still, the EPA wrote in a 2016 memo that it "continues to advocate the benefits of adopting numeric nutrient criteria because they provide measurable water quality–based goals that are easier to implement than the narrative criteria measurements in many state water quality standards."

The EPA keeps track of major sewage treatment plants with numeric limits for nitrogen and/or phosphorus. (Major plants are defined as having a maximum permitted discharge volume of 1 million gallons per day or more.) Nationwide, 34 percent of all major plants have limits on how much nutrients can remain in treated sewage, but only 7 percent of major plants in Texas have such limits. The EPA also tracks plants that are required to monitor the level of nutrients in treated sewage. Nationwide, 63 percent of major plants have monitoring requirements, but only 4 percent of major plants in Texas do.

TCEQ created a plan to develop numeric nutrient criteria in 2001, which the EPA accepted six years later. TCEQ created a working group to develop nutrient criteria in 2002, which continues to meet annually. In 2010 the agency adopted a numeric nutrient standard — in the form of a quantitative measure using chlorophyll as a surrogate for the amount of algae present — for 75 reservoirs in Texas. The working group is currently developing nutrient criteria for estuaries. It plans to take up standards for streams and rivers only after that.

5.3 Case Study: Liberty Hill

Recent algae growths in Hill Country rivers and lakes have provided concrete evidence of the impact that nutrient pollution can have on the region's natural waters. In the summer of 2018, huge masses of algae choked the South Fork of the San Gabriel River upstream from Georgetown. After complaints from local landowners, TCEQ investigated the algae outbreak and found that it was caused by sewage from Liberty Hill's municipal treatment plant, located further upstream on the river.

While Liberty Hill is located in Williamson County, just north of the 17-county region covered in this report, the city's record is worth examining in detail because its sewage plant offers a worst-case scenario of how nutrient-saturated wastewater can cause chronic algae blooms. In addition, the South Fork of the San Gabriel River has many of the same characteristics of a Hill Country stream — rocky banks, clear water, less vegetation, and intermittent water flow.

According to TCEQ's 2018 report, algae covered up

Algae in the South Branch of the San Gabriel River downstream from Liberty Hill's sewage plant. (Photo: Stephanie Morris)

Austin American-Statesman

Nonprofit plans suit over Liberty Hill wastewater plant

By Claire Osborn
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Texas RioGrande Legal Aid has given the Liberty Hill mayor a 60-day notice of intent to file a federal lawsuit against the city claiming its wastewater treatment plant has violated the levels of nutrients it can release into the South San Gabriel River 3,108 times since 2015.

to 95 percent of the river's bottom, from 60 feet upstream of the Liberty Hill plant to three-and-a-half miles downstream. TCEQ determined that the specific cause was sludge that the Liberty Hill plant had illicitly dumped into the river. At one spot, investigators found 18 inches of sludge at the bottom of the river. As discussed earlier, sludge is the residue that settles at the bottom of collection ponds or chambers during primary treatment. Sludge is never supposed to be released with treated wastewater, but TCEQ found that Liberty Hill had done exactly that.

Liberty Hill's sludge disaster was all the more notable given that it had opened a new treatment plant at the beginning of the year. Shortly after that facility came online, the plant's superintendent told a local newspaper, "The new plant is so far ahead of what we had, that the quality of the effluent leaving the plant is light years from what we had."

Liberty Hill challenged TCEQ's findings, which its engineering firm called "a fabricated story." The city's public works director told a local newspaper that the algae growth could have had other causes, "such as, it's spring and at this point we've had low amounts of rain, plus a lot of people have fertilizer in their yards and developments in progress, any of which might potentially affect water quality." But TCEQ stood by its findings.

The city's discharge permit was first approved in 2004, and the city's sewage plant has been problem-plagued almost from the beginning. According to EPA's ECHO database (which has enforcement statistics going back to 2007), the plant has reported effluent exceedances almost every year for the past decade. Measured by days with effluent exceedances, the city's plant has released excessive pollutants into the South Fork of the San Gabriel River 32 percent of the time since 2007.

Residents downstream from the Liberty Hill plant continue to complain about excessive algae growths in the river. In August 2020, Texas RioGrande Legal Aid served the city with notice that it intended to file a federal lawsuit over the pollution on behalf of Stephanie Morris, a local resident. TRLA also asked TCEQ to have an administrative law judge review Liberty Hill's permit. The judge would also consider whether the terms of the existing permit are stringent enough. According to TRLA attorney Loraine Hoane, "Liberty Hill's compliance history is abysmal, with

Algae blooms started appearing in the Blanco River soon after the city's sewage plant began discharging treated wastewater.

hundreds of significant permit violations. The TCEQ is obligated to protect the property rights of downstream landowners, as well as the water quality of the South Fork of the San Gabriel."

5.4 Case Study: Blanco

Blanco, in the heart of the Hill Country, has provided another clear example of the harm that wastewater rich in nutrients can cause in a river that can't assimilate them. The city, located on the Blanco River, originally only had a wastewater land application permit. Sewage from Blanco's treatment plant was irrigated onto an adjoining field that the city leased from the property's owner. Because that lease was scheduled to expire, Blanco planned to redirect its wastewater onto a field that it had purchased, but the tract was unable to receive all of the city's wastewater.

Blanco had separately applied to TCEQ for a discharge permit, which the agency approved. The city began discharging treated sewage into the Blanco River in late 2018, and the effect was almost immediate. Large masses of algae blanketed the river below the discharge point, and remained in the stream for all of 2019. Blanco was able to renegotiate its lease for its original irrigation field, however, and was able to stop discharging sewage into the river at the end of 2019. Since then, the algae growths have dissipated and the Blanco River has returned to its normal appearance. In the words of David Baker, executive director of the Wimberley Valley Water Association, "The river is healing."

The increase in nutrient levels below the discharge point was documented by two independent researchers, Ryan King and Sandra Arismendez. King, a professor at Baylor University and director of its Center for Reservoir and Aquatic Systems Research, was commissioned by the Save Our Springs Alliance to study the effect of wastewater on aquatic biology at four Hill Country streams: the Blanco River; Barton Creek and Onion Creek, south of Austin; and Honey Creek, north of San Antonio. He conducted extensive water quality testing at two locations on each stream in June, August, and September 2019.

For Barton, Onion, and Honey creeks, King selected locations that could potentially be affected by wastewater discharge if proposed sewage treatment plants are built on those streams. King's measurements will serve as a useful benchmark if these plants are actually built, but his data also add to the picture of what Hill Country streams look like when they're relatively untouched by human development. In general, he found that these three streams had low levels of nitrogen and phosphorus, low levels of Cladophora algae, and a high variety of macroinvertebrate life.

For the Blanco River, King conducted water quality tests at one location upstream from the city's wastewater plant and at one location downstream. The differences between the two locations — likewise tested in

These aerial views show algae growths in the Blanco River in 2019, when the city was still discharging treated sewage, and earlier this year, soon after the city stopped discharging.

June, August, and September 2019 — were sharp. Phosphorus levels at the downstream location were much higher at all times. An isotope test indicated that nitrogen at the downstream site was coming from biogenic sources like wastewater. A test to gauge the volume of Cladophora found that the amount of this algae at the downstream location in June was almost 10 times greater than the upstream location.

The two testing locations on the Blanco River also displayed significant differences in aquatic life. The wide variety of macroinvertebrate life on display at the upstream site (and at the other three streams in King's study) was replaced at the downstream site by a mix dominated by four species commonly associated with sewage discharge. All of these changes in the river's biology also had an effect on the fish population, King found. Bigger game fish, including largemouth bass, were predominant at the upstream site, while small baitfish and juvenile sunfish were predominant at the location below the sewage plant.

Arismendez's study started in September 2019, picking up where King's study left off. Arismendez is the Water Quality Monitoring Coordinator at The Meadows Center for Water and the Environment at Texas State University. She conducted monthly water quality tests through June 2020 at two locations on the Blanco River – again one located upstream from the city's sewage plant, and another located downstream.

Arismendez found that nitrogen and phosphorus levels were significantly higher at the downstream location than at the upstream location last fall, when Blanco was still discharging treated sewage into the river. However, the levels of both nutrients at the downstream location have dropped steadily since the city stopped discharging sewage into the river.

5.5 Case Study: Belterra

Reducing nitrogen and phosphorus in treated sewage is possible. In fact, it's already being at one Hill Country sewage plant. The Belterra subdivision, located southeast of Austin, was initially developed with a TCEQ land application permit granted to Hays County Water Control and Improvement District (WCID) Number 1. The permit allowed the district to irrigate up to 150,000 gallons of treated wastewater per day onto a dedicated irrigation field.

In 2008, Belterra applied to TCEQ for a discharge permit that would allow it to dump sewage into Bear Creek, a tributary of Onion Creek and a creek that contributes recharge to the Edwards Aquifer. Despite opposition from the city of Austin, Hays County, the Barton Springs Edwards Aquifer Conservation Dis-

trict, the Hays Trinity Groundwater Conservation District, the Lower Colorado River Authority, and local environmental groups, TCEQ granted the permit. Before a hearing by a state administrative law judge, Belterra and most of the permit's opponents reached a settlement agreement. After the hearing, the judge recommended that TCEQ incorporate the settlement terms into a modified discharge permit. Belterra agreed to continue using irrigation as the primary means for wastewater disposal, and to only discharge sewage when the irrigation field was saturated, the holding tanks were full, and/or when Bear Creek was flowing with enough water to dilute the sewage. Because Belterra has a progressive wastewater reuse program within the subdivision for irrigating the effluent, the Belterra treatment plant has not discharged to Bear Creek to date.

The settlement also required Belterra to comply with pollutant limits that were described by TCEQ as the most stringent in Texas at the time. The final permit set limits of 5 milligrams per liter for CBOD (carbonaceous biochemical oxygen demand), 5 mg/L for total suspended solids, 2 mg/L for ammonia, 6 mg/L for total nitrogen, and 0.15 mg/L for total phosphorus. The settlement additionally required Belterra to use membrane bioreactor (MBR) technology for nutrient removal, and to use ultraviolet light treatment for the final stage of disinfection. While the Belterra nutrient limits were an improvement over permits with no nutrient limits at all, several experts consider the nitrogen and phosphorus limits to still be too high for Hill Country streams.

The impacts of both the regulated pollution from facilities operating in compliance with their permit from TCEQ, and unregulated pollution in the form of wastewater treatment plant failures as noted in Chapter 2, may be having demonstrable impacts on the quality of Hill Country water resources. Barton Springs is the primary discharge point of the Barton Springs Segment of the Edwards Aquifer, habitat for two species of federally endangered aquatic salamanders, and where more than 800,000 visitors swim annually. The City of Austin and US Geological Survey have been monitoring Barton Springs for decades, and observe that nitrogen levels in Barton Springs continue to increase over time. Isotopic analysis of the nitrogen indicates that it is of a "biogenic" source, meaning it is derived not from fertilizer or rainfall but from human or animal waste. Livestock operations have decreased over time as urbanization expands in the area feeding Barton Springs, and is not likely contributing to the increasing nitrogen. Review of other water quality contaminant changes in Barton Springs over time further suggests that the pollution is not from non-point source pollution, or runoff from urban areas or roads, but from wastewater disposal which has increased substantially in the area contributing recharge to Barton Springs. This trend illustrates not only the inadequacy of current wastewater treatment methods, but also the sensitivity of these karst systems to contamination.

CHAPTER 6

Recommendations

One of the themes of this report is evolution. Our knowledge of the pollutants in sewage and their effects on the environment has gradually evolved over time. As a result, the way that we treat sewage, and the way that we regulate it, has also evolved.

When Austin's population started to grow at a faster pace in the 1970s, the amount of wastewater that it produced grew so fast that its treatment plants couldn't keep up. One plant was so overwhelmed that raw sewage had to be trucked to other plants for treatment. The city periodically discharged partially treated or raw sewage, causing algae blooms downstream on the Colorado River. Austin's plants had more than 600 permit violations in 1982 and 1983. But the city responded by convincing residents to approve bonds to expand Austin's wastewater system. And the Lower Colorado River Authority, which the Legislature had authorized to monitor the river's water quality, convinced the city to treat its sewage to lower pollutant limits than required by the state.

The state took action, too. A commission appointed by the governor in 1985 to study ways to protect the Colorado River's water quality recommended a ban on new sewage discharge permits around the Highland Lakes. The following year, the prohibition was enacted. In 1996, the state implemented a ban on new discharge permits in the Edwards Aquifer Recharge Zone. Since then, there's been no further evolution of sewage regulations in the Hill Country, even though more advanced options for treating and managing wastewater exist now than ever before.

As this report has shown, a majority of existing municipal sewage plants in the Hill Country are unable to even comply with the lax pollutant limits in their permits. The following steps are essential for preserving and improving water quality in a region beloved by all Texans.

1 Ban new wastewater discharge facilities in the Texas Hill Country

A ban is the most effective tool to prevent sewage pollution and is appropriate for the most sensitive waterways in our state. TCEQ has the authority to establish a ban.

- TCEQ should ban new discharge facilities in the Edwards Aquifer Contributing Zone and other parts of the Hill Country.

2 Establish nutrient limits for water quality standards and wastewater permits

Wastewater standards are set in relation to water quality standards. Both sets of standards should contain strict limits on total nitrogen and total phosphorus for Hill Country streams.

- TCEQ should update the state's water quality standards to include strict nutrient limits for Hill Country streams based on naturally occurring levels of total nitrogen and total phosphorus.
- TCEQ should include strict nutrient limits in new wastewater discharge permits, especially when cumulative discharges have the potential to significantly harm naturally occurring nutrient levels in receiving water bodies.
- TCEQ should use nutrient monitoring data to determine whether to add more protective nutrient limits to existing permits when they come up for renewal.

3 Fund upgrades for nutrient removal technology at existing sewage plants

The federal Clean Water Act established the funding to pay for sewage plant upgrades. This funding mechanism continues today as the Clean Water State Revolving Fund, with an 80 percent contribution from the federal government and a 20 percent from each state's government.

- The Texas Legislature should increase funding for the enhancement and improvement of nutrient removal technology at existing sewage plants.

4 Require and promote the beneficial reuse of wastewater

The better option for treated wastewater is to use it for landscape irrigation or reuse it in buildings.

- Cities and counties should adopt development policies to require and promote the use of decentralized on-site sewage treatment facilities, including in public buildings, as well as wastewater reuse systems for outside irrigation and interior low-priority needs.
- Cities and counties should explore a tax credit to incentivize wastewater reuse and direct potable reuse.

5 Improve the enforcement of permit limits at existing sewage plants

Stricter permit enforcement is necessary for existing wastewater plants, which are already responsible for significant amounts of sewage pollution and environmental degradation.

- TCEQ should set specific rules for effluent exceedances (for example, a warning for the first set of exceedances, an enforcement order for the next set, a fine for the next set, etc.).
- TCEQ should inspect plants more regularly. Inspections should not be announced in advance. The agency should periodically collect and test its own samples of wastewater in order to verify plants' self-reported data.
- The Legislature should provide the necessary funding for TCEQ to increase its enforcement work.
- TCEQ should issue larger fines not only to deter future pollution, but to help fund increased enforcement.
- After a new plant begins discharging treated sewage, the permit-holder should fund a short-term water quality testing program to determine whether the effluent is affecting critical receiving areas.

6 Explore other ways to reduce sewage pollution and improve water quality

- Survey key staff from cities, counties, groundwater conservation districts, river authorities, and water or wastewater utility providers to understand their perspective on wastewater discharge, identify opportunities for education, and characterize knowledge gaps for future studies.
- Increase the funding and resources for water quality testing through TCEQ's Clean Rivers Program.
- Explore the creation of wastewater service and reuse districts that operate across jurisdictional lines.
- Explore the creation of a nonprofit wastewater plant operator that could take over the operation of poorly functioning plants, and establish best practices for plant operation and information-sharing procedures.
- Hill Country governments should adopt the One Water management approach, since natural water, stormwater, and wastewater are different forms of the same resource.

Government officials, professional and academic experts, and nonprofit groups must work together to protect this beautiful region's pristine streams from sewage pollution. We hope that this report serves as a foundation for new regulations, new collaborations, and new conversations to keep the Hill Country a special place for all Texans.

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