Trinity River Basin Master Plan

Trinity River Authority of Texas

JUNE 2021


Photo: COE 1899 Survey

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Photo: COE 1899 Survey

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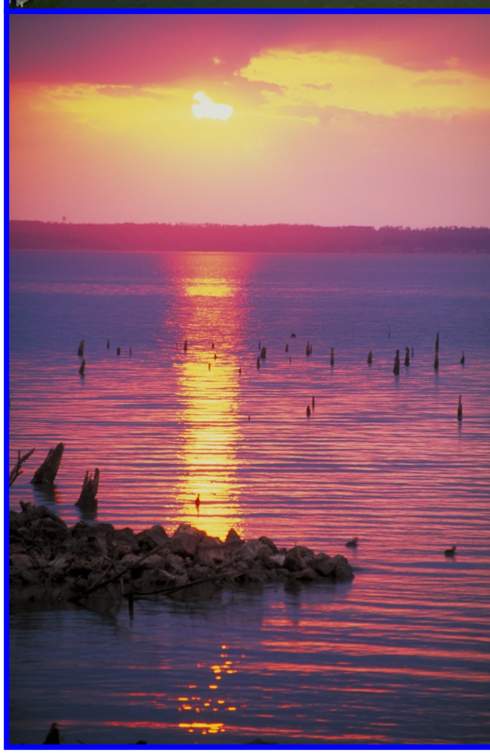


Photos: Wolf Creek Park (top), Trinity River in the Fall (bottom right), Lake Livingston Scene (bottom center), Lake Livingston Sunset (bottom left).

Trinity River Authority of Texas

Basin Master Plan

Foreword

Message from the General Manager

J. Kevin Ward, General Manager
Trinity River Authority of Texas

The 54th Texas Legislature created the Trinity River Authority (TRA) of Texas in 1955 as a conservation and reclamation district, requiring that TRA prepare a master plan for responsible water use and reclamation that would ensure a healthy river basin. TRA completed the first master plan in 1958 after a series of public meetings throughout its statutory boundaries – since then, it has been revised and amended on a regular basis to keep up with dynamic technical, legal, environmental and economic changes.

While TRA is a leader in basin planning, the Authority does not control permitting or water rights issues — those duties are fulfilled by various state agencies. Instead, TRA coordinates with other entities, mostly municipalities, to implement water-related programs that serve the needs of Texas residents. When requested, TRA has served as a facilitator to help federal, state, regional and local entities develop projects based on the needs of their populations. To that end, the master plan does not advocate specific projects; instead, the master plan establishes basin-wide objectives designed to benefit the population of the entire basin, regardless of the implementing agency.

Trinity River Basin Master Plan Documents

Report on Master Plan of the Trinity River and Tributaries, Texas, adopted by the Board of Directors of the Trinity River Authority	April 18, 1958
Report on Soil Conservation and Upstream Flood Prevention of the Trinity River and Tributaries, Texas approved by the Texas State Conservation Board	January 7, 1959
Supplemental Report on Master Plan of the Trinity River and Tributaries, Texas, adopted by the Board of Directors of the Trinity River Authority	October 21, 1960

Trinity River Basin Master Plan, revisions adopted:

February 22, 1978	February 24, 1993	April 23, 2003	April 25, 2012
June 27, 1984	February 26, 1997	February 28, 2007	May 31, 2016
February 22, 1989	February 28, 2001	December 9, 2010	June 23, 2021

Trinity River Authority of Texas

Basin Master Plan

Introduction

Objectives

These are the objectives for the Trinity River basin (Fig. 1a) regardless of the implementing agency. Jurisdictional, financial, or engineering details are not a part of the plan and may vary without changing it. TRA Board of Directors may review or revise this Master Plan at any time. The order in which these objectives are listed is not intended to establish priorities.

- **Access**

  Provide public access and facilities for water-oriented recreation, and promote port facilities at Liberty, Texas.
- **Conservation**

  Support efforts and programs designed to conserve water, land, soil and ecological resources and riverine and estuarine systems.
- **Education**

  Promote human, environmental, and economic well-being through education and information programs that foster an understanding of the complex water-related issues throughout the Trinity basin and Trinity Bay.
- **Flood Protection**

  Support flood risk reduction efforts throughout the basin.
- **Water Supply**

  Support the development of water resources within the basin consistent with regional water planning groups.
- **Reuse**

  Support the use of highly-treated wastewater for beneficial purposes, including both direct and indirect potable and non-potable applications.
- **Wastewater Treatment Plants**

  Wastewater treatment plants should be expanded and upgraded as needed. Whenever feasible, regional wastewater treatment should be implemented.
- **Water Management Policy**

  Support water management policies that balance the values of both the Trinity River and Trinity/Galveston Bay Complex, and promote the most efficient use of water resources for all beneficial purposes.
- **Water Quality**

  Continue to promote improvements to the water quality of the Trinity River and all of its associated water bodies.

Trinity River Basin and Subwatersheds

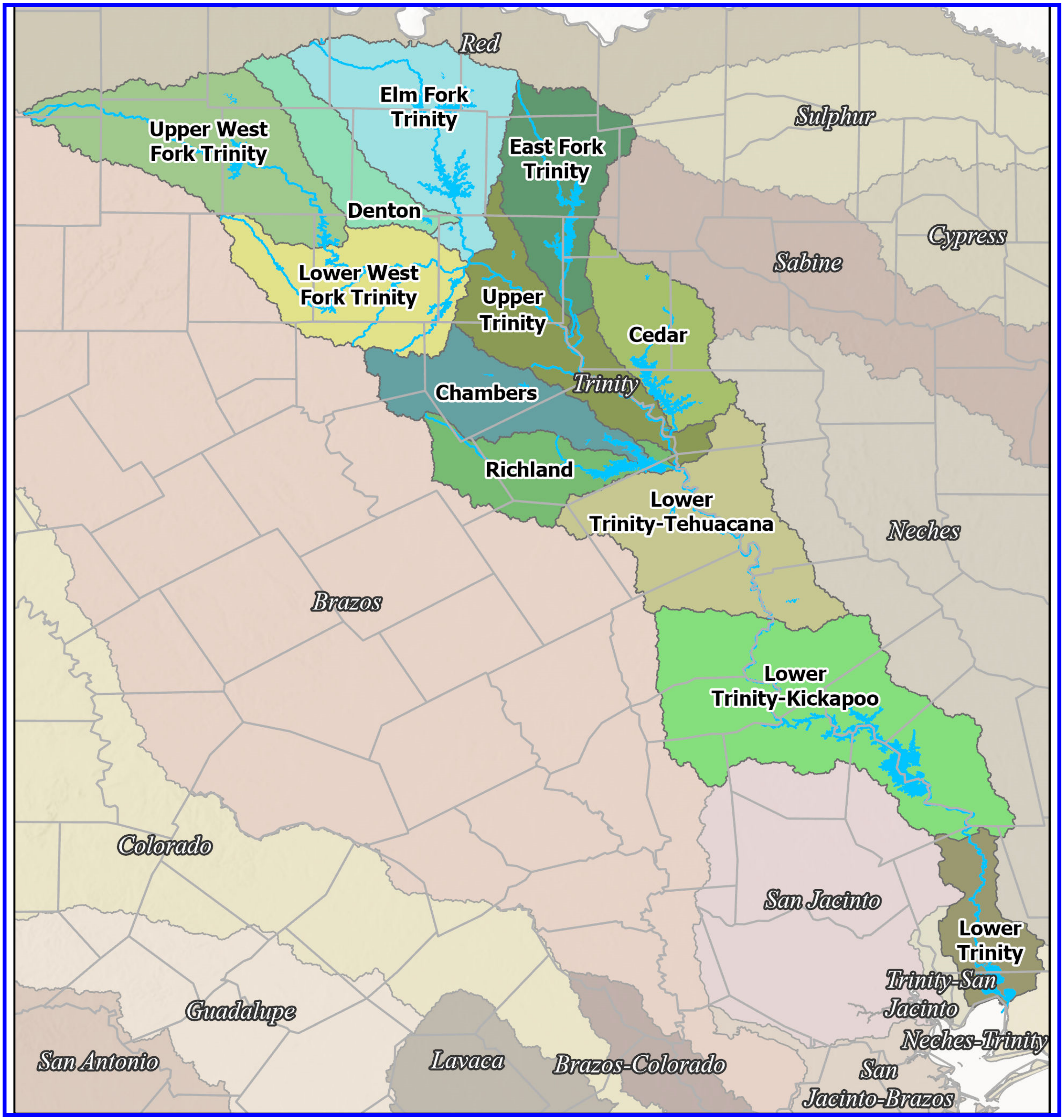


Fig. 1a. Map of Trinity River Basin and Subwatersheds

The Trinity River Authority Overview

The Trinity River Authority (TRA) was created in 1955 as a conservation and reclamation district by House Bill 20, an Act of the 54th Legislature[1]. TRA is governed by a 25-member board of directors who are appointed by the governor with the approval of the senate (Table 1a). Unless the board member is "at large," they must live and own taxable property within the area from which they are appointed. The political boundary of TRA is divided into 17 areas and includes all or part of 17 counties (Fig. 1b).

Table 1a. TRA Board of Directors Allotments

Area	County	No. of Directors
1	Tarrant	3
2	Dallas	4
3	Kaufman	1
4	Henderson	1
5	Ellis	1
6	Navarro	1
7	Anderson	1
8	Freestone	1
9	Leon	1
10	Houston	1
11	Trinity	1
12	Madison	1
13	Walker	1
14	San Jacinto	1
15	Polk	1
16	Liberty	1
17	Chambers	1
18	"At Large"	3

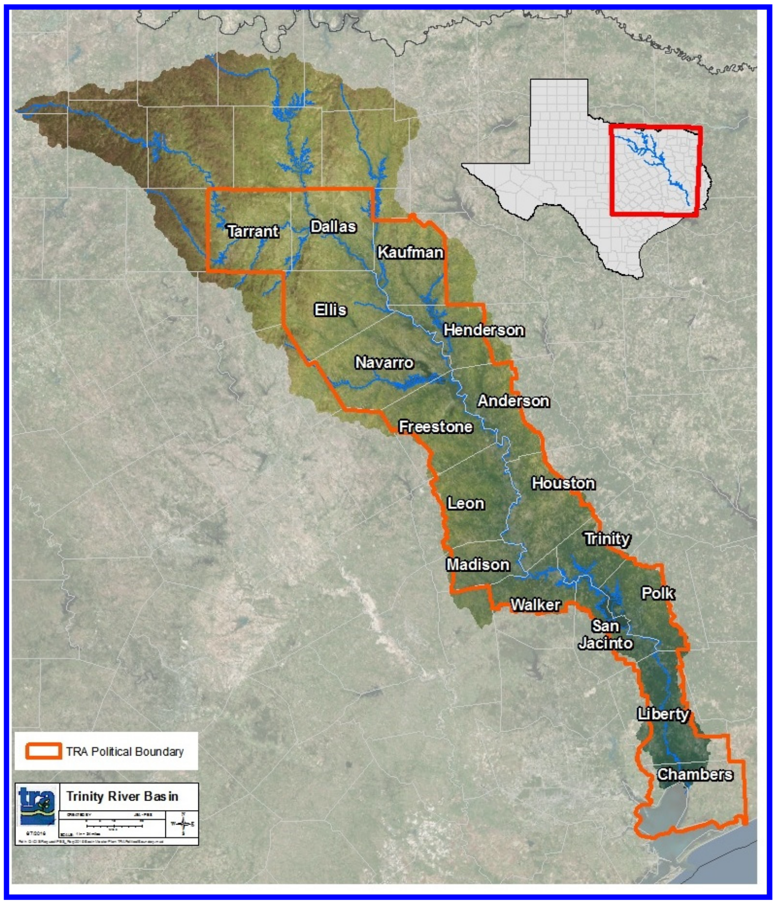


Fig. 1b. Map of TRA Political Boundary

By statute, the Trinity River Authority is charged with:

1. Maintaining a master plan for the Trinity River basin;
2. Acting as local sponsor for federal water projects; and
3. Providing services authorized by the Texas Legislature within the Authority's territory.

The Trinity River Authority has the legislative authority to tax, but has never done so. Instead, the Authority generally provides a service to entities that wish to partner with TRA to create wastewater and water supply projects. TRA was tasked with overseeing the creation of a navigable waterway from Liberty to the Dallas/Fort Worth Metroplex. By the 1970s, the U.S. Army Corps of Engineers' cost vs. benefit analysis concluded that the navigation project should be postponed indefinitely. About this time, TRA began to focus its efforts toward creating and operating regional wastewater collection and treatment systems. These systems were huge improvements to the existing septic systems, small, inefficient package plants, and municipal plants, which were not functioning efficiently.

House Bill 20 also authorized TRA to construct, own, and operate reservoirs and to supply and sell water. To help the city of Houston satisfy its water demand, TRA completed construction on Lake Livingston in 1969. Currently, Lake Livingston alone accounts for approximately 75% of Houston's surface water supplies. TRA funded the construction of Livingston through the sales of revenue bonds that were redeemed with income from the sale of water.

In addition, TRA acts as a local sponsor for major water supply projects. TRA has served as a local sponsor for four major U.S. Army Corps of Engineers multiple-purpose water resource projects: Bardwell Lake, Joe Pool Lake, Navarro Mills Lake, and the Wallisville Saltwater Barrier.

House Bill 20 granted TRA certain powers but did not mandate, nor fund, these powers. TRA *is not a permitting entity* and does not control permitting or water rights issues within the basin. Those functions are handled by various state agencies. TRA's primary function is to work and coordinate with other entities, mostly municipalities, to implement water related programs that serve the needs of Texas residents.

[1] *See Appendix 1 for an in-depth explanation of the Role of the Trinity River Authority.*

Trinity River Basin Overview

The Trinity River begins in the Four Forks region in the northern portion of the basin. Just south of the Dallas-Fort Worth Metroplex, the Clear Fork, West Fork, Elm Fork and East Fork merge to form the Main Stem of the Trinity River. The Trinity River extends about 715 miles long and drains nearly 18,000 mi². The Trinity River basin is the largest river basin in Texas that begins and ends within the state. The climate and land type vary greatly across the basin. The basin transforms from sandy soils and rangeland in the northwest, to Blackland prairies and row crop agriculture around the Dallas-Fort Worth Metroplex, to the East Texas piney woods, and finally to the Gulf Coastal prairies. Annual precipitation ranges from less than 36 inches at the headwaters to 52 inches near the Gulf of Mexico.

The Trinity River provides water to over half of the population of Texas and serves two major population centers: Dallas-Fort Worth Metroplex in the upper reaches and the City of Houston in the south (Fig. 1c). These major population centers drain into the Galveston Bay and estuary system, one of the most productive ecosystems and commercial fisheries in the United States.

Because of the scarcity of groundwater availability, residents of the Trinity River basin rely on surface waters to fulfill their water demand. According to Texas Water Development Board, there are 32 reservoirs in the Trinity River Basin. Because of the importance of surface water to both the upper and lower portions of the basin, water quality is a major consideration throughout the Trinity River basin.

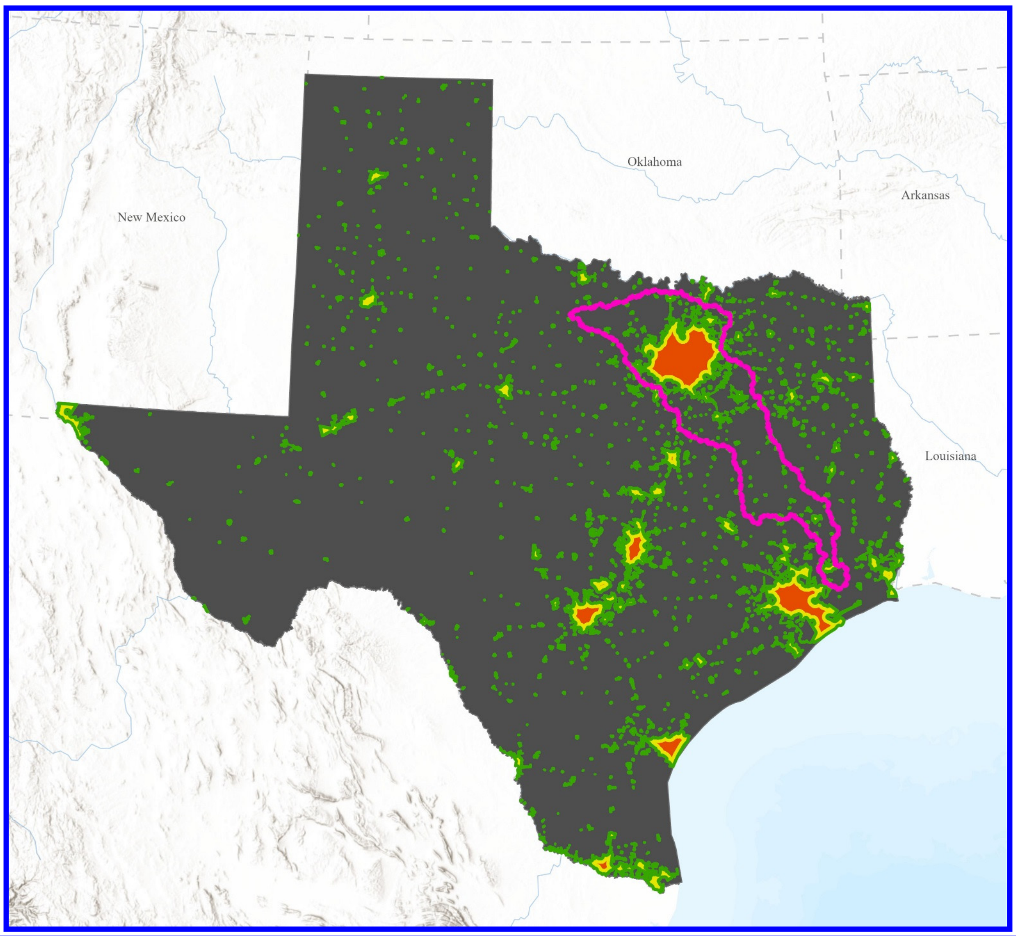


Fig. 1c. Map of Light Pollution in Texas. As seen from space, light can be used as a surrogate for population density; the darker the color (from green to red), the denser the population. Note the amount of light in the upper basin from Dallas-Fort Worth, which now represents the fourth-largest metropolitan area in the country

Future Review Procedures

The Master Plan may be reviewed and revised by the Board of Directors of the Trinity River Authority at any time. Annually, the Board of Directors will receive and review a report on the status of implementation of the plan and consider any revisions that might be indicated at that time. An annual status report has been submitted to the Board every year since 1977. Periodically, there should be a comprehensive review of the plan. The most recent significant revision to the Master Plan occurred in 2021 when amendments were made, including updated information in several sections involving regional planning, flood planning, special projects, et al.

Trinity River Authority of Texas

Basin Master Plan

Water Supply

Background

To mitigate the effects of future droughts, the state created the Texas Water Development Board (TWDB) in 1957. In 1997, TWDB, in cooperation with Texas Parks and Wildlife Department, Texas Natural Resource Commission (now Texas Commission of Environmental Quality or TCEQ), and numerous stakeholder groups, produced the last water plan *developed at the state level*. Since 1997, state water planning has been a regional and local effort that is compiled into the state water plan.

Texas Water Planning

The Texas Legislature passed Senate Bill 1 in 1997. Senate Bill 1 directed the TWDB to create regional water planning entities, representing specific geographical areas. In all, 16 regional planning groups were created. Some of the factors used to delineate the regional water planning entities included: river basin and aquifer boundaries, water utility development patterns, socioeconomic characteristics, existing regional water planning areas, political subdivision boundaries, and public input. Each of the 16 regions create and submit a water plan to the TWDB, which approves each plan and combines all regional plans into a single state water plan. According to the TWDB, the Board will consider adopting the *2022 State Water Plan* in July, 2021. The plan forecasts water-supply efforts through 2070. Each of the 16 regions is comprised of a planning group that was required by Senate Bill 1 to include agriculture, industry, environment, public, municipalities, business, water districts, river authorities, water utilities, counties, groundwater management areas, and power generation. The tasks of the regional water planning process include:

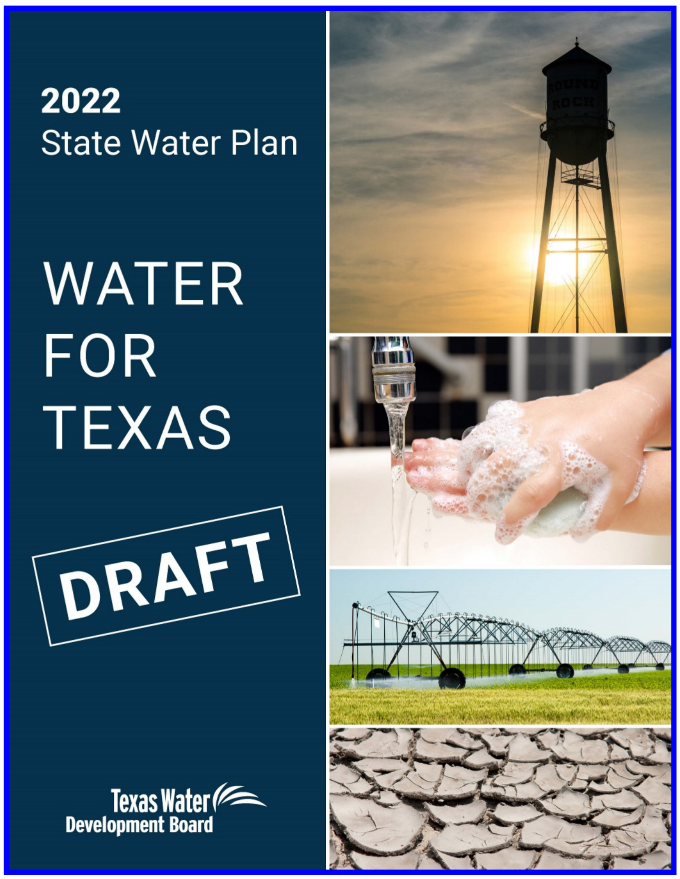


Photo: Draft 2022 Texas State Water Plan Cover Page

- Describe the regional water planning area
- Quantify current and projected population and water demand over a 50-year planning horizon
- Evaluate and quantify current water supplies
- Identify surpluses and needs
- Evaluate water management strategies and prepare plans to meet needs
- Evaluate impacts of water management strategies on water quality, agricultural and natural resources, as well as water resources of the state
- Describe how the plan is consistent with long-term protection of the state's water, agricultural, and natural resources
- Develop drought response information and recommendations
- Recommend regulatory, administrative, and legislative changes
- Describe how sponsors of water management strategies will finance projects
- Describe the state of project implementation in the regional planning area
- Prioritize the recommended projects in the regional water plan
- Adopt the plan, including the required level of public participation

The planning groups meet and conduct all functions during open meetings. Public meetings are held while developing the scope of work, and hearings take place prior to the adoption of the plans. Consensus building within the planning groups is crucial to ensure sufficient support for adoption of the plan. Planning group members adopt plans by voting at open meetings in accordance with each group's respective bylaws.

See page 12-15 for a summary of the latest Trinity basin (Regions C and H) regional water plans.

Regional Planning

The majority of the Trinity basin (81%) falls into on of two regional planning group: Region C or Region H (Fig. 2a). Region C is centered around the Dallas/Fort Worth metroplex in the upper basin and lies almost entirely (80%) within the Trinity basin. Further to the south, Region H is focused around the Houston area, however, only 29% of that region is within the Trinity basin. This is despite the fact that the Trinity supplies the majority of Region H's surface water supplies. By 2070, regional planning estimates project that 51% of Texas' population will live within Regions C and H. The 2021 Regional water plans were approved by TWDB in 2020. Overviews of the plans for Region C and Region H are included below.

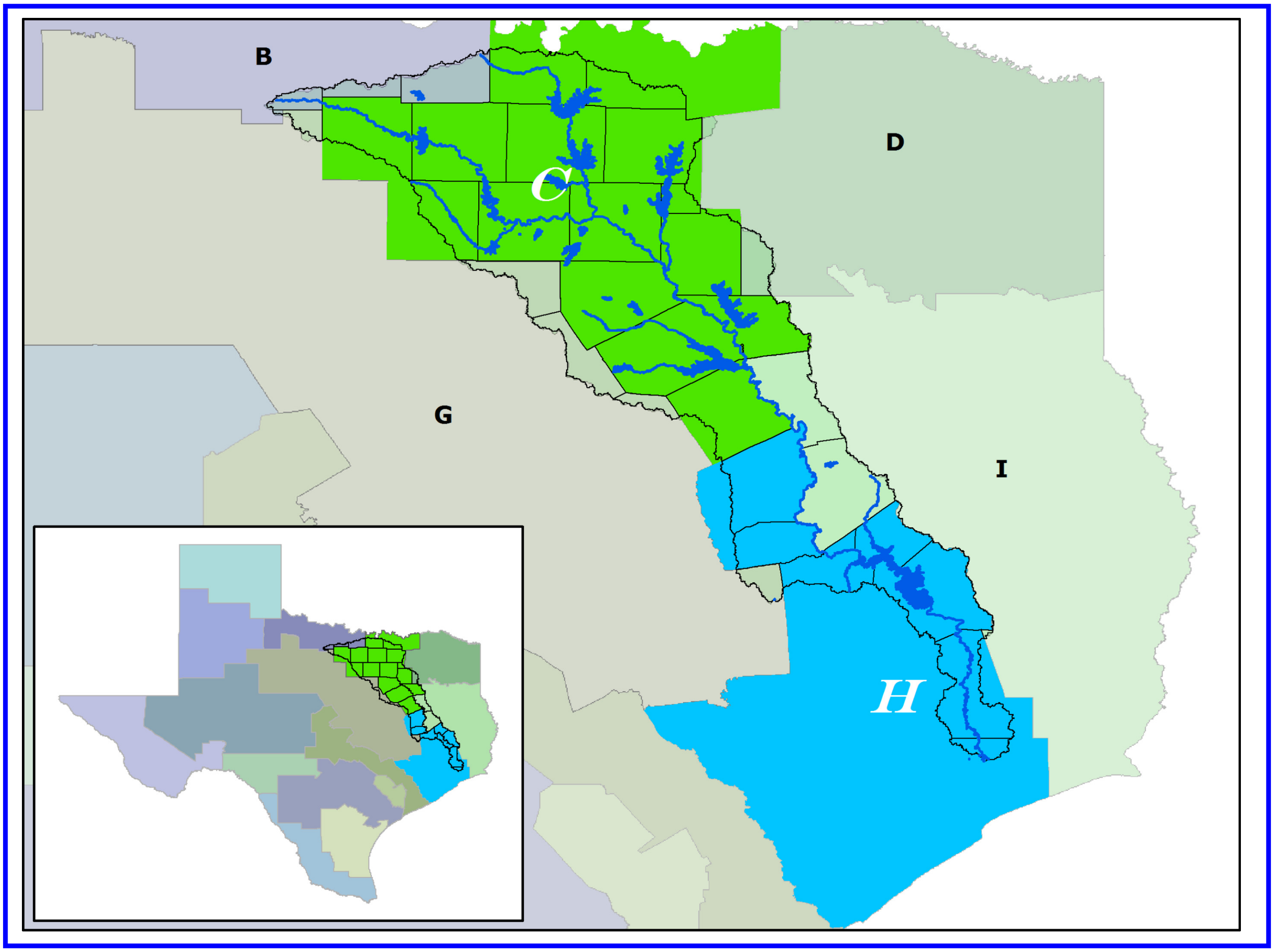


Fig. 2a. Map of Regional Water Planning Groups C and H

The Study Commission on Region C Water Supply was established by SB-3, Section 4.04, of the 80th Legislative Session. The Study Commission consisted of six members, three appointed each from Regions C and D. This commission was established in response to opposition to the proposal to build Marvin Nichols Reservoir in Region D to supply Region C in the future. The Study Commission was required to perform 8 tasks to evaluate water supply alternatives available to the Region C Regional Water Planning Area. The scope of work was divided into two Phases. The Phase I study included data collection, literature review and data gap analysis, with respect to five alternative water sources: Lake O' the Pines, Lake Texoma, Marvin Nichols Reservoir, Toledo Bend Reservoir and Lake Wright Patman. The Phase II study took the findings and recommendations from Phase I and conducted further data collection and analysis focusing on Lake Wright Patman and Lake O' the Pines as equivalent alternatives to the Marvin Nichols project. The Phase II study concluded that additional water is available from Lake Wright Patman and Lake O' the Pines. The amount of water available, however, varies depending on the strategy implemented and it was decided that a basin-wide study of the Sulphur River Basin is needed to fully evaluate these alternatives.

Summary of 2021 Regional Water Plans for Regions C and H

Region C (16 counties)

Population: The estimated population of Region C as of July 2016 was about 7.23 million, an increase of over 750,000 (11.7%) from 2010. The population is projected to grow to 10.15 million in 2040, and more than14 million by 2070 (28.5% of Texas' population) (Fig. 2b).

Water Use: The regional water use in 2016 was 1.34 million acre-ft, only 9.4% of the state's water use. About 90% of the total use is for municipal supply (Fig. 2c).

Water Demand & Supplies: Currently available water supplies for Region C are constant over time at 1.6 million af per year. The projected demand is 2.9 million af/y by 2070 (Fig. 2d). This will result in a shortage of 1.3 million af/y by 2070.

Water Sources: About 90% of the water supply for Region C is surface water, almost all of which originates from reservoirs. Groundwater is also an important source of water in some rural areas. Because about half of municipal water used in Region C is discharged as return flows from wastewater treatment plants, reuse and wastewater reclamation will continue to be a major component of future water supplies for Region C.

Water Management Strategies: The Region C plan includes water management strategies to develop 1.86 million acre-feet per year of new supplies, for a total available supply of 3.48 million acre-feet per year in 2070, about 20% greater than the projected demand. Among the 3.48 million af/y, 37% is the current available supply from surface water and groundwater; 32% or 1.35 million is developed from water conservation programs and reuse projects; 13% is from the connection of existing supplies, and 18% is from the development of new supply. In addition, the conservation and reuse strategies will result in a dry-year per capita municipal use of 96 gallons-per-capita daily (GPCD).

Five major new reservoirs are recommended in the plan. Selected major strategies are listed in Table 2a. The estimated total cost of implementing all of the recommended strategies is $30.44 billion.

Region H (15 counties)

Population: The population in Region H was approximating 6.8 million in 2015. That number is projected to grow to 11.7 million by 2070 (about 23% of Texas' population) (Fig. 2b).

Water Use: In 2015, the municipal water use in Region H was 971,759 acre-ft, and the total non-municipal water demand was 790,671 acre-ft. Municipal demands account for 55% of the total water use (Fig. 2c).

Water Demand & Supplies: The total current available water supply for Region H is 3.5 million af/y in 2020. The water demand is projected to increase from 2.7 million af/y in 2040 to 3.1 million af/y in 2070 as reservoirs lose storage through sedimentation, restrictions on the use of the Gulf Coast Aquifer, and groundwater reduction. The water supply shortages are projected to be 883,136 af/y in 2070 (Fig. 2e).

Water Sources: For Region H, majority of water supply consists of groundwater, surface water stored in reservoirs, and run-of-river sources. TWDB reports that in 2015 approximately 71% of water supply for Region H was from surface water, groundwater 28%, and reuse 1%.

Water Management Strategies: The recommended water management strategies will provide 945,474 acre-ft/y of additional water supply and conservation savings by 2070 for Region H. The water management strategies include increased source availability, newly developed water, and long-term demand management. The average targets for total gallons-per-capita daily (GPCD) is to 138 in 5 years, and 133 GPCD in 10 years. Some needs for Irrigation and Livestock remain unmet after the application of the recommended water management strategies and key projects.

Select major strategies with potential supply equal or greater than 50,000 acre-ft are listed in Table 2b. The estimated total capital cost to implement all of these strategies is $20 billion.

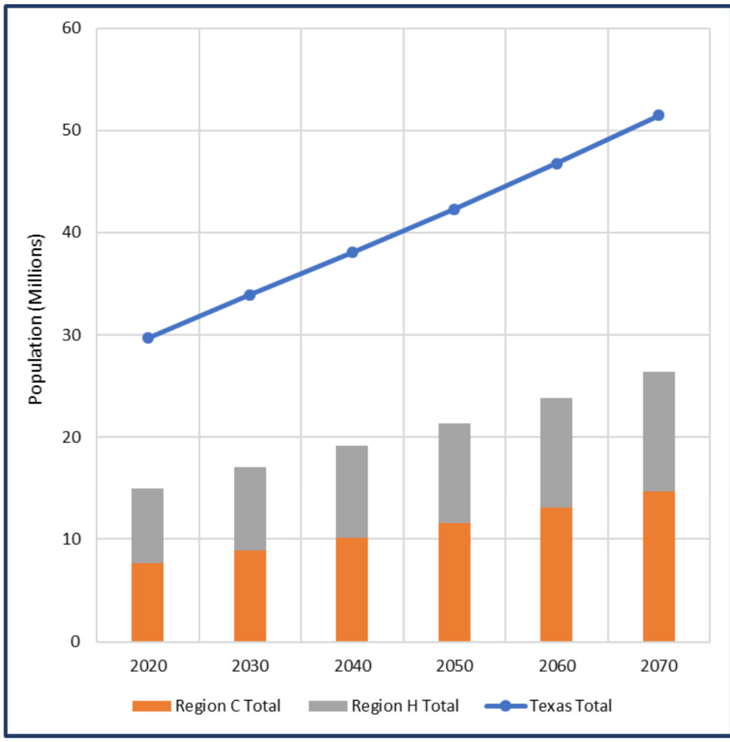


Fig. 2b. Population Estimates 2020-2070 for Texas, Region C, and Region H

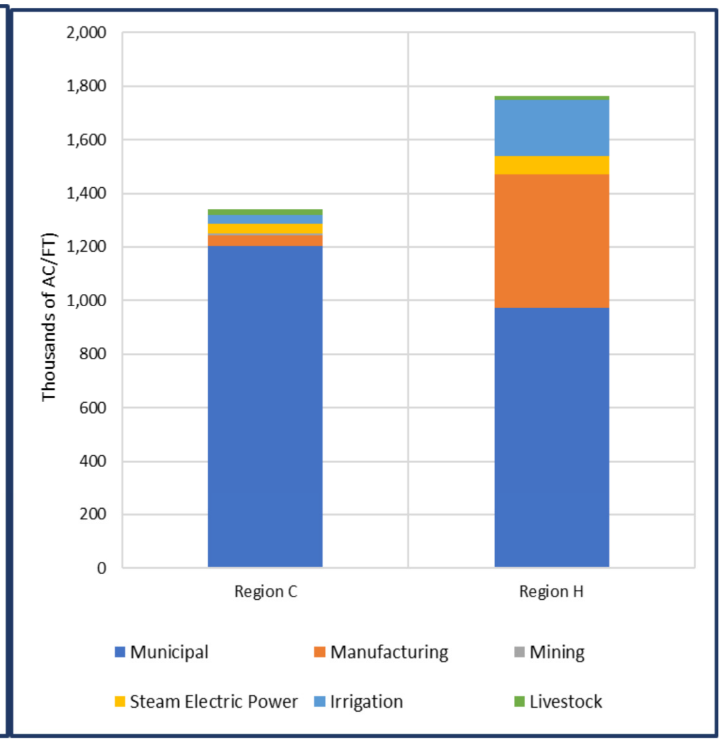


Fig. 2c. 2016/2015 Water Use for Regions C and H (By Category)

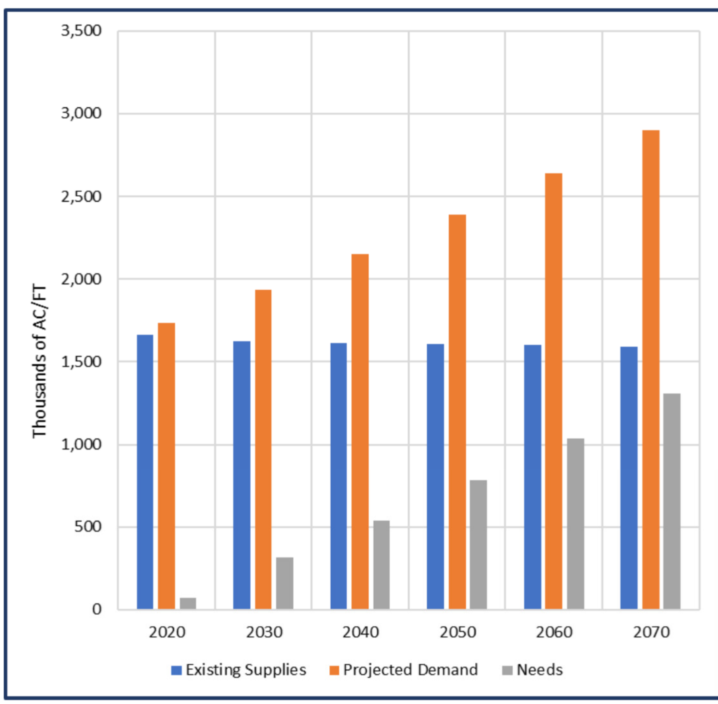


Fig. 2d. Region C Existing Supplies, Projected Demand and Needs 2020-2070

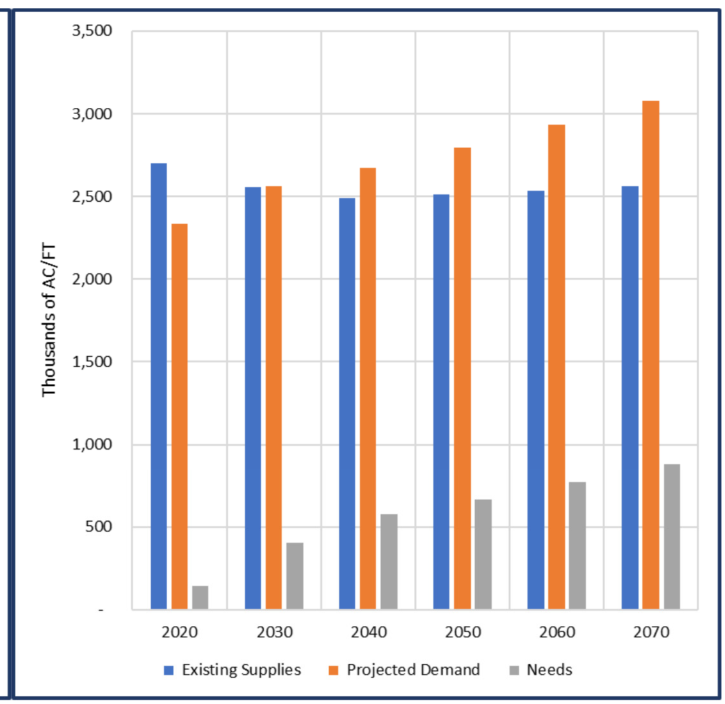


Fig. 2e. Region H Existing Supplies, Projected Demand and Needs 2020-2070

Access more Regions C and H information at:

https://www.twdb.texas.gov/waterplanning/rwp/plans/2021/index.asp

Table 2a. 2021 Region C Major Water Management Strategies

Strategy	Supplier	Supply in 2070 (Acre-Feet per Year)	Date to be Developed
Conservation	Multiple	202,676	Ongoing
Main Stem Balancing Reservoir (Reuse)	Dallas	95,829	2050
Connect Lake Palestine (IPL)	Dallas	105,370	2030
Neches Run-of-River	Dallas	47,250	2060
Lake Columbia	Dallas	56,000	2070
Bois d'Arc Lake	NTWMD	120,200	2020
Lake Texoma Blending	NTWMD	113,933	2040 Phase I 2060 Phase II
Marvin Nichols Reservoir	NTWMD	167,524	2050
	TRWD	167,524	2050
	UTRWD	26,152	2050
Wright Patman Flood Storage Reallocation	NTWMD	56,676	2070
	TRWD	56,676	2070
	UTRWD	8,848	2070
Oklahoma	NTWMD	50,000	2070
Cedar Creek Wetland Reuse	TRWD	88,059	2030
Reuse from TRA Central WWTP	TRWD	60,000	2030
Lake Tehuacana	TRWD	21,070	2040
Lake Ralph Hall and Associated Reuse	UTRWD	54,299	2030
GTUA Regional Water System (Lake Texoma Desalination)	GTUA	35,872	2020 Phase I 2030 Phase II

Table 2b. 2021 Region H Select Management Strategies (with Potential Supply >=50,000 af)

Project	Potential Vol (af)	Start Decade
Northeast Water Purification Plant Expansion	448,000	2030
CWA Transmission Expansion	349,785	2040
East Texas Transfer	250,000	2050
City of Houston Reuse	242,554	2040
WHCRWA/NFBWA Transmission Line	169,030	2030
GCWA Shannon Pump Station Expansion	162,400	2030
COH, NHCRWA, and CHCRWA Shared Transmission	154,575	2030
NHCRWA Distribution Expansion	143,360	2030
NHCRWA Transmission Lines	143,360	2030
NHCRWA GRP	143,360	2030
City of Houston GRP	124,914	2020
Municipal Conservation (Advanced Conservation)	123,251	2020
San Jacinto Basin Regional Return Flows4	119,673	2020
City of Houston West Water Purification Plant	103,385	2040
SJRA GRP	100,000	2030
Allens Creek Reservoir	99,650	2040
Irrigation Conservation	93,562	2020
WHCRWA Distribution Expansion	92,288	2030
WHCRWA GRP	92,288	2030
City of Houston Treatment Expansion	89,396	2040
Dow Reservoir and Pump Station Expansion	80,000	2030
BRA System Operation Permit	78,276	2020
LNVA Neches-Trinity Basin Interconnect	67,000	2040
Municipal Conservation (Water Loss Reduction)	62,601	2020
NFBWA Phase 2 Distribution Segments	62,496	2030
NFBWA GRP	62,496	2030
City of Houston Area 2 Groundwater Infrastructure	50,400	2030
Lake Livingston to SJRA Transfer	50,000	2050

Reservoirs

The vast majority of water supplies in the Trinity River basin are from surface water reservoirs. According to the TWDB, there are 32 reservoirs within the Trinity River basin (Fig. 2h, Table 2d). In addition, according to the 2021 Region C plan, five reservoirs located in Sulphur, Sabine and Neches Basins are permitted to import water to the Trinity Basin.

Reservoirs also serve an important economic and recreation function for their communities. Major resort and residential developments adjacent to water supply reservoirs can bring tremendous increase to a city's sales revenue, tax base, and jobs. Recreation on and around water supply reservoirs provide an important source of revenue and jobs for local residents. Anglers, boaters, campers, and day visitors support local economics through marinas, campgrounds, hotels, and restaurants.

Groundwater

The laws governing the pumping of groundwater stand in stark contrast to those of surface water. In 1904, the Texas Supreme Court cemented the idea of "absolute ownership" of groundwater by the landowner in Houston & T.C. Railway Co. v. East. The Court decided that landowners had the "right of capture" to groundwater in part because the "existence, origin, movement, and course of such waters, and the causes which govern and direct their movements, are so secret, occult, and concealed that an attempt to administer any set of legal rules in respect to them would be involved in hopeless uncertainty, and would, therefore, be practically impossible."

Groundwater may be used for any beneficial use but may not be: wasted, intentionally contaminated, maliciously pumped for the sole purpose of hurting adjoining landowners, or pumped to the point of causing land subsidence. As the scarcity of water increases, more focus is being placed on the efficient uses of groundwater. Parts of Texas are creating Groundwater Conservation Districts (GCD) whose goals are to: provide the most efficient use of groundwater, prevent waste, control and prevent subsidence, address conjunctive surface water and drought issues, and address conservation, recharge enhancement, brush control, and rainwater harvesting. According to the TWDB, GCD's are the "state's preferred method of groundwater management." GCD's are created by the legislature or TCEQ and have the authority to regulate the spacing of water wells and/or the production of water from wells. The Trinity River basin crosses the boundaries of 11 confirmed Groundwater Conservation Districts (Fig. 2f).

Eighty-six percent of the Trinity River basin lies over either a major (80%) aquifer, minor (59%) aquifer, or both. Aquifers are dynamic systems and are not constant across space or time and are dependent on surface water infiltration for recharge. In some cases, water is being pumped faster than the aquifer can recharge resulting in wells having to be extended, higher pumping costs, and land subsidence. The Trinity River basin overlays three major aquifers (Table 2c and Fig. 2g).

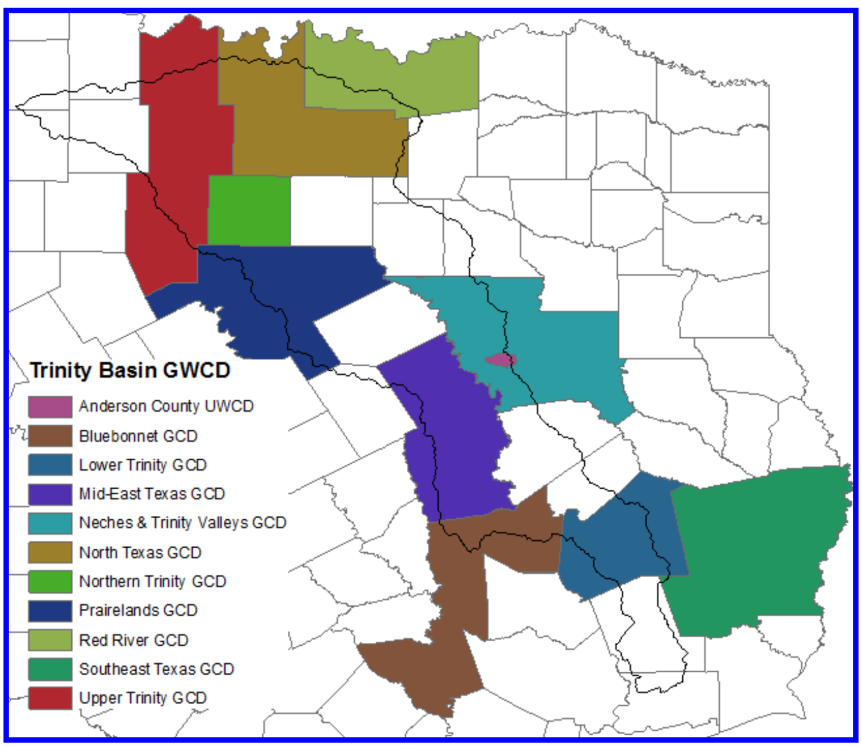


Fig. 2f. Trinity Basin Groundwater Conservation Districts (www.twdb.texas.gov/groundwater/conservation_districts/index.asp)

Table 2c. Major Aquifers in Trinity River Basin

Aquifer	Facts
Trinity Aquifer	• 10,692 mi² outcrop • 21,308 mi² in subsurface • 1.4 billion af of total storage • 357.2 million to 1.0 billion af of recoverable storage • Water is generally fresh but very hard • Some of the state's largest water level declines (ranging from 350 ft to more than 1,000 ft)
Carrizo-Wilcox	• 11,227 mi² outcrop • 25,491 mi² in subsurface • 5.2 billion af of total storage • 1.3 to 3.9 billion af of recoverable storage • Water is hard in unconfined area and softer in confined area
Gulf Coast	• 41,970 mi² area • 5.1 billion af of total storage • 1.2 billion to 3.8 billion af of recoverable storage • Water quality varies across and with depth (TDS varies: 500 – 10,000 mg/L) • Some wells show high level of radionuclides and arsenic

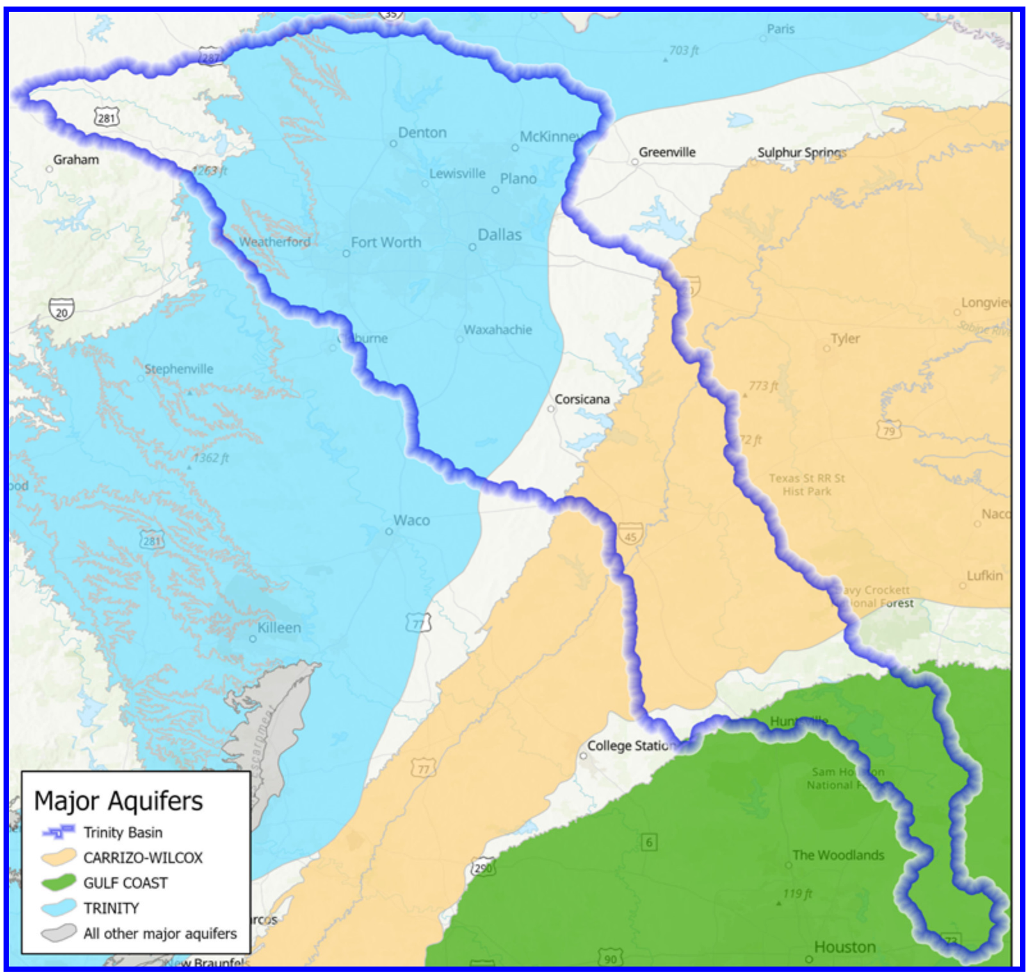
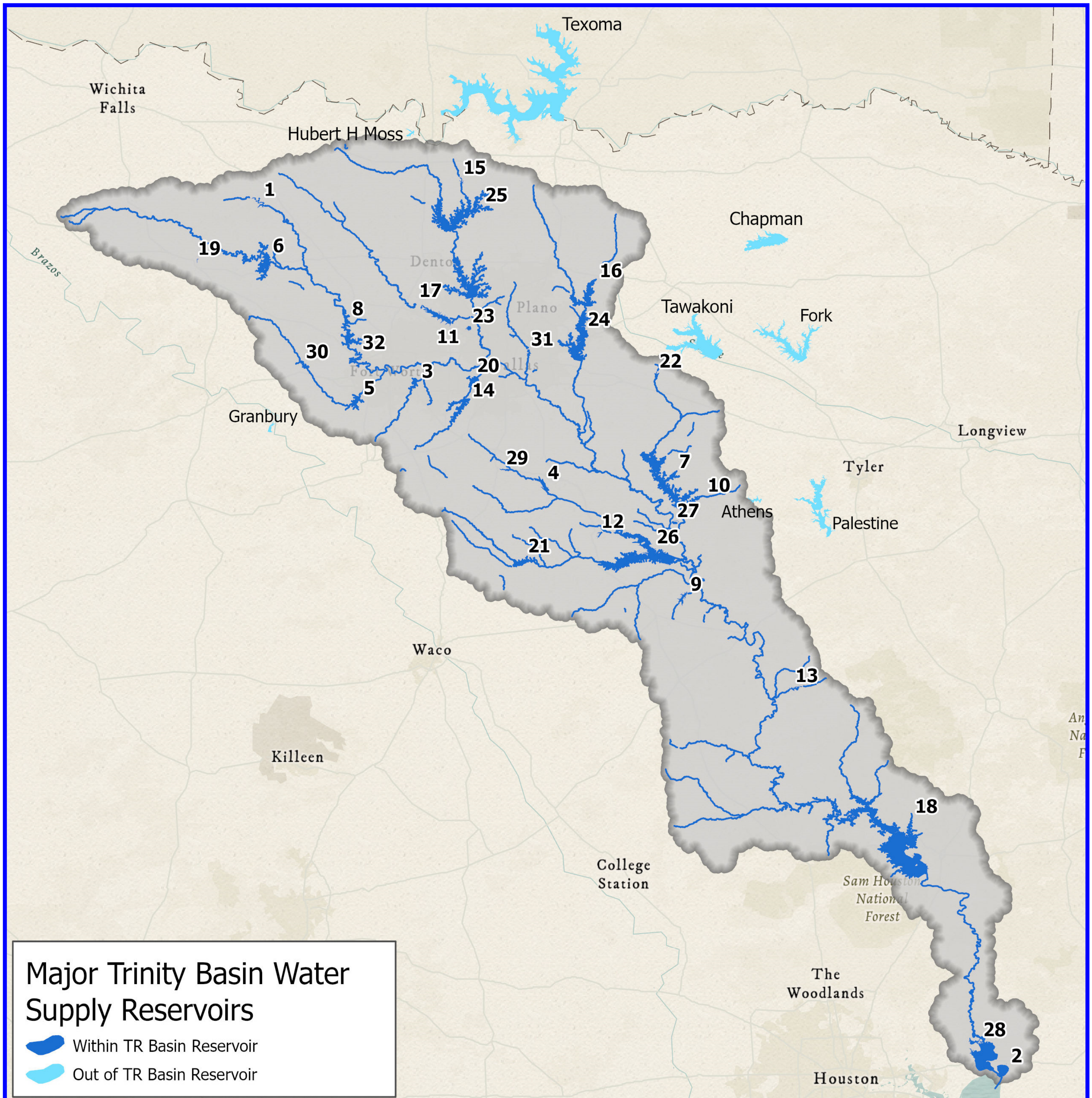


Fig. 2g. Trinity Basin Aquifers (www.twdb.texas.gov/groundwater/aquifer/major.asp)



Out of Basin Reservoir	Conservation Capacity [1] (acre-ft)
Athens	29,503
Chapman	260,332
Fork	605,061
Granbury	132,949
Moss	24,058
Palestine	367,303
Tawakoni	871,685
Texoma	1,243,801 [2]

Fig. 2h. Trinity Basin Major Water Supply Reservoirs (In/Out-of-Basin) as of 2021 (see Table 2c for Trinity Basin reservoirs)

Note:
1. Conservation capacity data is from Water Data for Texas and does not represent the amount of water imported into the Trinity Basin
2. Texas has rights to 50% of Texoma.

Table 2d. Lakes and Reservoirs in Trinity River Basin

# on Map	Reservoir	Conservation Capacity	Surface Area	Firm Yield (mgd)	Owner/Operator	Uses
1	Amon G Carter	19,266	1,422	2.3	City of Bowie	Mun/ind/min/rec
2	Anahuac	33,348	5,035	21.7	Chambers-liberty CND	Mun/irr/ind/min
3	Arlington	40,157	1,869	4.3	City of Arlington	Mun/ind/rec
4	Bardwell	46,122	3,138	9.8	U. S Government/ U.S. Army Corps of Engineers	Mun/flood/rec
5	Benbrook	85,648	3,414	6	U. S Government/ U. S. Army Corps of Engineers, Fort Worth District	Flood/conservation
6	Bridgeport	366,236	11,091	*b	Tarrant Regional Water District	Flood/storage/rec
7	Cedar Creek	644,686	32,873	156	Tarrant Regional Water District	Mun/flood/rec
8	Eagle Mountain	179,880	8,268	70	Tarrant Regional Water District	Mun/irr/flood/rec
9	Fairfield	44,169	2,159	6.9	TXU	Ind
10	Forest Grove	20,038	1,502	1.6 *d	TXU	Ind
11	Grapevine	163,064	6,707	19.1	U.S. Army Corps of Engineers	Flood/navigation
12	Halbert	6,033	548	0.5	City of Corsicana	Mun/ind/rec
13	Houston County	17,113	1,330	6.3	Houston County WCID #1	Mun
14	Joe Pool	175,800	7,232	14	U.S. Army Corps of Engineers	Mun/flood/rec
15	Kiowa	7,000	563	NA	Lake Kiowa Property Owners Association, Inc	rec
16	Lavon	406,388	20,559	93	U.S. Army Corps of Engineers	Flood/mun/rec
17	Lewisville	563,228	27,175	165	U. S. Government/ U.S. Army Corps of Engineers, Fort Worth District	Mun/flood/rec
18	Livingston	1,741,867	84,686	1120	Trinity River Authority	Flood/mun/ind/irr/rec
19	Lost Creek	11,950	413	1	City of Jacksboro	Mun/irr/rec
20	Mountain Creek	22,850	2,863	13.4	Texas Utilities Electric Company	ind
21	Navarro Mills	49,827	4,736	14.7	U.S. Government/ U.S. Army Corps of Engineers, Fort Worth District	Flood/mun/rec
22	New Terrell	8,583	849	0.7	City of Terrell	Mun
23	North	17,000	800	0.4	Dallas power and light company	Ind
24	Ray Hubbard	439,559	20,973	50	City of Dallas/Dallas Water Utilities	Mun/ind/flood/rec
25	Ray Roberts	788,167	28,151	*c	U.S. Government/U.S. Army Corps of Engineers, Fort Worth District	Mun
26	Richland-Chambers	1,087,839	42,946	187	Tarrant Regional Water District	Mun/flood/irr/rec
27	Trinidad	6,200	690	2	TXU	ind
28	Wallisville	no pools		80	US government/Corps for navigation	Salinity control/mun/fish/wildlife/rec
29	Waxahachie	10,780	631	2.4	Ellis County Water Control and Improvement District Number One	Mun/ind
30	Weatherford	17,812	1,039	2	City of Weatherford	Mun/ind
31	White Rock	10,230	995	4.8 *d	City of Dallas	Mun
32	Worth	24,419	3,198	*b	City of Fort Worth	Mun/rec

Notations for Table 2d
Firm Yield:

a. Where source documentation provides a basis for yield estimates for future years, estimates closest to 2010 conditions are used.
b. Bridgeport yield is included in the yield shown for Eagle Mountain.
c. Ray Roberts yield is included in the yield shown for Lewisville.
d. Calculated using WAM RUN3.

Uses: mun - municipal; ind - industry; rec - recreation; flood - flood control; min - mining; irr - irrigation

Water Rights

Water has been a source of life, prosperity, and conflict since settlement began in Texas. Because of the importance of water on the Texas plains, colonizers sought to secure legal water rights. Texas water law has evolved from a mixture of Riparian Doctrine and Prior Appropriation Doctrine into what it is today.

Texas water law is based on the principle of "first in time, first in right." In other words, senior water rights holders have the authority to take their allotted portion of water before a junior water rights holder. It has been said that water does not flow downhill, it flows towards priority dates. If a senior water right holder is downstream of a junior water rights holder, the junior holder must allow the water to flow through to the senior rights holder. During a drought, the decision to shut off water pumping is made by a Texas Watermaster. Currently, four areas operate under a Watermaster Program: Rio Grande, Concho River, South Texas, and Brazos.

Water Rights Adjudication – The adjudication of the Trinity River Basin water rights was completed in the 1980s. It has upheld in full almost all rights which had been granted under permits and certified filings. Of the many small claims which had been based upon riparian or other rights, only a minority were acceptable under the various legal and factual tests which were applied. All water rights and priorities are now completely defined. Each water right was given a priority date that essentially sets the holders place for the "first in time" line. The earliest priority date in the basin is 1906 and the earliest in Texas is 1731.

Large Run-of-River Water Rights – In the Lower Trinity basin, there are several canal systems which supply water primarily to rice farmers, with lesser quantities supplied for municipal and industrial needs. Three of these systems entered into written agreements with the co-sponsors of the Livingston and Wallisville projects to ensure that a fixed amount of water would be made available. These agreements became known as the "Fixed Rights Agreements." Releases of water stored in Lake Livingston, together with available streamflow originating downstream of Lake Livingston, are to be provided to each system in amounts shown in Table 2e.

The water rights of the "Fixed Rights" parties have been modified significantly since 1995. The San Jacinto River Authority (SJRA) purchased from the Devers system the rights to 56,000 af/y year for use in Montgomery County in the San Jacinto River basin. That water is no longer intended for irrigation use in the Trinity basin, as was the case when the fixed rights agreements were made, and does not retain the claim on Lake Livingston stored water that was indicated in those agreements. The city of Houston has purchased the Dayton Canal System. Also, the Chambers-Liberty Counties Navigation District and SJRA have agreed to convey 30,000 af/y of the District's water to SJRA for use in Montgomery County. In addition to the "Fixed Rights Agreement," the city of Houston holds permits totaling 78,000 af/y on the Trinity River below Lake Livingston which were formerly held by the Southern Canal Company (45,000 af/y) and Dayton (33,000 af/y). The trend of water rights shifting away from irrigation and towards municipal uses is expected to continue.

Small Run-of-River Water Rights – There are numerous relatively small diversions with little or no storage to firm up the supply during low flows. For a list of lower Trinity water rights with a diversion equal or greater than 1,000 ac-ft/yr see Appendix 4. Many of these rights are for irrigation purposes.

Photo: Coastal Water Authority's Trinity River Water Conveyance and Distribution Systems

Table 2e. Summary of Historic Lower Trinity Fixed Water Rights

Original System Name	Current Owner	Amount of Rights (AF/YR)	Water Right Priority Year
Chambers-Liberty Counties Navigation District (CLCND)	CLCND	58,820	1906, 1914
	San Jacinto River Authority (SJRA)	30,000	
	Total	88,820	
Devers Canal System	Devers	30,000	1917, 1926, 1929, 1936, 1959
	SJRA	56,000	
	Total	86,000	
Dayton	Houston	33,000	1913
	Total	33,000	
Southern Canal Company	Houston	45,000	1913
	Total	45,000	

Photo: TRA and TPWD Lake Livingston Fish Procurement 2018

Trinity River Authority of Texas

Basin Master Plan

Conservation and Preservation

Background

Need for Water Conservation – Most of the more desirable sites for surface water development have been, or soon will be, utilized to meet intra-basin and extra-basin water supply needs. This fact, in addition to the increasing expense of providing water from sources located far distances from needs, places a practical limit upon the availability of surface water. In addition, existing water supplies are gradually reduced by sedimentation in reservoirs.

Moreover, various amounts of water are used beyond the point of providing for basic needs. Examples include overwatering lawns, and leaking toilets and other water fixtures. When a drought strikes, it is important that these non-essential uses be curtailed in order to preserve supplies for essential uses. This is often achieved by both voluntary and compulsory restrictions, but also by making people aware of the crisis. Planning for water supplies generally attempts to provide adequate water for peak rates of use, plus a safety factor. This has resulted in more and more distant supplies as urban centers have exhausted local sources.

The transportation of water over long distances can in fact become more expensive than the construction of the source, usually a reservoir, itself. The construction of the Coastal Water Authority system to transport water from the lower Trinity River to Houston cost approximately twice as much as the construction of Lake Livingston, which provides the water to be moved.

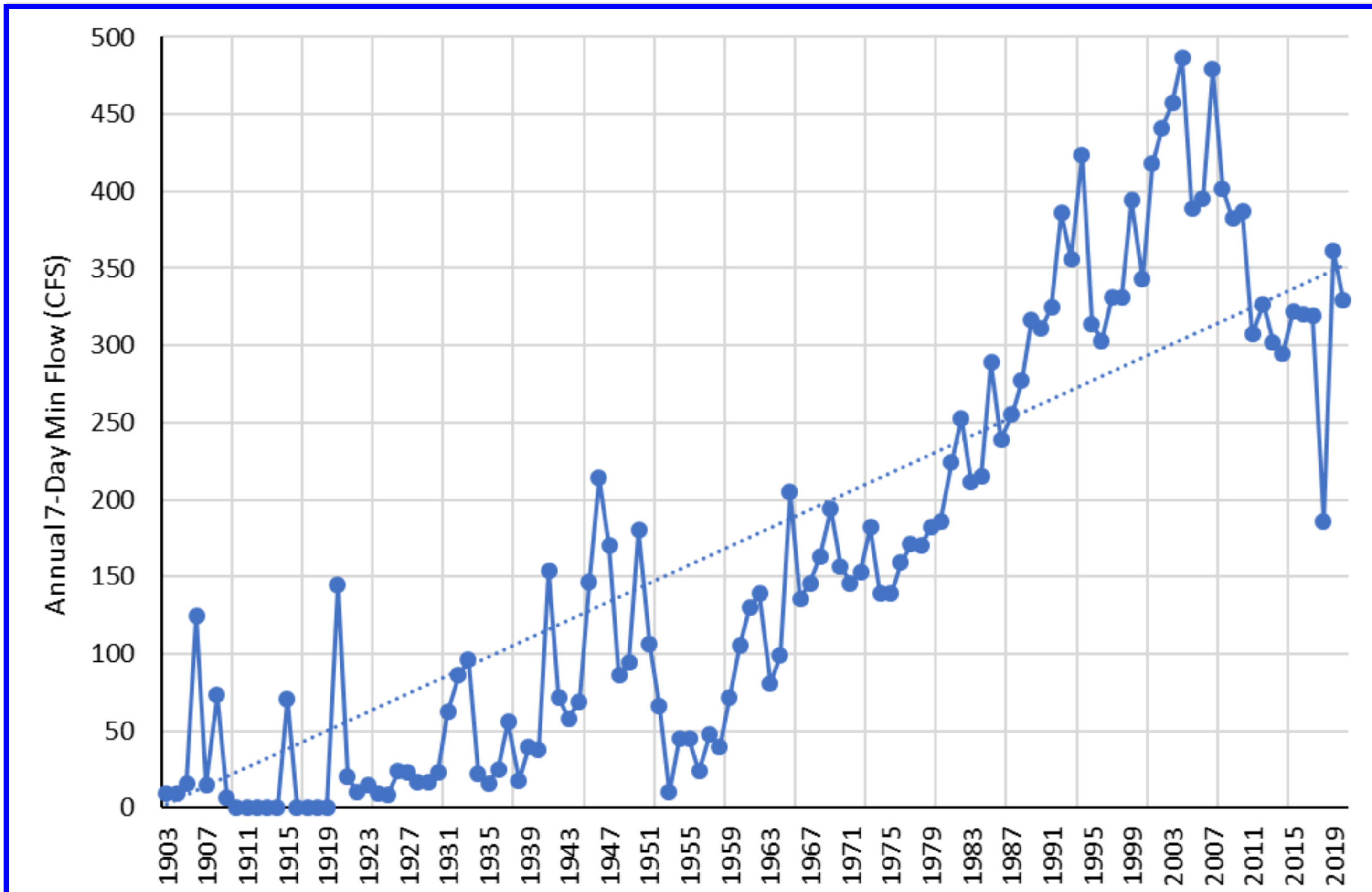


Fig. 3a. Annual 7-Day Minimum Flow at Trinity River at Dallas 1903-2020. Note the big drop in low flows resulting from a dry summer in 2018 and water conservation. Monthly precipitation was less than 2 inches consecutively from April to July 2018.

Conservation Strategies – Historically it was common for water suppliers to encourage consumption through rate structures that provided discounts to large users. A level or reversed rate structure, which has become much more common, encourages judicious consumption of water. The city of Dallas uses a scaled rate in order to encourage conservation and lower peak water demands during summertime lawn watering. While this has the immediate benefit of conserving water supplies for vital uses, it can also save the massive capital expenses of developing new supplies, and the ongoing operation and maintenance expenses of running them.

As the need for, and benefits from, conservation have become more apparent, conservation has become much more main stream. The Texas Water Development Board, for instance, requires any applicant for financial assistance through that agency to have a conservation plan.

Soil and Water Conservation

The programs of the soil and water conservation districts of the basin include land management programs which are designed to control soil erosion and water runoff, the construction of small reservoirs for soil and floodwater retention and, in the Trinity basin, a small amount of stream channelization. The land management programs of the districts are the essence of conservation, as they are designed to make best use of naturally-occurring rain water. Even the programs which involve structural changes in streams and waterways, including floodwater retarding structures and stream channelization, are designed for local watershed requirements and require application of conservation techniques in the associated watershed.

This plan recognizes the responsibility of the soil and water conservation districts and the State Soil and Water Conservation Board to provide the plan for their programs in the basin, rather than attempt to reproduce them here. Their plans are recognized and included by reference in this Master Plan for the Trinity River basin.

Photo: TRA Wolf Creek Park

Trinity River Authority of Texas

Basin Master Plan

Water Reuse

Background

Photo: Las Colinas Urban Water Reclamation Project in Irving, Texas

When reuse in the Trinity was first seriously considered after the drought of the late 1950s, the standard for municipal wastewater treatment was called "secondary" treatment. It was designed to produce water with a biochemical oxygen demand (BOD) and total suspended solids (TSS) of approximately 30 mg/l each. The quality was suitable for some irrigation purposes, but very little of it was used that way in the Trinity basin. Almost all of it was discharged to streams, where it was aptly named "Wastewater", and in most cases produced a distinct reduction in dissolved oxygen and some toxicity due to ammonia and chlorine residuals. Moreover, a lack of enforcement and public interest resulted in many plants not performing as well as designed.

The environmental movement in the mid-1960s created a fundamental change in the industry. Under the Texas Water Quality Act (1967) the major permit limits in the Dallas-Fort Worth area were lowered to 10 mg/l for BOD and 12 mg/l for TSS. The new standards required improved biological treatment and sand filters. The federal Clean Water Act (1972) adopted those requirements and, over time, continued to require more improvements. BOD limits were lowered further and ammonia limits were added, requiring complete nitrification. Treatment to remove chlorine residuals were added. Moreover, since the permit limits are the limits of what is legally allowed, the plants must perform even better than those limits almost all the time in order to still meet them under the most adverse conditions. The result is consistently high water quality.

The Trinity River basin has relatively high rainfall and runoff on average but it is notoriously erratic. Even a normal year has much of the rain and streamflow in the late spring followed by very hot dry weather from mid-June through August. Population growth and economic activity in the Trinity basin has necessitated extensive development of water supplies to get through the dry periods. On average, about 60-65% of the water supplied in a municipal system is subsequently discharged into the wastewater system. The return flow is fairly constant: a characteristic that is essential for water supply (refer to the annual 7-day minimum flows at Trinity river USGS gage at Dallas from 1903-2020 in Fig. 3a). However, the quality of treated wastewater for many years was not of sufficient quality for most forms of reuse. It was discharged to a stream and natural processes gradually purified and diluted it. In many cases, the water entered and supplemented another water supply downstream. This was not done intentionally to supplement a water supply, but as a practical matter, and became accidental reuse.

It does not appear that it will ever be possible or desirable to reuse all reclaimed water. Some flows need to remain in the stream to support the natural environment and to protect downstream water rights and supplies. Moreover, repeated cycles of reuse become progressively more difficult and expensive. Reuse will be an ever more important part of water supplies, but there are limits and constraints to what is practical.

Reuse Explained

What is reuse? In the Trinity River basin, the same parcel of water is reused several times over before being discharged into Trinity Bay. For example, runoff collects in Lake Lewisville, is then pulled out of Lake Lewisville and pumped north to be used by the city of Denton. Denton treats the water and discharges the water back into Lake Lewisville. The same water could then be pumped out of Lewisville and used by Dallas. Dallas treats the water and discharges it back into the Trinity River. Continuing south, the same water could be pumped out by the city of Huntsville, cleaned, and discharged into Lake Livingston. Once in Lake Livingston, the water could be pulled out by Houston and used again. Finally, Trinity River water could be discharged from Houston into the San Jacinto River and arrive in Galveston Bay from a different river basin altogether.

Two types of reuse exist: direct reuse and indirect reuse. Direct reuse is using water that is pumped directly from a treatment plant to another location without ever entering a surface water system. Currently, direct reuse does not require a water rights permit because the original user still controls the water. Indirect reuse is using treated water after it has been discharged into a receiving stream or other surface water. For example, a treatment plant discharges water into the stream and that water is later pumped from the stream to irrigate a golf course. Because the water is being diverted from Texas surface waters, the golf course must own a water right's permit to divert the water.

Past and Present Issues

Reclaimed Water – In 1959, the quality of treated wastewater did not make it attractive for reuse. Over the next four decades, improvements in wastewater treatment by all parties in the basin have made it very feasible. New treatment technologies increase the possibilities every year. The word "wastewater," as applied to water produced by a wastewater treatment plant, is now out-of-date in several respects:

- It is not "waste" in the sense of "poor quality." It is good quality and getting better. Most "waste" has been removed.
- It is not "waste" in the sense of "unusable." It is suitable for many uses and there is an increasing demand for it.
- It is not "waste" in the sense of "cheap." A large amount of money has been spent to remove the waste.
- It is not "waste" in the sense of "without value." There is a market of buyers willing to pay a price for it.

Today a more appropriate term is "reclaimed" water. It may be wastewater when it enters the plant and what happens there may be considered wastewater treatment. But after treatment, it is no longer "waste" water. Even "treated wastewater" is ambiguous and fails to convey the radical transformation that has occurred.

Quantity of Reclaimed Water – The great majority of reclaimed water in the Trinity basin comes from municipal plants (approximately 95%). According to the 2021 Region C Water Plan, Region C anticipates that the reuse portion of the water supply will increase from 337,067 acre feet in 2020 to 411,487 acre feet in 2070. In the 2021 Region H Water Plan, reuse is expected to increase from 42,148 acre feet in 2020 to 50,463 acre feet by 2070 (Fig. 4a).

New Treatment Technologies – A number of treatment technologies have advanced dramatically in recent years. For example, various types of membrane technologies have been used successfully in water reuse treatment. There are a variety of types of reliable membranes which can produce almost any desired level of purity, including the removal of all cysts, bacteria, viruses, organics, metals and inorganics. Membrane treatment is rapidly increasing in both wastewater treatment and drinking water treatment. Other technologies are also being widely developed and applied for removal of nutrients. Carbon is widely used to remove organics, disinfection byproducts, and tastes and odors. In addition, many treatment plants are using ultraviolet light or ozone instead of chemicals to disinfect effluent.

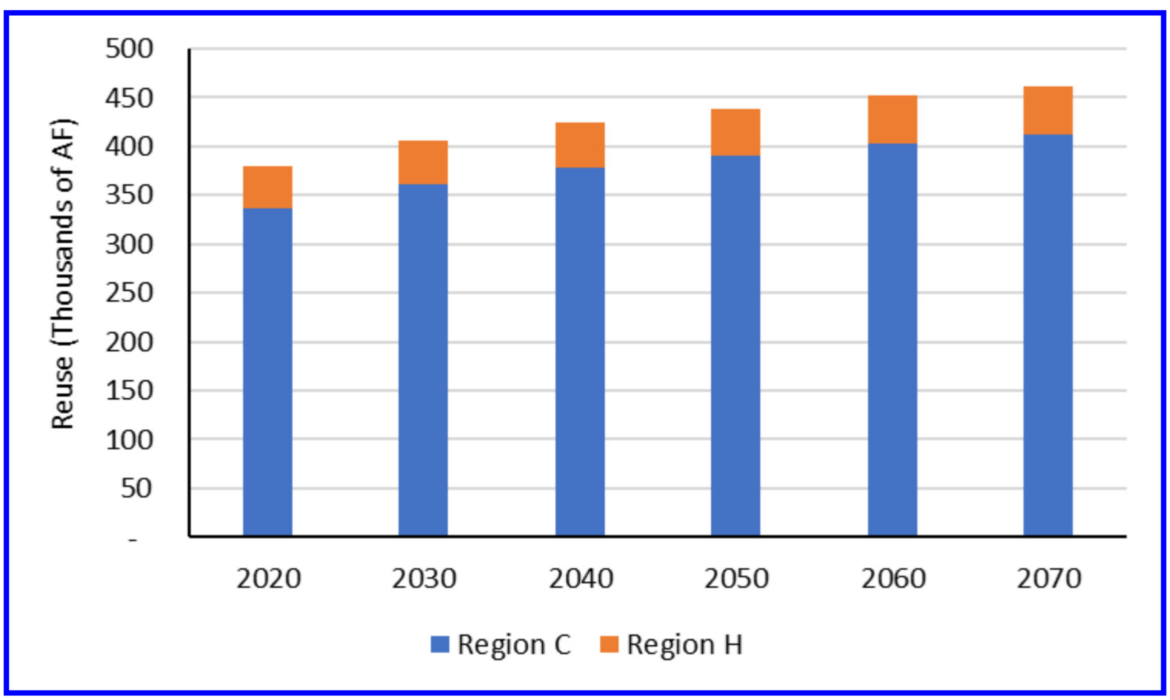


Fig. 4a. 2020 to 2070 Indirect/Direct Reuse Estimates for Regions C and H

Regulations that May Require New Treatment Technology – State and federal regulatory agencies have developed regulations for both drinking water and wastewater treatment which require one or more of the new technologies discussed above. For example, the Enhanced Surface Water Treatment Rule under the Safe Drinking Water Act focuses on the removal of the smallest solid particles in order to exclude infectious organisms, such as *Cryptosporidium* that are resistant to disinfection, or to reduce organic substances that can form carcinogens during disinfection. Such requirements apply regardless of any reuse that may be involved, but may result in the requirement of membrane technology, which in turn addresses a wide range of contaminants and constitutes a broad barrier to contamination. The Disinfectants / Disinfection-Byproduct Rule and the Total Trihalomethane MCL, which address mainly potential carcinogens, and the Arsenic MCL, among others, may also require membrane or carbon treatment. Also, under the Clean Water Act, the Environmental Protection Agency requires all states to develop numeric stream standards for nutrients. In Texas, TCEQ has been conducting studies to develop numerical nutrient criteria for select streams, rivers and estuaries.

"Emerging Concerns" that May Require New Treatment Technology – There is concern about various pharmaceuticals that get into water via human excretion and by drugs being flushed down the toilet. Other sources of pharmaceuticals in water are thru drug manufacturing plants, healthcare institutions and agriculture. Antibiotics and drugs used in the livestock industry can also enter the water. Antibiotics in the receiving stream might create an environment that selects and propagates new antibiotic-resistant pathogens. Hormones such as estrogen might affect fish or water supplies downstream. These are possibilities that are being studied by scientists at present, but if they are determined to be a real problem, advanced treatment of the type discussed above would be called for. Advancements in detection technologies have allowed scientists to study these emerging contaminants and it is anticipated that the next decade will bring better understanding of their importance.

Reclaimed Water as a Commodity with Several Stakeholders – The steady, reliable flow of reclaimed water, its high quality, the cost of producing it, and increasing demand make reclaimed water a commodity. At the same time, it is a resource in which several stakeholders have an interest, especially in the upper basin (Fig. 4b), where large volumes are routinely discharged. The ratepayers of the utilities have paid for both the water supply and wastewater treatment and they have an interest in how it is reused. Other factors to consider include: environmental needs and requirements to maintain flow in the stream, and the protection of prior water rights. Reuse will have to be implemented in ways that are consistent with its characteristics as both a commodity and a public resource.

Existing Markets and Uses for Reclaimed Water – Various reuse markets and uses have developed over the last two decades. TRA implemented a reuse project with the Las Colinas development in Irving in 1985. Reclaimed water is purchased by the Dallas County Utility and Reclamation District (DCURD) to maintain the level of scenic lakes, and to irrigate landscaping and several golf courses. A number of sales of reclaimed water have been made in the Trinity basin, and elsewhere in Texas, for water supply cooling water for commercial electric generating plants and for watering golf courses. The North Texas Municipal Water District constructed a 2,000 acre constructed wetland adjacent to the East Fork of the Trinity. Return flows from various sources, including up to 56,060 AF/yr of TRA discharges, are polished through the wetland before being pumped to Lake Lavon for water supply.

The Tarrant Regional Water District (TRWD) has created a reuse project that diverts return flows from the Trinity River into a constructed wetland adjacent to Richland Chambers Reservoir. The wetland reduces the amount of nutrients that enter the reservoir and helps prevent eu-

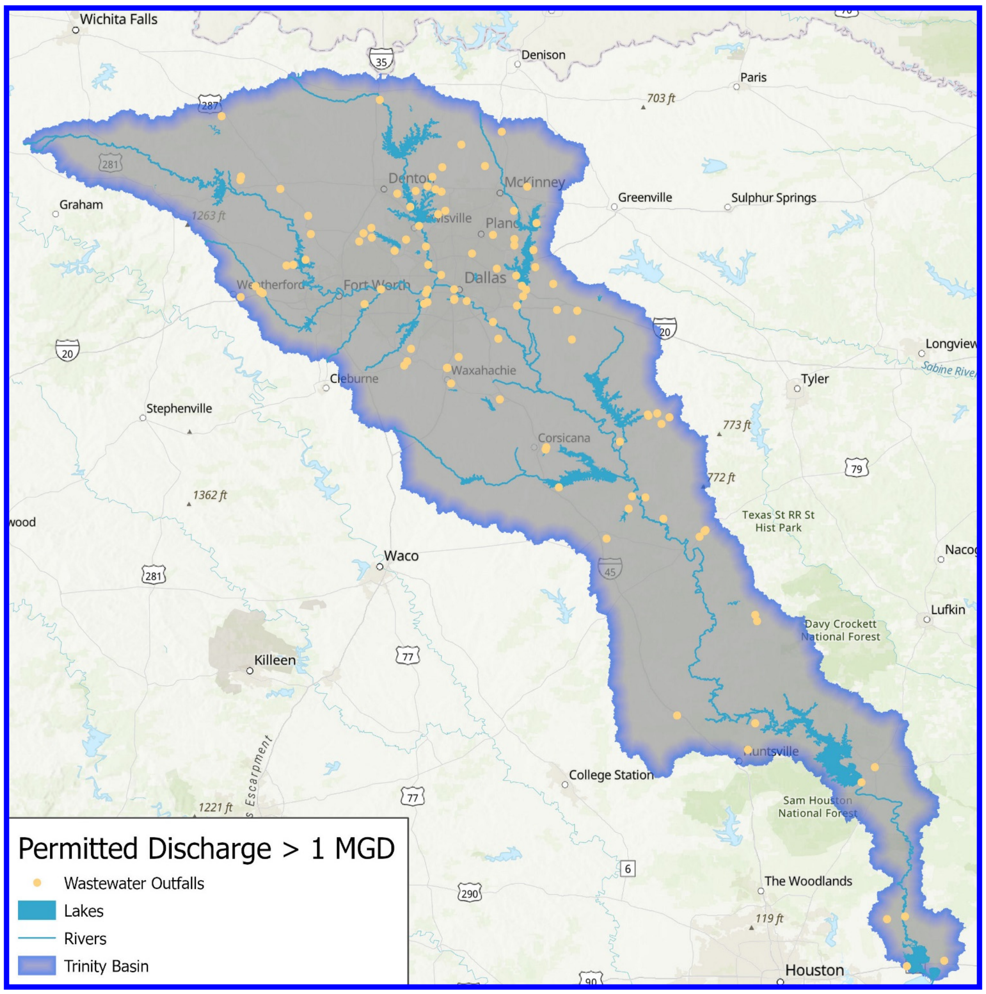


Fig. 4b Dischargers Permitted Above 1 MGD in Trinity River Basin

trophication. TRWD is in the process of developing a second wetland that will be used to treat Main Stem return flows that will be pumped through Cedar Creek Reservoir.

Direct Potable Reuse—During the drought of 2011-2014, two towns in west Texas implemented direct potable projects. In May 2013, the Colorado River Municipal Water District began operating the first direct potable reuse facility in the state and the nation by reclaiming the wastewater effluent from the city of Big Spring and producing about 2 MGD of potable water. In July 2014, the city of Wichita Falls began operating a direct potable reuse facility under emergency conditions by conveying wastewater effluent from the River Road Wastewater Treatment plant to a desalination facility, producing approximately 5 MGD of potable water. The plant was converted to indirect potable reuse in July 2015. El Paso Water Utilities conducted pilot-scale testing for an advanced water purification facility in 2016. Additionally, Dallas plans to reuse some of their reclaimed water in Ray Hubbard and Lewisville reservoirs. The Upper Trinity Regional Water District (UTRWD) also has contracts to buy raw water from Dallas and Denton and has an indirect reuse permit.

Reuse and Lake Livingston – At the time of TRA's founding in 1955, there were already many *de facto* cases of reuse, however, it was not specifically identified as reuse and the amounts of water were relatively small. TRA's enabling legislation empowered TRA to do several things, but only one was required. That was to prepare a Master Plan for the water resources of the basin. This occurred during the drought of the 1950's as all water suppliers were seeking new sources, both near-term and long-term. The Legislature's purpose in requiring TRA to create a Master Plan was to combine all the separate water supply plans within a single document and to help reconcile differences. This particular function has largely been superseded by the regional water planning process.

The most controversial proposal of the time was for a large lake on the lower Trinity River to supply water to the Houston area. TRA and its Master Plan became the vehicle of the Trinity basin interests to ensure that the reservoir did not damage competing interests to limited water supplies. As a result, TRA became a partner with the city of Houston in the development of the reservoir, which became Lake Livingston. As a compromise, several assurances were incorporated into Livingston's permit to provide water to the mid- and lower- Trinity basin and to protect upstream supplies. During the development of Lake Livingston, the unusual step was taken in the process of acquiring water rights for the lake to specifically recognize that wastewater discharges from upstream made up a significant portion of the drought period inflows, or firm yield, and resulting water appropriation. An engineering report in 1959 noted that, "Although the two principal cities in the Upper Basin so far do not seem to contemplate the reuse of Trinity waters, the Trinity River Authority does consider that possibility." Consequently, the Lake Livingston water rights permit is specifically subordinate to the reuse of upstream return flows.

Legal Issues

Water Rights Permits Involving Reclaimed Water – Several permits have been issued for water rights involving reclaimed water since 2000. They are all quite different from each other as to physical scheme and legal basis. They include the Tarrant Regional Water District, the Trinity River Authority for the reclaimed water from four of its wastewater treatment plants, the city of Dallas from its two wastewater treatment plants and two additional wastewater treatment plants. The North Texas Municipal Water District (NTMWD) also owns permits for reclaimed water from several wastewater treatment plants (Table 4a). The Upper Trinity Regional Water District and the city of Irving have permits for reclaimed water associated with water imported from the Sulphur River basin.

Sequential Ownership and Control in Regional Systems – Many small cities and districts in rural areas own and operate their entire water supply and wastewater systems. In such cases the city or district can design and implement a reuse project in whatever way is most efficient for them without concern about ownership or control because they own the entire cycle. Regional systems, however, which provide almost all service in urban areas and even some rural areas, are completely different. There are eight steps through which water passes in a water supply and wastewater system: raw water sourcing, raw water transmission, drinking water treatment, potable distribution system, users' homes and workplaces, primary collection system, secondary collection system and wastewater treatment. The water and facilities at each step may be owned and controlled by a different party. Moreover, each owner may acquire water from more than one entity at the prior step and convey it to more than one entity at the next step. In fact, the water utilities of the Dallas-Fort Worth Metroplex are made up of many networks of this type. Notwithstanding the complexity, it works and adapts efficiently to the constantly changing requirements of the area.

Wastewater Plants as Key Locations for Reuse Decisions – In the above-described sequence through which water passes, the wastewater plant is the focal point for decisions regarding reuse. Prior to the retail users, reuse is not relevant because the water has not even been used the first time. Afterward it is too dirty to reuse until it is reclaimed. At the wastewater plant, when treatment is complete, the water is of known, consistent quality and quantity. If it needs further treatment to be suitable for a certain potential reuse, or transport to reach the point of reuse, it is at the wastewater plant that the fullest range of options exists, from which the best alternative can be chosen. Among the options are further treatment at the plant, or treatment at the point of use; it can be transported by pipeline or discharged into a natural waterbody for conveyance downstream.

Water Rights – Many different doctrines, guidelines, and legal theories have been advocated and applied regarding water rights involving treated water from wastewater plants. Historically, most calculations of yields and water rights have not included wastewater flows, but some have, and for some, the records do not show whether they were considered or not. Wastewater is a small fraction of the total appropriation in some cases, but in some it is large. In some cases the wastewater source is specifically acknowledged, and in others not. There are distinctions and debates about "direct" and "indirect" reuse, the "four corners" of water rights, "bed and banks" permits, the "seniority" of reuse, "reclaimed," "developed," and "surplus" water, "return flows" and other matters.

There is no settled and consistent approach to water rights involving reuse that adequately comprehends 1) the great variety of arrangements regarding water ownership and liabilities among municipalities, users, and regional water utilities, 2) the developing markets and competition for water supplies, 3) the requirement by law of progressively more advanced treatment by both wastewater and drinking water treatment plants, 4) the advanced treatment technologies which enable the production of extremely purified water at progressively lower costs, and 5) the state's need to manage and monitor the use of its water.

For more information about water reuse, visit the Water Reuse Association at:

www.watereuse.org

Table 4a. List of Water Right Permits Involving Reclaimed Water

Entity	Permitted Return Flows (af/yr)	Permit Number	Remarks
NTMWD	71,882	08-2410E	Discharges from Wilson Creek WWTP
	157,393	08-2410F	Discharges from Buffalo Creek WWTP, Farmersville #1 and #2, Garland Duck Creek, Garland Rowlett Creek, Muddy Creek, Murphy, Rowlett Creek, Rush Creek, Seis Lagos, Shepherds Glen, South Mesquite, Southside, Squabble, Terry Lane and Wylie; When USGS East Fork nr Crandall >=25.8cfs; 30% of District Return Flows be left in the Trinity
	28,340	12472	Discharges from Panther Creek WWTF, Stewart Creek West RWWTF and Cotton Creek WWTF into Elm Fork and its tributaries
DALLAS	97,200	08-2456E	Discharges from city of Lewisville WWTP, Town of Flower Mound WWTP, Dallas Southside WWTP and Dallas Central WWTP
	150,000	08-2462G	Combined with 08-2456, leave 114,000 AF/yr discharged from Dallas Southside and Central in Trinity
	247,200	PM 12468 (A)	Divert when Trinidad USGS flows greater than a certain value each month
TRA	8824.5	08-5021BC	City of Ennis, city of Waxahachie return flows to Bardwell
	4,368	08-3404D	Discharges from Mountain Creek WWTP; Less 6.5% channel loss
	246,219	08-4248B	Discharges from CRWS, ROCRWS and TMCRWS
TRWD	52,500	08-4976C	Divert from Trinity River when Trinidad USGS > 350cfs
	63,000	08-5035C	Divert from Trinity River when Trinidad USGS > 350cfs
IRVING	31,600	03-4799C	Subject to TRA's right, prior to discharge, to make direct reuse of return flows

Conclusion

Reuse has steadily grown into an important component of water supply in the Trinity basin. It is important that certain criteria and principles be followed:

- Develop reuse in ways that can adapt to new technologies and markets.
- Develop projects that are efficient in their use of resources.
- Negotiate equitable arrangements among stakeholders.
- Treat reclaimed water as a commodity with value.
- Wastewater treatment plants are focal points for planning reuse systems.
- Maintain the health and safety of water supplies.
- Protect existing water rights and supplies.
- Protect the natural environment and
- Work with regulators to make sure water rights for reuse supplier are issued appropriately and with a consistent vision toward maximizing the state's water supply while protecting permit holders.

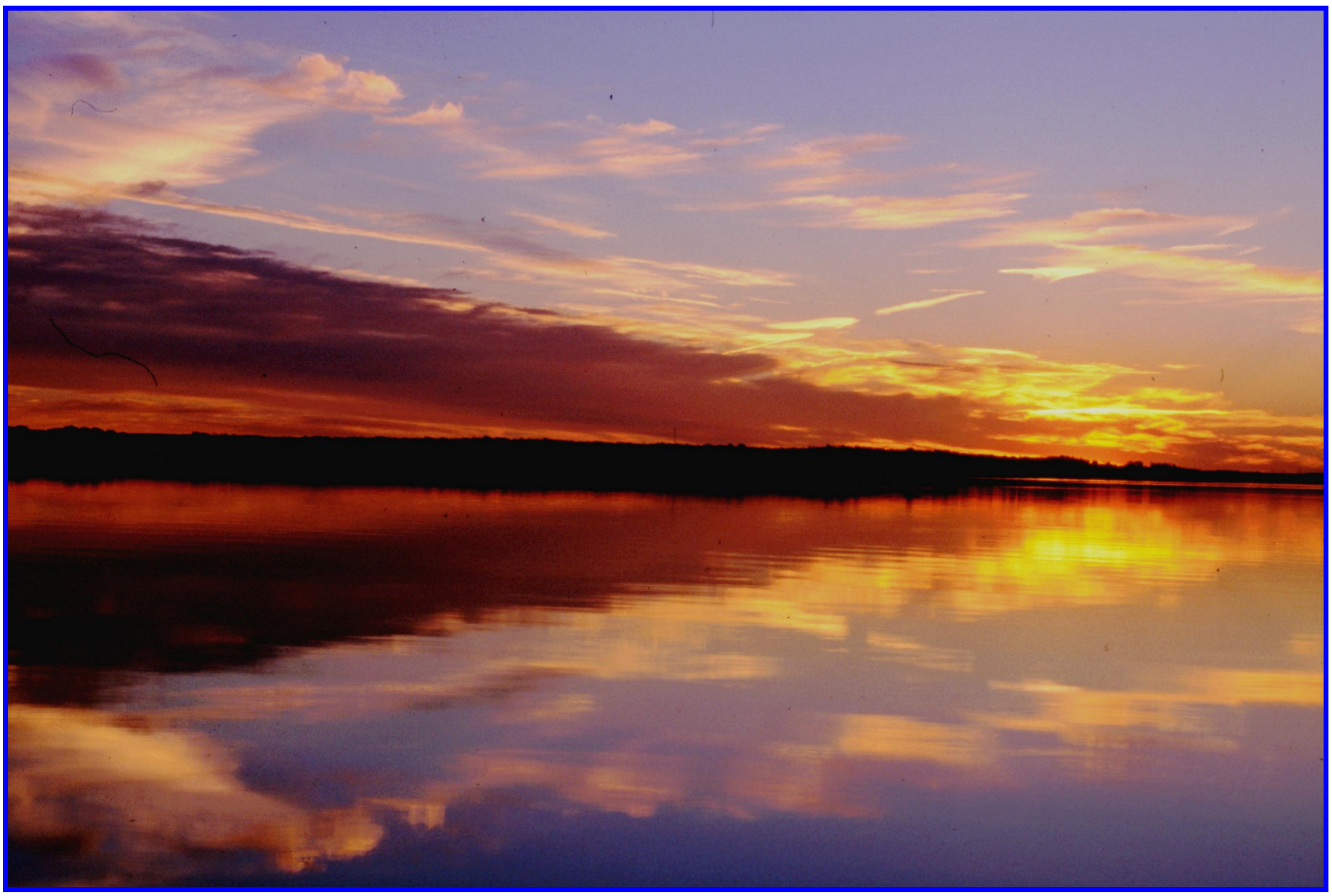


Photo: Lake Livingston Sunrise

2011—2020 Weather Events Review

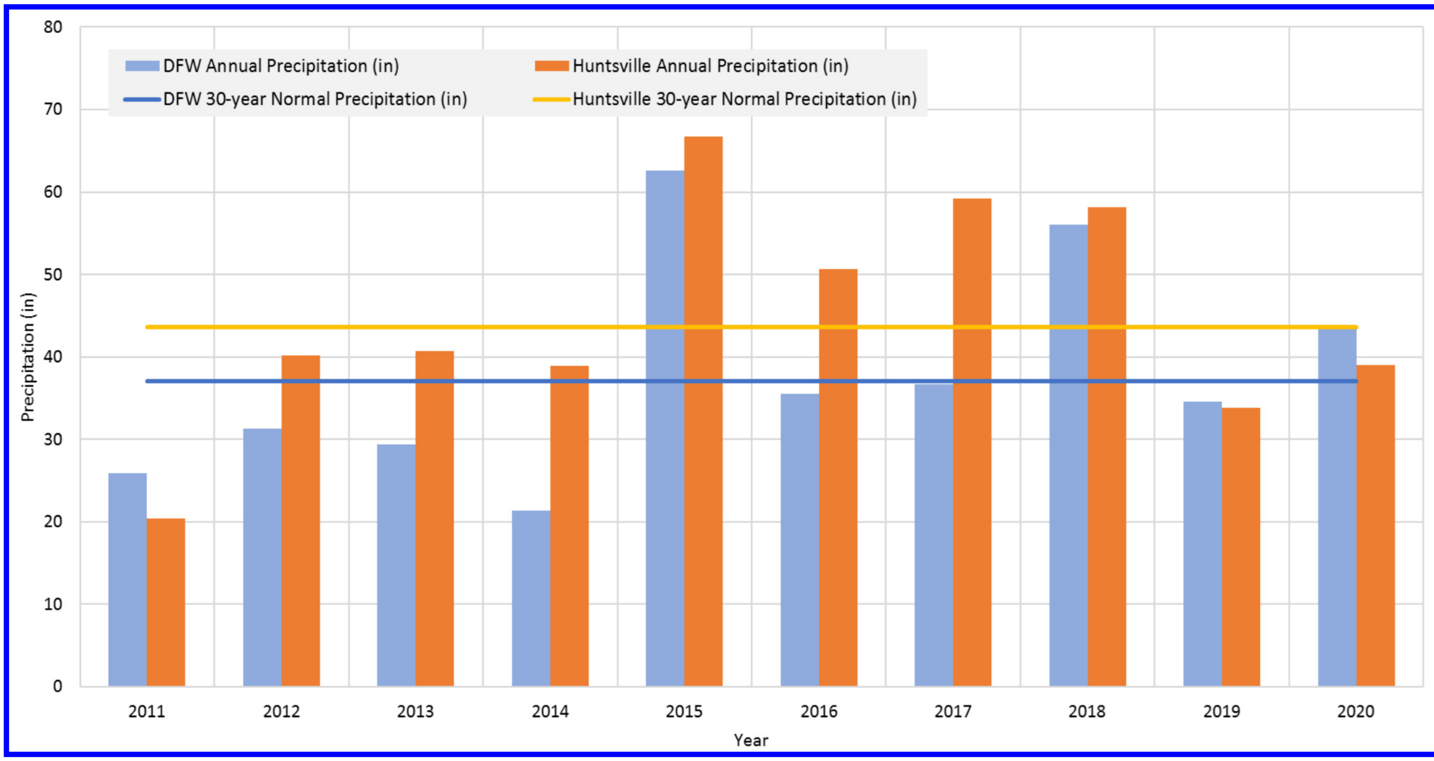


Fig. 5a. 2011-2020 Precipitation vs 1991-2020 Normal at DFW International Airport and Huntsville Municipal Airport

The year of 2011 was the driest year on record for the state of Texas. The lack of rainfall was accompanied by exceptionally-high temperatures that set a record for the hottest three-month period (June through August). This led to dangerous conditions that resulted in devastating wildfires in some areas of the state. Rains in late 2011 and early 2012 replenished water-supply reservoirs and brought soil-moisture levels back up for the eastern half of the state. Unfortunately drought conditions returned and persisted through 2014. Extreme drought conditions can stress water supply infrastructure not only through diminished water supplies and high-peak demands, but also by causing water main breaks when drying soil cracks and shifts.

The year of 2015 was a year of extreme weather events. It was recorded as both the wettest year on record and the year with the third most consecutive days without rainfall.

Hurricane Harvey was a category 4 hurricane that made landfall along Texas coast on August 25, 2017. Between August 27-September 9, 2017, the measured flows resulting from rainfall above Liberty and estimated rainfall directly on the watershed below Liberty resulted in total releases to the bay of an estimated 912 billion gallons. That figure equates to approximately 2.8 million acre feet of water, or enough water to have filled Lake Livingston 1.6 times.

In 2018, record-breaking rainfall was received in the Dallas-Fort Worth area in February (11.31"), September(12.7"), and October (15.66"), making 2018 the second wettest year on record for the Dallas-Forth Worth. Only one year later, the total precipitation in Huntsville TX, where Lake Livingston is located, was about 10 inches (or 20%) less than the 30-year normal.

Trinity River Authority of Texas

Basin Master Plan

Flood Planning

Photo: The Trinity River flooding on 8 July 1908

The Trinity River is no stranger to flooding. Historical incidents have shaped the modern skyline of Fort Worth and Dallas, and served as the impetuous for the construction of levees and flood control reservoir. Of particular note was the flood of 1908. Occurring in the spring of that year, the river in Dallas reached an historic depth of 52.6ft and a width of 1.5 miles. While fatalities were ultimately light, with five people losing their lives, the devastation was significant and widespread. Over 5% of the total population was left homeless (Payne, 1982 [1]). A similar incident occurred in Fort Worth in the spring of 1949 when the Trinity spilled its banks and covered much of downtown (Start Telegram, 2017 [2]). Flooding can and has occurred at any point along the river, and can cause significant impacts to both urban and rural areas.

These incidents describe a type of flooding known as river flooding. This is probably the most recognized type of flooding in the Trinity basin because of both the frequency with which it occurs and the dramatic nature of such events. River flooding occurs when water from upland areas drains into rivers, filling them past their normal capacity and causing them to overflow their banks. This type of flooding can cause significant damage to life and property, as it did in Dallas in 1908 and Fort Worth in 1949. It is also a part of the river's natural cycle. However, changes in land use can greatly affect a river's flood characteristics. Urbanization, for instance, increases the amount of impervious surface in a river's watershed, and can dramatically affect not only how much water runs off the landscape, but also how quickly. Both of these factors affect flooding and are of concern in rapidly growing areas such as the Dallas-Fort Worth metroplex. Other historical examples of Trinity River flooding include 1844, 1866, 1890, 1922, and 1990.

While river flooding may be the most widely recognized, there are other types of flooding. Upland or local drainage flooding occurs as rainwater overwhelms local topography and drainage systems, both natural and manmade. This is typically caused by unusually heavy rainfall which falls on the landscape faster than it can drain away. This type of flooding is common during tropical storms, especially in coastal areas where flat topography makes drainage even more challenging. It can also be caused by poor land management in both urban and rural settings. Drainage issues are a major concern for municipalities and in fact the majority of deaths from flooding involve vehicles as people attempt to drive through inundated roadway.

Photo: a horse perches atop a house flooded by the Trinity River in Fort Worth in 1949. In the background can be seen the Montgomery Ward building, which was also affected by the flooding. Photograph by Hills Miessner. Collection available through the University of North Texas : https://texashistory.unt.edu/ark:/67531/metapth27968/

A third type of flooding involves storm surges, which are wind-drive high tides that can affect coastal areas. This occurred during Hurricane Ike in 2008. Water levels in Galveston Bay, pushed ahead of the approaching storm, swelled and poured over much of Galveston Island. Storm surges are caused by strong, sustained winds that stack and drive water from large water bodies (e.g. the ocean) into low-lying coastal areas. During hurricanes, flooding can be compounded when locally heavy rains cause inland flooding at the same time storm surging is driving water inland.

<u>*Flood Control Structures*</u> As a result of historical floods, numerous flood control projects have been undertaken. These include

levees, flood control reservoirs, flood retardation structures, drainage improvements and flood forecasting and warning systems. Levees operate by artificially raising the banks around a river, thereby preventing water from leaving the channel. Both Fort Worth and Dallas have significant levee systems that protect those cities. There are also numerous levee systems at other locations along the river that protect agricultural interests. While these systems are highly-effective at protecting local areas from flooding, by preventing water from spilling into the natural floodplain, they can increase the severity of downstream flooding. When rivers leave their channels, the flow rate slows down as water is forced to flow through and among trees, grasses, and other obstacles. By preventing this from happening, levees send more water downstream over a shorter period of time. This raises the peak flow downstream, exacerbating flooding.

Flood control reservoirs in the Trinity basin are operated as multi-purpose reservoirs with both water supply and flood control. Flood control is achieved by maintaining an empty pool above the water supply pool. When empty, this excess capacity can capture and store flood waters until downstream conditions improve, at which time the water is released slowly to avoid further flooding. Water supply reservoirs, which must be maintained as full as possible, cannot be used to significantly mitigate flooding. However, water supply reservoirs do not aggravate flooding because water is not released from storage during high-flow events. Rather flood flows, which would have occurred with or without the water supply reservoir, are passed through. This is done as a matter of safety to preserve the integrity of the dam. The United States Army Corps of Engineers operates a system of five flood control reservoirs in the upper forks of the Trinity with an additional three on significant tributaries. Of these eight, only two are downstream of the Dallas-Fort Worth area. Combined, these reservoirs have a flood storage capacity of 1.5 million acre feet and help regulate the flow from 4,295 square miles of drainage. Operated in conjunction with the levee systems in Dallas and Fort Worth, these reservoirs provide vital protection and have proven their worth. The United States Army Corps of Engineers estimates that this system, which cost $1.67 billion in 2013 dollars, has prevented $129 billion in damages. While important to protecting the Dallas-Fort Worth area, the 4,295 square miles regulated by the USACE's flood control reservoirs represents less than a quarter of the total drainage area of the Trinity basin. Accordingly, the majority of the basin is not protected by flood control reservoirs.

Flood retardation structures include small impoundments that, as the name suggests, slow down or impede, rather than trap and store, flood flows. In aggregate, the slowing down of flows can significantly reduce peak flow rates and provide considerable downstream benefits. However these structures are perhaps most important in local drainage control. They can include Soil Conservation Service reservoirs as well as amenity ponds and storm water retention basins. Other drainage control structures include both complex municipal storm water systems as well as proper grading and swaling of agricultural land.

A final class of flood protection involves seawalls and other structures to prevent or reduce the damage done by storm surges. The importance of these structures was demonstrated by the damage done by Hurricane Ike. The USACE, in partnership with the Texas General Land Office, is currently studying an extensive plan to protect portions of the Texas coast, including Galveston Bay, from future events. The Coastal Barrier would include 70 miles of gates and levees. This study is projected to be completed in 2021.

For more information, visit the Coastal Texas Study at:

https://coastalstudy.texas.gov/

Recent History and Basin-Wide Flood Planning

In 2015 Texas emerged from a prolonged drought to plunge into one of the deadliest and wettest periods on record. Whereas 2011 was the hottest and driest year on record for the Trinity basin, 2015 was the wettest. This began a period of five years of exceptionally heavy precipitation that included Hurricane Harvey and tropical Storm Imelda. This unique situation involved deadly floods across the state and created a strong political desire to improve the states' flood risk reduction efforts. As a result, Senate Bill 8 was passed by the 86th Texas Legislature. This legislation creates a statewide flood planning process modeled after the state's water planning process. The Texas Water Development Board oversees the effort. Fifteen regional flood planning groups have been created, each with an identical set of prescribed voting members representing various interest categories (Fig. 6a). This group is then charged with devel-

Photos: TRA personnel assist with rescues during Hurricane Harvey in Aug 2017 oping a regional flood plan that analyzes flooding issues and prioritizes solutions. The Trinity basin in its entirety is represented by the Region 3 Regional Flood Planning Group and was convened in October of 2020. The first Regional Flood Plan is due in January of 2023. The regional plans will then be compiled into a single, statewide plan. The projects within the plan will be prioritized for funding and implementation. The process is by design permissive, and inclusion in the plan is in no way required for implementation of flood risk reduction measures. This is paramount because entities must have the flexibility to react to changing flood dynamics; a restrictive process that requires group approval would run contrary to the intent of the legislation of reducing flood risk across the state. The primary benefits of the flood planning process will be to create a formalized planning process that brings resources to every corner of the state, and facilitate the funding of projects where there has previously been a lack of funding mechanisms. This has always been a challenge because unlike water supplies that create their own revenue to support the development of supplies, flood control measures do not. While properly-implemented flood risk reduction projects can save dollars for every penny spent, cost offsets are not the same as working capital to fund projects and pay debt service and operating expenses.

TRA's Role in Senate Bill 8

The Trinity River Authority is well positioned to help facilitate the flood planning process in the Trinity basin, and will assist as appropriate, including serving as the local sponsor for the regional planning group, and by representing basin interests.

Photos: Hurricane Harvey in Aug 2017

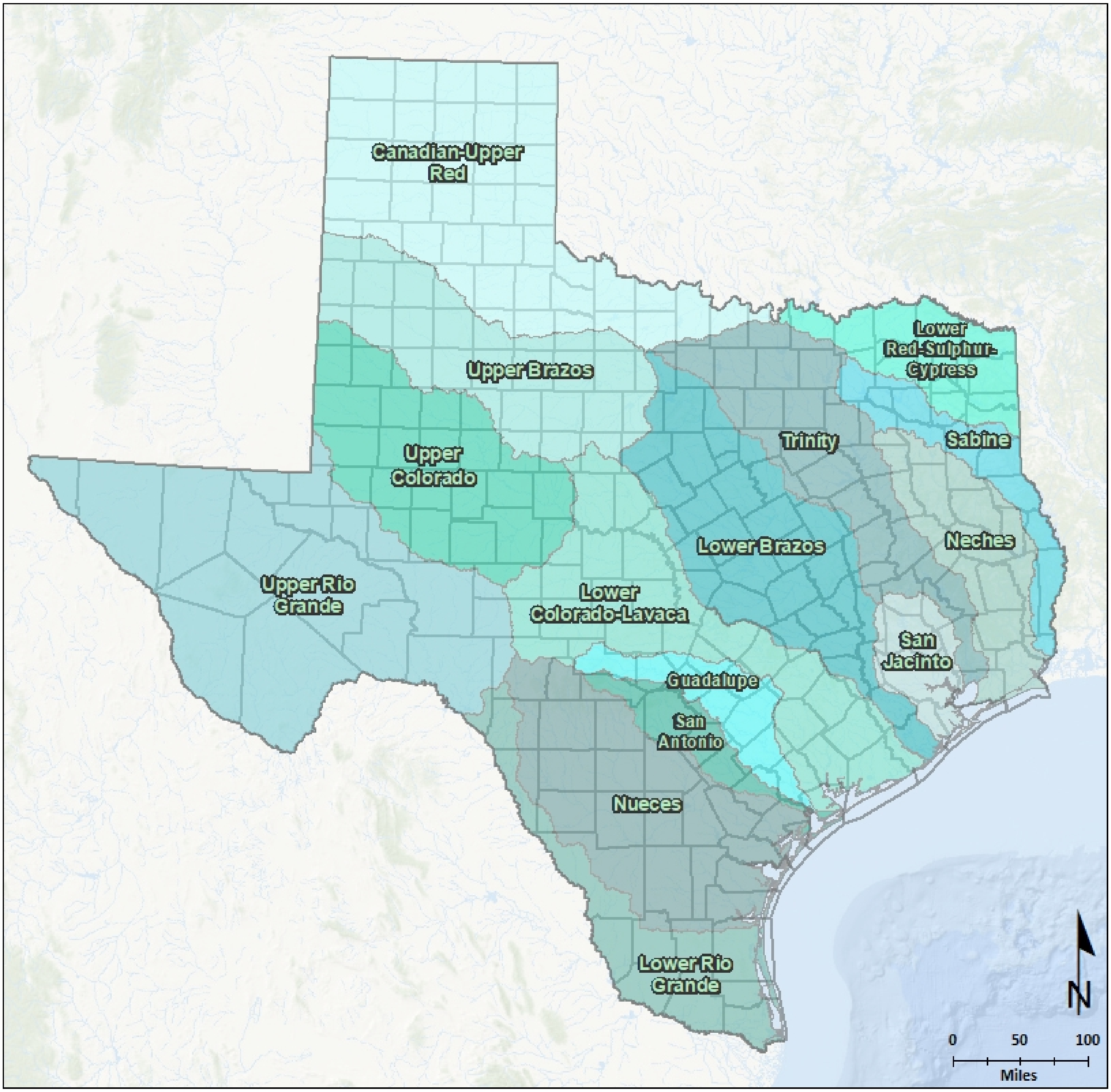


Fig. 6a. Regional Flood Planning Groups

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1. Payne, Darwin (1982). "Chapter V: A New Century, A New Dallas". *Dallas, an illustrated history*. Woodland Hills, California: Windsor Publications. pp. 119–155. ISBN 0-89781-034-1.
2. https://www.star-telegram.com/opinion/bud-kennedy/article169902202.html

Water Quality

Background

On a Federal level, the Clean Water Act (CWA) of 1972 established the basic structure for regulating discharges of pollutants into water bodies. The Act gave the Environmental Protection Agency (EPA) authority to implement pollution control programs such as setting wastewater standards, water quality standards, and point and nonpoint source discharge permits. For the Trinity River basin, the CWA of 1972 does not tell the whole story.

Fig. 7a. TRA's Denton Creek Regional Wastewater System

In 1846, during his reconnaissance of Texas, A.W. Moore described the Trinity River as a "little narrow deep stinking affair." Historically, many of the major tributaries, and sometimes the main stem, of the Trinity River would dry up during the long, hot summer months and periods of drought. As settlement increased, people relied heavily on the Trinity for water supply and waste removal. Drinking water was pumped directly from the main stem for Dallas' water supply until 1896 when Record Crossing was built on the Elm Fork so that a cleaner, more reliable water supply was available. The Trinity River received large amounts of untreated and partially treated sewage from sources including small, inefficient wastewater treatment facilities, dysfunctional septic systems, and direct discharges from citizens and industry. Consequently, in 1925, Texas Department of Health characterized the Trinity River as a "mythological river of death" because of the number of people that died from typhoid fever, a bacteria associated with polluted water sources.

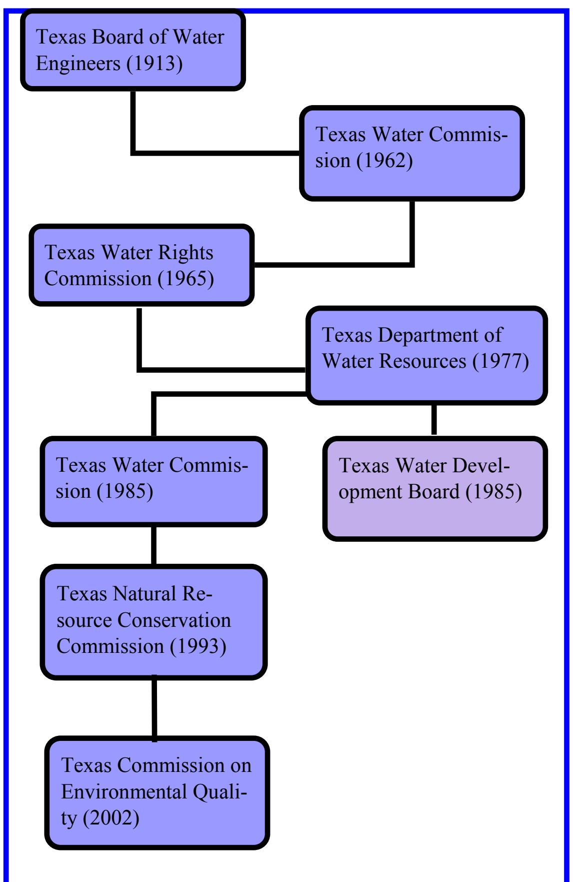

Fig. 7b. Evolution of TCEQ.

In the 1950s, the legislature granted the Trinity River Authority the authority to construct and operate regional wastewater treatment and collection systems. The first of these was TRA's Central Regional Wastewater System (CRWS). The legal groundwork and this idea of "cooperation" between municipalities, entities, and the state, helped to create a blueprint that other regions of Texas soon followed.

Prior to 1967, the Texas Department of Health (TDH) reviewed wastewater treatment plant designs. TDH had few resources allocated to wastewater and no comprehensive permit system for wastewater dischargers existed. The Texas Water Quality Board was created in 1967 around the same time this concept of cooperation among dischargers (which later evolved into the "The Compact") developed. The major dischargers and their consultants met with the Texas Water Quality Board and committed to using the best technology, that was proven to work, for large scale plants. In addition, prior to the CWA of 1972, permits written by the Texas Water Quality Board included permit levels of 10 mg/L biochemical oxygen demand (BOD) and 10 mg/L total suspended solids (TSS). The science and administrative base for the creation of these "10/10" permits by the Trinity River basin entities became the groundwork for other permitting issues throughout Texas.

Improvements in water quality since the 1950s has been quite dramatic. Permit levels have greatly reduced loadings from point sources and increased wastewater quality such that it has become a commodity. For decades, the Trinity River Authority has been integral to improving water quality in the Trinity basin, and that commitment continues today.

The Trinity River Basin

Photo: Outfall of TRA's Center Regional Wastewater System

The natural flow in the great majority of streams in the Trinity River basin is highly variable. Most of the Trinity's flow is from rainfall runoff. In the summer, flow can become quite low, and streams may dry up completely. This makes for very poor water supply. To combat the intermittent nature of the Trinity River, reservoirs were built throughout the basin to solidify a water supply for a growing population. The characteristics of the streams have changed over time and at present there are five distinct water body types:

- Intermittent streams
- Perennial streams
- Effluent dominated streams
- Reservoir release dominated streams
- Reservoirs

Intermittent Streams Intermittent streams throughout the basin are generally characterized by the runoff characteristics of their watersheds. Some small urban watersheds may have poor water quality during dry periods and during the "first flush" of a rain event. In addition, dissolved oxygen is occasionally low and bacteria are often high. Suspended and attached algae sometimes produce scums and odors and cloud the water. Notwithstanding these problems, fish such as shad and sunfish are often seen in numbers and recreational uses are intensive in park areas along such streams.

Intermittent streams with larger and less developed watersheds generally have turbid but otherwise good quality water following a rain, decreasing turbidity as the runoff decreases, standing pools which may remain clean or slowly stagnate after the flow ceases, and finally a dry channel. It is not uncommon for these streams to stay dry for months at a time. Although the data is limited, water quality parameters, other than suspended solids, are generally good. In some streams, occasional elevated levels of total dissolved solids, chlorides, or bacteria are noted at times of rising or peak runoff, apparently due to non-point sources.

Perennial Streams In the eastern portion of the basin from around Cedar Creek Reservoir to Liberty, a number of the Trinity's tributaries receive some of their baseflow from groundwater. Menard and Big Creeks in the lower basin and Catfish Creek in Anderson County are examples. These waters are clear, have excellent water quality, and retain a constant baseflow even during periods of drought. The hydrograph in Fig. 7c shows that groundwater influenced Menard Creek retains a consistent but patterned flow regime and no instances of zero flow during the period of record, despite having a relatively small watershed.

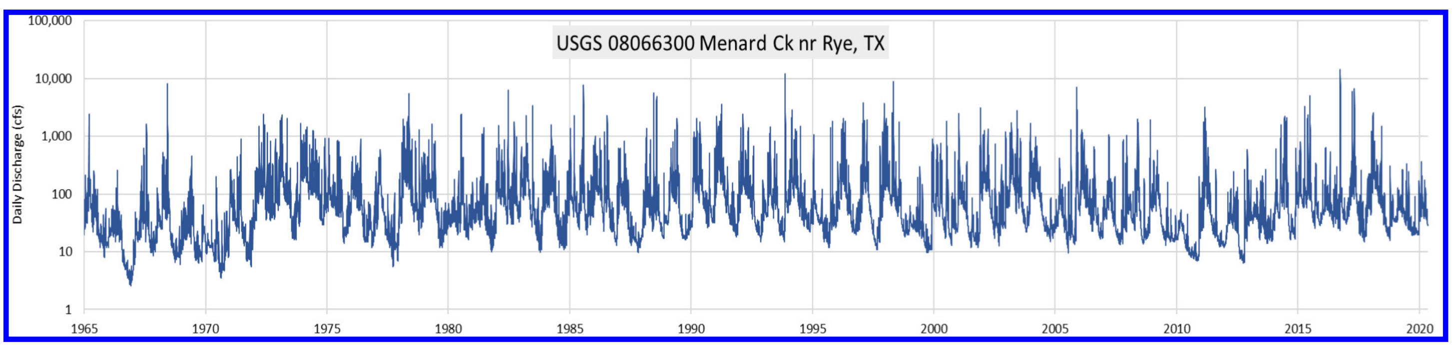

Fig. 7c. USGS Daily Flow from 1965 - 2021 at Menard Creek (Lower Basin) and Hwy 146

Effluent Dominated Streams In many situations wastewater treatment plant discharges into a stream constitute the majority of flow during dry periods. Those situations are considered effluent dominated streams, and exist for some distance downstream from many wastewater plants in the basin.

Effluent dominated streams exist in all sizes from small discharges into small streams or large discharges into large streams. During dry periods, river beds upstream of discharges may be completely dry. In some cases the discharge can entirely evaporate or soak into the bed and banks downstream leaving a dry channel with a small stretch of perennial flow.

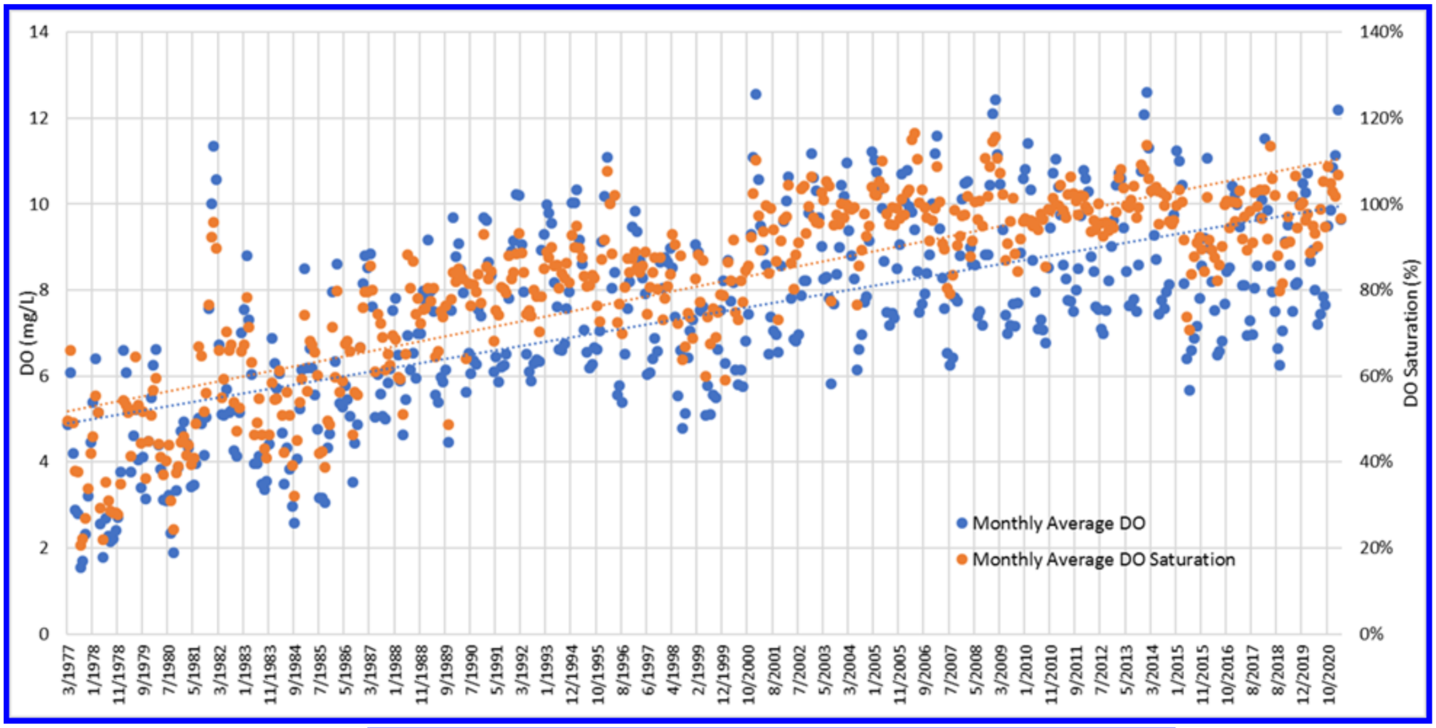

Fig. 7d. DO and DO Saturation (3/1977—3/2021 USGS gage at Rosser)

The biggest effluent dominated reach is the main stem from the DFW Region to Lake Livingston. In dry weather, the flow is almost entirely wastewater effluent. Even as the population has doubled in the Trinity River Basin, dissolved oxygen levels in the river have increased over the years with the introduction of wastewater treatment facilities and subsequent advancements in treatment technology. These wastewater treatment facilities provide baseline flow of known quantity and quality that benefits aquatic life.

Dissolved oxygen (DO) in water is necessary for fish and other aquatic life. The TCEQ sets the standard for high aquatic life use at 5 mg/L. The concentration of dissolved oxygen will reach an equilibrium with the oxygen in the air at its *saturation* (100%) point.

With all organisms, there is a constant competition for resources. Wastewater provides nutrients for algal growth which produces oxygen. Yet, wastewater also contains bacteria and certain other chemicals that consume oxygen. When consumption is greater than available oxygen, fish kills may occur.

Reservoir Release Dominated Streams Because of the extensive reservoir network, the majority of water in the Trinity basin is reservoir water, was reservoir water, or is going to be reservoir water. With all of the physical, chemical, and biological forces at work, reservoirs do an excellent job of cleaning water. When runoff or stream flow moves through a reservoir system, the water slows down allowing suspended sediment to settle out, nutrients to be used, and pollutants to sorb to particulates. Released water generally provides clean baseflow for streams. In general, these reaches are saturated with dissolved oxygen and have only isolated, infrequent pollution problems. There are five reaches of stream in the basin that are commonly supported at baseflow with releases from reservoirs (Fig. 7e) and these segments are monitored closely by the agencies using them for water supply.

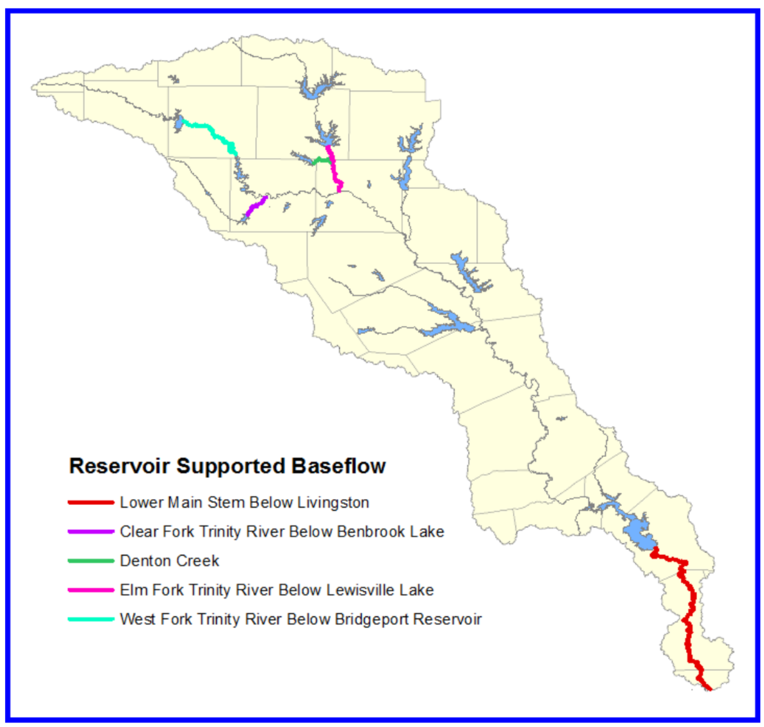

Fig. 7e. Map of Reservoir Supported Base Flow Segments

Reservoirs There are no natural lakes in the Trinity basin. Artificial lakes are known as reservoirs are built for water supply. Water supply reservoirs in the Trinity are predominantly located on forks and streams. The exception to this is Lake Livingston in the lower basin, which is the only impoundment directly on the main stem of the Trinity River. Lake Livingston is the only reservoir owned and operated by the Trinity River Authority, however, TRA is the local sponsor for three other reservoirs in the basin: Lakes Joe Pool, Navarro Mills, and Bardwell.

Photo: Joe Pool Lake

The water quality in all of the Trinity basin reservoirs is more than adequate to support its intended uses. Several older, small urban ponds show elevated levels of legacy pollutants and are listed as impaired by the Texas Commission on Environmental Quality. Other common water quality issues include occasionally pH values above the 8.5 standard, elevated nutrient and algae concentration, or taste and odor problems in raw water supplies. In most cases these problems are not an immediate concern, and while they may represent eutrophic pressures in some lakes, there may be natural causes or mitigating circumstances.

Water quality in the basin's reservoirs is a major interest for TRA and other controlling entities. Residential subdivisions, boat launches, marinas, and parks adjacent to lakes are capable of generating sizable amounts of domestic sewage and other wastes. Along with devising best management practices (BMPs) at Lake Livingston, TRA provides services for a fee in the operation of some sewage treatment plants, chemical analysis of treatment plant discharges, and the operation of a vacuum truck. In addition, TRA requires that on-site sewage facilities and excavation and/or construction projects be permitted through TRA's Lake Livingston Project.

Watersheds

Wastewater discharge permits and standards have greatly improved water quality within the basin. Although it is no small task to regulate these point discharges, non-point sources present an even greater challenge. The Trinity River watershed is nearly 18,000 m^2 and has been divided into 12 major sub watersheds (Fig. 1a). A river segment typically shares the characteristics of its watershed. For example, segments in the Upper Main Stem tend to be quite turbid which is characteristic of the prairie soils found in the subwatershed. Whatever happens in a watershed can have an impact on the water quality of that segment, as well as any downstream river segment.

In the Trinity River basin, the constituents that contribute to non-point source pollution include: oxygen demanding material, nutrients, dissolved and suspended solids including sediments, heavy metals, pesticides, complex compounds, bacteria, PAH's, litter, and floatables. Other potential sources of pollutants include wastewater overflows, septic system leakage, leachate from solid waste facilities, construction activities, and agricultural operations. Materials which may be contributed from agricultural sources include pesticides, nutrients, salts, and sediments in runoff and return flows. Non-point pollutants have been associated with low dissolved oxygen concentrations, algae blooms, periodic toxicity to aquatic life, and sediment accumulations of toxic and organic substances.

In 1990, EPA initiated a stormwater permitting program for cities with populations exceeding 100,000 residents. Since 1996, Norther Central Texas Council of Governments (NCTCOG) has assisted local entities through a cooperative regional stormwater monitoring program to address stormwater quality issues affecting North Central Texas. During the first permit term (1996-2001), seven municipalities and two TxDOT districts cooperated to sample and analyze outfalls from small watersheds of a predominantly single land use type. The goal for the second permit term (2006-2010) was to determine long-term trends and assess impacts of stormwater on receiving streams. The third permit term (2011-2016) continued the assessment of urban impact on receiving streams and document improvement from best management practice implementation. The ongoing fourth permit term (2018-2022) is to continue the long-term assessment of water quality trends, evaluate urban impacts on receiving streams, and document any improvement to water quality from best management practice implementation.

In the Dallas/Fort Worth area, subdivisions and mobile home parks have grown along the leading fringes of the rapid urban expansion. These developments are beyond the economic range of existing collection systems and are frequently beyond any city limits or extraterritorial jurisdictions. They provide sewage treatment with either septic tanks or small package plants. Maintenance, operations, and system designs are often not very good. There is concern and interest on the part of the water supply agencies to begin taking reasonable and prudent steps toward good wastewater management as these areas grow. Of greatest interest are the geographic areas within the watersheds of the regions major water supply lakes: Arlington, Benbrook, Eagle Mountain, Worth, Grapevine, Lewisville, Lavon, Ray Hubbard, and Joe Pool.

Dallas, Fort Worth, Mansfield, Arlington, along with the Trinity River Authority, the Tarrant Regional Water District and the North Texas Municipal Water District have been studying, separately and together, ways to encourage and assist with water quality management in these areas. One approach is to make quality wastewater services available, such as are now provided by the Trinity

River Authority around Lake Livingston and the North Texas Municipal Water District in the East Fork watershed, and to urge their use. When justified by the amount of development in an area, eventual connection to a regional system would be encouraged.

The TRA Denton Creek Regional Wastewater System is an example of this approach. It serves an area of northern Tarrant County and southern Denton County at the upstream end of Grapevine Lake. In its service area are a growing residential population, Alliance Airport, and the Texas Motor Speedway. The TRA Mountain Creek Regional Wastewater System began providing services in 2005 to the expanding populations of Midlothian, Grand Prairie, Mansfield and Venus.

The Joe Pool Lake Watershed Protection Plan (WPP) project was accepted by TCEQ in 2017. The project goals consist of protecting water quality in Joe Pool Lake, improving water quality in the tributaries, and mitigating future impacts of rapid urbanization. Water quality monitoring was completed in 2020. Data analysis, Stakeholder meetings, and Watershed Protection Plan development is underway. Development of a water quality model for the Joe Pool Lake watershed commenced January 2021. The objective of this watershed modeling is to assist with pollutant source identification, quantification of load reduction targets, and the strategic application of best management practices. The implementation phase would use these recommendations to propose and construct projects aimed at addressing the water quality issues identified in the planning phase, usually with assistance from federal grant programs. Assuming that the WPP is approved by Summer 2022, implementation projects could begin construction in 2023.

Year	Developed Areas
1992	4%
2001	18%
2006	21%
2011	24%
2016	25%

Table 7a. Percentages of Developed Areas in JPL Watershed

The Village Creek-Lake Arlington (VCLA) Watershed Protection Plan was approved and accepted by EPA in 2019. The plan was created by the VCLA Watershed Partnership, the City of Arlington and the Trinity River Authority to restore water quality in Village Creek, and in turn protect Lake Arlington's water quality. With the plan approved, local planning partners now have wider access to state and federal assistance programs that will encourage sustainable development as the watershed continues to urbanize.

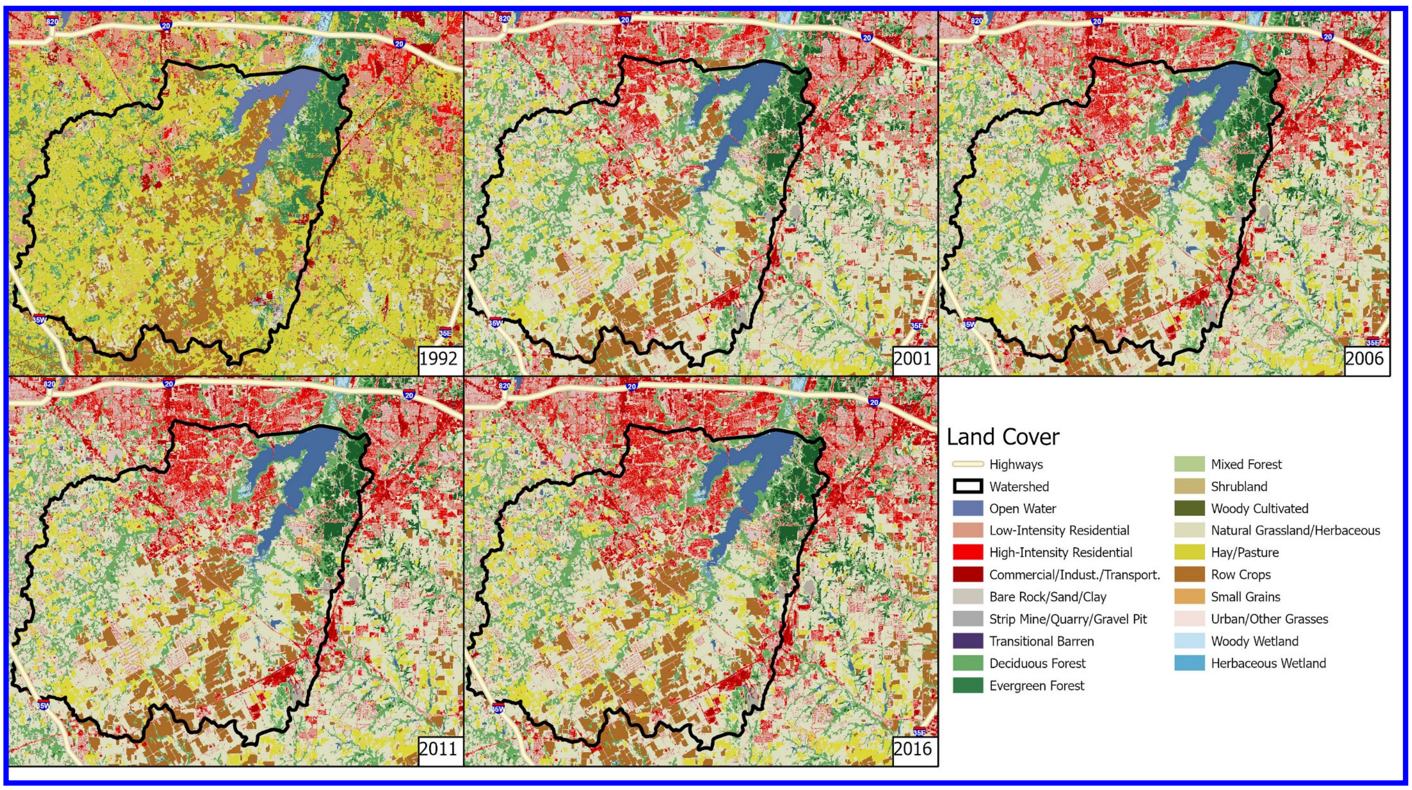

Fig. 7f. Land Cover Changes from 1992 to 2016 in Joe Pool Lake Watershed (www.mrlc.gov)

Water Quality Planning and Assessments

As the commitment to improving water quality picked up speed throughout the 1960s, it was apparent that a system of collecting organizing, and analyzing water quality data was needed. Entities throughout the basin began stream and reservoir sampling programs that ranged in size from single event sampling to systematic basin-wide collection efforts. Every aspect of the water business has evolved. On the political side, agencies are constantly changing their priorities and goals. On the science side, technological improvements are re-shaping how samples are collected and analyzed.

From the 1950s to the 1990s, entities throughout the basin collected water quality data for various reasons with limited coordination with various state agencies. The Texas Legislature created the Clean Rivers Program (CRP) in 1991 in response to concerns that water resource issues were not being addressed in a holistic manner. The CRP is funded by fees paid by wastewater dischargers and the program is implemented by TCEQ contracting with 15 partner agencies across the state. Because of its basin-wide scope, TRA was selected to implement the CRP for the Trinity River basin.

Over the years, TRA CRP has partnered with several entities to collect quality-assured water quality data that is used in the biannual state surface water assessment. This partner network has provided excellent coverage of the basin. The amount of water bodies covered continues to increase with addition of more cities and agencies. The CRP promotes coordination and communication so that a comprehensive sampling program can ensure the highest quality data with little overlap and/or duplicated effort. The CRP has become an essential source of routine water quality data.

Water Quality Reports

Many water quality reports are completed on the Trinity River basin each year. The scale and scope of these reports varies drastically. As required by law, TCEQ completes the Texas Integrated Report every two years. This report assesses the surface water quality based on historical data in the state, and must be approved by EPA before it is final. TRA produces a Basin Highlights Report each year to summarize CRP activities in the Trinity Basin. Every third biennium, TRA develops a Basin Summary Report which provides detailed data analysis and recommendations for future activities.

The TCEQ 2020 Texas Integrated Report (assessment date range 12/1/2011 to 11/30/2018) and the Trinity River Authority Clean Rivers Program 2020 Basin Summary Report (date range 12/1/2003 to 11/30/2018) indicate that water quality in the Trinity River Basin is generally of high quality. The major issues prevalent within the basin are listings for bacteria, concerns for chlorophyll-a and nutrients, low dissolved oxygen in smaller tributaries, and fish consumption advisories.

Legacy pollutants, such as PCBs and dioxins, continue to be a problem in Trinity River basin. These chemicals have been banned for decades, yet are still found in sediments and in the edible portions of fish tissue. Efforts to remove contaminated sediments have resulted in exacerbating problems downstream nationwide.

Bacteria impairments are prevalent in most part of the basin, especially in many of the intermittent urban streams in the D-FW Metroplex (Fig. 7g). A research indicates that more than 60% of the bacteria is related to birds, mammalian wildlife, and other unknown sources while the remaining is related to human, pet, and livestock.

Nutrients are not causing widespread problems in the basin and correlation analysis shows little relationship between nutrients and harmful algal blooms that cause widespread fish kills. Numeric standards for chlorophyll-a have been developed and approved by EPA for four reservoirs in the Trinity River basin. Other reservoirs are assessed against screening level or narrative criteria.

Dissolved oxygen (DO) level is affected by algal activity, sanitary sewer overflows, rapid temperature changes or other factors. Many of the listings for low DO are on low order intermittent streams so that the default standard of 5 mg/L may be inappropriate. Some of higher order streams with low DO are not experiencing fish kill and biological indicators show a healthy environment.

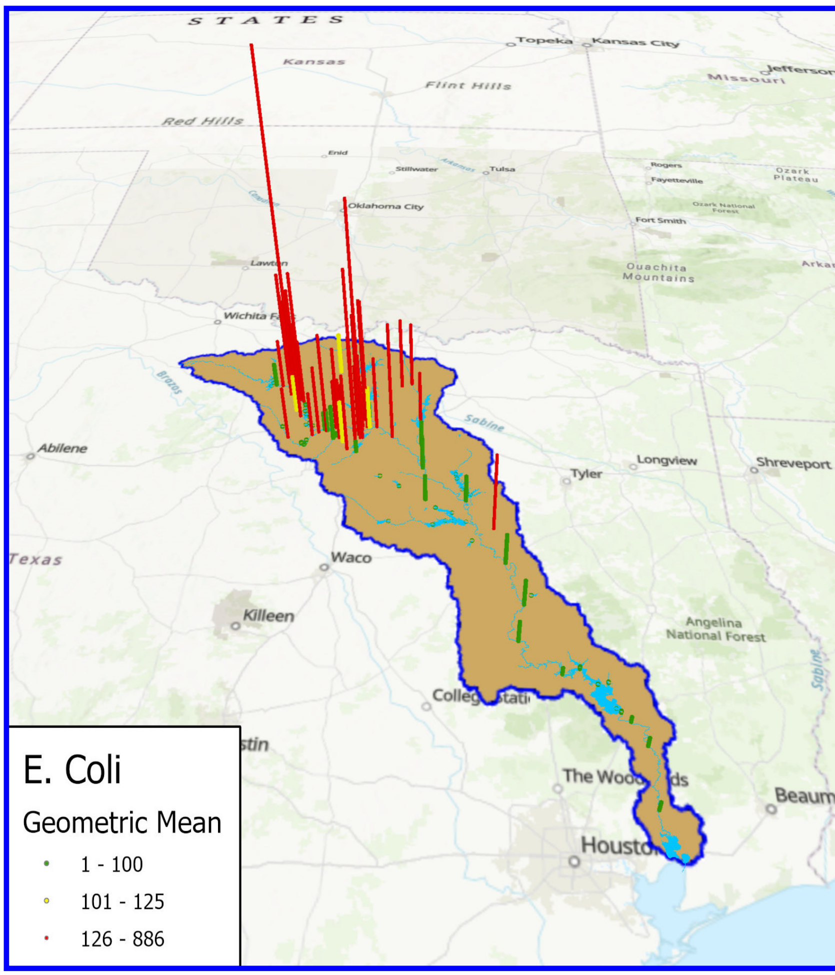

Fig. 7g. E. coli. Geometric Means across Trinity Basin (samples collected from 2000 to 2020)

Special Projects

Biological Monitoring In each summer since 2013, TRA has conducted aquatic life monitoring in streams. The benthic macroinvertebrate, fish population, and the available habitat in and around the stream for up to a 500-meter reach are assessed in the monitoring. The assessment is used to determine if those streams support aquatic life.

PCBs, Dioxins and Furans in Sediments In 2017, TRA began a study to measure concentrations of PCBs, dioxins and furans in the sediments along the Trinity River from upstream of Fort Worth to downstream of Lake Livingston. These chemicals are not usually observed at high concentrations in water column. They tend to bind to sediment particles and bioaccumulate in sediment dwelling organisms, and may build up in the fatty tissues of animals making them unhealthy to eat. This has led to fish consumption advisories for several reaches of the Trinity (Fig. 7h). Based on the results of the sampling in 2017, some areas have been identified as potential sources of these contaminants. Additional monitoring is planned for the areas of concern.

E. coli in Sediment Since 2018, TRA has conducted a study to identify the extent to which bacteria in sediments may affect water column concentration of E. Coli. The goal of the study is to determine the impacts of sediment disturbance on water quality and the bacterial impairment issues in streams of the Trinity basin. Bacteria sampling activities consist of three distinct samples collected at study sites: (1) the collection of sediment E. coli, (2) water column E. coli collected pre-disturbance, and (3) water column E. coli after artificial sediment disturbance. The findings of phase I indicate that the artificial disturbance events increase the observed E. coli count in the water column. Additional data collection is planned for the phase II study during the FY 2020-2021.

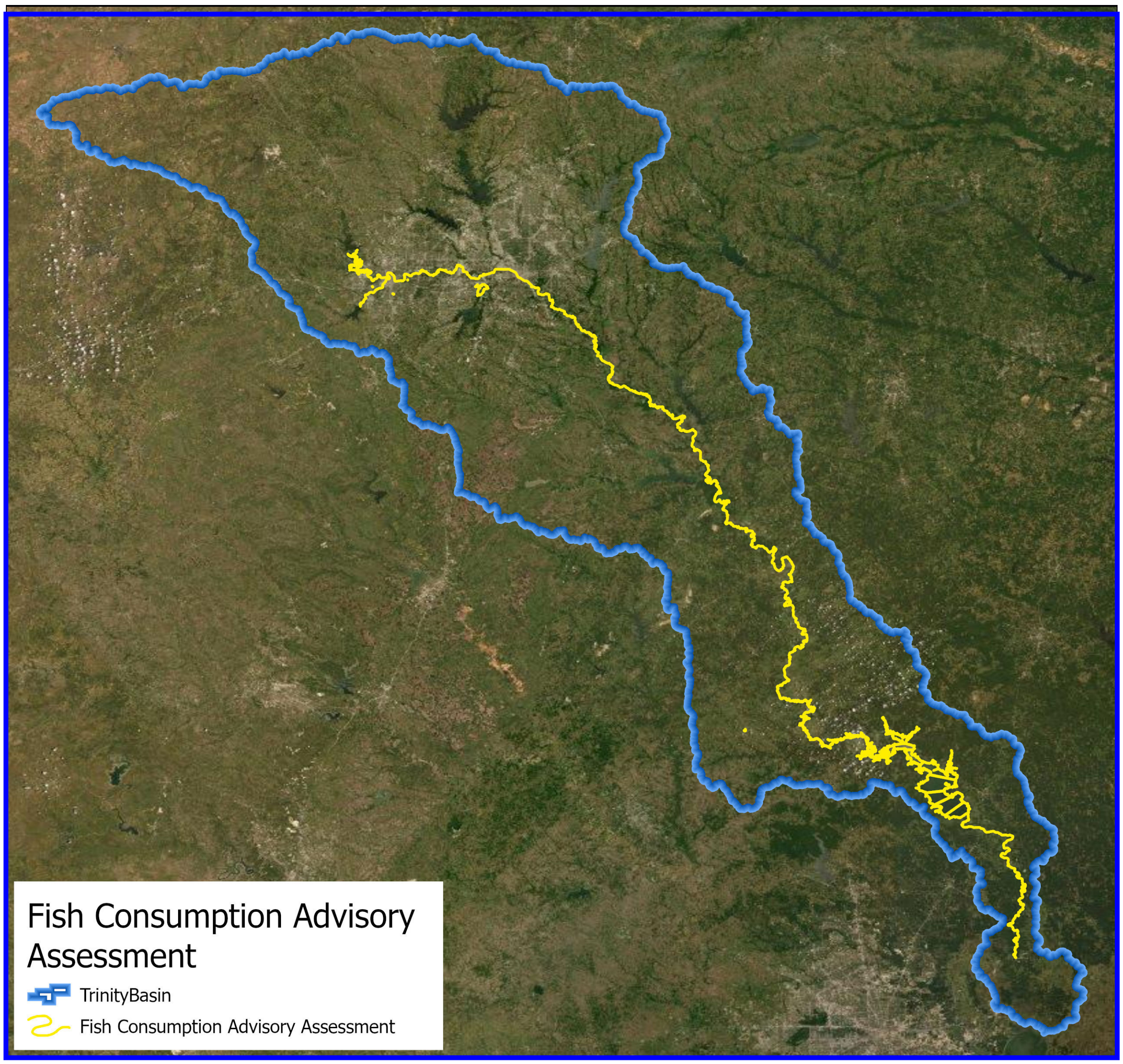

Fig. 7h. Trinity Basin Fish Consumption Advisories (https://www.dshs.texas.gov/seafood/TFCAV.aspx)

Aquatic Invasive Species

According to Texas Parks and Wildlife Department, the biggest current threats to Texas waters from invasive species include Zebra mussels, giant Salvinia and Lionfish.

Zebra Mussels — Zebra mussels are small, non-native mussel originally found in Eurasia. They were introduced to the Great Lakes region in the late 1980s and rapidly spread throughout the Great Lakes and other waterbodies in the middle-portion of the country, from Chicago to New Orleans. Zebra mussels profoundly affect natural ecosystems and can cause significant operational challenges to water infrastructure as they attach to any hard surface, including the interior pipelines, screens, etc.

In Texas, zebra mussels were found in Lake Texoma in 2009. As of 2021, zebra mussels have been found in lakes and rivers located in six river basins across Texas. In Trinity River basin, seven lakes have been classified as fully infested with zebra mussels, meaning the lakes have an established, reproducing population. In addition, zebra mussels or their larvae have been detected in two Trinity Basin lakes and Trinity rivers. No evidence of reproducing population has been found yet. One lake is classified as suspect lake in Trinity Basin because zebra mussels or their larvae have been found once (Fig. 3i).

Zebra mussel infestations can be spread by boat traffic and connectivity of water sources by natural flows and interbasin transfer. One potential consequence of a zebra mussel infestation is to put further pressure on native mussel populations. This increases the likelihood they will be found to be in need of protection under the federal Endangered Species Act.

Since 2015, TRA has partnered with the USGS to monitor for zebra mussels in Lake Livingston: plankton tows and microscopy twice a year at 6-8 sites to detect zebra mussel veligers; install artificial substrate at each site and inspect twice a year for zebra mussel settlement. While Lake Livingston is categorized as infested, the zebra mussel population appears to be in decline. In addition, starting in June 2019, the USGS, in cooperation with TRA and TCEQ, has performed sampling at four monitoring sites in Lake Arlington to determine the presence or absence of environmental DNA (eDNA), larva (veligers), or adult/juvenile zebra mussels. To date, although there have been two positive samples for eDNA, no adults, juveniles, or veligers have been found in Lake Arlington.

Aquatic Weeds — Several invasive, aquatic plants, including water hyacinth, water lettuce and giant Salvinia, are present in the Trinity basin. All three are floating, vascular plants of tropical origin. Specifically, water hyacinth and giant Salvinia are originally from South America, while water lettuce is believed to be from the Nile River in Africa. These plants are well suited to East Texas' warm, humid climate. Growing in the absence of natural predators or controls, they can rapidly grow to form thick mats over open water and under ideal conditions can double their density in a matter of days. These mats can impede the diffusion of oxygen into the water, degrading water quality to the detriment of fish and other aquatic species. The densities they reach can also form a physical impediment to recreation, frustrating fishermen, swimmers and boaters alike.

The Trinity River Authority, with the assistance of the Texas Parks and Wildlife Department, has an ongoing program to control these invasive plants in Lake Livingston. While this program cannot eradicate these species, it has been very successful in controlling their spread across much of the lake. Contrary to zebra mussels, which thrive in colder climates, winter freezes can assist in the control of these tropical species.

Lionfish — which are native to the Indo-Pacific region, was first reported in South Florida in 1985 and established rapidly to the East Coast in the 2000s, the Caribbean by 2009, the Gulf of Mexico and Texas coast in 2011. While beautiful, these fish are voracious predators that can decimate native fish populations. Due to its poisonous spines, Lionfish have few predators of their own to help control populations.




Photos: Invasive species in Texas, from left to right: Salvinia, Water Hyacinth, Water Lettuce, and Lionfish.
Photo credits: TPWD, TAMU, and TX State Aquarium

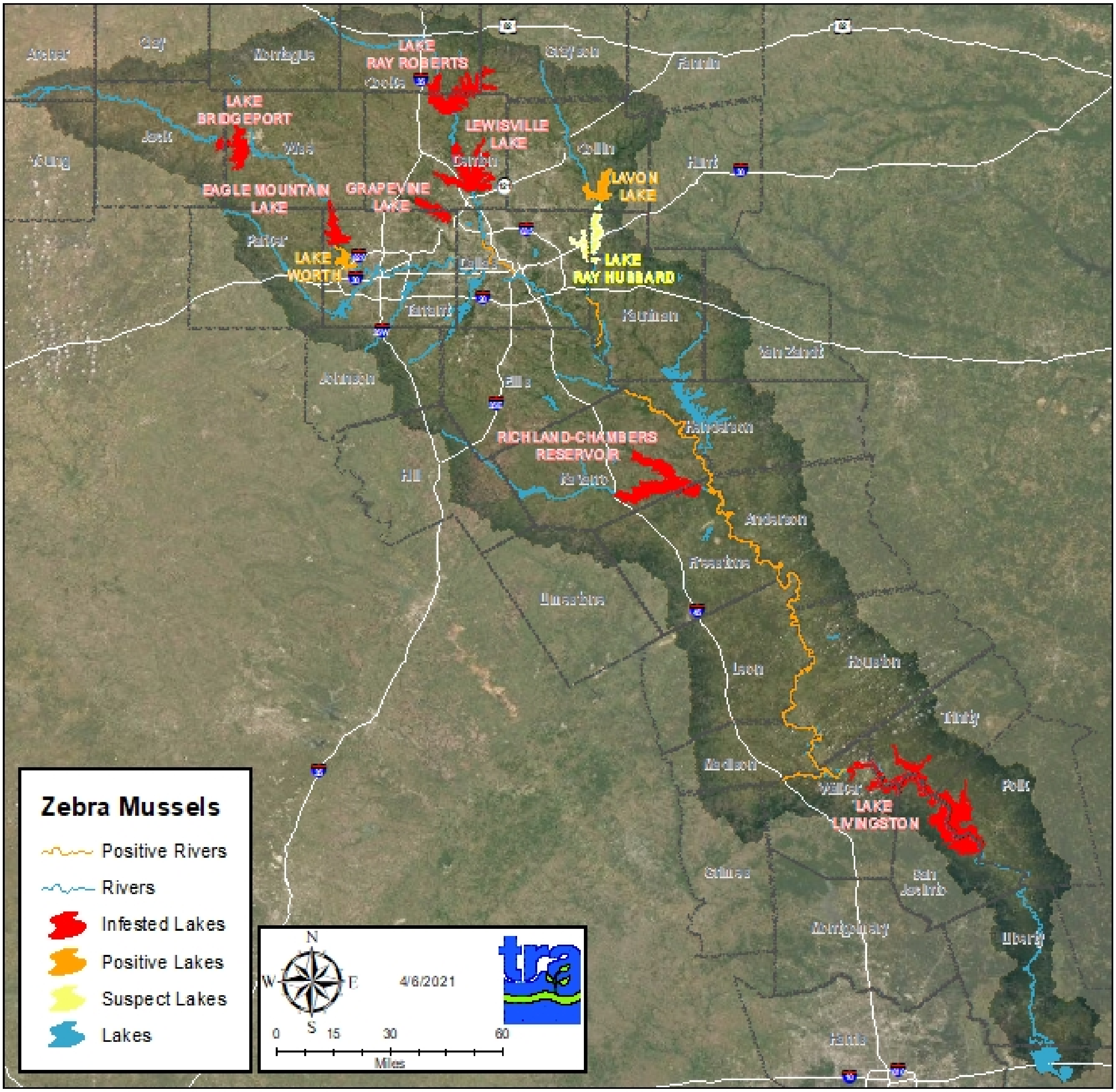

Fig. 7i. Zebra Mussel Infestation in Trinity River Basin as of April 2021
(tpwd.texas.gov/huntwild/wild/species/exotic/zebramusselmap.phtml)



Photo credit: Texasinvasive.org

Trinity River Authority of Texas

Basin Master Plan

Galveston Bay System and Environmental Flows

Background

As the largest bay in Texas, Galveston Bay covers approximately 600 square miles. The Galveston Bay watershed extends from North Central Texas to the Gulf of Mexico, including two large metropolitan areas, Houston and Dallas-Fort Worth. Half of the Texas population lives in the 24,000 square miles Galveston Bay watershed. The Trinity River enters the north end of the Galveston Bay complex through Trinity Bay. The San Jacinto Rivers enters the northwest corner of the sub-bay, the Galveston Bay (Fig. 8a).

Marshes and estuaries are an integral part of the Galveston-Trinity Bay ecosystem. The estuary is a rich ecosystem with diverse habitats. The Trinity-Galveston Bay system provides a necessary environment to support an important sport and commercial fishery. The health of the estuary is impacted by the quantity and quality of freshwater coming from the watershed. The salinity gradient in the bay is important in the life of oyster reefs. The quantity, quality, and timing of inflows to the Trinity-Galveston Bay System are factors that affect the ecosystem, but are very poorly understood.

Among the natural factors, there are wide variations over time – every season and year are different. Some specific relationships (the salinities at which oysters and their parasites grow) are known, but there are many important relationships which are known only in general, particularly as their relationship to natural, annual variations between wet and dry years. There have been numerous studies of these subjects by universities and government agencies. Each study sheds new light on its subject, but the complexity of this system, with the number and range of variables involved, is expected to take many more years to fully understand. It may also require a paradigm shift to recognize that ranges and tolerances are more important that absolute targets.

Environmental Flows

Freshwater Inflow As early as 1985, the Texas Legislature enacted laws directing the Texas Parks and Wildlife Department and the Texas Water Development Board to jointly maintain a data collection and analytical study program focused on determining the needs for freshwater inflows to the state's bays and estuaries. Bays and estuaries are some of the most productive areas on earth, and Galveston Bay is the most productive bay in Texas and the second most productive bay in the nation. Five river coastal basins feed Galveston Bay.

Senate Bill 2—Instream Flows In 2001, the Texas Legislature enacted Senate Bill 2 (SB-2), which established a partnership between the Texas Water Development Board, Texas Parks and Wildlife, and the Texas Commission on Environmental Quality to "determine flow conditions in the state's rivers and streams necessary to support a sound ecological environment." The group created a work plan and scope that includes peer review, oversight from the National Academy of Sciences and stakeholder input. The Draft Technical Overview was revised in 2006 and several stakeholder meetings took place throughout the state. The resulting program, the Texas Instream Flows Program (TIFP), conducts detailed instream flow studies.

Instream flows are defined as a flow regime adequate to maintain an ecologically sound environment in streams, rivers, riparian areas, and floodplains. The flows must be able to support the diversity and productivity of ecologically characteristic fish and wildlife and the living resources on which they depend. Instream flow may also be defined as those flows needed to support economically and aesthetically important activities, such as water-oriented recreation and navigation. The goal of an instream flow study is to determine an appropriate flow regime (quantity and timing of water in a stream or river) that conserves fish and wildlife resources while providing sustained benefits for other human uses of water resources. Determining adequate instream flow is quite difficult as river ecosystems are complex due to the interactions of many biological, chemical, and physical processes. The Trinity River (middle subbasin) was designated as a priority for an instream flow study in 2001 by the Texas State Legislature. The field work portion of the SB 2 project is complete, though extended periods of high flows in 2015 and 2016 required a modification of the original study plan. TRA personnel were engaged in all aspects of the field-sampling portion of this project. In addition, information collected during other TRA river surveys have proven extremely valuable to this work. Data analysis is complete and the draft report should be released for comment by TPWD in the late summer of 2021.

Senate Bill 3—Environmental Flow Standards In 2007, the 80th Legislature passed Senate Bill 3 (SB-3), an omnibus water bill related to the development, management, and preservation of the water resources of the state. It was the first broad water legislation to be passed since 1997. It addressed environmental flows, designation of unique reservoir sites, establishment of the Study Commission on Region C Water Supply, implementation of various water conservation efforts including authorizing a Statewide Water

Photo: Port of Liberty

Conservation Public Awareness Program, and creation of an eight member Legislative Joint Interim Committee tasked with studying water infrastructure needs, costs, and funding issues. SB-3 created several committees and a schedule of actions culminating in the Texas Commission on Environmental Quality (TCEQ) establishing flow standards for each major river basin and bay complex in the state. Environmental Flow standards are composed of a set of flow conditions (flow regime) deemed necessary to maintain ecologically-healthy aquatic systems. Standards are set for both rivers and bay/estuary systems. In river systems, the amount of flow required is referred to as an instream flow regime and is typically composed of low (subsistence and base) flows and high (peak or pulse) flows. Bay and estuary requirements differ from rivers in that the total volume of freshwater entering the system is paramount, rather than the instantaneous amount coming in at any one point in time. Freshwater inflows to bays keep the salinity in balance; if flows are too low for too long, the bay risks becoming overly salty.

Because flows naturally change throughout the year, increasing during wet periods such as the spring and winter months, and in the drier months, both river and bay flow requirements have seasonal components.

The process to derive flow standards was based largely upon the creation of two local stakeholder committees. One, the Basin and Bay-area Expert Science Team, is composed of subject-matter experts related to ecology, hydrology and other similar disciplines. This group is charged with determining the amount of flows necessary to maintain the ecological health of the Trinity and San Jacinto Rivers and Galveston Bay complex. The second committee, the Basin and Bay-area Stakeholders Committee, was charged with balancing the recommendations of the Expert Science Team pertaining strictly to ecological needs with the needs of man. In this fashion, consensus-based balanced flow standards were to be determined and recommended to the TCEQ for adoption. Due to a lack of data and understanding of how flows affect the ecological health of aquatic systems, a consensus was not reached. Two sets of recommendations were forwarded to the TCEQ. Although both were derived from statistical descriptions of historical flows, there were significant differences. One recommendation contained significantly more levels of flow requirements while the second set opted for a simpler set of standards with fewer control points (USGS gages) and levels of flow requirements.

In April of 2011, the TCEQ adopted environmental flow standards for the Trinity and San Jacinto Rivers and the Galveston Bay complex. The standards consist of flow requirements as measured at four gages along the Trinity River and two gages on the San Jacinto River. The required flow values vary by season and have subsistence, base, and pulse flow components. Freshwater inflow requirements for Galveston Bay consist of annual and seasonal flow targets with achievement frequency goals. The actual flow standards for both the instream flow and freshwater inflow requirements are listed in appendix 5.

Discussion

Development of freshwater supplies and other activities affecting inflows to the bay and estuary system must consider the impact on the system and strive to avoid adverse impacts. The impact of various changes to inflow need to be understood accurately and reliably. More studies are desirable to make progress in that direction.

The health and productivity of the bay must be protected and maintained. Not only studies, but informed action based on sound science should be used in making the necessary decisions. Where there is uncertainty, decisions should be designed to keep impacts small and to provide the flexibility to adapt to new information.

This master plan gives high priority to maintaining the health and productivity of Trinity and Galveston Bays, and has since the twenty-two public hearings and master plan revisions of 1975-77. Both Trinity and Galveston Bays are valued statewide. It is part of the life and livelihood of the lower Trinity Basin counties, particularly Liberty and Chambers Counties. All of Trinity Bay and a large part of Galveston Bay are within the boundary of Chambers County and within Trinity River Authority territory. It is necessary for all interested parties to be informed and involved in this concern.

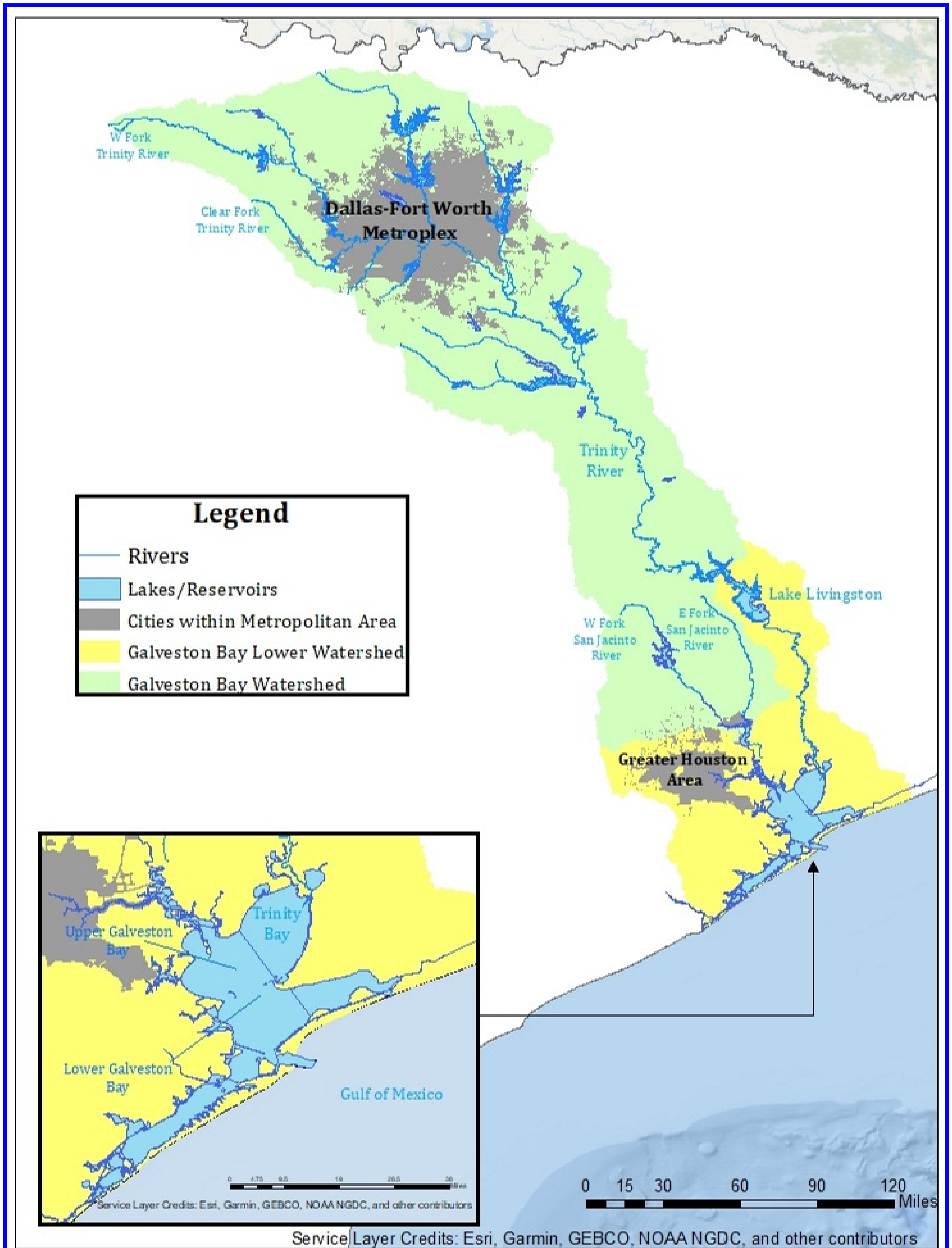

Fig. 8a. Galveston Bay Watershed and Galveston Complex

Trinity River Authority of Texas

Basin Master Plan

Appendices

Appendix 1. Description of the Trinity River Authority

Description of the Trinity River Authority

Legal Basis. The Authority is a political subdivision and agency of the State of Texas created by the authority of Article XVI, Section 59 of the Texas Constitution by various acts codified as Article 8280-188, Revised Civil Statutes of Texas.

Powers. In the acts creating and governing the Authority, the Texas Legislature has authorized the Authority to exercise fifteen powers to:

1. effectuate flood control;
2. store and conserve water;
3. supply and sell water;
4. conserve soils and other surface resources;
5. provide water for irrigation;
6. provide water for commerce and industry;
7. construct reservoirs, dams, water supply levees, and water purification and pumping facilities;
8. import water;
9. develop recreational facilities;
10. provide ingress and egress to lakes on the Trinity River;
11. preserve fish and wildlife;
12. provide for navigable water ways and ports;
13. provide sewage services;
14. prepare and maintain a master plan for the entire Trinity River watershed (basin); and
15. generate electricity with hydropower facilities.

Through other acts, the Texas Legislature has authorized all river authorities, including the Trinity River Authority to:

1. provide water quality management services;
2. provide comprehensive regional plans for water quality management control and abatement of pollution;
3. provide financial services for water and air pollution control projects; and
4. provide solid waste disposal services.

Taxes cannot be levied by the Authority unless approved in an election held throughout the defined territory.

Territory. The Authority's defined territory includes all of Tarrant, Dallas, Ellis, Navarro, and Chambers Counties and parts of Kaufman, Henderson, Anderson, Freestone, Leon, Houston, Madison, Walker, Trinity, San Jacinto, Polk and Liberty Counties. The Authority's defined territory is shown in Fig. 1b.

Governing Body. The Authority is governed by a 25-member Board of Directors appointed by the Governor with the approval of the Senate. Three Directors must come from Tarrant County, four must come from Dallas County, one must come from each of those parts of the other 15 counties within the Authority, and three may come from anywhere within the defined territory.

Appendix 2. Natural Characteristics of the Trinity River Basin

Natural Characteristics of the Trinity River Basin

The Trinity River Basin lies in the eastern half of Texas and has an overall length of 360 miles. It extends from a 130 mile wide headwater region, located generally along a northwest-southeast axis from Archer County to Chambers County, at Trinity Bay. The total area drained by the Trinity River and its tributaries is approximately 17,969 square miles.

Formed as primordial seas gradually withdrew to the present location of the Gulf of Mexico, the Trinity River serves as a major element of an extended coastal drainage system including such other Texas rivers as the Nueces, San Antonio, Guadalupe, Lavaca, Colorado, Brazos, San Jacinto, Neches, Sabine and Red.

Generally, stream flows in the Trinity River Basin follow the rainfall pattern of the area. In the Northcentral portion of Texas where the Trinity River rises, the annual average rainfall ranges from 27 inches in the west to about 33 inches in the east. Annual rainfall amounts increase progressively along the river's southeasterly course to 51 inches at Romayor, a short distance upstream from the tidal effect of the Gulf of Mexico. Of the average annual rainfall of 36.7 inches for the Trinity River Basin above Romayor, an average of 6.46 inches, less than 18 percent of the total, runs off and appears as flow in the stream at Romayor. The rainfall which does not appear as runoff is accounted for principally by evaporation and seepage into underground formations.

Stream flow records since 1925 at Romayor stream flow gauge show that the minimum annual runoff occurred in 1956 and the maximum flow occurred in 2015.

The Trinity River rises in its East Fork, Elm Fork, West Fork and Clear Fork in Grayson, Montague, Archer and Parker counties, respectively. The main stream begins with the junction of the Elm and West Forks at Dallas and follows a meandering course for 500 river miles to its mouth at Trinity Bay on the Gulf of Mexico. The maximum elevation in the basin is 1,522 feet Mean Sea Level (MSL) in an area northwest of Fort Worth. From this area, which averages over 1,000 feet MSL, the land gradually slopes down to sea level along the southeasterly route of the river.

The mouth of the Trinity River is on Trinity Bay, an arm of Galveston Bay, the largest of the estuaries on the Gulf of Mexico between the Mississippi and Rio Grande Rivers. The Trinity River is the major source of freshwater inflow to Galveston Bay. Despite large volumes of storm water entering Galveston Bay from the Houston area, much of it, and particularly Trinity Bay, yields the largest commercial fish and shellfish catches of all Texas bays.

The trends in precipitation and vegetation, taken in conjunction with land slopes and some other factors, cause runoff in the upper basin to be rapid, but low in total volume. Runoff becomes progressively slower, but higher in total volume as one proceeds downstream. As a result, stream flows in the upper basin are more erratic and quite often zero. Most of the smaller streams in the basin cease to flow within a few days or weeks without rain, depending on the season and drainage area.

Several of the Trinity River's tributaries, and the river itself below Dallas, have a base or dry weather flow of return flows discharged from wastewater treatment plants. Extensive sampling and monitoring have proven that more than 90 percent of the river's flow below Dallas in dry weather originates in the wastewater treatment plants of Fort Worth, Dallas, Garland and the Trinity River Authority. A limited number of smaller streams have a consistent base flow maintained by springs.

As a result of geological and climatic conditions, the Trinity River basin is divided into eight distinctively different physical regions. These regions are discernible by their vegetation, animal life and the uses to which they have been put by man. The North Central Prairie comprises approximately seven percent of the basin. This region is characterized by the lightest average rainfall of the entire watershed, stony and steeply sloping ridges made up of dense, shallow soils, grasslands and large sections of shrubs, mesquite, noncommercial cedars and other native vegetation. Primary agricultural activities are cattle and the cultivation of limited amounts of grains, hay and feed crops.

The East and West Cross Timbers are soil groups formed during different periods of time, but are very similar in composition. The East Cross Timbers extend southward from the Red River through eastern Denton County and along the Dallas-Tarrant County boundary through Johnson County into Hill County. The West Cross Timbers is a much larger formation that extends south from the Red River through Clay, Montague, Jack, Wise and Parker Counties on to the Colorado River. The soils contained in these formations are adapted to fruit and vegetable crops; and as a result, much of these areas have been converted to croplands of significant economic value despite the moderate rainfall. Other agricultural activities include dairy and beef cattle, sheep and goats raised on improved grazing land.

Appendix 2. Natural Characteristics of the Trinity River Basin (Cont.)

The Grand Prairie region is a ten mile wide belt that separates the East and West Cross Timbers. It extends south from the Red River in an irregular band through Cooke, Montague, Wise, Denton, Tarrant, Parker, Hood and Johnson Counties. Sometimes called the Fort Worth Prairie, it has a primarily agricultural economy and largely rural population with no large cities except Fort Worth on its eastern boundary. The soil is predominantly limestone, but the terrain is generally rockier and steeper in the southern sections than in the gently rolling plains around Fort Worth. Generally treeless, this area is primarily used for livestock including beef and dairy cattle, sheep and poultry. The majority of the crops are grown for livestock feed with some cotton grown as a cash crop.

The Blackland Prairies include the largest part (38 percent) of the Trinity River basin. Its rich rolling prairies developed rapidly as a farming cotton producing area of Texas. The region extends from the Rio Grande gradually widening as it runs northeast to the Red River. Because of its early agricultural development the Blackland Prairie is still the most populated physical region in the state, containing within it and along its borders many of the state's large and middle-sized cities, including Dallas. Primarily because of the early population concentrations, this belt has developed the most diversified manufacturing industry of the state. As a result of the fertile soil and adequate rainfall, agricultural activity abounds in this area with cotton serving as the principal crop.

The East Texas Timberlands, which cover 25 percent of the Trinity River basin, may be divided into two distinct sections. The Post Oak Savannah is a transitionary region between the Blackland Prairie on the west and the true East Texas Timberlands or "Piney Woods" on the east. This area has characteristics of both regions that can be seen in its native grasses and trees. As a result of poor drainage and low organic content, the soil is not suited for extensive cultivation, but many areas have been improved for cattle grazing.

The East Texas Timberlands proper is the source of practically all of Texas' large commercial timber production and is characterized by fairly heavy rain and wider-spread, better-developed forest areas than the Post Oak Savannah. This region was settled early in Texas history and is an older farming area of the state. The area's soils and climate are adaptable to production of a variety of fruit and vegetable crops, but has experienced an increase in cattle production accompanied by the improvement of large sections of pasture land. In addition to lumber production, the area possesses large oil, clay, lignite and other mineral deposits with potential for development.

The Coast Prairie and Marsh can be seen in Chambers County and a portion of the Liberty County area of the basin and characterized by heavy rainfall and alluvial soil. The lower portion of the watershed is suited primarily for the production of rice and dense salt-tolerant grasses which provide excellent forage for cattle. The virtually featureless terrain of the area is poorly drained as a result of the dense soils and low elevations. Rice grown in this area of the watershed is almost totally dependent on the Trinity River for irrigation water. The lush grass grown along the Coastal Prairie supports the densest cattle population in the state. This physical region, which includes Houston, has experienced the most extensive industrial development in Texas history since World War II.

The Bottomland of the Trinity River basin consists of the flood plain areas adjacent to the tributaries and main stream and primarily consists of alluvial soil washed from the Blackland Prairies upstream. While this region contains the most potentially productive soil resources of the basin, and possibly the state, farming is a gamble due to frequent flooding; and as a result, generally not attempted. Land on higher river terraces is routinely farmed and is notable for large-scale production of corn, cotton, feed crops, livestock and commercial hardwoods. The primary use of the river bottom area is stock grazing. The largest part of the flood plain is covered in native grasses and hardwoods similar to those found in the East Texas Timberlands.

History to 1958

One of the primary results of the distribution of the basin's physical regions was the concentration of the Trinity River basin's population in the Dallas/Fort Worth area, with smaller cities and rural populations distributed throughout the rest of the basin. While this concentration originally formed due to the feasibility of profitable agricultural activity, it has evolved and expanded since the mid 1800s to an economy dependent on transportation, fabrication, assembly, marketing, insurance, corporate and government administration and other activities.

In order to support and allow for the continued growth of the population concentration in the Dallas/Fort Worth area, which in effect is a semi-arid region devoid of natural lakes and groundwater of adequate quantity and quality, it became necessary to develop numerous impoundments along tributaries. Water for the population of the most rural areas of the basin is supplied primarily by groundwater resources and a limited number of impoundment. A notable exception to the use of Trinity River water within the basin is Lake Livingston which was constructed principally as a bulk supply of water for Houston.

Appendix 3. Evolution of the Master Plan

Evolution of the Master Plan

1958 Master Plan

The development of the original *Master Plan for the Trinity River and Tributaries* was authorized by the Trinity River Authority Board of Directors on March 2, 1956 in accordance with the 1955 legislative act creating and governing the Authority.

In 1956 and 1957 the Authority held 15 public hearings to collect citizen input on the types of projects that should be included in the Master Plan. During the public hearings, requests were made for the following projects:

- Saltwater barrier
- Lake Liberty (Capers Ridge Site)
- Water supply for Livingston
- Water supply for Huntsville
- Water supply reservoir on Gail or White Rock Creek above FM 1280
- Four reservoir projects on White Rock Creek in Trinity County for conservation purposes
- Caney Creek development for conservation purposes
- Hurricane Bayou Reservoir
- Little Elkhart Creek Reservoir
- Big Elkhart Creek Reservoir
- Flood control dams on Bedias Creek
- Reservoir for recreation on Boggy Creek
- Reservoir on Beaver Creek
- Reservoir on Two Mile Creek
- Water supply for Fairfield
- Flood control project on Cottonwood Creek in Freestone County
- Water supply for Malakoff and Trinidad
- Water and soil conservation project on Cedar Creek
- Water supply and flood control reservoir on Cummings Creek in Navarro County
- Channel rectification of Waxahachie and Chambers Creek
- Extension of Fort Worth Floodway and levee system on Big Fossil
- Reservoirs for water supply and/or flood control on Big Fossil Creek, Mary's Creek, Silver Creek, and the West Fork of the Trinity River near Boyd
- Interior drainage improvements for the Fort Worth Floodway
- Water supply reservoir project on Cedar, Richland, and Tehuacana Creeks and an increase in the conservation storage in Grapevine Reservoirs
- Grade the existing Dallas Floodway
- Extension of Dallas Floodway levees
- Rehabilitate Dallas County Levee Improvement District No. 5 Northwest Levee to conform to design criteria for the Dallas Floodway Project
- That a re-examination be made in light of 1957 floods of flood storage and spillway design requirements for reservoirs above Dallas and of interior drainage design criteria used for the Dallas Floodway project
- White Rock Levee
- Roanoke, Aubrey, Ray Roberts and Forney Reservoir projects for water supply
- Ten Mile Creek sewage disposal plant and water supply system for seven small towns in Dallas County
- Canalization of the Trinity River for barge navigation to Fort Worth

Based on the requests made during the public hearings, the firm of Forrest and Cotton, Consulting Engineers, prepared in consultation with the Authority's Directors a document entitled "Report on the Master Plan of the Trinity River and Tributaries, Texas." This report presented a plan of improvement that provided for development of the soil and water resources of the basin in an orderly and economical manner. A basic premise used in developing the Master Plan was that all of the runoff of the Trinity River and tributaries that could be regulated economically would be required in future years for watershed development. As a result, the plan called for a high degree of development of water resources by the construction of four water supply reservoirs on the main stem of the river and 13 water supply reservoirs on tributary streams in addition to reservoirs proposed by other agencies.

As required by the Act creating the Authority, the portion of the Master Plan relating to soil conservation and upstream flood prevention structures was prepared by the Soil Conservation Districts and approved by the State Soil Conservation Board. This portion of the Master Plan was coordinated with the soil conservation aspects of the overall plan and submitted in a separate volume to the State Board of Water Engineers.

The Master Plan incorporated existing plans of cities, counties, state and federal agencies.

Following completion of all related public hearings and investigations, the Trinity River Authority Board of Directors at its meeting on April 18, 1958 adopted the Master Plan.

Events Since 1958

After the Master Plan was adopted in 1958 many of its elements were implemented as a result of the coordinated efforts of many local, state and federal agencies. Navarro Mills, Bardwell, Ray Hubbard, Cedar Creek, Little Elkhart, and Livingston reservoirs were built. Lake Lavon was enlarged. Construction of the Wallisville project was begun. Many small flood and silt control dams have been built in the rural areas of the Trinity watershed and substantial lands brought into soil conservation practices. Wastewater treatment systems were upgraded. Brine discharges from oil fields were virtually eliminated. Water quality management plans required by 1966 and 1972 federal laws were completed to insure that all local governments in the Trinity watershed were eligible for federal grants for the construction and enlargement or improvement of wastewater systems.

In addition to the projects that were completed, 11 projects, all consistent with the Trinity River Master Plan, received Congressional authorization. They were Tennessee Colony Lake, Lake Joe Pool, Ray Roberts Lake, Roanoke Lake, West Fork Floodway, Dallas Floodway Extension, Elm Fork Floodway, Liberty Local Protection, Water Conveyance Facility and Multiple-purpose Channel.

1977 Revision

The Trinity River Master Plan review began with the passage of a resolution on January 22, 1975 at a Special Meeting of the Trinity River Authority Board of Directors. This resolution summarized the legislative origins of the Authority, the specific legislative directive and resulting procedures that caused the creation of the original Master Plan as well as the progress that had been made in implementing various elements through the coordinated efforts of many local, state and federal agencies. It further summarized events and developments both in and out of the Basin that required a comprehensive review of the Master Plan and specified the method of accomplishing this goal.

To determine what revisions were desirable, a total of 20 public hearings and two conferences with state and federal agencies were held. Again, existing plans were incorporated. Many issues which were brought out repeatedly in the hearings were brought into the plan for the first time. The revised plan was adopted by the Board of Directors on February 22, 1977.

1984 Revision

In the late 1970s, and early 1980s, there were developments in water quality and water supply planning which necessitated revisions to the Master Plan. Improvements in wastewater plans, which had been under design and construction since as early as 1969, were completed and came on line. There were notable improvements in the quality of the Trinity River. The Corps of Engineers' general design memorandum and environmental impact statement on the Trinity River Project was published in 1979. Construction began on Lake Ray Roberts, Richland-Chambers Lake and Lake Joe Pool. The city of Dallas and the North Texas Municipal Water District made arrangements for new out-of-basin water sources. New thought was given to the role of the Trinity basin as a source of water for the greater Houston and Gulf Coast area. These developments resulted in revision, primarily to the Water Supply and Water Quality sections of the Master Plan, in June 1984.

1989 Revision

In 1989 further developments in water supply and water quality warranted revisions in the Master Plan. Improvement in water quality continued as dissolved oxygen levels in the Trinity River became more plentiful and oxygen demanding material from major wastewater treatment plants declined. Lake Joe Pool was completed in 1989, providing a water supply for southern Dallas County and northern Ellis County and creating recreational facilities for the Dallas/Fort Worth Metroplex.

Appendix 3. Evolution of the Master Plan (Cont.)

1993 Revision
The Water Quality section was again updated to include information from the 1992 Water Quality Assessment under the Clean Rivers Act.

1997 Revision
The Water Supply section was updated to current development and planning.

2001 Revision
The Water Supply section was updated to reflect regional plans prepared pursuant to Senate Bill 1.

2003 Revision
A new section on Reuse of Reclaimed Water was added to cover the many interactions between this subject and both water supply and water quality, and also to outline principles for implementation of reuse.

2007 Revision
The Regional Planning section was updated with information from the most recent state water plan, *Water for Texas 2007.* Additionally, the format of the document was changed from black and white to full color with added photographs, maps, and graphs.

2010 Revision
Goals and Action Plan was restated into nine objectives to reflect current Trinity basin needs and to better complement the regional water planning process.

2012 Revisions
The Regional Planning section was updated with information from the most recent regional water plans and the state water plan, *Water for Texas 2011.* Additional information on water rights was added, including a new appendix, and a new section on drought was included. The section on environmental flows was also updated to describe the adoption of flow standards, which were detailed in a new appendix.

2016 Revisions
Included a comprehensive review of content and modifications to make in the information in the plan current.

2021 Revisions
Included a comprehensive review of content and modifications in order to bring the plan up to date. Added a new section: Flood Planning

Appendix 4. Trinity Basin Run-of-River Major Water Rights (Diversion ≥ 1,000 Acre-Ft Per Year) below Lake Livingston Dam

WAM* CONTROL POINT	AMOUNT (AF/YR)	USE**/ PRIORITY DATE	WATER RIGHT PERMIT ID	OWNER	STREAM NAME
CP579341	1,050	IRR/2003/01/13	08-5793	WELDON ALDERS/ IRONWOOD HOLDINGS, LLC.	LONG ISLAND BAYOU
CPB4261A	458,800	IND/1959/09/23	08-4261	CITY OF HOUSTON	TRINITY RIVER
	444,000	MUN/1959/09/23	08-4261	CITY OF HOUSTON	TRINITY RIVER
	31,600	IND/1913/12/30	08-4261	CITY OF HOUSTON	TRINITY RIVER
	30,000	MUN/1914/06/26	08-4279	SAN JACINTO RIVER AUTHORITY	TRINITY RIVER
	28,000	IND/1959/09/23	08-4261	CITY OF HOUSTON	TRINITY RIVER
	20,000	IND/1926/09/08	PM 5271B	SAN JACINTO RIVER AUTHORITY	TRINITY RIVER
	17,500	IND/1929/12/12	PM 5271B	SAN JACINTO RIVER AUTHORITY	TRINITY RIVER
	13,400	IRR/1913/12/30	08-4261	CITY OF HOUSTON	TRINITY RIVER
	11,000	IND/1936/09/24	PM 5271B	SAN JACINTO RIVER AUTHORITY	TRINITY RIVER
	10,000	MUN/1959/09/23	08-4261	CITY OF HOUSTON	TRINITY RIVER
	7,500	IND/1917/02/26	PM 5271B	SAN JACINTO RIVER AUTHORITY	TRINITY RIVER
CPB4261D	36,667	IRR/1906/04/14	08-4279	CHAMBERS-LIBERTY COS ND	TRINITY RIVER
	36,667	IRR/1914/02/12	08-4279	CHAMBERS-LIBERTY COS ND	TRINITY RIVER
CPB4269A	1,932	IRR/1969/12/11	08-4269	TRINITY PLANTATION INC ET AL	MENARD CREEK
CPB4277A	33,000	IRR/1913/07/02	08-4277	CITY OF HOUSTON	TRINITY RIVER
CPB4277D	5,000	IRR/1969/08/25	08-4277	CITY OF HOUSTON	TRINITY RIVER
CPB4279C	30,000	IND/1971/11/11	08-4279	CHAMBERS-LIBERTY COS ND	TRINITY RIVER
	6,666	IRR/1914/06/26	08-4279	CHAMBERS-LIBERTY COS ND	TRINITY RIVER
	2,147	MUN/1971/11/11	08-4279	CHAMBERS-LIBERTY COS ND	TRINITY RIVER
CPB5271P	2,500	IRR/1929/12/12	PM 5271A	Lower Neches Valley Authority	TRINITY RIVER

* Source: TCEQ Water Availability Model (WAM) RUN3, updated in 2014
** Use: IRR - irrigation; IND - industry; MUN - municipal

Appendix 5. Trinity River and Galveston Bay Environmental Flow Standards

West Fork Trinity River near Grand Prairie			
Season	Subsistence	Base	Pulse
Winter	19 cfs	45 cfs	Trigger: 300 cfs Volume: 3,500 af Duration: 4 days
Spring	25 cfs	45 cfs	Trigger: 1,200 cfs Volume: 8,000 af Duration: 8 days
Summer	23 cfs	35 cfs	Trigger: 300 cfs Volume: 1,800 af Duration: 3 days
Fall	21 cfs	35 cfs	Trigger: 300 cfs Volume: 1,800 af Duration: 3 days

Trinity River at Dallas			
Season	Subsist-ence	Base	Pulse
Winter	26 cfs	50 cfs	Trigger: 700 cfs Volume: 3,500 af Duration: 3 days
Spring	37 cfs	70 cfs	Trigger: 4,000 cfs Volume: 40,000 af Duration: 9 days
Summer	22 cfs	40 cfs	Trigger: 1,000 cfs Volume: 8,500 af Duration: 5 days
Fall	15 cfs	50 cfs	Trigger: 1,000 cfs Volume: 8,500 af Duration: 5 days

Trinity River Near Oakwood			
Season	Subsistence	Base	Pulse
Winter	120 cfs	340 cfs	Trigger: 3,000 cfs Volume: 18,000 af Duration: 5 days
Spring	160 cfs	450 cfs	Trigger: 7,000 cfs Volume: 130,000 af Duration: 11 days
Summer	75 cfs	250 cfs	Trigger: 2,500 cfs Volume: 23,000 af Duration: 5 days
Fall	100 cfs	260 cfs	Trigger: 2,500 cfs Volume: 23,000 af Duration: 5 days

Trinity River at Romayor			
Season	Subsistence	Base	Pulse
Winter	495 cfs	875 cfs	Trigger: 8,000 cfs Volume: 80,000 af Duration: 7 days
Spring	700 cfs	1,150 cfs	Trigger: 10,000 cfs Volume: 150,000 af Duration: 9 days
Sum-mer	200 cfs	575 cfs	Trigger: 4,000 cfs Volume: 60,000 af Duration: 5 days
Fall	230 cfs	625 cfs	Trigger: 4,000 cfs Volume: 60,000 af Duration: 5 days

Appendix 5. Trinity River and Galveston Bay Environmental Flow Standards (Cont.)

Bay and Estuary Freshwater Inflow Standards for the Galveston Bay System										
Basin	Annual Inflow Quantity (af)	Annual Target Frequency	Winter Inflow Quantity (af)	Winter Target Frequency	Spring Inflow Quantity (af)	Spring Target Frequency	Summer Inflow Quantity (af)	Summer Target Frequency	Fall Inflow Quantity (af)	Fall Target Frequency
Trinity	2,816,532	50%	500,000	40%	1,300,000	40%	245,000	40%	N/A	N/A
	2,245,644	60%	250,000	50%	750,000	50%	180,000	50%	N/A	N/A
	1,357,133	75%	160,000	60%	500,000	60%	75,000	60%	N/A	N/A
San Jacinto	1,460,424	50%	450,000	40%	500,000	40%	220,000	40%	200,000	40%
	1,164,408	60%	278,000	50%	290,000	50%	100,000	50%	150,000	50%
	703,699	75%	123,000	60%	155,000	60%	75,000	60%	90,000	60%

Appendix 6. 2020 Texas Integrated Report - Assessment Results for Trinity River Basin

FS=Fully supporting; NS=Nonsupport; NC=No concern; CS=Screening level concern; CN=Use concern

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Consump-tion	Domestic Water Supply
0801	Trinity River Tidal	01	FS	FS	CS - Chlorophyll-a		FS
0801B	Old River	01	FS		CS - Chlorophyll-a		
0801C	Cotton Bayou	01	NS - DO	NS - Entero	CS - Chlorophyll-a, NO3, TP		
0801D	Lynchburg Canal	01	FS	NC	CS - Chlorophyll-a	FS	
0802	Trinity River Below Lake Livingston	01	FS	FS	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
		02	FS		FS	NS - PCBs, Dioxin	FS
		03	FS	FS	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
		04	FS	FS	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
		05	FS	FS	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
0802B	Long King Creek	02	NC	CN - E. coli	NC		
0802D	Menard Creek	01	FS	CN - E. coli	NC		
0802E	Big Creek	01	FS	CN - E. coli	NC		
0803	Lake Livingston	01	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		02	NC		NS - SO4	NS - PCBs, Dioxin	
		03	NC		NS - SO4	NS - PCBs, Dioxin	
		04	FS		NS - SO4	NS - PCBs, Dioxin	
		05	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		06	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		07	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		08	FS		NS - SO4	NS - PCBs, Dioxin	
		09	CS - DO		NS - SO4	NS - PCBs, Dioxin	
		10	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		11	FS	FS	NS - SO4	NS - PCBs, Dioxin	FS
		12			NS - SO4	NS - PCBs, Dioxin	
0803A	Harmon Creek	01	FS	NC	CS - NO3, TP		
0803B	White Rock Creek	01	FS	NC	CS - Chlorophyll-a		
0803E	Nelson Creek	01	FS	NC	NC	FS	
0803F	Bedias Creek	01	FS	CN - E. coli	CS - Chlorophyll-a	FS	
		02	CN - Zn	CN - E. coli	NC	FS	
0803G	Lake Madisonville	01	FS	NC		NS - Mercury	
0804	Trinity River Above Lake Livingston	01	FS	FS	CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	FS
		02			CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	
		03			CS - NO3	NS - PCBs, Dioxin	
		04	FS	FS	CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	FS
		05			FS	NS - PCBs, Dioxin	
		06			FS	NS - PCBs, Dioxin	
		07	FS	FS	CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	FS
0804F	Tehuacana Creek	01	FS	CN - E. coli	CS - Chlorophyll-a	FS	
		02	FS	CN - E. coli	NC	FS	
0804G	Catfish Creek	01	NS - DO	NS - E. coli	NC		
0804H	Upper Keechi Creek	01	NS - DO	CN - E. coli	NC	NC	
0804J	Fairfield Lake	01	FS	FS	CN - Fish Kill		
0804K	Lower Keechi Creek	01	CS - DO	NS - E. coli	NC	FS	
0804L	Town Creek	01	FS	NS - E. coli	CS - NO3, TP		
0804M	Bassett Creek	01	NS - Fish, Benthics				
		02	CN - Benthics				
0805	Upper Trinity River	01			CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	
		02	FS	FS	CS - Chlorophyll-a, NO3, TP	NS - PCBs, Dioxin	
		03	FS	NS - E. coli	CS - NO3, TP	NS - PCBs, Dioxin	
		04	FS	NS - E. coli	CS - NO3, TP	NS - PCBs, Dioxin	
		06			CS - NO3, TP	NS - PCBs, Dioxin	

Appendix 6. (Cont.) *(Note: the segments that are not included in the table were not assessed)*

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Consumption	Domestic Water Supply
0806	West Fork Trinity River Below Lake Worth	01	FS	FS	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
		02	FS	CN - E. coli	FS	NS - PCBs, Dioxin	FS
0806A	Fosdic Lake	01				NS - PCBs; CS - Arsenic	
0806B	Echo Lake	01				NS - PCBs, Dioxin, Dieldrin	
0806D	Marine Creek	01	FS	NS - E. coli			
0806E	Sycamore Creek	01	FS	NS - E. coli			
0806F	Little Fossil Creek	01	FS	CN - E. coli			
0807	Lake Worth	01	FS	FS	FS	NS - PCBs, Dioxin	FS
0808	West Fork Trinity River Below Eagle Mountain Reservoir	01				NS - PCBs	
0809	Eagle Mountain Reservoir	01	CS - DO	FS	FS		FS
		02			FS		
		03			FS		
		04			FS		
		05	FS	FS	FS		FS
		06			FS		
		07			FS		
		08	FS	FS	FS		FS
		10	FS	FS	FS		FS
		11			FS		
		12	FS	FS	FS		FS
		14			FS		
0809A	Walnut Creek	01	FS	CN - E. coli	NC		
0809B	Ash Creek	01	FS	NS - E. coli	CS - NO3		
0809C	Dosier Creek	01	FS	NS - E. coli	NC		
0809D	Derrett Creek	01	FS	NS - E. coli	NC		
0810	West Fork Trinity River Below Bridgeport Reservoir	01	FS	NS - E. coli	CS - Chlorophyll-a		FS
		02	FS	FS	FS		
0810A	Big Sandy Creek	01	FS	FS			
0810B	Garrett Creek	01	FS	NC			
0810C	Martin Branch	01	FS	NS - E. coli			
0810D	Salt Creek	01	FS	NA			
0811	Bridgeport Reservoir	01	FS	FS	FS		FS
		02			FS		
		03	FS	FS	FS		FS
		04	FS	FS	FS		FS
		05			FS		
0811A	Big Creek	01	FS	CN - E. coli	NC		
0811B	Beans Creek	01	FS	NS - E. coli	NC		
0812	West Fork Trinity River Above Bridgeport Reservoir	01	FS	NS - E. coli	NS - TDS		FS
		02			NS - TDS		
0813	Houston County Lake	01	FS	FS	FS		FS
0814	Chambers Creek Above Richland-Chambers Reservoir	01	FS	FS	CS - TP		FS
		02	FS	NS - E. coli	CS - NO3		FS
		03			FS		
		04			FS		

Appendix 6 (Cont.)

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Con-sumption	Domestic Water Supply
0815	Bardwell Reservoir	01	FS	FS	NS - SO4		FS
0815A	Waxahachie Creek	01	NC	CN - E. coli	CS - NO3		
0816	Lake Waxahachie	01	FS	FS	FS		FS
0817	Navarro Mills Lake	01	FS	FS	FS	FS	FS
0818	Cedar Creek Reservoir	01	FS	FS	FS		FS
		02			NS - High pH		
		03			NS - High pH		
		04	FS	FS	NS - High pH		FS
		05			NS - High pH		
		06	FS	FS	FS		FS
		07			NS - High pH		
		08			NS - High pH		
		09	FS	FS	NS - High pH		FS
		10			FS		
		11	FS	FS	NS - High pH		FS
		12			NS - High pH		
		13	CS - DO		FS		
		14	FS	FS	FS		FS
0818B	Cedar Creek above Cedar Creek Reservoir	01	FS	NS - E. coli	NC		
0818C	Kings Creek	01	FS	NS - E. coli	CS - NO3, TP		
0818D	Lacy Fork	01	FS	CN - E. coli	NC		
0818F	Clear Creek	01	FS	CN - E. coli	NC		
0818G	North Twin Creek	01	FS	CN - E. coli	NC		
0818H	South Twin Creek	01	FS	CN - E. coli	NC		
0818I	Caney Creek	01	FS	CN - E. coli	NC		
0819	East Fork Trinity River	01	FS	NS - E. coli	NS - SO4; CS - Chloro-phyll-a, NO3, TP		
0819B	Buffalo Creek	01			CS - NO3, TP		
0820	Lake Ray Hubbard	01	FS		FS	FS	FS
		02	FS	FS	FS	FS	FS
		04	FS	FS	FS	FS	FS
		05	FS		FS	FS	FS
		06	FS		FS	FS	FS
0820B	Rowlett Creek	01	FS	NS - E. coli	CS - NO3	FS	
0820C	Muddy Creek	01	FS		CS - NO3	FS	
0821	Lake Lavon	01	FS	FS	FS		FS
		02	FS	FS	FS		FS
		03	FS	FS	FS		FS
		04	FS	FS	FS		FS
0821A	Pilot Grove Creek	02	FS	CN - E. coli	NC		
0821B	Sister Grove Creek	01	CS - DO	CN - E. coli	NC		
0821C	Wilson Creek	01	FS	NS - E. coli	NC		
0821D	East Fork Trinity River above Lake Lavon	01	FS	NS - E. coli	NC		

Appendix 6 (Cont.)

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Con-sumption	Domestic Water Supply
0822	Elm Fork Trinity River Below Lewisville Lake	01	FS	FS	CS - Chlorophyll-a	FS	FS
		02	CN - Cd		FS	FS	FS
		03	FS		FS	FS	FS
		04	FS		CS - Chlorophyll-a	FS	FS
0822A	Cottonwood Branch	01	FS	FS	CS - Chlorophyll-a	FS	
		02	FS	NS - E. coli		FS	
0822B	Grapevine Creek	01	FS	NS - E. coli	NC		
0822C	Hackberry Creek	01	FS	NC	CS - Chlorophyll-a	NC	
0822D	Ski Lake	01	FS			FS	FS
0823	Lewisville Lake	01			FS	FS	
		02	FS		FS	FS	FS
		03	FS		FS	FS	FS
		04	FS		FS	FS	FS
		05	FS		FS	FS	FS
		06			FS	FS	
0823A	Little Elm Creek	01	FS			NC	
0823B	Stewart Creek	01			CS - NO3, TP		
0823C	Clear Creek	01	FS	NS - E. coli	NC	NC	
0823D	Doe Branch	01	FS			FS	
0824	Elm Fork Trinity River Above Ray Roberts Lake	01	FS		CS - Chlorophyll-a, NO3	FS	FS
		02			CS - NO3	FS	FS
		03	FS	NS - E. coli	CS - Chlorophyll-a	FS	FS
		04			FS	FS	FS
		05			FS	FS	FS
0825	Denton Creek	01	FS	CN - E. coli	FS	FS	FS
0826	Grapevine Lake	01	FS	FS	CS - Excessive Algal Growth	FS	FS
		02			CS - Excessive Algal Growth	FS	
		03			CS - Excessive Algal Growth	FS	
		04			CS - Excessive Algal Growth	FS	
		05	FS		CS - Excessive Algal Growth	FS	FS
		06	FS	FS	CS - Excessive Algal Growth	FS	FS
		07			NS - pH; CS - Excessive Algal Growth	FS	
		08			CS - Excessive Algal Growth	FS	
0826A	Denton Creek	01	FS		CS - NO3	FS	
		02	CN - Zn			FS	
		03				FS	
		04				FS	
0827	White Rock Lake	01	FS	FS	CS - Excessive Algal Growth		
0827A	White Rock Creek above White Rock Lake	01	FS	NS - E. coli	NC	FS	

Appendix 6 (Cont.)

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Con-sumption	Domestic Water Supply
0828	Lake Arlington	01			FS		
		02	FS	FS	FS		FS
		03			FS		
		04			FS		
		05	FS	FS	FS		FS
		06	FS	FS	FS		FS
		07	FS	NC	FS		FS
		08			FS		
0828A	Village Creek	01	FS	NS - E. coli	NC		
0829	Clear Fork Trinity River Below Benbrook Lake	01			FS	NS - PCBs, Dioxin	
		02	FS	NS - E. coli	CS - Chlorophyll-a	NS - PCBs, Dioxin	FS
		03			FS	NS - PCBs, Dioxin	
0829A	Lake Como	01				NS - PCBs, Dioxin, Dieldrin; CS - Arsenic	
0830	Benbrook Lake	01	FS	FS	FS		FS
		02	FS	FS	FS		FS
		03	FS	FS	FS		FS
		05	FS	FS	FS		
0830A	Rock Creek	01	FS		NC		
0830B	Bear Creek	01	FS		NC		
0831	Clear Fork Trinity River Below Lake Weatherford	01	FS	NS - E. coli	CS - NO3, TP		FS
		03			FS		
		04	NS - DO		FS		
		05	CS - DO		FS		
0831A	South Fork Trinity River	01	FS	CN - E. coli	CS - NO3, TP		
0831B	Unnamed Tributary of South Fork Trinity River	01	NC				
0832	Lake Weatherford	01	FS	FS	FS		FS
0833	Clear Fork Trinity River Above Lake Weatherford	03	NS - DO		FS		
		04	NS - DO		FS		
		05	FS		FS		
0833A	Clear Fork Trinity River Above Strickland Creek	01	NS - DO		CS - Chlorophyll-a		
0834	Lake Amon G. Carter	01	FS	NC	FS		FS
0836	Richland-Chambers Reservoir	01	FS	FS	FS		FS
		02	FS	FS	FS		FS
		03	FS	FS	FS		FS
		04	FS	FS	FS		FS
		05	FS	FS	FS		FS
		06	FS	FS	FS		FS
		07	CS - DO	NS - E. coli	FS		FS
		08			FS		

Appendix 6 (Cont.)

Segment ID	Segment Description	AU	Aquatic Life	Recreation	General	Fish Consumption	Domestic Water Supply
0836B	Cedar Creek	01	NS - DO				
0836C	Grape Creek	01	CN - DO				
0836D	Post Oak Creek	01	FS	CN - E. coli	NC		
0837	Richland Creek Above Richland-Chambers Reservoir	01	CS - DO	NS - E. coli	CS - Chlorophyll-a		FS
0838B	Sugar Creek	01	FS	FS	NC		
0838C	Walnut Creek	01	FS	FS			
0838D	Hollings Branch	01	FS	FS	NC		
0838E	Soap Creek	01	FS	FS	NC		
0838F	Unnamed tributary of Mountain Creek	01	NC	NC			
0839	Elm Fork Trinity River Below Ray Roberts Lake	01	FS		FS	FS	FS
0840	Ray Roberts Lake	01	FS	FS	FS	FS	FS
		02	FS	FS	FS	FS	FS
		03	FS		FS	FS	FS
		04	FS		FS	FS	FS
		05			FS	FS	
		06	FS	FS	FS	FS	FS
		07	FS		FS	FS	FS
		08	CS - DO		FS	FS	
0841	Lower West Fork Trinity River	01	FS	NS - E. coli	CS - NO3, TP	NS - PCBs, Dioxin	
		02	FS	FS	CS - NO3, TP	NS - PCBs, Dioxin	
0841A	Mountain Creek Lake	01				NS - PCBs, Dioxin	
0841B	Bear Creek	01	FS	FS	NC	FS	
0841D	Big Bear Creek	01	FS	NC	NC		
0841E	Copart Branch Mountain Creek	01	FS	FS	NC		
0841F	Cottonwood Creek	01	CS - DO	NS - E. coli	NC	FS	
0841G	Dalworth Creek	01	FS	NS - E. coli	NC		
0841H	Delaware Creek	01	FS	FS	NC	FS	
0841I	Dry Branch Creek	01	FS	NS - E. coli			
0841J	Estelle Creek	01	FS	FS			
0841K	Fish Creek	01	CS - DO, Habitat; CN - Benthics	NS - E. coli	NC	FS	
0841L	Johnson Creek	01	FS	NS - E. coli	NC	FS	
0841M	Kee Branch	01	CS - DO	NS - E. coli		FS	
0841N	Kirby Creek	01	CS - DO	NS - E. coli	NC	NC	
0841O	Mountain Creek	01	FS	CN - E. coli	CS - Chlorophyll-a, NH3	NC	
0841P	North Fork Cottonwood Creek	01	FS	NS - E. coli	NC	FS	
0841Q	North Fork Fish Creek	01	FS	NS - E. coli	NC	FS	
0841R	Rush Creek	01	FS	FS	NC	FS	
0841S	Vilbig Lakes	01	FS	FS			
0841T	Village Creek	01	FS	CN - E. coli		FS	
0841U	West Irving Creek	01	FS	NS - E. coli			
0841V	Crockett Branch	01	FS	NS - E. coli	NC		
0841W	Mountain Creek above Mountain Creek Lake	01	FS	FS	NC		

Appendix 7. 2020 Texas Integrated Report - Texas 303 (d) List (Category 5) for Trinity River Basin

This 303 (d) list identifies the water bodies in Trinity River basin for which effluent limitations are not stringent enough to implement water quality standards, and for which the associated pollutants are suitable for measurement by maximum daily load. TCEQ develops a schedule identifying Total Maximum Daily Loads (TMDLs) that will be initiated in the next two years for priority impaired waters.

Category 5: The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.

- Category 5a - TMDLs are underway, scheduled, or will be scheduled for one or more parameters.
- Category 5b - A review of the standards for one or more parameters will be conducted before a management strategy is selected, including the possible revision to the TSWQS.
- Category 5c - Additional data or information will be collected and/or evaluated for one or more parameters before a management strategy is selected.

For the complete 2020 Texas 303(d) list, visit TCEQ at:
https://www.tceq.texas.gov/waterquality/assessment/20twqi

SegID: 0801C Cotton Bayou
From the confluence of Cotton Lake southeast of Mont Belvieu in Chambers County upstream to a point (NHD RC 12040203000496) approximately 1 mi north of IH 10 in Chambers County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2010**

0801C_01 From the confluence of Cotton Lake southeast of Mont Belvieu in Chambers County upstream to a point (NHD RC 12040203000496) approximately 1 mi north of IH 10 in Chambers County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5c**	**2006**

0801C_01 From the confluence of Cotton Lake southeast of Mont Belvieu in Chambers County upstream to a point (NHD RC 12040203000496) approximately 1 mi north of IH 10 in Chambers County

SegID: 0802 Trinity River Below Lake Livingston
From a point 3.1 km (1.9 mi) downstream of US 90 in Liberty County to Livingston Dam ir Polk/San Jacinto County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2016**

0802_01	Lower 17 mi of segment
0802_02	Approximately 9 mi upstream to approximately 15 mi downstream of SH 105
0802_03	11 mi upstream to approximately 9 mi downstream of FM 787
0802_04	5 mi upstream to 11 mi downstream of US 59
0802_05	Upper 6 mi of segment

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**2016**

0802_01	Lower 17 mi of segment
0802_02	Approximately 9 mi upstream to approximately 15 mi downstream of SH 105
0802_03	11 mi upstream to approximately 9 mi downstream of FM 787
0802_04	5 mi upstream to 11 mi downstream of US 59
0802_05	Upper 6 mi of segment

SegID: 0803 **Lake Livingston**
From Livingston Dam in Polk/San Jacinto County to a point 1.8 km (1.1 mi) upstream of Boggy Creek in Houston/Leon County, up to normal pool elevation of 131 feet (impounds Trinity River)

Impairment Description(s)		*Category*	*Year Segment First Listed*
Dioxin in edible tissue		**5a**	**2016**
0803_01	Lowermost portion of reservoir, adjacent to dam		
0803_02	Lower portion of reservoir, East Wolf Creek		
0803_03	Lower portion of reservoir, East Willow Springs		
0803_04	Middle portion of reservoir, East Pointblank		
0803_05	Middle portion of reservoir, downstream of Kickapoo Creek		
0803_06	Middle portion of reservoir, centering on US 190		
0803_07	Upper portion of reservoir, west of Carlisle		
0803_08	Cove off upper portion of reservoir, East Trinity		
0803_09	West Carolina Creek cove, off upper portion of reservoir		
0803_10	Upper portion of reservoir, centering on SH 19		
0803_11	Riverine portion of reservoir, centering on SH 21		
0803_12	Remainder of reservoir		

Impairment Description(s)		*Category*	*Year Segment First Listed*
PCBs in edible tissue		**5a**	**2016**
0803_01	Lowermost portion of reservoir, adjacent to dam		
0803_02	Lower portion of reservoir, East Wolf Creek		
0803_03	Lower portion of reservoir, East Willow Springs		
0803_04	Middle portion of reservoir, East Pointblank		
0803_05	Middle portion of reservoir, downstream of Kickapoo Creek		
0803_06	Middle portion of reservoir, centering on US 190		
0803_07	Upper portion of reservoir, west of Carlisle		
0803_08	Cove off upper portion of reservoir, East Trinity		
0803_09	West Carolina Creek cove, off upper portion of reservoir		
0803_10	Upper portion of reservoir, centering on SH 19		
0803_11	Riverine portion of reservoir, centering on SH 21		
0803_12	Remainder of reservoir		

Impairment Description(s)		*Category*	*Year Segment First Listed*
Sulfate in water		**5b**	**2006**
0803_01	Lowermost portion of reservoir, adjacent to dam		
0803_02	Lower portion of reservoir, East Wolf Creek		
0803_03	Lower portion of reservoir, East Willow Springs		
0803_04	Middle portion of reservoir, East Pointblank		
0803_05	Middle portion of reservoir, downstream of Kickapoo Creek		
0803_06	Middle portion of reservoir, centering on US 190		
0803_07	Upper portion of reservoir, west of Carlisle		
0803_08	Cove off upper portion of reservoir, East Trinity		
0803_09	West Carolina Creek cove, off upper portion of reservoir		
0803_10	Upper portion of reservoir, centering on SH 19		

SegID: 0803 **Lake Livingston**
From Livingston Dam in Polk/San Jacinto County to a point 1.8 km (1.1 mi) upstream of Boggy Creek in Houston/Leon County, up to normal pool elevation of 131 feet (impounds Trinity River)

0803_11	Riverine portion of reservoir, centering on SH 21
0803_12	Remainder of reservoir

SegID: 0803G Lake Madisonville
From Lake Madisonville Dam in Madison County up to the normal pool elevation of 285 feet (impounds Town Branch)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Mercury in edible tissue	**5c**	**2010**

0803G_01 From Lake Madisonville Dam in Madison County up to the normal pool elevation of 285 feet (impounds Town Branch)

SegID: 0804 Trinity River Above Lake Livingston
From a point 1.8 km (1.1 mi) upstream of Boggy Creek in Houston/Leon County to a point immediately upstream of the confluence of the Cedar Creek Reservoir discharge canal in Henderson/Navarro County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2010**

0804_01 From the lower end of the segment up to just above the confluence with Hurricane Bayou in Houston County.

0804_02 From just upstream of the confluence with Hurricane Bayou up to just above the confluence with Boons Creek.

0804_03 From just upstream of the confluence with Boons Creek up to just above the confluence with Caney Creek.

0804_04 From the confluence with Caney Creek up to just above the confluence with Indian Creek in Anderson County.

0804_05 From just above the confluence with Indian Creek in Anderson County up to just above the confluence with Tehuacana Creek.

0804_06 From just above the confluence with Tehuacana Creek to just above the confluence with Richland Creek.

0804_07 From just above the confluence with Richland Creek in Henderson County, up to the upper end of the segment.

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**2010**

0804_01 From the lower end of the segment up to just above the confluence with Hurricane Bayou in Houston County.

0804_02 From just upstream of the confluence with Hurricane Bayou up to just above the confluence with Boons Creek.

0804_03 From just upstream of the confluence with Boons Creek up to just above the confluence with Caney Creek.

0804_04 From the confluence with Caney Creek up to just above the confluence with Indian Creek in Anderson County.

0804_05 From just above the confluence with Indian Creek in Anderson County up to just above the confluence with Tehuacana Creek.

0804_06 From just above the confluence with Tehuacana Creek to just above the confluence with Richland Creek.

0804_07 From just above the confluence with Richland Creek in Henderson County, up to the upper end of the segment.

SegID: 0804G Catfish Creek
Twenty mile stretch of Catfish Creek running upstream from US 287 in Anderson Co., to Catfish Creek Ranch Lake just upstream of SH 19 in Henderson Co.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5b**	**2010**

0804G_01 A 20 mi stretch of Catfish Creek running upstream from US 287 in Anderson Co., to Catfish Creek Ranch Lake just upstream of SH 19 in Henderson Co.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5b**	**2006**

0804G_01 A 20 mi stretch of Catfish Creek running upstream from US 287 in Anderson Co., to Catfish Creek Ranch Lake just upstream of SH 19 in Henderson Co.

SegID: 0804H Upper Keechi Creek
From confluence with segment 0804 Trinity River to the upper end of NHD stream Upper Keechi Creek (NHD RC 12030201001075)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5b**	**2010**

0804H_01 From the confluence with segment 0804 Trinity River up to confluence with Twin Branch (NHD RC 12030201027099)

SegID: 0804K Lower Keechi Creek
Perennial stream from the confluence with the Trinity River in Leon County upstream to the headwaters in Jewett in Leon County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2018**

0804K_01 Perennial stream from the confluence with the Trinity River in Leon County upstream to the headwaters in Jewett in Leon County

SegID: 0804L Town Creek
Perennial stream from the confluence with Keechi Creek upstream to SH 256 (Appendix D)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0804L_01 Perennial stream from the confluence with Keechi Creek upstream to SH 256 (Appendix D)

SegID: 0804M Bassett Creek
Perennial stream from the confluence with Town Creek upstream to Blue Lake

Impairment Description(s)	*Category*	*Year Segment First Listed*
Impaired fish community in water	**5c**	**2018**

0804M_01 From the confluence with Town Creek upstream to approximately 15m upstream of the processing plant outfall

Impairment Description(s)	*Category*	*Year Segment First Listed*
Impaired macrobenthic community in water	**5c**	**2018**

0804M_01 From the confluence with Town Creek upstream to approximately 15m upstream of the processing plant outfall

SegID: 0805 Upper Trinity River
From a point immediately upstream of the confluence of the Cedar Creek Reservoir discharge canal in Henderson/Navarro County to a point immediately upstream of the confluence of Elm Fork Trinity River in Dallas County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2010**

0805_01 From confluence of the Cedar Creek Reservoir discharge canal upstream to confluence of Smith Creek.

0805_02 From confluence of Smith Creek upstream to confluence of Tenmile Creek.

0805_03 From the confluence of Fivemile Creek upstream to the confluence of Cedar Creek.

0805_04 From confluence of Cedar Creek upstream to confluence of Elm Fork Trinity River

0805_06 From confluence of Tenmile Creek upstream to confluence of Fivemile Creek

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**2002**

0805_01 From confluence of the Cedar Creek Reservoir discharge canal upstream to confluence of Smith Creek.

0805_02 From confluence of Smith Creek upstream to confluence of Tenmile Creek.

0805_03 From the confluence of Fivemile Creek upstream to the confluence of Cedar Creek.

0805_04 From confluence of Cedar Creek upstream to confluence of Elm Fork Trinity River

0805_06 From confluence of Tenmile Creek upstream to confluence of Fivemile Creek

SegID: 0806 **West Fork Trinity River Below Lake Worth**
From a point immediately upstream of the confluence of Village Creek in Tarrant County to Lake Worth Dam in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2010**

0806_01 From confluence of Village Creek upstream to confluence of Clear Fork Trinity River
0806_02 From confluence of Clear Fork Trinity River upstream to Lake Worth Dam

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**1996**

0806_01 From confluence of Village Creek upstream to confluence of Clear Fork Trinity River
0806_02 From confluence of Clear Fork Trinity River upstream to Lake Worth Dam

SegID: 0806B **Echo Lake**
From Echo Lake Dam to the reservoirs headwaters in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dieldrin in edible tissue	**5a**	**2016**

0806B_01 From Echo Lake Dam to the reservoirs headwaters in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2016**

0806B_01 From Echo Lake Dam to the reservoirs headwaters in Tarrant County

SegID: 0806D **Marine Creek**
Marine Creek from the confluence with West Fork Trinity River Below Lake Worth upstream to the Marine Creek Reservoir dam

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2006**

0806D_01 Marine Creek from the confluence with West Fork Trinity River Below Lake Worth upstream to the Marine Creek Reservoir dam

SegID: 0807 **Lake Worth**
From Lake Worth Dam in Tarrant County to a point 4.0 km (2.5 mi) downstream of Eagle Mountain Dam in Tarrant County, up to normal pool elevation of 594 feet (impounds West Fork Trinity River)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2018**

0807_01 From Lake Worth Dam in Tarrant County to a point 4.0 km (2.5 mi) downstream of Eagle Mountain Dam in Tarrant County, up to normal pool elevation of 594 feet (impounds West Fork Trinity River)

SegID: 0809B **Ash Creek**
Intermittent stream with perennial pools from Eagle Mountain Lake in Tarrant County upstream to its confluence with Mill Branch in Parker County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5b**	**2014**

0809B_01 Intermittent stream with perennial pools from Eagle Mountain Lake in Tarrant County upstream to its confluence with Mill Branch in Parker County

SegID: 0809C **Dosier Creek**
Perennial stream from the confluence of Dosier Slough cove upstream to the confluence with an intermittent stream 1 km upstream of Boat Club Road

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0809C_01 Perennial stream from the confluence of Dosier Slough cove upstream to the confluence with an intermittent stream 1 km upstream of Boat Club Road

SegID: 0809D **Derrett Creek**
Perennial stream from the confluence with Derrett Creek cove to 0.22 km upstream of FM 718 where the waterbody meets an intermittent stream

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0809D_01 Perennial stream from the confluence with Derrett Creek cove to 0.22 km upstream of FM 718 where the waterbody meets an intermittent stream

SegID: 0810 **West Fork Trinity River Below Bridgeport Reservoir**
From a point 0.6 km (0.4 mi) downstream of the confluence of Oates Branch in Wise County to Bridgeport Dam in Wise County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**1998**

0810_01 Lower 25 mi of segment

SegID: 0810C **Martin Branch**
The eight mi stretch of Martin Branch running upstream from confluence with Center Creek to FM 730 south of Decatur, Wise County.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2006**

0810C_01 Eight mi stretch of Martin Branch running upstream from confluence with Center Creek to FM 730 south of Decatur, Wise County.

SegID: 0811B **Beans Creek**
Perennial stream from the confluence with Bridgeport Reservoir at normal pool elevation upstream to the headwaters approximately 4.4 km north of Perrin in Jack County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0811B_01 Perennial stream from the confluence with Bridgeport Reservoir at normal pool elevation upstream to the headwaters approximately 4.4 km north of Perrin in Jack County

SegID: 0812 **West Fork Trinity River Above Bridgeport Reservoir**
From a point immediately upstream of the confluence of Bear Hollow in Jack County to SH 79 in Archer County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2016**

0812_01 Lower 25 mi of segment

Impairment Description(s)	*Category*	*Year Segment First Listed*
Total dissolved solids in water	**5c**	**1998**

0812_01 Lower 25 mi of segment

0812_02 Upper 60 mi of segment

SegID: 0814 **Chambers Creek Above Richland-Chambers Reservoir**
From a point 4.0 km (2.5 mi) downstream of Tupelo Branch in Navarro County to the confluence of North Fork Chambers Creek and South Fork Chambers Creek

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0814_02 From just above the confluence with Cummins Creek up to just above the confluence with Waxahachie Creek.

SegID: 0815 **Bardwell Reservoir**
From Bardwell Dam in Ellis County up to the normal pool elevation of 421 feet (impounds Waxahachie Creek)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Sulfate in water	**5c**	**2016**

0815_01 From Bardwell Dam in Ellis County up to the normal pool elevation of 421 feet (impounds Waxahachie Creek)

SegID: 0818 **Cedar Creek Reservoir**
From Joe B. Hoggsett Dam in Henderson County up to normal pool elevation of 322 feet (impounds Cedar Creek)

Impairment Description(s)	*Category*	*Year Segment First Listed*
pH	**5b**	**2002**

0818_02 Caney Creek cove

0818_03 Clear Creek cove

0818_04 Lower portion of reservoir east of Key Ranch Estates

0818_05 Cove off lower portion of reservoir adjacent to Clearview Estates

0818_07 Twin Creeks cove

0818_08 Prairie Creek cove

0818_09 Upper portion of reservoir adjacent to Lacy Fork cove

0818_11 Upper portion of reservoir east of Tolosa

0818_12 Uppermost portion of reservoir downstream of Kings Creek

SegID: 0818B **Cedar Creek above Cedar Creek Reservoir**
Perennial stream from the confluence with Cedar Creek Reservoir at normal pool elevation upstream to the confluence of Muddy Cedar Creek and Rocky Cedar Creek in Kaufman County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2018**

0818B_01 Perennial stream from the confluence with Cedar Creek Reservoir at normal pool elevation upstream to the confluence of Muddy Cedar Creek and Rocky Cedar Creek in Kaufman County

SegID: 0818C **Kings Creek**
Intermittent stream with perennial pools from the confluence with Cedar Creek Reservoir at normal pool elevation upstream to the headwaters adjacent to FM 986 approximately 5 km north of Terrell in Kaufman County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2018**

0818C_01 Intermittent stream with perennial pools from the confluence with Cedar Creek Reservoir at normal pool elevation upstream to the headwaters adjacent to FM 986 approximately 5 km north of Terrell in Kaufman County

SegID: 0819 **East Fork Trinity River**
From the confluence with the Trinity River in Kaufman County to Rockwall-Forney Dam ir Kaufman County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0819_01 From the confluence with the Trinity River in Kaufman County to Rockwall-Forney Dam in Kaufman County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Sulfate in water	**5c**	**2008**

0819_01 From the confluence with the Trinity River in Kaufman County to Rockwall-Forney Dam in Kaufman County

SegID: 0820B **Rowlett Creek**
Perennial stream from the normal pool elevation of Lake Ray Hubbard upstream to the Parker Road crossing

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2014**

0820B_01 Perennial stream from the normal pool elevation of Lake Ray Hubbard upstream to the Parker Road crossing

SegID: 0821C **Wilson Creek**
From the confluence with Lake Lavon in Collin County up to West FM 455 (NHD RC 12030106000086), just east of Celina, Collin Co., TX.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2010**

0821C_01 From the confluence with Lake Lavon in Collin County up to West FM 455 (NHD RC 12030106000086), just east of Celina, Collin Co., TX.

SegID: 0821D **East Fork Trinity River above Lake Lavon**
A portion of the East Fork Trinity River extending from the confluence with Lake Lavon (segment 0821) to the upper end of the water body (NHD RC 12030106000074) in Grayson County, Texas.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2010**

0821D_01 A portion of the East Fork Trinity River extending from the confluence with Lake Lavon (segment 0821) to the upper end of the water body (NHD RC 12030106000074) in Grayson County, Texas.

SegID: 0823C **Clear Creek**
From the confluence with Lake Lewisville in Denton County to the headwaters west of Montague in Montague County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0823C_01 Lower 25 mi of segment

SegID: 0824 **Elm Fork Trinity River Above Ray Roberts Lake**
From a point 9.5 km (5.9 mi) downstream of the confluence of Pecan Creek in Cooke County to US 82 in Montague County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2016**

0824_03 3.5 mi reach near SH 51

Appendix 7 (Cont.)

SegID: 0826 **Grapevine Lake**
From Grapevine Dam in Tarrant County up to normal pool elevation of 535 feet (impounds Denton Creek)

Impairment Description(s)	*Category*	*Year Segment First Listed*
pH	**5c**	**2012**

0826_07 Upper portion of reservoir east of Marshall Creek Park

SegID: 0827A **White Rock Creek above White Rock Lake**
Perennial stream from the headwaters of White Rock Lake upstream to the headwaters at Hilcrest Road in Frisco

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2016**

0827A_01 Perennial stream from the headwaters of White Rock Lake upstream to the confluence with McKamy Branch east of the City of Addison

SegID: 0828A **Village Creek**
From the confluence with Lake Arlington in Tarrant County to the headwaters east of Joshua in Johnson County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2010**

0828A_01 From Lake Arlington to the headwaters

SegID: 0829 **Clear Fork Trinity River Below Benbrook Lake**
From the confluence with the West Fork Trinity River in Tarrant County to Benbrook Dam in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2018**

0829_02 From 1 mi upstream of the confluence with West Fork Trinity River up to the confluence with Mary's Creek

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2010**

0829_01 From the confluence with West Fork Trinity River to 1 mi upstream

0829_02 From 1 mi upstream of the confluence with West Fork Trinity River up to the confluence with Mary's Creek

0829_03 From the confluence with Mary's Creek up to Benbrook Dam in Tarrant County, TX

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**1996**

0829_01 From the confluence with West Fork Trinity River to 1 mi upstream

0829_02 From 1 mi upstream of the confluence with West Fork Trinity River up to the confluence with Mary's Creek

0829_03 From the confluence with Mary's Creek up to Benbrook Dam in Tarrant County, TX

SegID: 0829A **Lake Como**
From Lake Como Dam to the reservoir headwaters in Lake Como Park in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2016**

0829A_01 From Lake Como Dam to the reservoir headwaters in Lake Como Park in Tarrant County

SegID: 0831 **Clear Fork Trinity River Below Lake Weatherford**
From a point 200 meters (220 yards) downstream of US 377 in Tarrant County to Weatherford Dam in Parker County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2016**

0831_01 Lower 12.75 mi, downstream from South Fork Trinity River confluence

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5c**	**1996**

0831_04 2 mi upstream of South Fork Trinity River confluence to Squaw Creek Confluence

SegID: 0833 **Clear Fork Trinity River Above Lake Weatherford**
From a point 3.1 km (1.9 mi) upstream of FM 730 in Parker County, to the confluence with Strickland Creek approximately 8 km (5 mi) upstream of FM 51 in Parker County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5b**	**1998**

0833_03 From the confluence of McKnight Branch to the confluence of Strickland Ck. approximately 8 km (5 mi) upstream of FM 51 in Parker County.

0833_04 From the confluence with Dobbs Branch to confluence with McKnight Branch

SegID: 0833A **Clear Fork Trinity River Above Strickland Creek.**
From the confluence with Strickland Creek up to Turpin Lake Road in Parker County.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5c**	**1998**

0833A_01 From the confluence with Strickland Creek up to Turpin Lake Road in Parker County.

SegID: 0836 **Richland-Chambers Reservoir**
From Richland-Chambers Dam to a point immediately upstream of the confluence of Pin Oak Creek on the Richland Creek Arm and to a point 4.0 km (2.5 mi) downstream of Tupelo Branch on the Chambers Creek Arm, up to the normal pool elevation of 315 ft (impoun

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2018**

0836_07 Remainder of reservoir

SegID: 0836B **Cedar Creek**
From the confluence with Richland Chambers Reservoir to the upper end of the creek (NHD RC 12030109012807)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Depressed dissolved oxygen in water	**5b**	**2010**

0836B_01 From the confluence with Richland Chambers Reservoir to the upper end of the creek (NHD RC 12030109012807)

SegID: 0837 **Richland Creek Above Richland-Chambers Reservoir**
From the confluence of Pin Oak Creek in Navarro County to Navarro Mills Dam in Navarro County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0837_01 From the confluence of Pin Oak Creek in Navarro County to Navarro Mills Dam in Navarro County

SegID: 0841 **Lower West Fork Trinity River**
From a point immediately upstream of the confluence of the Elm Fork Trinity River in Dallas County to a point immediately upstream of the confluence of Village Creek in Tarrant County

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2010**

0841_01 From confluence of the Elm Fork Trinity River to the confluence with Johnson Creek.

0841_02 From the confluence with Johnson Creek upstream to the confluence of Village Creek.

Impairment Description(s)	*Category*	*Year Segment First Listed*
PCBs in edible tissue	**5a**	**1996**

0841_01 From confluence of the Elm Fork Trinity River to the confluence with Johnson Creek.

0841_02 From the confluence with Johnson Creek upstream to the confluence of Village Creek.

SegID: 0841A **Mountain Creek Lake**
From Mountain Creek Lake Dam to the reservoir headwater at the confluence of Mountain and Fish Creeks, in Dallas County (impounds Mountain Creek)

Impairment Description(s)	*Category*	*Year Segment First Listed*
Dioxin in edible tissue	**5a**	**2016**

0841A_01 From Mountain Creek Lake Dam to the reservoir headwater at the confluence of Mountain and Fish Creeks, in Dallas County (impounds Mountain Creek)

SegID: 0841I **Dry Branch Creek**
An 1.5 mi stretch of Dry Branch Creek running upstream from confluence with Lower W. Fork Trinity to Rock Island Road in Irving, Dallas County.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5c**	**2020**

0841I_01 An 1.5 mi stretch of Dry Branch Creek running upstream from confluence with Lower W. Fork Trinity tc Rock Island Road in Irving, Dallas County.

SegID: 0841P **North Fork Cottonwood Creek**
A 4.4 mi stretch of North Fork Cottonwood Creek running upstream from confluence with the S. Fork Cottonwood Creek in Grand Prairie, Dallas Co., to approx. 0.3 mi upstream of Carter St. in Arlington, Tarrant Co.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5a**	**2020**

0841P_01 A 4.4 mi stretch of North Fork Cottonwood Creek running upstream from confluence with the S. Fork Cottonwood Creek in Grand Prairie, Dallas Co., to approx. 0.3 mi upstream of Carter St. in Arlington, Tarrant Co.

SegID: 0841Q **North Fork Fish Creek**
North Fork Fish Creek from confluence with Fish Creek in Dallas Co. upstream to SH 360 in Tarrant Co.

Impairment Description(s)	*Category*	*Year Segment First Listed*
Bacteria in water (Recreation Use)	**5a**	**2016**

0841Q_01 North Fork Fish Creek from confluence with Fish Creek in Dallas Co. upstream to SH 360 in Tarrant Co.

All GIS maps and photography are provided by the Trinity River Authority, unless otherwise noted.