2023 Summer Fuel Field Study

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AST	Aboveground Storage Tank
API	American Petroleum Institute
BPA	Beaumont-Port Arthur
CAS	Chemical Abstracts Service
CG	Conventional Gasoline
COVID-19	Coronavirus Disease 2019
cST	centistokes (a unit used for the measurement of kinematic viscosity)
DFW	Dallas-Fort Worth
DHA	detailed hydrocarbon analysis
E200	Lower Volatility Percentage
E300	Upper Volatility Percentage
EAC	Early Action Compact
EIA	Energy Information Administration
ERG	Eastern Research Group, Inc.
ETBE	Ethyl Tert-Butyl Ether
ETOH	Ethanol
FIPS	Federal Information Processing Standards
GHA	Greater Houston Area
HGAC	Houston-Galveston Area Council
HGB	Houston-Galveston-Brazoria
IATA	International Air Transport Association
IC	Independent Contractor
MOVES	Motor Vehicle Emission Simulator
MPO	Metropolitan Planning Organization
MTBE	Methyl Tert-Butyl Ether

MU	Midgrade Unleaded gasoline
NAAQS	National Ambient Air Quality Standards
NCTCOG	North Central Texas Council of Governments
PADD	Petroleum Administration Defense Districts
ppm	parts per million
psi	pounds per square inch
PST	Petroleum Storage Tank
PU	Premium-Grade Unleaded gasoline
PYA	Previous Year Average (the average of the 2017 and 2020 survey values)
QA/QC	Quality Assurance/Quality Control
RFG	Reformulated Gasoline
RU	Tegular Unleaded gasoline
RVP	Reid vapor pressure
SETRPC	South East Texas Regional Planning Commission
SFC	Supercritical Fluid Chromatography
SIP	State Implementation Plan
SPR	Strategic Petroleum Reserve
SwRI	Southwest Research Institute
TAME	Tert-Amyl Methyl Ether
TCEQ	Texas Commission on Environmental Quality
TexN	Texas NONROAD model
TTI	Texas A&M Transportation Institute
TxDOT	Texas Department of Transportation
U.S. DOT	U.S. Department of Transportation
U.S. EPA	U.S. Environmental Protection Agency
ULSD	Ultra-Low-Sulfur Diesel
UST	Underground Storage Tank
VOC	Volatile Organic Ccompound

EXECUTIVE SUMMARY

The TCEQ commissioned a study to conduct a 2023 summer fuel survey and lab analysis, and using the results develop updated Texas-specific fuel parameter files for use in the U.S. EPA's MOVES (MOVES3) model and the TCEQ's TexN utility (TexN2). This study was conducted by the TTI along with subcontractors ERG and SwRI. TTI was the primary recipient of the project grant to oversee the entire study and provide QA/QC on all analyses, results, and products that were produced by this study.

SwRI collected fuel samples across Texas in the summer of 2023. All gasoline grades (low, mid, and high) and diesel were sampled at 91 gasoline service stations, covering all of the 25 TxDOT districts. The SwRI laboratory tested fuel samples for various properties, work that involved speciation of hydrocarbon compounds including oxygenates, determination of RVP, estimation of sulfur content in fuel, and quantification of aromatics, olefins, distillation analysis, and cetane. SwRI also calculated E200 and E300 using the results from the distillation tests.

ERG assigned fuel regions based on sampling locations and corresponding to the MOVES3 model's fuel regulatory and fuel distribution boundaries to all the analytical data records for gasoline and diesel samples. The fuel parameters for gasoline and diesel were averaged for each of these fuel regions. For gasoline, ERG calculated weighted averages across the fuel grades using the latest available fuel sales data for Texas. These data were then used to develop updated fuel parameter files for MOVES3 and TexN2.

Additionally, SwRI performed a second round of sampling and lab analysis for the sampling stations in the Houston district. This round was performed to determine the temporal variability of fuel properties within the same district and at the individual station level. ERG also compiled TxDOT district-level fuel parameter data from previous studies and performed a trends analysis for 2003–2023 fuel parameter data at the district level.

1 INTRODUCTION

To maintain confidence in the fuel parameters it uses in developing on-road and nonroad emission inventories, trend analyses, and control strategy analyses, the TCEQ has undertaken a program to periodically collect and analyze fuel samples. The results ensure the accuracy of location-specific fuel information and provide the best data available for analyses to support the Texas SIP and control strategy development.

For this project, TTI along with subcontractors ERG and SwRI (hereafter referred to as the study team) worked under the TCEQ's Grant 582-21-10369 to develop updated Texas-specific fuel parameter rules for use with the MOVES3 and TexN2 emission models. To that end, the study team was also tasked with developing physical properties and speciation profiles and with sampling and testing gasoline and diesel at retail stations across Texas.

SwRI was tasked to collect samples of RU unleaded gasoline, MU gasoline, PU gasoline, and ULSD fuel from 91 retail gas stations, representing the 25 different TxDOT districts. SwRI then tested these samples for various properties. The tests involved speciation of VOCs including oxygenates; determination of RVP and sulfur content in gasoline; and quantification of aromatics, cetane, and sulfur in diesel. Distillation analysis tests were also performed on the collected gasoline and diesel samples.

1.1 Background

Texas is one of the largest contributors to the oil production and refining industry in the U.S. It is the largest crude oil-producing state in the country, responsible for producing more than two-fifths of the nation's oil reserves. Texas also boasts a substantial oil reserve, holding more than one-fourth of the nation's 100 largest oil fields by reserve. It is also home to two of the four U.S. SPR crude oil storage facilities, which were created to reduce the impact of supply disruptions. These facilities have a combined capacity to hold over 700 million barrels of crude oil, making them an essential component in the country's oil supply chain [1]. Combined, these gave the state a competitive edge in the energy market, allowing it to generate a lot of revenue and contribute towards the growth of the national economy.

In addition to oil production, Texas also has a highly developed refining industry. The state boasts 30 operable petroleum refineries, with most of them located near ports along the Gulf Coast. These refineries have a combined total processing capacity of 5.9

million barrels of crude oil per day, contributing to a significant portion of the national refining capacity [1]. These fuel products are supplied through large pipeline networks, trucks, and marine vessels, making them easily accessible to U.S. markets.

1.2 Fuel Production and Supply

The production and distribution of gasoline involve a complex process that comprises multiple stages. According to the EIA, identifying the origin of gasoline at fueling stations can be a challenging task due to the many processes involved in producing gasoline from crude oil.

Figure 1 shows a simplified flow of crude oil and gasoline. The process begins at refineries, where crude oil is refined, and various fuel and petroleum products (henceforth just “fuel products”) are produced. The fuel products from these refineries are supplied through large pipeline networks, trucks, and marine vessels. After refining, the gasoline is transported to storage locations before being blended with other additives to meet specific requirements. The blending of gasoline is necessary to ensure that the fuel is suitable for use in vehicles and complies with environmental regulations. Finally, the gasoline is delivered to fuel stations for use by consumers.

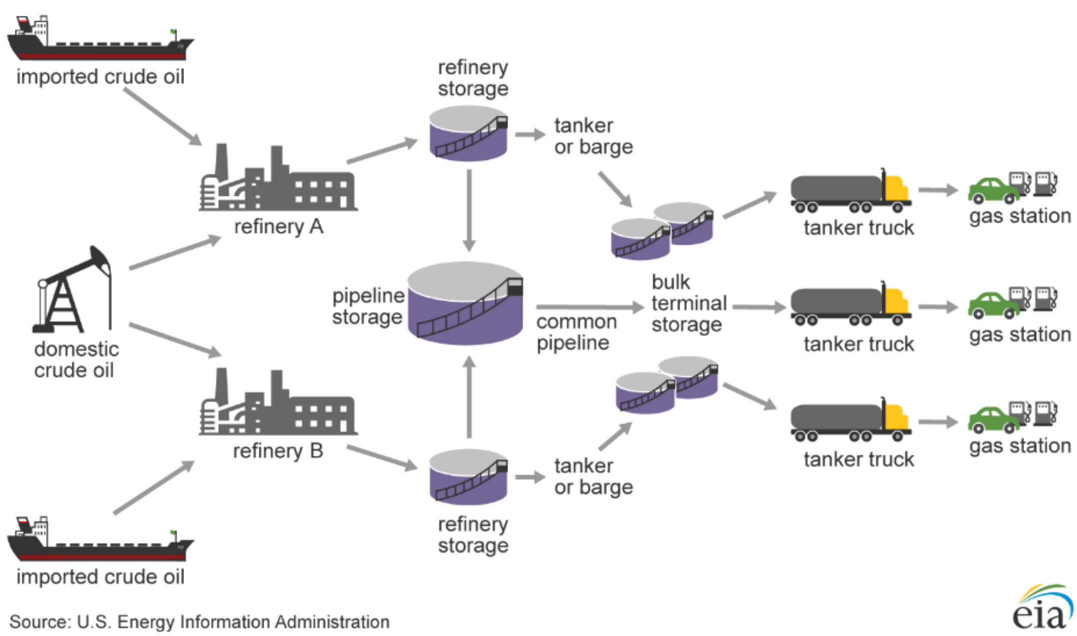

Figure 1. Flow of Crude Oil and Gasoline

Source: EIA (2023). Gasoline explained: Where our gasoline comes from. Available at: https://www.eia.gov/energyexplained/gasoline/where-our-gasoline-comes-from.php.

1.2.1 Collection of Crude Oil

In the U.S., petroleum refineries play a crucial role in transforming crude oil and other liquids into gasoline and various fuel products. Crude oil is the primary raw material used in the production of these products and is usually either imported from other countries or extracted from domestic crude oil wells. Refineries consider the cost and availability of crude oil from different sources and determine the distribution network they will use to transport their products to various markets to optimize their operations, minimize costs, and still meet the demand for fuel products.

1.2.2 Refining Crude Oil

Petroleum refineries convert crude oil into fuel for transportation, heating, and electricity generation, as well as materials for paving roads and feedstocks for chemical production. Refining breaks crude oil down into various components, which are then selectively reconfigured into new products.

The three basic steps in refining are separation, conversion, and treatment:

- **Separation** - Modern separation involves piping crude oil through hot furnaces. The resulting liquids and vapors are discharged into distillation units, where they separate into petroleum components, called fractions, according to their boiling points. Heavy fractions settle at the bottom, while light fractions rise to the top.
- **Conversion** - After distillation, conversion processes heavy, lower-value distillation fractions further into lighter, higher-value products such as gasoline. The most widely used conversion method is called cracking, which uses heat, pressure, catalysts, and sometimes hydrogen to break heavy hydrocarbon molecules into lighter ones. Other refinery processes rearrange molecules to add value without splitting them.
- **Treatment** - The finishing touches occur during the final treatment, where various streams from the processing units are combined. The blend of gasoline is determined by its octane level, vapor pressure ratings, and other special considerations. After the final treatment, the outgoing final products are temporarily stored in large tanks before being transported across the country via pipelines, trains, and trucks.

1.2.3 Transportation of the Fuel

Oil is transported from the well to the refinery and ultimately to the end user using a variety of methods such as tankers, barges, pipelines, tank trucks, or even railroad tank cars. These methods serve as vital links in the transportation network, ensuring that oil products can be delivered to their intended destinations. After the oil products have been refined, they are stored temporarily in terminals, which can be found in various locations. These terminals play a critical role in the distribution of refined products, serving as hubs for the redistribution of products.

The transportation from refineries to storage terminals involves the use of large, shared pipelines that transport gasoline and all other fuel products in batches. In other words, different types of products and grades of gasoline are transported in the same pipeline. These pipelines do not offer physical separation for different products and grades, which can result in mixing or contamination. Due to this, the U.S. EIA recommends testing fuels at the receipt point in the pipeline to ensure they meet local, state, or federal specifications. If the fuels do not meet the standards, they are sent back to refineries for additional processing.

Further from the refineries to the large storage terminals, the fuel products are then moved to smaller blending terminals. These blending terminals are often located further away from the refineries and are used to blend ETOH with gasoline to create the finished product. The blending process is necessary to ensure that the fuel meets specific requirements and is suitable for use in vehicles while complying with environmental regulations.

Once the gasoline has been blended, it is then transported to over 100,000 retail fuel stations across the U.S. using tanker trucks. It is important to note that different companies that own fueling stations in the same area may purchase gasoline from the same bulk storage terminals.

1.3 PADDs

PADDs are a crucial system used in the U.S. to organize and administer the allocation of fuels. They serve as an important tool for tracking the flow of oil and refined products across the country and for analyzing changes in supply and demand. The U.S. is divided into five PADDs, each representing a specific geographic region of the country. These regions are further divided into sub-regions, each with its own unique characteristics and fuel demands. The U.S. EIA maintains a database containing information about the transportation of fuel products between these five PADDs using pipelines, tankers, barges, and rail [2].

PADD 3 represents the Gulf Coast, which is further divided into five sub-regions: Texas Gulf Coast, Texas Inlands, Louisiana Gulf Coast, North Louisiana-Arkansas, and New Mexico. The Texas Gulf Coast sub-region includes Texas counties located on or just inland from the state's Gulf of Mexico coastline. It is home to many oil refineries and petrochemical plants and is a major hub for the transportation of fuel products.

The Texas Inlands sub-region includes the remainder of Texas. This sub-region boasts several pipeline systems and fuel product distribution centers that are clustered around major consumption areas like DFW, Austin, San Antonio, and El Paso.

The following sections discuss the refineries, the distribution networks, and the fueling stations within each PADD.

1.3.1 Refineries

There are 30 petroleum refineries within the state of Texas. As shown in Table 1, there are eight refineries in the Texas inland sub-region, with Valero's Sunray and WRB's Borger locations being the two largest refineries in the Texas Panhandle. These refineries supply fuel products to markets in West Texas, New Mexico, and regions in PADD 2 and PADD 4 using pipelines. The refineries in West Texas, which comprises the Western Refining refinery in El Paso and the ALON refinery in Big Spring, supply fuel products to local markets in West Texas, as well as markets in Arizona and Mexico via pipeline.

Table 1. List of Refineries in Texas Inland Region

Corporation	Company Name	Location	Operation Capacity (Barrels per calendar day)
Valero Energy Corp.	Diamond Shamrock Refining Co., L.P.	Sunray	195,000
Valero Energy Corp.	Diamond Shamrock Refining Co., L.P.	Three Rivers	89,000
Delek Group, Ltd.	ALON USA Energy, Inc.	Big Spring	73,000
Delek Group, Ltd.	Delek Refining, Ltd.	Tyler	71,000
Blue Dolphin Energy Co.	Lazarus Energy, L.L.C.	Nixon	14,000
Starlight Relativity Acquisition Co.	The San Antonio Refinery, L.L.C.	San Antonio	20,000
Marathon Petroleum Corp.	Western Refining Company, L.L.C.	El Paso	133,000
WRB Refining, L.P.	WRB Refining, L.P.	Borger	149,000

Source: EIA (2023). Refinery Capacity Data With Data for June 21, 2023. Available at: https://www.eia.gov/petroleum/refinerycapacity/refcap23.xls

As listed in Table 2, the Texas Gulf Coast sub-region is home to 22 refineries. Most of these refineries are clustered around ports, with 12 of them located in the Greater Houston area, specifically along the Houston Ship Channel, Baytown, Sweeny, and Texas City. The rest of these refineries are located in BPA and Corpus Christi, with four and six refineries, respectively. The southern market is covered by three refineries, including Valero's Three Rivers refinery, which supplies fuel to Corpus Christi and Nuevo Laredo.

Table 2. List of Refineries in Texas Gulf Coast Region

Area	Corporation	Company Name	City/ Location	Operation Capacity (Barrels per calendar day)
Corpus Christi	Buckeye Partners, L.P.	Buckeye Texas Processing, L.L.C.	Corpus Christi	60,000
Corpus Christi	PDV America, Inc.	Citgo Refining & Chemical, Inc.	Corpus Christi	167,500
Corpus Christi	Valero Energy Corp.	Valero Refining Co Texas, L.P.	Corpus Christi	290,000
Corpus Christi	Magellan Midstream Partners, L.P.	Magellan Processing, L.P.	Corpus Christi	42,500
Corpus Christi	Koch Industries, Inc.	Flint Hills Resources, L.P.	Corpus Christi East	74,500
Corpus Christi	Koch Industries, Inc.	Flint Hills Resources, L.P.	Corpus Christi West	268,500
BPA	Exxon Mobil Corp.	ExxonMobil Refining & Supply Co.	Beaumont	369,024
BPA	Saudi Aramco	Motiva Enterprises, L.L.C.	Port Arthur	626,000
BPA	Valero Energy Corp.	Premcor Refining Group, Inc.	Port Arthur	335,000
BPA	Totalenergies SE	TotalEnergies Petrochemicals & Refining USA, Inc.	Port Arthur	238,000
GHA	Exxon Mobil Corp.	ExxonMobil Refining & Supply Co.	Baytown	564,440
GHA	Hartree Partners, L.P.	Hartree Channelview, L.L.C.	Channelview	45,000
GHA	Pemex	Deer Park Refining, L.P.	Deer Park	312,500
GHA	Kinder Morgan Energy Partners, L.P.	Kinder Morgan Crude & Condensate	Galena Park	105,000
GHA	Texas Intl Terminals	Texas International Terminals	Galveston	45,000
GHA	Marathon Petroleum Corp.	Marathon Petroleum Co., L.P.	Galveston Bay	593,000
GHA	Access Industries	Houston Refining, L.P.	Houston	263,776
GHA	Valero Energy Corp.	Valero Refining Co Texas, L.P.	Houston	25,000
GHA	Chevron Corp.	Pasadena Refining Systems, Inc.	Houston	205,000
GHA	Chevron Corp.	Pasadena Refining Systems, Inc.	Pasadena	112,229
GHA	Phillips 66 Company	Phillips 66 Company	Sweeny	265,000
GHA	Valero Energy Corp.	Valero Refining Co Texas, L.P.	Texas City	225,000

Source: EIA (2023). Refinery Capacity Data With Data for June 21, 2023. Available at: https://www.eia.gov/petroleum/refinerycapacity/refcap23.xls

1.3.2 Distribution Network

A distribution network connects refineries and terminals, allowing for the efficient transportation of gasoline and other fuel products to consumers statewide and across the country. This section briefly describes the distribution network within the state of Texas and the ones connecting Texas refineries to regions outside of the state.

1.3.2.1 Texas Statewide

Figure 2 shows the distribution network that connects refineries, pipelines, and terminals in the Texas Inland sub-region. Within this sub-region, there are eight refineries along with numerous bulk terminals. Fuel products distribution centers are clustered around major consumption areas, including DFW in North-Central Texas, Austin and San Antonio in South-Central Texas, McAllen in South Texas, and El Paso in West Texas.

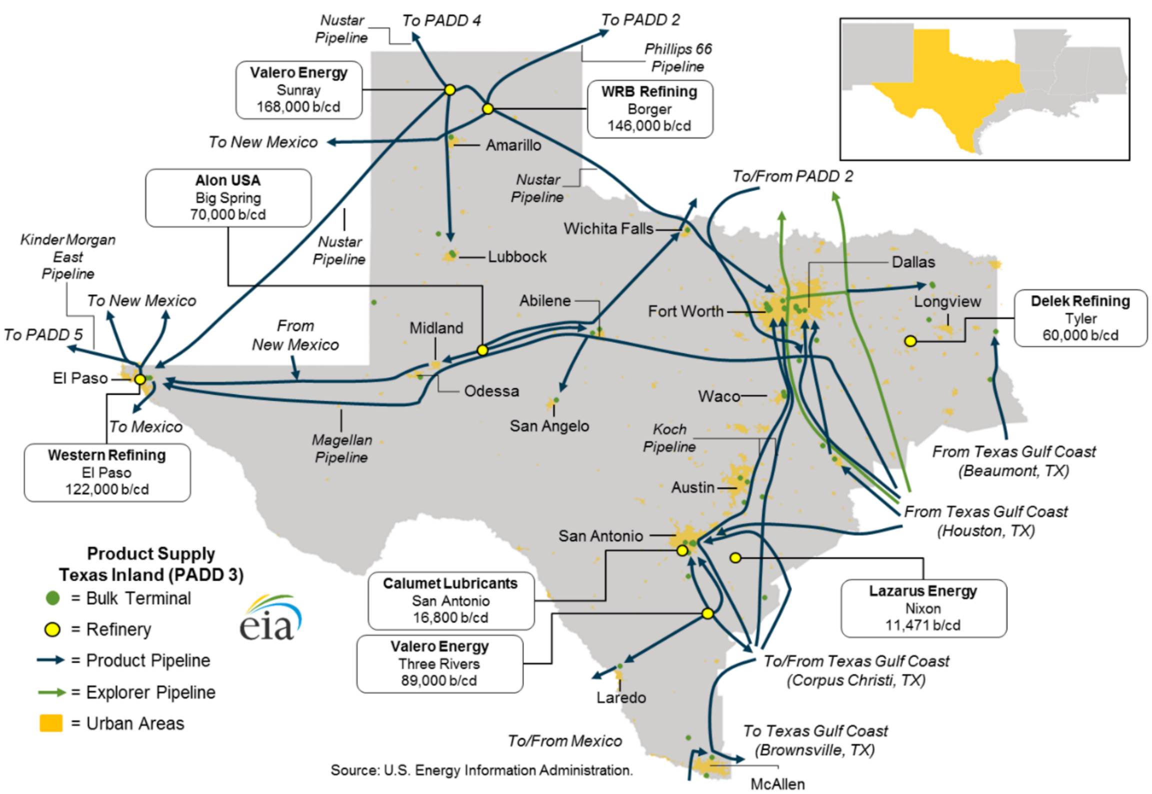

Figure 2. Network of Refineries, Pipelines, and Terminals in Texas Inland Region

Source: EIA (2016). East Coast and Gulf Coast Transportation Fuels Markets. Available at: https://www.eia.gov/analysis/transportationfuels/padd1n3/

As shown in Figure 2, the pipelines near state borders transport fuel products to other states and Mexico. The refineries in the northern parts of Texas, around Amarillo, provide fuel products to PADD 4 and PADD 2, while the El Paso refineries supply to

PADD 5 and Mexico. Some pipelines both collect and transport fuel products to and from out of Texas. For example, in South Texas, a pipeline crossing Laredo to Mexico both transports and collects fuel products to and from Mexico. Similarly, pipelines crossing the DFW area may send or receive fuel products to and from states in PADD 2. Lastly, the Texas Inland sub-region is connected to numerous pipelines that gather fuel products from the Texas Gulf Coast sub-region.

As shown in Figure 3, the refineries in the Texas Gulf Coast sub-region are mainly located near or within the Greater Houston Area, BPA, and Corpus Christi. These refineries supply fuel products to both domestic and international markets through a vast pipeline network that connects this sub-region to different parts of the U.S. and foreign markets. Domestically, the pipeline network transports fuel products to other sub-regions, including Texas Inland, Louisiana Gulf Coast, and North-Louisiana Arkansas. The pipelines also transport the fuel products to seaports, where ships and barges are used to transport these products to foreign markets.

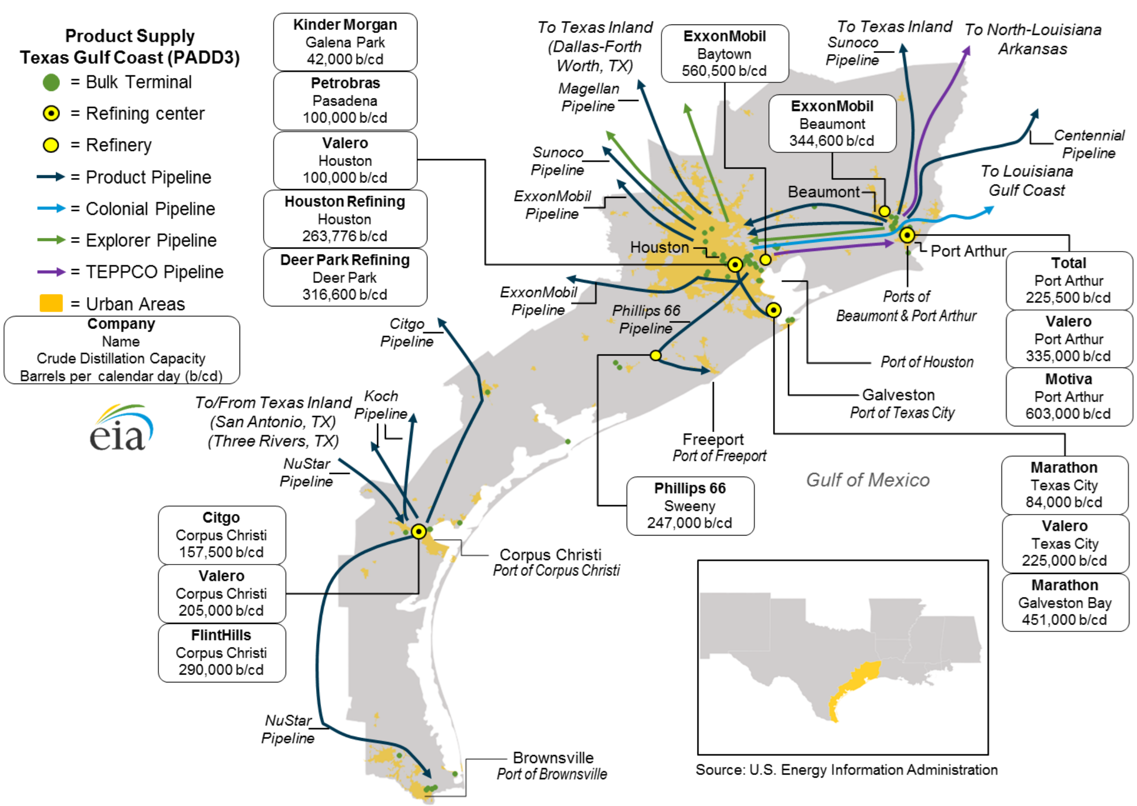

Figure 3. Network of Refineries, Pipelines, and Terminals along Texas Gulf Coast

Source: EIA (2016). East Coast and Gulf Coast Transportation Fuels Markets. Available at: https://www.eia.gov/analysis/transportationfuels/padd1n3/

A list of the pipelines in both PADD 3 sub-regions in Texas is presented in Appendix A.

1.3.2.2 Texas Nonattainment Areas

Nonattainment areas are geographic regions where air quality levels do not meet the levels set by the EPA's NAAQS, whereas maintenance areas refer to those that were formerly in nonattainment and are currently under a maintenance plan. The nonattainment and maintenance areas in Texas are shown in Table 3.

Table 3. Texas Air Quality Nonattainment Areas and Counties

Non-Attainment or Maintenance Area	NAAQS	Affected Counties	MPO	Designation Classification
HGB	2008 ozone	Brazoria, Chambers, Fort Bend, Galveston, Harris, Liberty, Montgomery, Waller	HGAC	Severe
HGB	2015 ozone	Brazoria, Chambers, Fort Bend, Galveston, Harris, Montgomery	HGAC	Moderate
BPA	1997 ozone	Hardin, Jefferson, Orange	SETRPC	Formerly Attainment Maintenance
DFW	2008 ozone	Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker, Rockwall, Wise	NCTCOG	Severe
DFW	2015 ozone	Collin, Dallas, Denton, Tarrant, Ellis, Johnson, Kaufman, Parker, Wise	NCTCOG	Moderate
El Paso[1]	PM10	El Paso	El Paso MPO	Moderate
El Paso[1]	CO	El Paso	El Paso MPO	Attainment Maintenance
San Antonio	2015 ozone	Bexar	Alamo Area MPO	Moderate

[1] On June 30, 2023, the D.C. Circuit Court issued a decision reversing the 2021 El Paso County Nonattainment Area Designation for the 2015 ozone NAAQS. As a result of the Court's decision, El Paso reverts to its prior attainment designation. Available at: https://www.epa.gov/ozone-designations/ozone-designations-regulatory-actions.
Source: TxDOT (2023). Texas Air Quality Nonattainment or Attainment-Maintenance Areas and Counties. Available at: https://ftp.dot.state.tx.us/pub/txdot-info/env/toolkit/200-02-fig.pdf

Below are brief discussions of the gasoline distribution mechanism in the aforementioned Texas nonattainment areas:

- **DFW** - DFW lacks its own refineries and depends on several pipeline systems to receive fuel products. These include the Explorer pipeline, which has the Houston-to-Ardmore and the Houston-to-Wood River trunklines. The former runs through the central part of DFW, while the latter runs through the eastern part. Other pipelines that service DFW include ExxonMobil's Baytown-to-Irving pipeline, Magellan pipelines from Oklahoma, and NuStar Energy's Southlake Products pipeline from the Texas Panhandle.

- **San Antonio** - San Antonio receives its fuel products from local refineries and pipeline systems originating in Corpus Christi and Houston. The Three Rivers Refinery, located midway between San Antonio and Corpus Christi, delivers fuel products to both cities, as well as Laredo, through a pipeline network operated by NuStar Energy. The Flint Hills Refinery in Corpus Christi supplies fuel products to San Antonio via pipelines owned by the Texas Pipeline System, which is owned by Koch Pipeline Company. Citgo's refinery in Corpus Christi supplies fuel to San Antonio via CAA's pipeline system. ExxonMobil's Baytown-to-San-Antonio pipeline network delivers fuel from its Baytown refinery in the Greater Houston Area.
- **Houston** - The Greater Houston Area is the largest refining hub in the country. In addition to the local refineries, the area also receives fuels from BPA via two Sunoco pipelines, as well as from foreign markets through shipping. The fuel products refined at local refineries are distributed locally area via tanker trucks, and to domestic and foreign markets via pipelines and tanker/barges. The Colonial and Enterprise TEPPCO pipelines supply fuels from the Greater Houston area to the Midwest and East Coast, whereas the Explorer pipelines, running from Port Arthur through Houston, supply products to the Midwest and markets in the Texas Inland sub-region. The Exxon Mobil pipeline delivers fuel from the Baytown refinery to markets in San Antonio and Irving. Additionally, fuels from Houston serve the DFW area via the Magellan pipelines.
- **El Paso** - El Paso is an important supply hub for markets in West Texas, New Mexico, and Arizona. Several sources supply fuel products to El Paso, including the Western Refining refinery in El Paso and the HollyFrontier refinery in Artesia, NM. El Paso also receives fuel supplies from the Texas Panhandle through NuStar's pipeline network, and oil supply from the Greater Houston Area through Magellan Midstream's South System. Fuel products are distributed from El Paso to the Tucson and Phoenix areas in Arizona via Kinder Morgan's SFPP East Pipeline. The Magellan pipeline also transfers products from El Paso to the Albuquerque area in New Mexico. Lastly, Pemex, a Mexican oil company, supplies products from El Paso to Ciudad Juarez in North Mexico through the Frontera Juarez Pipeline.

1.3.2.3 Other States and Regions

This section briefly discusses the distribution network in New Mexico and PADD 2, which are connected to Texas, but were not discussed in the previous section.

As seen in Figure 4, New Mexico is home to two refineries: the HollyFrontier Corp. refinery in Artesia, New Mexico (NM), and the Western Refining refinery in Gallup, NM. These refineries produce more gasoline than the in-state demand, resulting in a surplus of fuel products. Thus, throughout most of the year, NM distributes these surplus fuel products to neighboring states via pipeline networks and trucks. The HollyFrontier Corp refinery supplies fuel products to Texas through the Holly Energy Partners pipeline [3].

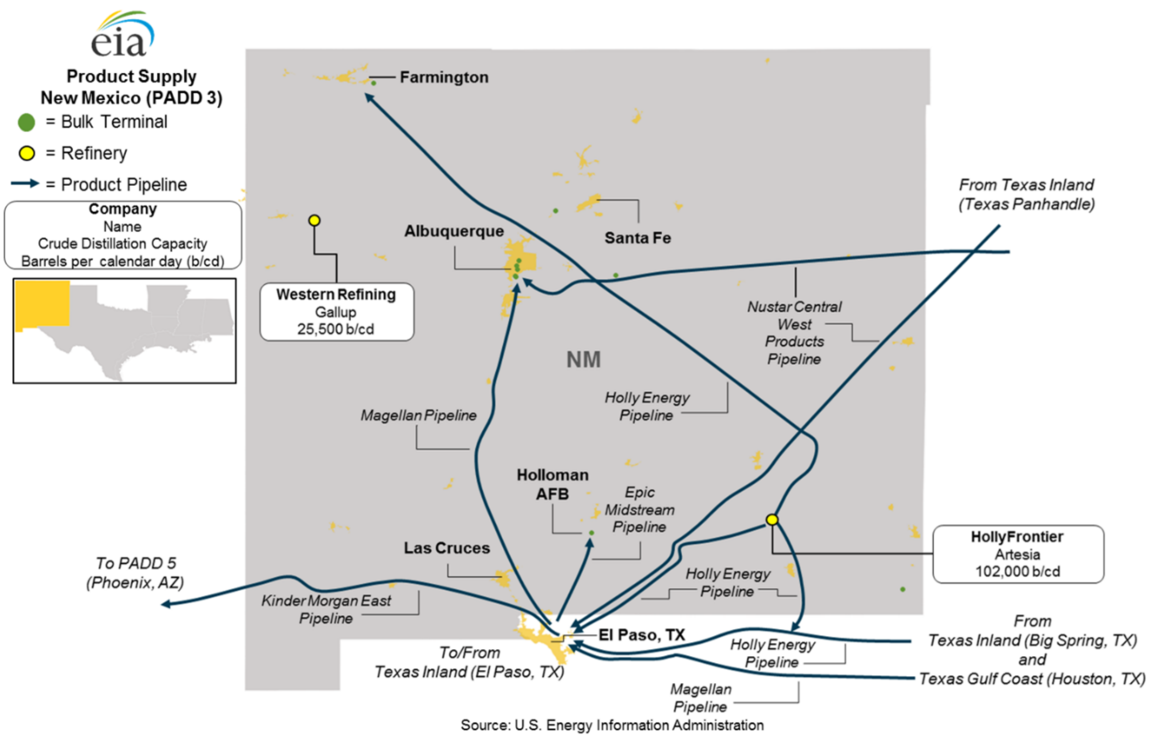

Figure 4. Network of Refineries, Pipelines, and Terminals in New Mexico

Source: EIA (2016). East Coast and Gulf Coast Transportation Fuels Markets. Available at: https://www.eia.gov/analysis/transportationfuels/padd1n3/

PADD 2, also known as the Midwest region, consists of five states: Nebraska (NE), Kansas (KS), Oklahoma (OK), Missouri (MO), and Iowa (IA). Major PADD 2 markets near PADD 3 include Des Moines, IA; Wichita, KS; Omaha, NE; Tulsa, OK; and Springfield, MO. The southern Midwest sub-region, which includes Oklahoma and Kansas, has eight refineries, along with a series of pipeline and storage networks connecting the sub-region to the Permian Basin of western Texas and NM. The Magellan Midstream pipelines distribute fuel products from Kansas and Oklahoma to west Fort Worth (see Figure 2).

1.3.3 Fueling Stations

Fueling stations play a critical role in the distribution of refined fuel products, acting as the final link in the supply chain between refineries and consumers. As shown in Table 4, in 2020, there were nearly 11,000 fueling stations in Texas, accounting for 10% of the entire nation's number [1], with nearly 10,000 of these having convenience stores.

Table 4 Fueling Station Distribution by TxDOT District

TxDOT District	Population (2020 Census)	No. of counties with over 100,000 residents	No. of Gas Stations with Convenience Stores	Total No. of Gas Stations
Abilene	266,921	1	129	145
Amarillo	388,323	2	163	194
Atlanta	307,005	-	132	141
Austin	2,413,274	3	774	815
Beaumont	600,759	1	295	319
Brownwood	125,642	-	75	78
Bryan	483,084	1	214	227
Childress	34,299	-	23	23
Corpus Christi	586,539	1	244	265
Dallas	5,082,634	6	1,401	1,513
El Paso	888,720	1	236	271
Fort Worth	2,657,650	3	822	885
Houston	6,953,874	5	2,589	2,756
Laredo	410,496	1	127	139
Lubbock	486,931	1	134	156
Lufkin	306,075	-	115	119
Odessa	417,184	2	128	176
Paris	397,376	1	186	196
Pharr	1,404,035	2	317	334
San Angelo	163,226	1	84	100
San Antonio	2,654,290	3	816	874
Tyler	704,800	2	296	322
Waco	815,764	2	310	238
Wichita Falls	245,420	1	107	120
Yoakum	339,211	-	179	204
Total	**29,133,532**	**40**	**9,896**	**10,610**

1.3.3.1 RVP

RVP is the measure of the volatility of gasoline, which is its tendency to vaporize. High RVP values indicate that fuel has a higher tendency to vaporize at a given temperature, while low RVP values indicate a lower vaporization tendency.

To maintain air quality standards, it is essential to ensure that fuel meets specific requirements set by local, state, and federal regulations. RFG is a blend of gasoline that burns more cleanly than CG. The RFG program was first mandated in the 1990 Clean Air Act amendments and is currently in its second phase, which began in 2000. As per the RFG program requirements, regions that are in nonattainment of the ozone NAAQS are required to sell RFG in place of CG; this requirement is optional for regions in attainment with the ozone NAAQS. In Texas, RFG is required to be sold in four counties in DFW and eight counties in HGB [4]. Thus, fueling stations play a crucial role in this process as they connect refineries to consumers. Thus, the EPA regulates the RVP of gasoline sold at fueling stations during summer to reduce emissions of VOC, which contribute to ozone formation.

For most parts of the country, the EPA mandates a 9.0 pounds per square inch (psi) RVP limit for the gasoline sold between June 1st and September 15th. Certain areas, especially those where air quality levels do not meet the NAAQS, may have additional restrictions set on their RVP limits. To reduce emissions and improve air quality in NAAQS nonattainment areas (see Table 3), gasoline sold during the summer months must meet a lower RVP limit. Starting in December 2020, the Fuel Streamlining rule established a 7.4 psi RVP standard for summer RFG [4].

Fuel with an RVP above the mandated limit may indicate that the fuel was from other states or was leftover produced during the previous winter season. Table 5 provides a list of RVP limits for various counties in Texas and its neighboring states. Some Texas counties and cities have lower RVP limits than those in neighboring states. Therefore, using products from other states may exceed the limitations put in place for Texas counties and cities.

Table 5. Summer RVP Limits in Texas and Neighboring States

State	County	City	May RVP (psi Max)	June RVP (psi Max)	July RVP (psi Max)	Aug RVP (psi Max)	Sep 1 - 15 RVP (psi Max)
NM	All counties	-	9.0	9.0	9.0	9.0	9.0
KS	Johnson	-	9.0	7.0[A]	7.0	7.0	7.0
KS	Wyandotte	Kansas City	9.0	7.0[A]	7.0	7.0	7.0
KS	All others	-	9.0	9.0	9.0	9.0	9.0
OK	All counties	-	9.0	9.0	9.0	9.0	9.0
TX	Eastern Texas (95 counties)[1]	-	7.8[A,B]	7.8	7.8	7.8	7.8 (Oct 1)
TX	El Paso	El Paso	7.0[A,B]	7.0	7.0	7.0	7.0 (Sept 16)
TX	Hardin	-	9.0	7.8	7.8	7.8	7.8
TX	Jefferson	Beaumont	9.0	7.8	7.8	7.8	7.8
TX	Orange	-	9.0	7.8	7.8	7.8	7.8
TX	All other counties	-	9.0	9.0	9.0	9.0	9.0

Source: EPA (2020). Gasoline Reid Vapor Pressure. Available at: https://19january2021snapshot.epa.gov/gasoline-standards/gasoline-reid-vapor-pressure_.html#F

State has received a waiver under the federal Clean Air Act 211(c)(4)(C) to adopt a state fuel program, more stringent than federal requirements, into the federally approved SIP.

State fuel program in federally approved SIP does not provide for the use of a 1.0 psi ETOH waiver. The 1.0 psi ETOH waiver is not applicable during the entire volatility control period defined in the SIP.

[1]Eastern Texas Counties include: Anderson, Angelina, Aransas, Atascosa, Austin, Bastrop, Bee, Bell, Bexar, Bosque, Bowie, Brazos, Burleson, Caldwell, Calhoun, Camp, Cass, Cherokee, Colorado, Comal, Cooke, Coryell, De Witt, Delta, Ellis, Falls, Fannin, Fayette, Franklin, Freestone, Goliad, Gonzales, Grayson, Gregg, Grimes, Guadalupe, Harrison, Hays, Henderson, Hill, Hood, Hopkins, Houston, Hunt, Jackson, Jasper, Johnson, Karnes, Kaufman, Lamar, Lavaca, Lee, Leon, Limestone, Live Oak, Madison, Marion, Matagorda, McLennan, Milam, Morris, Nacogdoches, Navarro, Newton, Nueces, Panola, Parker, Polk, Rains, Red River, Refugio, Robertson, Rockwall, Rusk, Sabine, San Jacinto, San Patricio, San Augustine, Shelby, Smith, Somervell, Titus, Travis, Trinity, Tyler, Upshur, Van Zandt, Victoria, Walker, Washington, Wharton, Williamson, Wilson, Wise, and Wood.

1.4 Objective

The following sections of this report summarize the sample collection plan, sample collection and lab analysis steps, data analyses on the collected gasoline and diesel test data and their results, the development of Texas-specific updated fuel parameter files for use in EPA's MOVES3 model and TCEQ's TexN2 utility, temporal analysis comparing round 1 and round 2 results for the Houston TxDOT district, and analysis of trends between the 2023 summer data and available data from previous years (2003–2020).

2 SAMPLING PLAN

ERG developed a fuel sampling plan that SwRI carried out during the summer of 2023 (June/July 2023). ERG began with the list of retail stations sampled in the 2020 Summer Fuel Field Study [5], which served as the primary sampling candidates for fuel sampling during the summer of 2023. ERG also developed a list of alternate sampling candidates in case sampling at the primary candidate locations was not possible. The sampling plan and list of retail stations along with alternate sampling candidates were reviewed by TTI and approved by the TCEQ.

2.1 Fuel Sampling Plan and Site Selection

ERG developed a sampling plan that specified the number of stations per TxDOT district, the total number of samples (including the number of diesel and gasoline samples, across gasoline grades), and the allocation of stations across the districts.

The sampling plan specifications included the following:

- Each fuel sampling district had at least three sample stations;
- Both diesel and gasoline samples were collected at each location;
- RU, MU, and PU gasoline grades were sampled; and
- Gasoline and diesel samples were collected separately (no compositing).

This approach required a lab test of every sample. As a result, this approach limited the total number of stations that could be sampled. However, it indicated differences *within* areas that a compositing approach would not have revealed. Specifically, it enabled the determination of minimum, maximum, and average fuel parameter values, instead of just averages for each region. This characterization is more consistent with MOVES modeling in that it will allow the TCEQ to specify maximum and average parameter values for model inputs, such as fuel sulfur levels.

Figure 5 indicates the TxDOT district boundaries and sampling city locations.

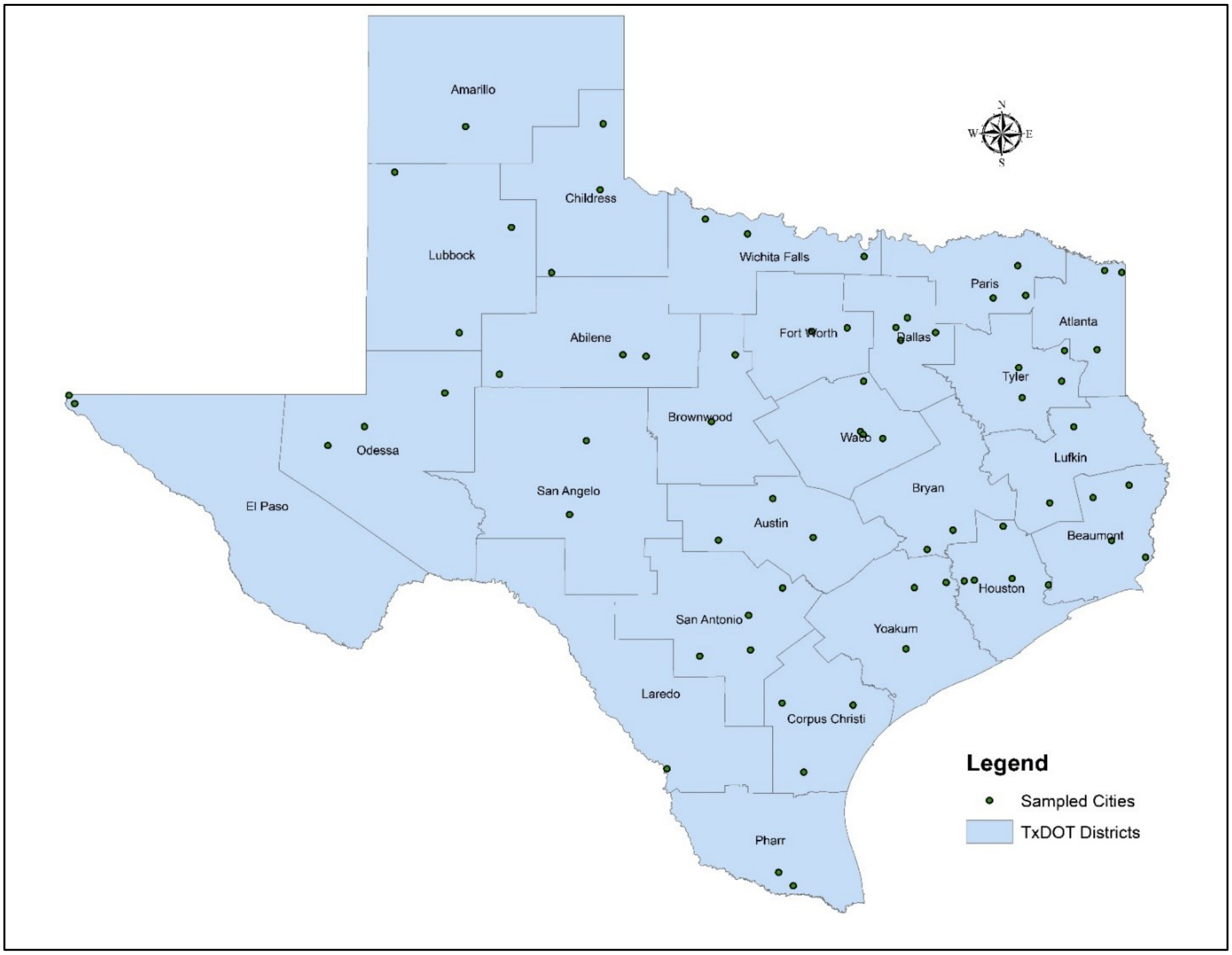

Figure 5. TxDOT Districts and Sampling Areas

Table 6 summarizes the number of stations that were sampled for each district. At each station, SwRI obtained three gasoline samples and one diesel sample.

Table 6. Sampling Plan Summary Table

TxDOT District	Number of Stations	District Ozone Standard Designation
Abilene	3	Attainment area
Amarillo	3	Attainment area
Atlanta	3	Attainment area
Austin	5	Attainment area, former EAC area
Beaumont	5	BPA attainment area
Brownwood	3	Attainment area
Bryan	3	Attainment area
Childress	3	Attainment area
Corpus Christi	3	Attainment area
Dallas	4	DFW nonattainment area

TxDOT District	Number of Stations	District Ozone Standard Designation
El Paso	5	Attainment area[1]
Fort Worth	4	DFW nonattainment area
Houston	7*	HGB nonattainment area
Laredo	3	Attainment area
Lubbock	3	Attainment area
Lufkin	3	Attainment area
Odessa	3	Attainment area
Paris	3	Attainment area
Pharr	3	Attainment area
San Angelo	3	Attainment area
San Antonio	5	Attainment area, former EAC area (Bexar County is classified as moderate nonattainment)[2]
Tyler	5	Attainment area (Smith County is a former EAC area)
Waco	3	Attainment area
Wichita Falls	3	Attainment area
Yoakum	3	Attainment area
Total	**91**	

* These stations were sampled a second time later in the summer.

[1] On June 30, 2023, the D.C. Circuit Court issued a decision reversing the 2021 El Paso County Nonattainment Area Designation for the 2015 ozone NAAQS. As a result of the Court's decision, El Paso reverts to its prior attainment designation. Available at: https://www.epa.gov/ozone-designations/ozone-designations-regulatory-actions.

[2] On October 7, 2022, the EPA reclassified Bexar County from marginal to moderate nonattainment. Available at: https://www.tceq.texas.gov/airquality/sip/san/san-status.

The retail stations that were sampled were all "active" retail establishments. The master sampling list did not include non-retail establishments such as bulk fuel terminals, fleet refueling stations, and automobile dealers. All 91 retail stations in the master list were identified as selling both gasoline and diesel and had tank capacities greater than or equal to 10,000 gallons.

As noted above, a list of alternate sampling stations (to be used if a primary station was out of business, was temporarily closed, did not sell three grades of gasoline, or was otherwise inaccessible) was developed. To develop this list, the TCEQ's latest PST data were utilized. The PST datasets contained the following information on facilities with USTs and/or ASTs:

- Facility information—status (active or inactive), type (retail, aircraft, fleet, etc.), location, number of tanks, and enforcement action;
- Tank information—tank size and status (in-use, removed, etc.); and
- Composition information—tank-specific information including fuel type.

The PST datasets only included active, retail establishments. Data from the UST and AST datasets were merged into one master file. From this merged list, the establishments that had active enforcement actions against them from the TCEQ were filtered. Only stations that sold both gasoline and diesel were included. Each of the retail stations on the list was then assigned to the appropriate TxDOT district based on county.

ERG then chose six to 14 alternate sampling stations for each TxDOT region, the goal being to select twice as many alternate stations as primary ones. ERG chose retail stations with the most tanks as alternate locations; as well, most alternate stations were within the same cities as the primary stations.

In an additional step, ERG checked the PST data to verify if the primary candidates (from the 2020 study) were still active. Out of the 91 primary candidates, 37 were not available by the same name in the PST data. ERG was able to match eight of these 37 stations based on physical address. These eight stations were present in the latest TCEQ data under different names (potentially due to a change of ownership). ERG could not match the remaining 29 stations by name or by physical address (potentially due to temporary or permanent shutdown). For these 29 cases, replacement sampling locations were chosen. The replacement locations are located within the same city as the original sampling station, except for Los Indios. The PST data did not contain any service stations in Los Indios. As a replacement, a service station in Weslaco was chosen. Weslaco and Los Indios are both located within the same TxDOT district (Pharr).

Additionally, one facility in the 2020 master list was indicated as "Out of Service" in the latest PST data. This facility was dropped from the 2023 master sampling list and a replacement was added within the same city.

2.2 Sampling

During round 1 of sampling (June 2 – June 11, 2023), SwRI took 273 gasoline samples (91 stations, three gasoline grades sampled at each station) and 91 diesel samples (one diesel sample per station) across the 25 TxDOT districts. The list of final sampling locations is presented in Appendix B.

A second round of sampling (July 3 – July 6, 2023) and testing were performed to better understand the temporal variability of fuel composition within a district. To enable a preliminary, station-level assessment of this variability, SwRI took a second round of samples from a small subset of the fueling stations (the seven sites in the Houston district), ensuring that enough time elapsed for complete tank turnover (four weeks).

3 SAMPLING AND LABORATORY ANALYSIS

This section describes the sampling protocol and laboratory tests performed for this study. SwRI provided sample containers and packaging, gasoline, and diesel sample acquisition services from retail stations, sample shipping, sample handling, and sample testing for summer fuels in 2023.

3.1 Retail Station and Sample Collection and Handling Procedures

ICs working with SwRI acquired the fuel samples from retail stations. Each IC received written instructions, master and alternate sampling lists, sampling procedures, sample containers, shipping instructions, etc., from SwRI. All contractors were instructed on retail station sampling procedures, with special emphasis on sample handling and safe disposal of flushed fuel.

SwRI used fuel sample containers and shipping cartons approved by the U.S. DOT and the IATA. Trained staff assembled the boxes at SwRI, and all appropriate shipping materials were provided to the ICs along with FedEx-approved instructions for shipment of hazardous materials/dangerous goods. The containers were delivered cleaned and dried to the ICs.

To take each sample, the IC purged three gallons of gasoline product through the pump nozzle before taking each sample—or ½ gallon, if a customer had just bought the appropriate grade of fuel. The IC recorded the temperature of the flushed sample. Immediately after flushing the fuel from the pump, the IC attached a spacer (if needed) to the pump nozzle. A nozzle extension was inserted into the sample container; the pump nozzle was in turn inserted into the extension with its slot over the air bleed hole. The sample container was slowly filled through the nozzle extension to 70% to 85% full. The nozzle extension was removed and the sample container was capped and sealed. Checks were also performed for leaks. The sample was then prepared for air shipment. The ICs also recorded the type of fuel pump pad material (e.g., concrete, asphalt) at each sampling station.

For a diesel sample, the IC filled the sample container slowly to 70% to 85% full. The sample container was then capped and sealed. The sealed container was then checked for leaks and prepared for air shipment. The IC also recorded the sulfur content labeling of the diesel pump used to obtain the diesel sample.

The ICs used FedEx to ship samples back to SwRI. Members of the SwRI shipping and receiving team meet regularly with FedEx and attend IATA and International Civil Aviation Association hazardous materials shipping and handling training sessions to keep abreast of current regulations. All samples were chilled.

3.2 Laboratory Testing

SwRI carried out all testing in its Petroleum Products Research Department laboratories, part of its Automotive Products and Emissions Research Division. The facilities are at 6220 Culebra Road, San Antonio, Texas.

3.2.1 Gasoline Testing

SwRI tested individual RU, MU, and PU gasoline samples. There was no compositing of samples, as discussed above. Key testing methods included:

- RVP (ASTM D5191-22);
- Sulfur (ASTM D2622-21);
- Distillation (ASTM D86-20b);
- Benzene (ASTM D3606-22);
- Total Aromatics and Olefins (ASTM D1319-20a);
- Oxygenates (ASTM D5599-22); and
- DHA (ASTM D6729-20).

Appendix C provides test results for all 273 gasoline samples collected in round 1. (These do not include the round 2 sampling at the seven locations in the Houston district.)

3.2.2 Diesel Testing

Diesel samples were acquired from all 91 sampling locations. Testing performed on each diesel sample included:

- Cetane number (ASTM D613-18ae1);
- Calculated cetane index (ASTM D976-21);

- API gravity (ASTM D287-12b [2019]);
- Specific gravity (ASTM D1298-12b [2019]);
- Sulfur (ASTM D5453-19a);
- Nitrogen (ASTM D4629-17);
- Total aromatic content (ASTM D5186-22);
- Polycyclic aromatic content (ASTM D5186-22);
- Distillation (ASTM D86-20b); and
- Flash point (ASTM D93-20).

Appendix D provides sample identification information and test results for all the diesel samples collected in the initial sampling round. (Again, these do not include round 2 samples.)

Summer fuel studies performed in the past used results from ASTM D1319 testing for aromatics, olefins, and saturates for both diesel and gasoline fuel samples. This ASTM test (D1319) was not conducted for diesel samples during this project because the dye required for this testing does not meet current ASTM quality standards. Therefore, alternate tests were performed for aromatics and olefins (D5186). For this reason, saturate (% volume) data for diesel samples collected during the summer of 2023 are not available. However, there is no impact on the development of MOVES3 and TexN2 fuel parameters files as the saturates fuel parameter is not required. In addition, the diesel trends analysis does not include aromatics, olefins, and saturates for 2023.

4 DEVELOPING UPDATED FUEL PARAMETERS FOR TEXAS

ERG used gasoline and diesel sample analysis data collected by SwRI to develop fuel parameter input data for MOVES3 and TexN2. Fuel parameter data were developed for each county in Texas using the fuel sample analysis data. TTI developed the MOVES3 and TexN2 fuel parameter input data independently to compare and QA ERG's results.

4.1 Gasoline Analysis

The SwRI gasoline data needed significant formatting before ERG could develop the average fuel parameter values. SwRI transmitted the gasoline data in two separate datasets: the "DHA" dataset for the DHA results and the "NoDHA" dataset for all other test results for gasoline samples. The DHA data were compiled in a single worksheet with a header, group summary, group component data, and group carbon data for each sample. The header section of the DHA data contained service station and sample information. The group summary section contained composition information (i.e., %-volume, %-weight, and %-mol) for various hydrocarbon groups (e.g., paraffins, aromatics, olefins, oxygenates). The group component section contained composition information for the various sub-components (i.e., ETBE, MTBE, TAME, ETOH, propane, butane, etc.) of the groups listed under the group summary section. This section also includes the CAS number for each of the sub-components. ERG extracted the DHA parameters into one flat file.

Historically, data from the DHA were used to report data for specific contaminants from each sample (e.g., benzene, ETBE, MTBE, TAME, EtOH, aromatics, olefins). However, beginning in 2011, data for these parameters were also reported using the ASTM D5599-22 test, while aromatics and olefins were determined using the ASTM1319-20a test method. For this study, the study team used the data results obtained from the "NoDHA" analysis using the ASTM D5599-22 and ASTM D1319-20a test methods to develop the required fuel parameters for MOVES3 and TexN2. The "NoDHA" dataset was already in a flat-file format and needed no further processing. Test results for the following fuel parameters were obtained from the "NoDHA" dataset for each gasoline sample for further analysis:

- RVP;
- Sulfur;
- Total Aromatics;

- Olefins;
- Benzene;
- Oxygenates—ETOH, ETBE, MTBE, and TAME; and
- Distillation results for 50% and 90% of sample fraction (Evap_50 and Evap_90).

E200 and E300 values were calculated using the distillation results from the ASTM D86-20b test.

County FIPS codes were assigned to the sampling results based on sampling station location (zip code and city). EPA's MOVES3 model contains county-to-fuel region mapping. These data were exported from the model and assigned the fuel region to each of the samples based on the county of the sampling station. All counties in Texas are assigned to one of the state's six fuel regions. The fuel region IDs follow the format provided below.

> AABBCCDDXX - AA=fuel base region ID, BB=max summer RVP x.y, CC= absence of RVP waiver, where 01 indicates no waiver, DD=min ETOH vol%, XX=reserved for future use.

Since three grades of gasoline were sampled, RU, MU, and PU data were extracted separately. Required fuel parameters (e.g., RVP, fuel sulfur, benzene, ETOH, MTBE, ETBE, and TAME) were then averaged by fuel region and by gasoline grade. For example, benzene was averaged for each of the six fuel regions, for RU, MU, and PU gasoline individually.

A weighted average across all three gasoline grades was calculated for each fuel region based on the latest Prime Supplier Sales Volume data obtained from the EIA[1]. EIA sales data for Texas in 2021 indicate RU gasoline constituted 87.4% of the market (33,684 thousand of gallons per day), MU gasoline constituted 1.2% (480 thousand of gallons per day), and PU gasoline constituted 11.4% (4,380 thousand of gallons per day) [6].

4.2 Diesel Analysis

The SwRI diesel analysis data were in a flat-file format, similar to the "NoDHA" file for gasoline data, as described in Section 4.1. The diesel data contained information on the

[1] The EIA's Texas Prime Supplier Sale Volume information is available at: https://www.eia.gov/dnav/pet/pet_cons_prim_dcu_stx_a.htm.

service station where the sample was collected, fuel composition data, and distillation data. The diesel analysis evaluated the following fuel parameters:

- Specific gravity;
- Aromatics;
- Sulfur content;
- Cetane number; and
- Distillation data (Evap_50).

The diesel test data were grouped by fuel region, and average fuel parameters were calculated for each of the six fuel regions.

4.3 Updated Fuel Parameter Files

Once the fuel parameter averages were calculated at the fuel region level for gasoline samples and diesel samples, county-level fuel parameter averages were developed. The county-to-fuel region allocation data from MOVES3 were used to assign fuel-region-level fuel parameter average values to each county within the same fuel region.

The summer fuel studies conducted for the TCEQ in 2008, 2011, 2014, and 2017 aggregated the sampling results at the TxDOT district level and developed fuel parameter averages for each district. These district-level averages were then assigned to all the counties located within the same district. To perform a 2003–2023 trends analysis for selected fuel parameters, district-level fuel parameter averages were developed using the 2023 sampling results. These district-level average values were used only for the trend analysis.

The fuel parameter data for the 2023 summer sampling results were compiled, processed, and formatted for use as an input file for the MOVES3 model. First, the County Data Manager module in the MOVES3 model was used and the fuel data template was exported as an Excel file. Next, the fuel formulation and the fuel supply tables in the fuel template were updated with the 2023 summer fuel sampling data. All other tables related to fuel data were left as defaults.

This process resulted in populating an Excel spreadsheet containing the 2023 summer fuel data collected for the TCEQ. This file may be edited according to user needs and imported into the model using the County Data Manager.

Similarly, the fuel data template was exported from the TexN2 utility in spreadsheet format and was updated with the applicable 2023 summer fuel sampling data. The spreadsheets containing data to update the fuel parameter inputs for MOVES3 and TexN2 are provided in Appendix E1. The spreadsheet also contains the MySQL scripts that are needed to update and load the new fuel parameter data into TexN2.

4.4 Findings

Table 7 shows the average fuel-region-level values for selected fuel parameters for gasoline. The table also includes statistics (minimum, maximum, average, etc.) developed using individual gasoline samples of all grades. Table 8 does the same for diesel.

Selected fuel parameters from the initial round of gasoline DHA and NoDHA datasets in a flat-file format, fuel-region-level averages by gasoline grade, fuel-region-level weighted averages across all grades, and county-level averages are provided in Appendix E2. The same attachment provides diesel test results, fuel-region-level averages, and county-level averages for diesel.

Table 7. Gasoline Fuel Properties by Fuel Region (Summer 2023)

MOVES Fuel Region[1]	RVP	Sulfur (ppm)	Aromatics (% vol)	Olefins (% vol)	Benzene (% vol)	EtOH (% vol)	MTBE (% vol)	ETBE (% vol)	TAME (% vol)	E200 (%)	E300 (%)
100000000	8.73	20.97	22.53	17.33	0.43	9.77	0	0	0	55.86	89.42
178000000	7.61	15.83	30.44	5.20	0.79	9.80	0	0	0	52.07	84.25
178010000	7.63	14.00	28.43	9.30	0.59	9.72	0.00015	0	0	50.20	84.36
300000000	9.19	11.59	25.63	10.26	0.69	9.90	0	0	0	54.09	86.06
370010000	7.13	9.39	27.04	5.62	1.06	9.90	0	0	0	47.59	85.87
1370011000	7.32	11.68	25.99	8.94	0.59	10.64	0	0	0	50.52	84.70
Average	***8.22***	***12.06***	***27.28***	***9.01***	***0.58***	***9.92***	***0.00005***	***0***	***0***	***49.87***	***86.20***
Min	***6.48***	***2.21***	***10.80***	***1.30***	***0.17***	***8.82***	***0***	***0***	***0***	***40.96***	***80.10***
Max	***11.75***	***31.22***	***54.80***	***28.30***	***1.88***	***15.01***	***0.007***	***0***	***0***	***60.45***	***95.00***
Range	***5.27***	***29.01***	***44.00***	***27.00***	***1.71***	***6.19***	***0.007***	***0***	***0***	***19.49***	***14.90***
Standard Deviation	***1.09***	***5.55***	***5.92***	***4.04***	***0.29***	***0.59***	***0.0006***	***0***	***0***	***3.84***	***2.36***

[1]100000000 – 11 Sourth Texas Counties; 178000000 – 3 BPA Counties; 178010000 – 95 Central and East Texas Counties; 300000000 -132 West Texas Counties; 370010000 – El Paso County; 1370011000 – 12 RFG Counties in DFW and HGB.

Table 8. Diesel Properties by Region (Summer 2023)

MOVES Fuel Region[1]	Aromatics, %-wt	Sulfur, ppm	Cetane No.	Specific Gravity	T50, °F
100000000	13.46	2.45	56.93	0.82	509.35
178000000	28.51	5.81	46.77	0.85	517.23
178010000	22.96	6.30	50.16	0.84	511.24
300000000	22.49	6.27	50.33	0.84	512.77
370010000	20.65	6.43	49.88	0.84	515.02
1370011000	20.26	5.42	55.96	0.83	522.59
Average	***22.09***	***5.99***	***51.15***	***0.84***	***513.55***
Min	***0.35***	***0.75***	***42.50***	***0.79***	***478.20***
Max	***33.49***	***10.13***	***78.50***	***0.85***	***574.10***
Range	***33.14***	***9.38***	***36.00***	***0.06***	***95.90***
Standard Deviation	***7.29***	***2.10***	***6.46***	***0.01***	***17.20***

[1]100000000 – 11 Sourth Texas Counties; 178000000 – 3 BPA Counties; 178010000 – 95 Central and East Texas Counties; 300000000 -132 West Texas Counties; 370010000 – El Paso County; 1370011000 – 12 RFG Counties in DFW and HGB.

5 TEMPORAL VARIABILITY AND TREND ANALYSIS

For 2023, SwRI conducted a second round of sampling and lab analysis for the seven stations in the Houston district. These round 2 data enabled the study team to analyze the temporal variation of fuel parameters within a single district and at individual retail stations. This section describes that analysis, along with the trend analyses that were performed using selected fuel parameter data from previous years (2003–2020) and the results from the sampling conducted in the summer of 2023.

5.1 Temporal Variability (Round 1 vs. Round 2 Data)

For the Houston district, SwRI sampled gasoline and diesel from seven retail gasoline stations during the initial sampling in the first week of June 2023, then again four weeks later. (The four-week wait period was to ensure complete tank turnover at all seven locations.) Table 9 lists the seven stations. During round 2 sampling, pumps at one of the stations (Loves Travel Stop 401) that was sampled in round 1 were inoperable and the station operator did not have an estimate on when they would begin operations. Therefore, the field sampling team had to select an alternate station (I-10 Stop) for Round 2 sampling.

Table 9. Houston District Sampling Stations

Station ID	Station Name
1	Angels Gas & Grocery 3
2	Flying J Travel Plaza 729
3	Flying J Travel Plaza 740
4	Loves Travel Stop 401/I-10 Stop[a]
5	Marina Shell
6	Spin N Go
7	TPG 581 07

[a] Round 1 sampling was conducted at Loves Travel Stop station; However, during Round 2 sampling this station was inoperable, and therefore sampling was conducted at an alternate station (I-10 Stop).

Test results for round 2 were identical in format to the initial sampling data received from SwRI. ERG carried out the same processing steps for the round 2 test results as for the round 1 results, as described in Section 4 of this report. Table 10 and Table 11 compare the round 1 and round 2 results. Table 10 presents the results for gasoline samples; Table 11 presents diesel sampling results.

Table 10. Station-Specific Gasoline Fuel Results, Round 1 vs. Round 2

Station ID	Fuel Component	Round 1 Results	Round 2 Results	Difference (R2 – R1)	% Difference
1	RVP, psi	7.36	7.34	0.02	-0.31%
1	Benzene, % volume	0.54	0.52	-0.01	-2.55%
1	Aromatics, % volume	22.47	26.65	4.19	18.63%
1	Olefins, % volume	10.21	10.11	-0.10	-1.00%
1	ETOH, % volume	10.25	10.21	-0.05	-0.46%
1	MTBE, % volume	0	0	0	N/A
1	ETBE, % volume	0	0	0	N/A
1	TAME, % volume	0	0	0	N/A
1	Sulfur, ppm	15.87	12.94	-2.93	-18.45%
1	E200	48.76	49.16	0.40	0.82%
1	E300	84.74	84.67	-0.06	-0.08%
2	RVP, psi	7.21	7.09	-0.12	-1.62%
2	Benzene, % volume	0.67	0.50	-0.17	-25.27%
2	Aromatics, % volume	26.35	23.04	-3.31	-12.57%
2	Olefins, % volume	10.35	10.75	0.40	3.90%
2	ETOH, % volume	14.44	14.45	0.01	0.05%
2	MTBE, % volume	0	0	0	N/A
2	ETBE, % volume	0	0	0	N/A
2	TAME, % volume	0	0	0	N/A
2	Sulfur, ppm	13.25	11.48	-1.76	-13.29%
2	E200	55.91	55.33	-0.58	-1.03%
2	E300	84.96	85.29	0.33	0.39%
3	RVP, psi	7.35	7.23	-0.12	-1.59%
3	Benzene, % volume	0.67	0.52	-0.15	-22.33%
3	Aromatics, % volume	28.56	24.13	-4.43	-15.52%
3	Olefins, % volume	11.18	11.74	0.56	5.05%
3	ETOH, % volume	14.36	14.25	-0.10	-0.72%
3	MTBE, % volume	0	0	0	N/A
3	ETBE, % volume	0	0	0	N/A
3	TAME, % volume	0	0	0	N/A
3	Sulfur, ppm	10.92	11.32	0.40	3.64%
3	E200	56.18	54.80	-1.38	-2.46%
3	E300	84.83	84.23	-0.60	-0.70%
4[a]	RVP, psi	7.35	7.13	N/A	N/A
4[a]	Benzene, % volume	0.35	0.47	N/A	N/A
4[a]	Aromatics, % volume	25.53	33.32	N/A	N/A

Station ID	Fuel Component	Round 1 Results	Round 2 Results	Difference (R2 – R1)	% Difference
4[a]	Olefins, % volume	7.65	7.80	N/A	N/A
4[a]	ETOH, % volume	10.00	10.29	N/A	N/A
4[a]	MTBE, % volume	0	0	N/A	N/A
4[a]	ETBE, % volume	0	0	N/A	N/A
4[a]	TAME, % volume	0	0	N/A	N/A
4[a]	Sulfur, ppm	9.59	9.21	N/A	N/A
4[a]	E200	51.05	50.23	N/A	N/A
4[a]	E300	84.11	83.22	N/A	N/A
5	RVP, psi	7.43	7.20	-0.22	-3.01%
5	Benzene, % volume	0.64	0.49	-0.14	-22.46%
5	Aromatics, % volume	27.01	24.08	-2.92	-10.83%
5	Olefins, % volume	11.63	10.86	-0.76	-6.58%
5	ETOH, % volume	9.88	10.13	0.26	2.60%
5	MTBE, % volume	0	0	0	N/A
5	ETBE, % volume	0	0	0	N/A
5	TAME, % volume	0	0	0	N/A
5	Sulfur, ppm	17.13	12.07	-5.06	-29.56%
5	E200	49.67	49.13	-0.54	-1.09%
5	E300	83.76	85.15	1.39	1.67%
6	RVP, psi	7.46	7.33	-0.12	-1.65%
6	Benzene, % volume	0.68	0.48	-0.20	-29.17%
6	Aromatics, % volume	25.38	24.58	-0.80	-3.15%
6	Olefins, % volume	9.06	9.65	0.59	6.55%
6	ETOH, % volume	10.08	10.12	0.04	0.35%
6	MTBE, % volume	0	0	0	N/A
6	ETBE, % volume	0	0	0	N/A
6	TAME, % volume	0	0	0	N/A
6	Sulfur, ppm	11.82	10.14	-1.68	-14.20%
6	E200	49.96	48.48	-1.47	-2.95%
6	E300	84.59	84.23	-0.36	-0.42%
7	RVP, psi	7.22	7.31	0.09	1.18%
7	Benzene, % volume	0.68	0.50	-0.18	-25.89%
7	Aromatics, % volume	27.78	22.91	-4.87	-17.53%
7	Olefins, % volume	10.02	10.23	0.21	2.11%
7	ETOH, % volume	9.97	10.03	0.06	0.63%
7	MTBE, % volume	0.00	0.00	0	N/A
7	ETBE, % volume	0.00	0.00	0	N/A

Station ID	Fuel Component	Round 1 Results	Round 2 Results	Difference (R2 – R1)	% Difference
7	TAME, % volume	0.00	0.00	0	N/A
7	Sulfur, ppm	11.71	11.61	-0.10	-0.86%
7	E200	49.77	48.65	-1.12	-2.26%
7	E300	84.61	84.62	0.01	0.01%

[a] Round 1 sampling was conducted at Loves Travel Stop station and Round 2 sampling was conducted at the I-10 Stop. Differences are not shown here as they are from different stations.

As Table 10 indicates, the round 1 and round 2 gasoline samples for the Houston district stations show substantial variations. The largest decrease between the round 1 and round 2 results is for sulfur content (in ppm), and the largest increase is for aromatics. The largest overall decrease (-29.6%) is for the sulfur content values for station 5 and the largest increase is for aromatics (18.6%) from station 1.

Table 11. Station-Specific Diesel Results, Round 1 vs. Round 2

Station ID	Fuel Component[a]	Round 1 Results	Round 2 Results	Difference (R2 – R1)	% Difference
1	Specific gravity	0.85	0.84	-0.003	-0.34%
1	Aromatics, % mass	30.17	24.95	-5.22	-17.30%
1	Sulfur, ppm	7.11	6.85	-0.27	-3.73%
1	Cetane number	44.70	46.00	1.30	2.91%
1	T50, °F	498.20	510.60	12.40	2.49%
2	Specific gravity	0.81	0.81	-0.0004	-0.05%
2	Aromatics, % mass	0.53	0.57	0.04	7.55%
2	Sulfur, ppm	0.87	0.73	-0.14	-16.44%
2	Cetane number	74.60	69.60	-5.00	-6.70%
2	T50, °F	574.10	573.70	-0.40	-0.07%
3	Specific gravity	0.80	0.80	-0.004	-0.52%
3	Aromatics, % mass	0.72	0.56	-0.16	-22.22%
3	Sulfur, ppm	0.75	0.32	-0.44	-58.00%
3	Cetane number	78.50	74.00	-4.50	-5.73%
3	T50, °F	570.30	567.90	-2.40	-0.42%
4[b]	Specific gravity	0.79	0.84	N/A	N/A
4[b]	Aromatics, % mass	0.30	28.70	N/A	N/A
4[b]	Sulfur, ppm	4.08	6.56	N/A	N/A
4[b]	Cetane number	74.30	46.70	N/A	N/A
4[b]	T50, °F	566.60	504.20	N/A	N/A
5	Specific gravity	0.84	0.84	-0.002	-0.20%
5	Aromatics, % mass	27.41	24.80	-2.61	-9.52%

Station ID	Fuel Component[a]	Round 1 Results	Round 2 Results	Difference (R2 – R1)	% Difference
5	Sulfur, ppm	5.96	6.12	0.17	2.84%
5	Cetane number	50.10	46.00	-4.10	-8.18%
5	T50, °F	501.90	505.40	3.50	0.70%
6	Specific gravity	0.84	0.84	-0.003	-0.31%
6	Aromatics, % mass	25.49	22.38	-3.11	-12.20%
6	Sulfur, ppm	6.66	6.24	-0.42	-6.34%
6	Cetane number	50.10	47.50	-2.60	-5.19%
6	T50, °F	511.30	510.10	-1.20	-0.23%
7	Specific gravity	0.84	0.84	-0.001	-0.17%
7	Aromatics, % mass	28.38	26.01	-2.37	-8.35%
7	Sulfur, ppm	6.33	6.44	0.11	1.71%
7	Cetane number	58.60	47.60	-11.00	-18.77%
7	T50, °F	502.00	505.40	3.40	0.68%

[a] ASTM D1319 test was not conducted for diesel samples for aromatics, olefins, and saturates due to quality issues with the dye used in testing. An alternate test (ASTM D5186) was performed for aromatics (percent mass).
[b] Round 1 sampling was conducted at Loves Travel Stop station and Round 2 sampling was conducted at I-10 Stop. Differences are not shown here as they are from different stations.

Round 1 and round 2 diesel sampling results indicate significant variations in diesel aromatics values and sulfur levels. It should be noted that the aromatics values shown in Table 11 are for percent mass rather than percent volume. Due to quality issues with the dye used for the ASTM D1319 test, an alternate test was performed on diesel samples for aromatics (ASTM D5186). The aromatics values range from a decrease of 22% to an increase of about 8%. The aromatics values exhibit a general downward trend for all stations, except station 2, which shows an increase of about 8%. For the other stations (1, 3, 5, 6, and 7), aromatics exhibit a decrease in the round 2 values; station 3 shows the highest decrease, about 22%.

Sulfur content values decreased for four stations (stations 1, 2, 3, and 6) ranging from 4% to 58%, and increased for the remaining two stations (stations 5 and 7) ranging from 2% to 3%. Overall, sulfur values range from a decrease of about 58% (station 3) to an increase of about 2% (station 7). The highest sulfur values for both sampling rounds were recorded at station 1 with 7.11 ppm in round 1 and 6.85 ppm in round 2.

All the gasoline and diesel analysis data from round 1 and round 2 for the Houston district are provided in Appendix F1, which includes the round 1 and round 2 raw sampling results received from SwRI, data presented in Table 10 and Table 11, as well as Houston district-level averages for selected fuel parameters for round 1 and round 2 sampling of gasoline and diesel.

5.2 Trends Analysis (2023 Data vs. Data from Previous Years)

ERG compared the sampling results for gasoline and diesel collected during the summer of 2023 with the results from the summers of 2003 through 2020. (Note that data from 2003–2023 are not available for all years: testing was not conducted in the summers of 2006, 2009, 2010, 2012, 2013, 2015, 2016, 2018, 2019, 2021, or 2022.)

For this trends analysis, ERG aggregated gasoline and diesel samples at the TxDOT District level and developed district-level averages.

Figure 6 through Figure 17 illustrate the trends in selected gasoline fuel parameters for selected districts from 2003 through 2023. Figure 18 through Figure 22 illustrate the diesel composition trends from 2003 through 2023 for selected diesel parameters and selected districts. All the trend analysis data are provided in Appendix F2.

Summer fuel studies performed in the past used results from ASTM D1319 testing for aromatics, olefins, and saturates for both diesel and gasoline fuel samples. ASTM D1319 testing was not performed on diesel samples during this project because the dye required for this testing does not meet current ASTM quality standards. Therefore, an alternate test was performed for diesel aromatics (D5186).

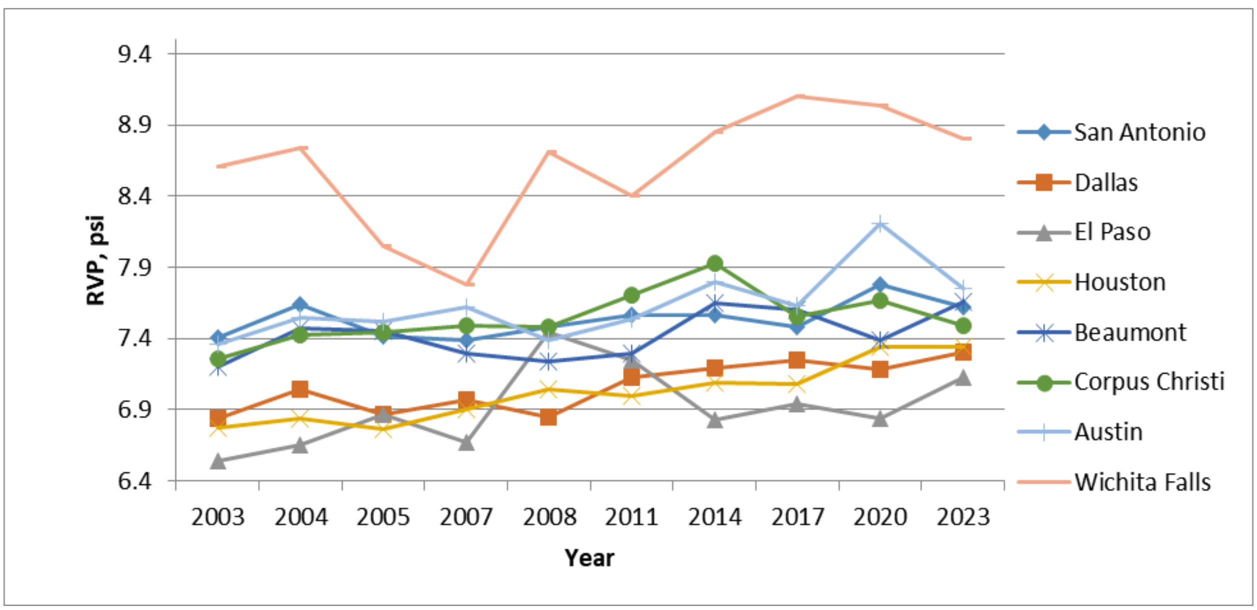

Figure 6. Gasoline RVP Trends for Selected Districts

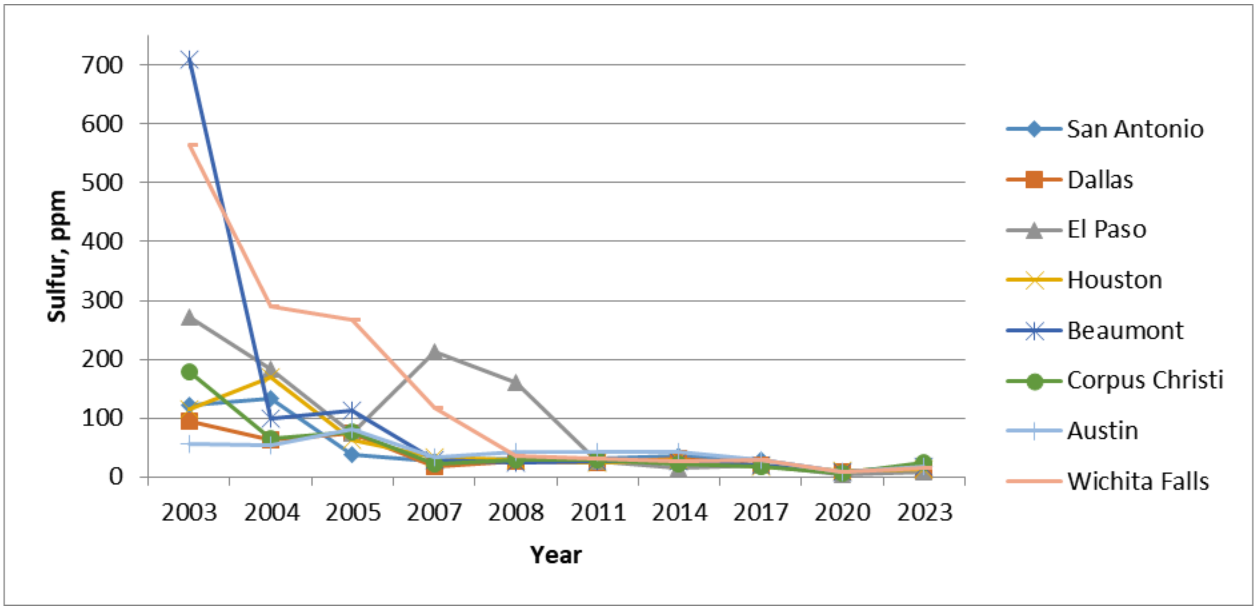

Figure 7. Gasoline Sulfur Trends for Selected Districts

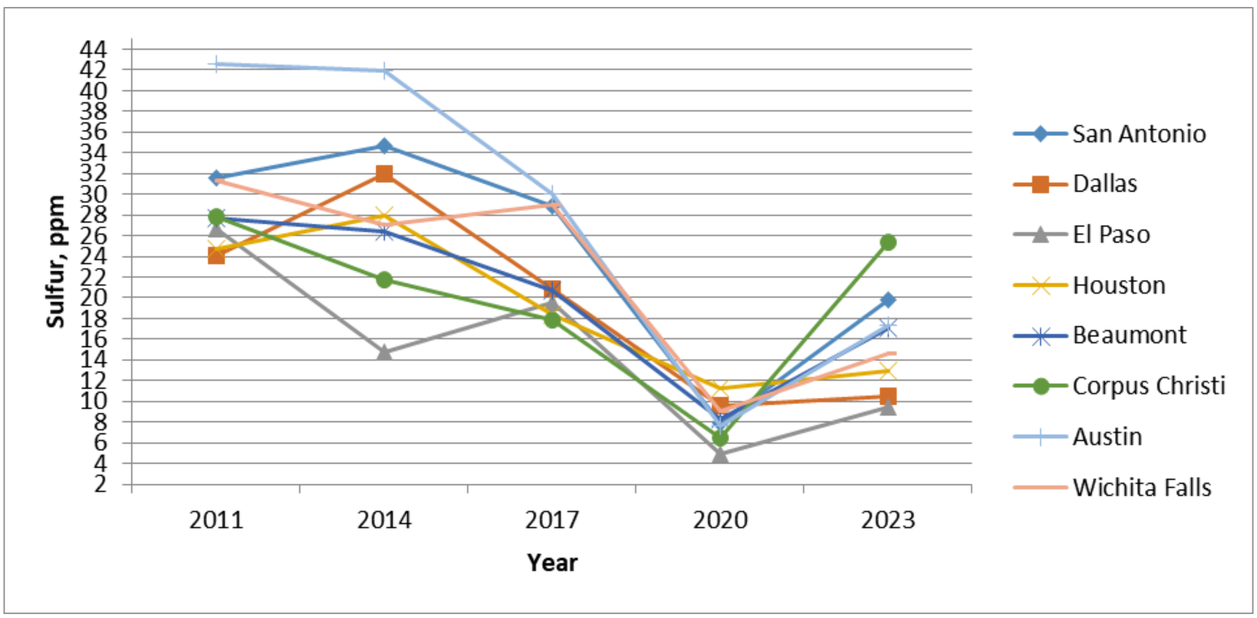

Figure 8. Gasoline Sulfur Trends for Selected Districts (2011–2023)

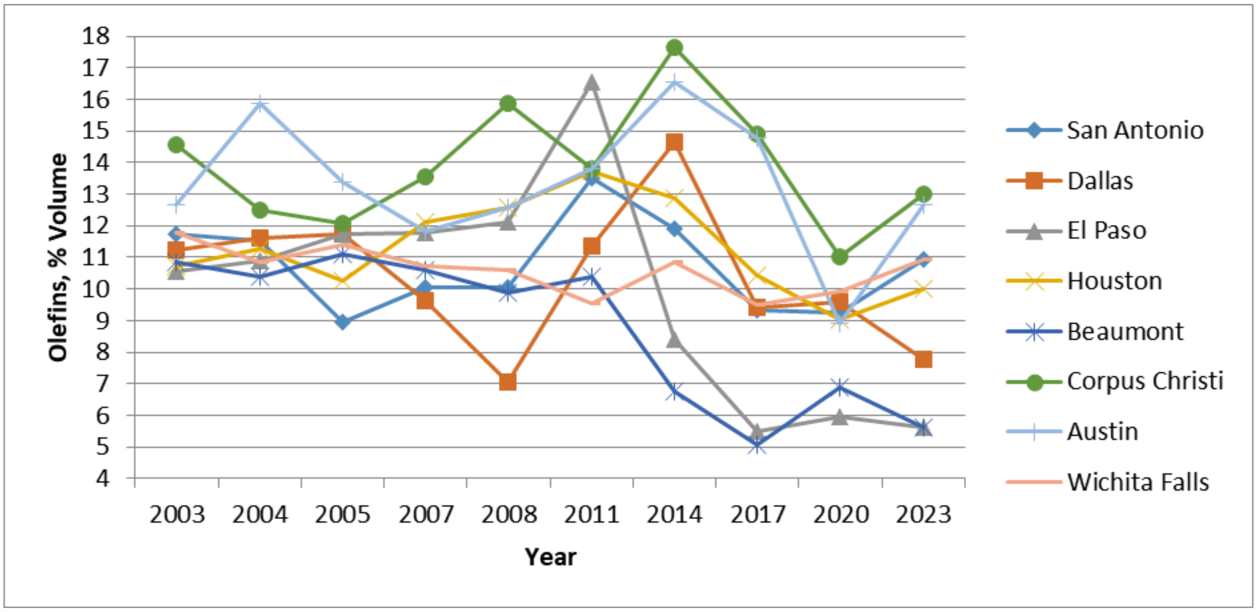

Figure 9. Gasoline Olefins Trends for Selected Districts

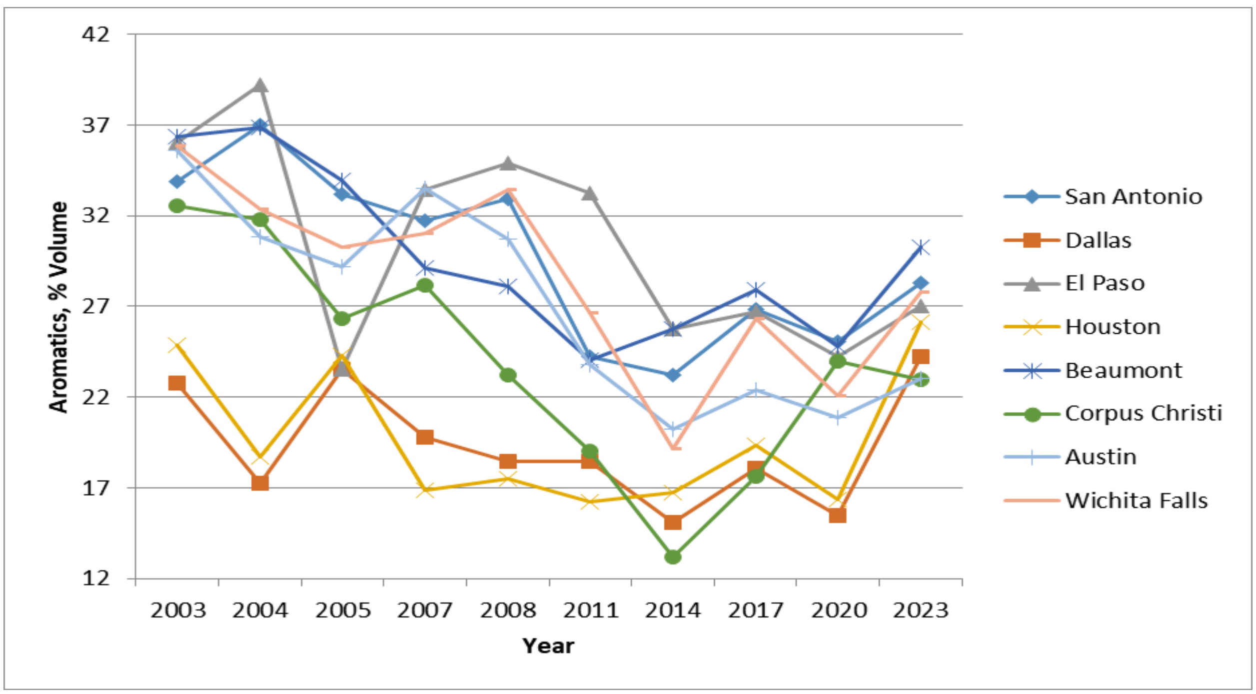

Figure 10. Gasoline Aromatics Trends for Selected Districts

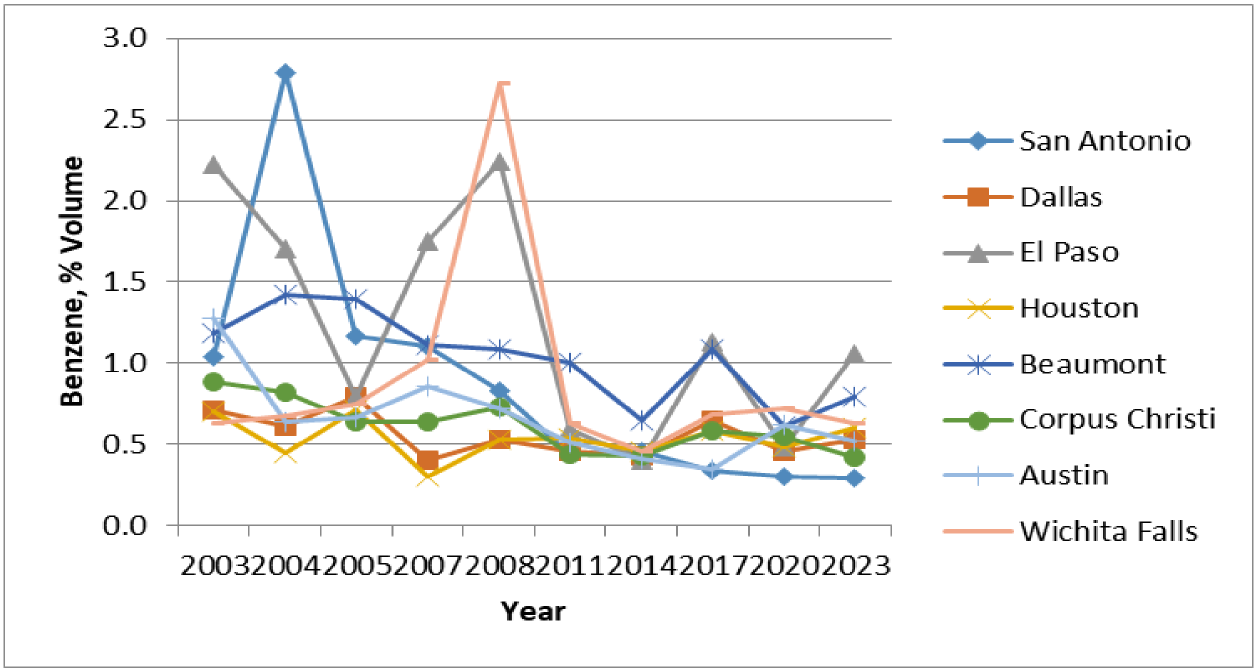

Figure 11. Gasoline Benzene Trends for Selected Districts

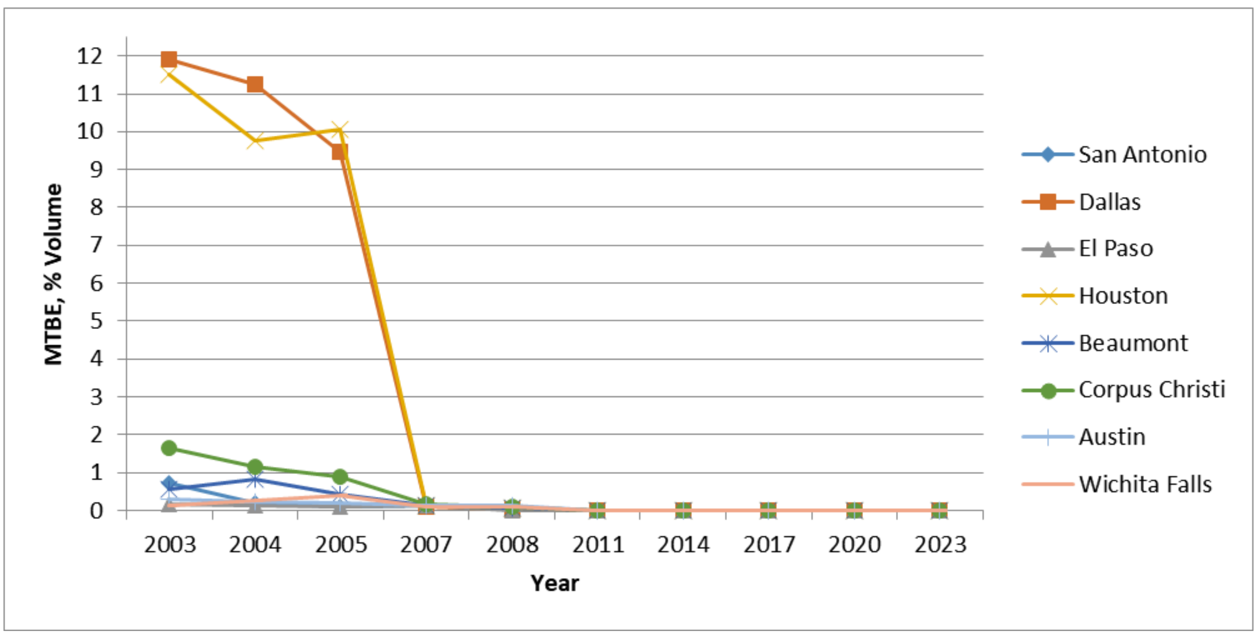

Figure 12. Gasoline MTBE Trends for Selected Districts

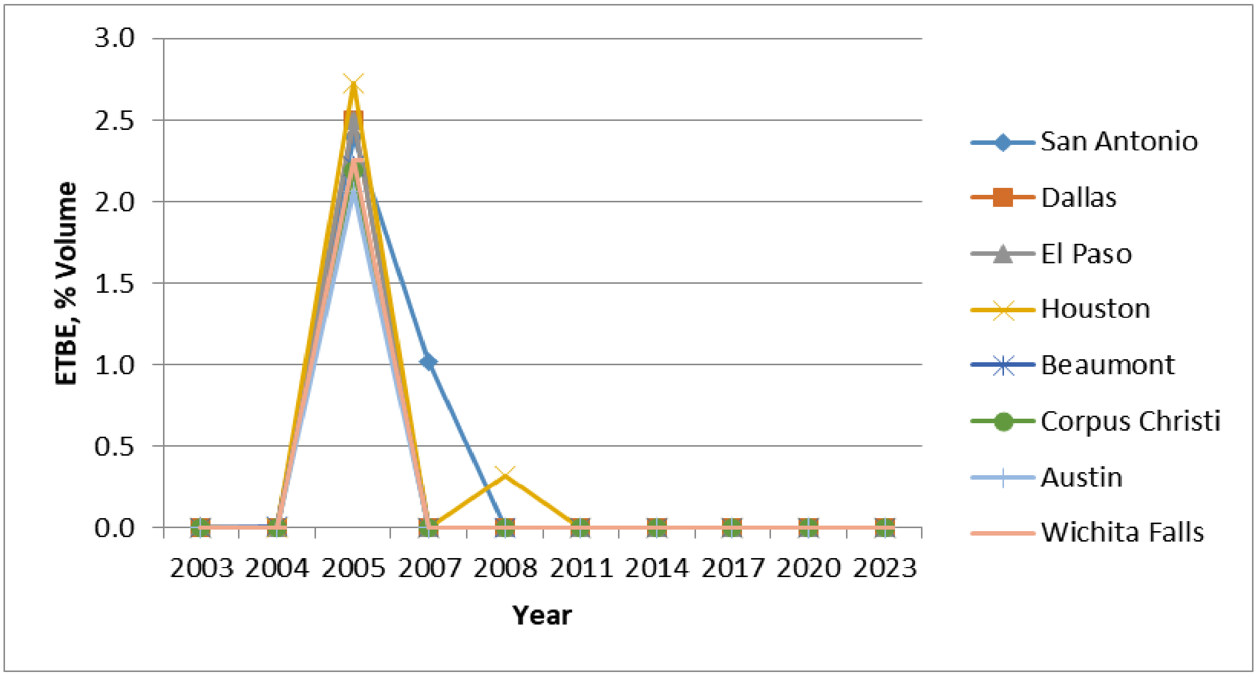

Figure 13. Gasoline ETBE Trends for Selected Districts

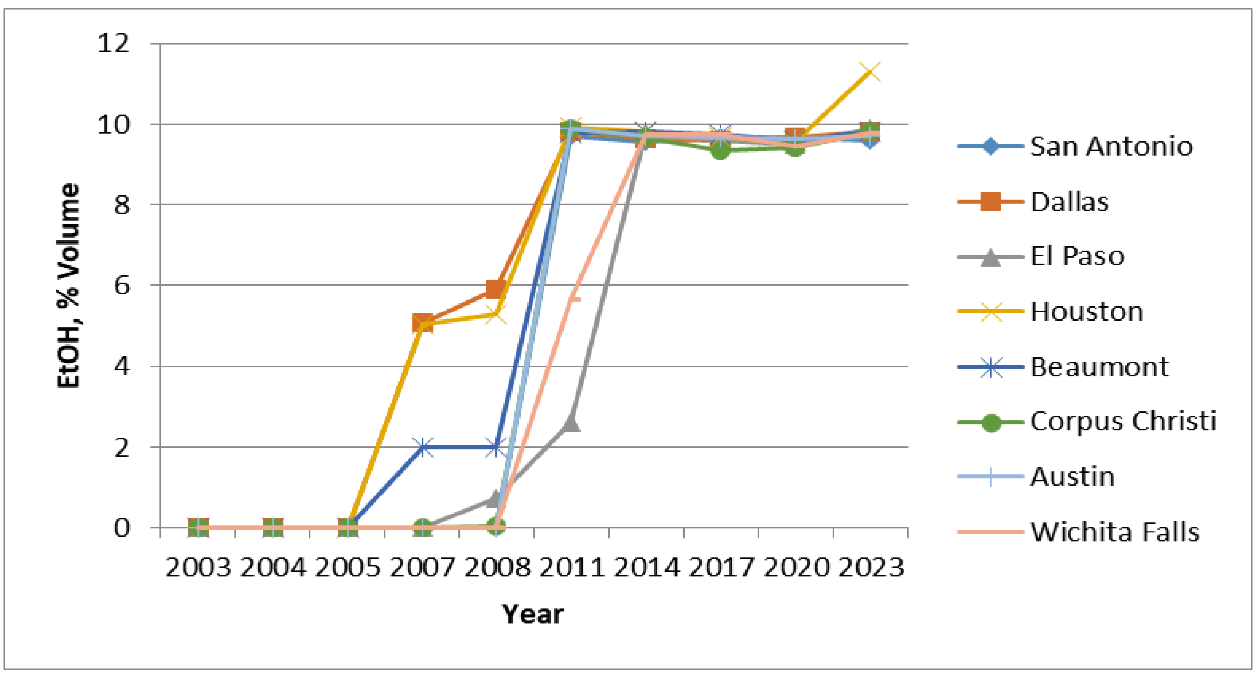

Figure 14. Gasoline ETOH Trends for Selected Districts

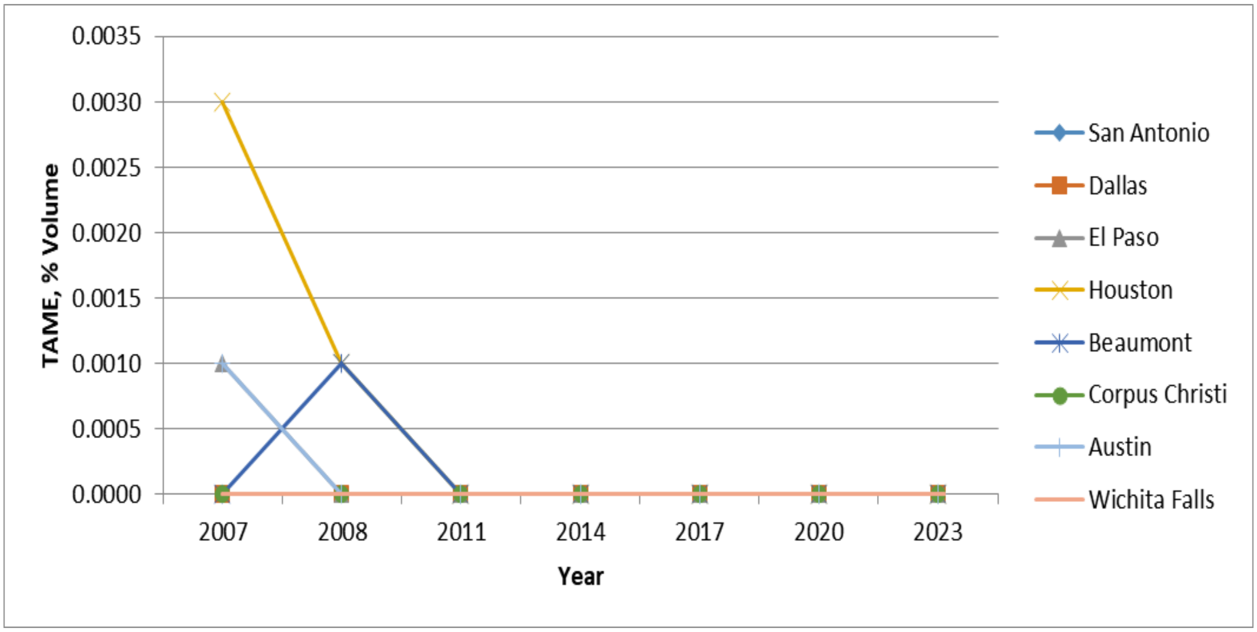

Figure 15. Gasoline TAME Trends for Selected Districts

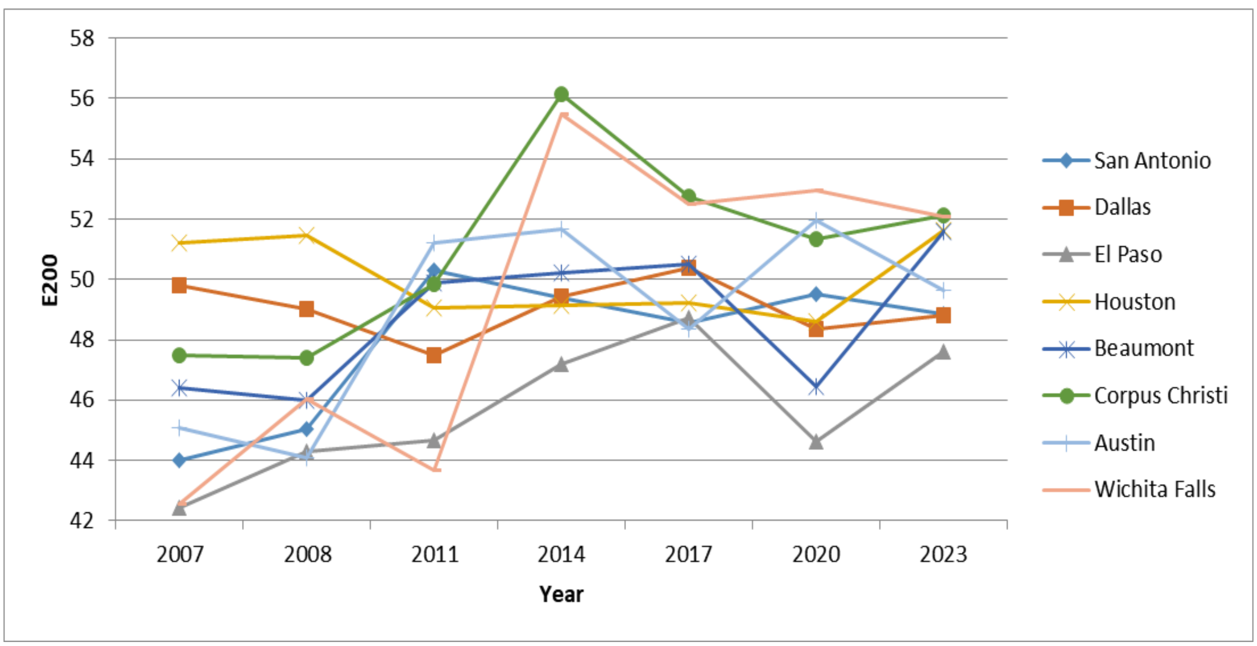

Figure 16. Gasoline E200 Trends for Selected Districts

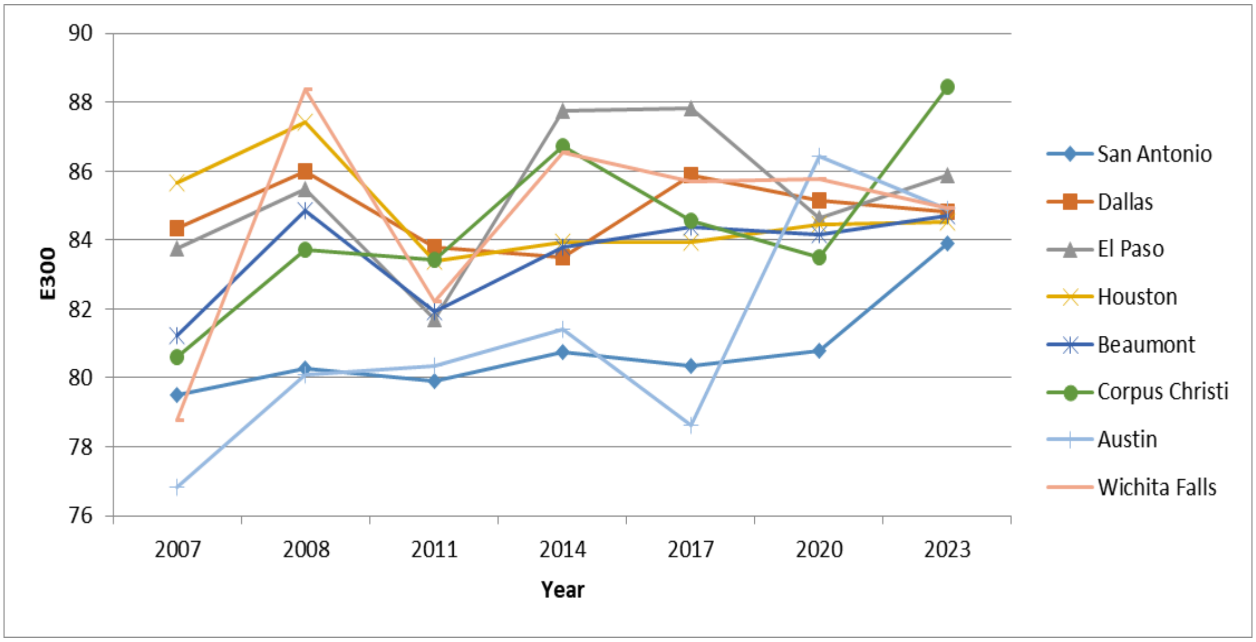

Figure 17. Gasoline E300 Trends for Selected Districts

Several general observations in the gasoline sampling data across the time-series were noted, as described below.

- RVP in most districts appears to be relatively stable over time. Most values range from 6.5 psi to 7.9 psi, except in the Austin and Wichita Falls districts. For Wichita Falls, the RVP values range from 7.78 psi in 2007 to 9.11 psi in 2017. For Austin, the RVP values range from 7.36 psi in 2003 to 8.21 psi in 2020.
- Some of the gasoline samples had higher RVP than allowable under the TCEQ's Regional Low RVP Gasoline Program (7.8 psi). However, results indicate that all 95 central and eastern Texas counties that are included in TCEQ's Regional Low RVP Gasoline Program have average RVP values below 7.8 psi.
- The average RVP value for El Paso (7.1 psi) is slightly higher than the requirements of El Paso's Low RVP Gasoline Program (7.0 psi). This is due to one high RVP value (10.3 psi) for a PU gasoline sample collected in El Paso.
- Sulfur levels have been below 50 ppm since 2011, reaching approximately 10 ppm by 2020, as expected with the federal gasoline sulfur fuel standards. The lowest sulfur levels for all districts were recorded in 2020, with values ranging from 4.9 ppm in El Paso to 11.3 ppm in Houston. However, in 2023 most sulfur values increased above the 10.0 ppm annual average level mandated under the Federal Tier 3 gasoline rule,

ranging from 9.4 ppm in El Paso to 25.3 ppm in Corpus Christi. Federal regulations mandate that the annual average sulfur content does not exceed 10 ppm; however, on a per-gallon basis, the sulfur content is capped at 80 ppm. Sulfur content values for individual gasoline samples (all grades) ranged from 2.2 ppm to 31.2 ppm. None of the individual samples exceeded the federal per-gallon sulfur content cap of 80 ppm. The 2023 summer fuel sampling was conducted in June and only provides a snapshot in time. Additional sampling throughout the year is needed to develop the annual average sulfur content values.

- There does not appear to be any obvious trend for olefins in most districts over time. Compared to 2020, average olefin values in 2023 increased for all districts except Beaumont, Dallas, and El Paso, . Aromatics display a general downward trend since 2008 for all districts, except Beaumont, Dallas, and Houston. Average aromatics values in 2023 are higher than in 2020 for all districts, except Corpus Christi. Benzene values also represent a general downward trend since 2008 for all districts, except Houston.
- Non-ETOH oxygenates (i.e., ETBE, TAME, and MTBE) were only observed in trace amounts, if at all. Ethanol values have been relatively stable for all districts since 2014 except for Houston which exceeded the 10 percent blend maximum in 2023.

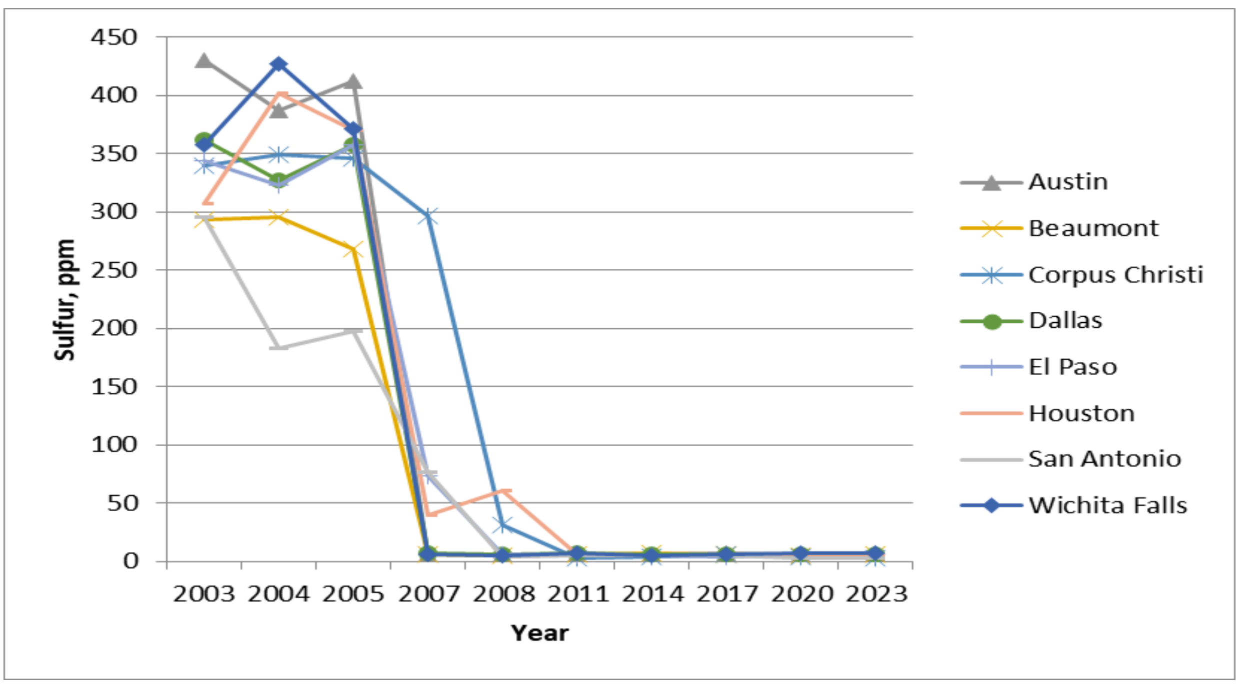

Figure 18. Diesel Sulfur Trends for Selected Districts

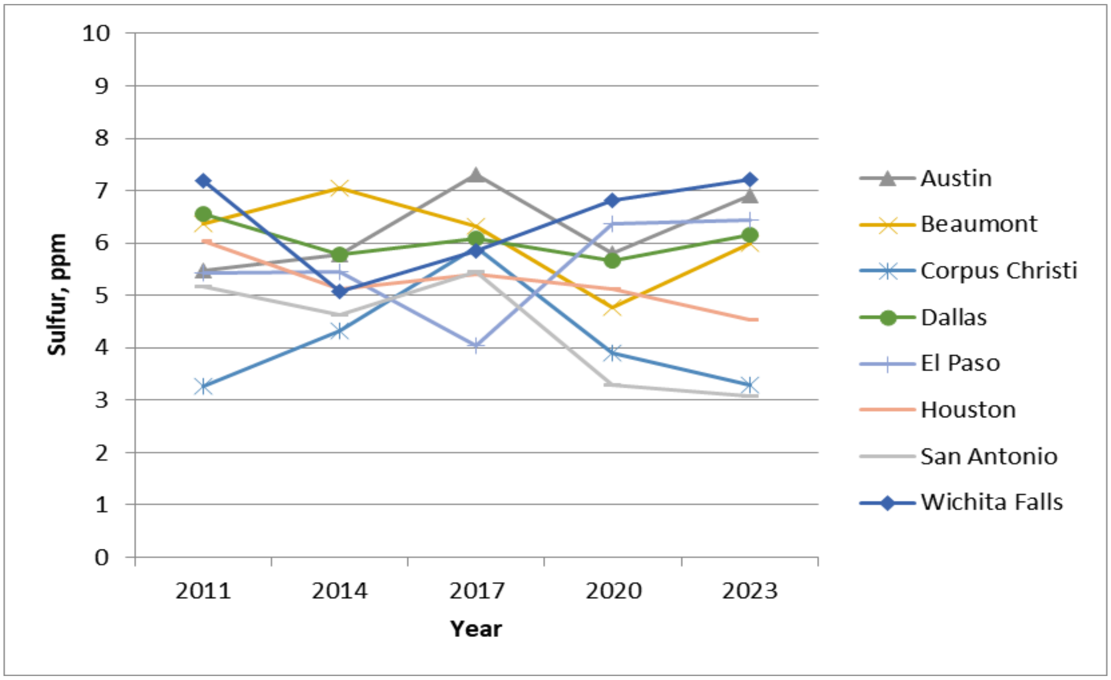

Figure 19. Diesel Sulfur Trends for Selected Districts (2011–2023)

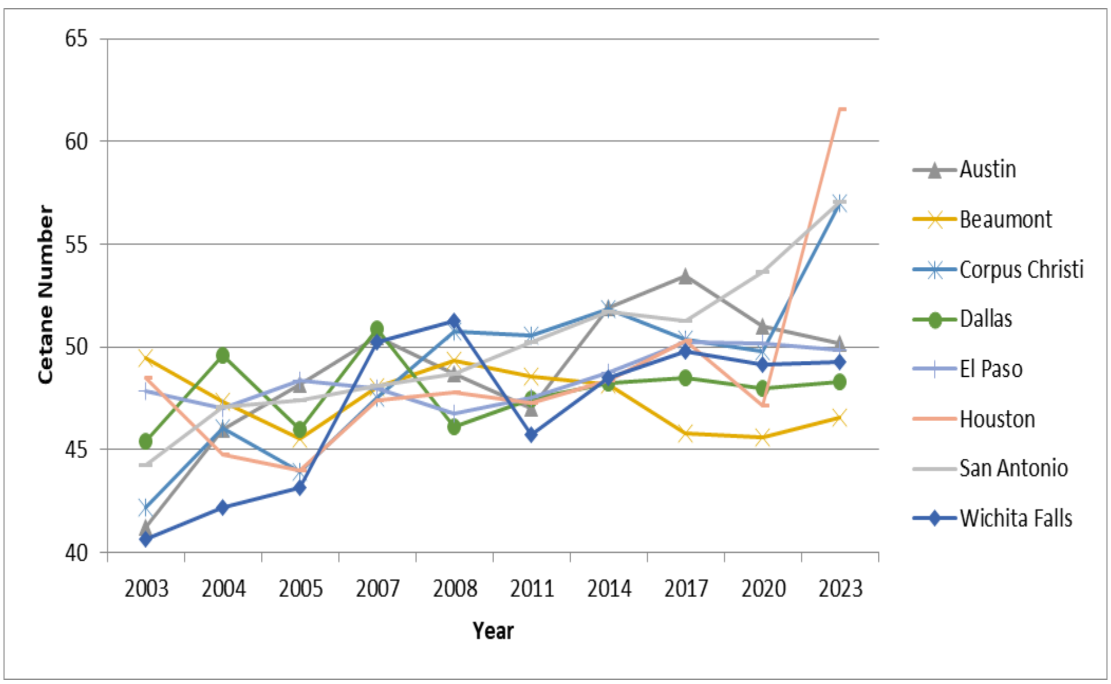

Figure 20. Diesel Cetane Number Trends for Selected Districts

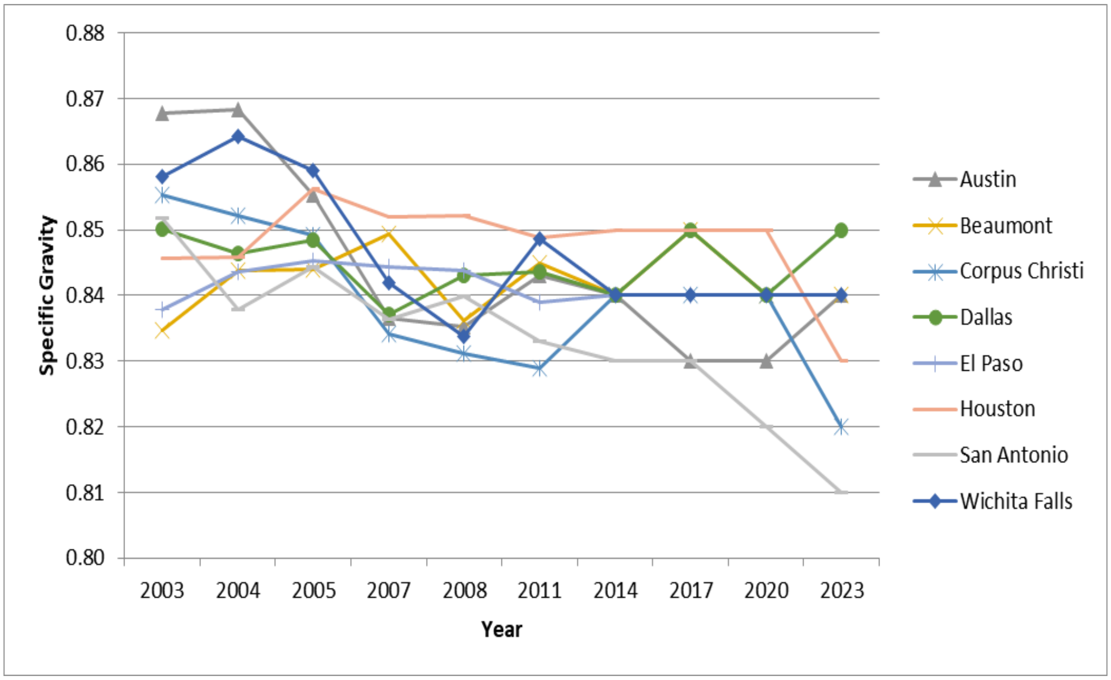

Figure 21. Diesel Specific Gravity Trends for Selected Districts

Figure 22. Diesel T50 Trends for Selected Districts

The following general observations about the diesel parameter trends were observed:

- Sulfur content values exhibited a sharp decline from 2005 to 2007, with roughly flat trends from 2011 through 2023. All districts had their peak average sulfur values during the 2003–2005 period. Since 2011, most districts had an average sulfur content value below 7 ppm. This trend is consistent with the federal ultra-low-sulfur fuel requirements. Sulfur content values in 2023 are below 7 ppm for all districts, except Wichita Falls (7.2 ppm). Compared to 2020 results, Sulfur content in 2023 increased for all districts, except Corpus Christi and Houston.
- Most districts exhibit relatively high variability with a generally upward trend for average cetane number values.
- For specific gravity values, most districts display a general downward trend from 2003 through 2007. District-level specific gravity values have been stable since 2008, and there has not been much change from 2008 to 2023. The biggest change in specific gravity values for 2003–2023 is for the San Antonio district (-4.9% change from the 2003 value).
- The T50 values for the selected districts are tightly grouped between 474 and 535 degrees, with a slight upward trend starting in 2008. The largest change from 2020 levels to 2023 is for the Beaumont district (3.9%).

6 QUALITY ASSURANCE

ERG reviewed the lab analysis results for all gasoline and diesel samples, looking for possible outliers or unusual data distributions. ERG evaluated the minimum, maximum, average, and standard deviation for lab testing results by the TxDOT district in the 2003–2023 trends analyses. The values were then plotted against previous years and other districts to highlight possible outliers. Trend lines created during post-processing of the lab results also aided in identifying outliers. No issues were identified with the 2023 sampling results.

Before ERG received the lab test results, SwRI performed rigorous QA/QC checks of the samples received and the equipment used during testing. These QA/QC procedures are described in detail below in Sections 6.1 through 6.3.

Section 6.4 documents the QA/QC work that TTI performed. Outliers were noted and any questions that TTI had were directed to ERG.

6.1 Calibrations and Quality Control Checks

6.1.1 Instrument/Equipment Calibration and Frequency

6.1.1.1 DHA, ASTM D 6729-20

The instrument is calibrated by running the calibration standard containing the 400-plus components and verifying their identification using the provided chromatogram.

6.1.1.2 RVP, ASTM D 5191-22

All instruments for this test are calibrated by an ISO 17025-accredited service company every six months.

6.1.1.3 Sulfur, ASTM D 2622-21

The x-ray instruments for this test are calibrated as needed. A calibration verification is performed daily, and a drift correction is performed as needed.

6.1.1.4 Distillation, ASTM D 86-20b

An in-house maintenance group calibrates each distillation rig every three months. The temperature probes are verified every six months using 100% toluene and hexadecane.

6.1.1.5 Cetane Number, ASTM D 613-18ae1

The rating units are calibrated daily to the range of each sample.

6.1.1.6 Aromaticity, ASTM D 1319-20a

The electronic caliper used for rod measurements is calibrated every six months. The pressure gauges used in the rod set-ups are calibrated annually. The black lights used in the procedure are also calibrated annually.

6.1.1.7 Sulfur, ASTM D 5453-19a

Samples are analyzed using ultraviolet fluorescence. The instrument is calibrated as needed. A calibration verification is performed before any sample analysis.

6.1.1.8 Specific Gravity, ASTM D 1298-12b (2017)

Newly calibrated hydrometers are acquired every 12 months to cover the range of gasoline and diesel samples.

6.1.1.9 Flashpoint, ASTM D 93-20

The in-house maintenance group calibrates the temperature probe and stirrer rotation every six months.

6.1.1.10 Nitrogen, ASTM D 4629-17

The instruments are calibrated as needed. A calibration verification is performed before sample analysis.

6.1.1.11 Polycyclic and Total Aromatic, ASTM D 5186-19

The system's performance is set to meet ASTM D5186-19.

6.1.1.12 Benzene, ASTM D 3606-22

Each instrument is calibrated as needed. A calibration verification is performed before any sample analysis. Every tenth sample and at the end of the tray a QA sample containing benzene and ETOH is run, to ensure instrument stability and performance. Purchased standards are also used for verification. Flow and valve timing is checked a minimum of once a month and at any other time that non-routine maintenance is performed. Control charts are maintained and monitored daily for process stability for each instrument.

6.1.1.13 Oxygenates, ASTM D 5599-20b

Each chromatograph is calibrated with a standard set at regular intervals, and the calibration is verified daily before any sample run. The verification includes the measurement of a set of QA/QC standards with internal standards. Several external standards are used that include varied concentrations of TAME, ETOH, and MTBE. A blank and one of the instrument calibration standards containing approximately 0.5% of each component are also included at the beginning of each tray to determine if proper resolution is being achieved on each column. Each sample contains an internal standard to correct for any variation in injection volume.

Two QA/QC samples are placed after every 10 samples and at the end of each tray. The QA/QC is run in duplicate to verify the instrument's precision. Regular instrument maintenance, multiple daily calibration checks, column performance checks, and review of the gas chromatograph traces for excessive noise, drift, or other operational problems assure that a system is in place that will generate quality data. Control charts are maintained and monitored daily for process stability for major oxygenate components for each instrument.

6.1.2 Quality Control

6.1.2.1 DHA, ASTM D 6729-20

The laboratory routinely monitors the repeatability and reproducibility of its analysis. The repeatability is monitored through the use of laboratory replicates at the rate of one per batch or at least one per 10 samples, whichever is more frequent. Reproducibility will be monitored through the use of a QC sample analyzed at the rate of one per batch or at least one per 15 samples, whichever is more frequent.

The range (R) for the duplicate samples should be less than the following limits.

Benzene	0.047*C
MTBE	0.032*C
2,2,4 Trimethyl pentane	0.034*C

Where:

$C = (C_o+C_d)/2$

C_o = Concentration of the original sample

C_d = Concentration of the duplicate sample

R = Range, $| C_o - C_d |$

The QC sample is plotted on an individual control chart and the upper and lower control limits are determined per OAE Standard Operating Procedure 4.20—Revision 5 *Statistical Methods*.

6.1.2.2 RVP, ASTM D 5191-22

RVP systems are verified every 20 samples with a QC gasoline sample. The systems are verified with a 44.0:56.0 Pentane/Toluene blend every six months.

6.1.2.3 Sulfur, ASTM D 2622-21

Sulfur is analyzed using the multi-point calibration curves specified in Method D 2622, which are stored in the system computer. At the beginning of each shift, the instrument is verified using a purchased QA standard. Drift corrections are applied as needed. Control charts are maintained on the sulfur procedure.

6.1.2.4 Distillation, ASTM D 86-20b

Full instrument verification is conducted on each unit on an annual basis, and daily system verification is completed before running any sample at the start of each day. Control charts are maintained on each instrument, and a verified barometer is used for barometric correction of the data. Electronic parts are checked as specified in the lab calibration and recall schedule and at any time that non-routine maintenance is performed.

6.1.2.5 Cetane Number, ASTM D 613-18ae1

The rating units are calibrated daily to the range of each sample.

6.1.2.6 Aromaticity, ASTM D 1319-20a

The results are monitored with a daily QA sample. The current QA material is a surrogate fuel blended to reflect reformulated gasoline aromatic concentrations. This test is run on a new column every day in the same manner as the sample testing is performed. Each analyzer column is checked for internal and external dimensions and silica gel parameters are monitored as per the ASTM procedure.

6.1.2.7 Sulfur, ASTM D 5453-19a

The instrument is monitored daily by running a quality control sample with known sulfur content. Control charts are maintained on each instrument.

6.1.2.8 Flash Point, ASTM D 93-20

The flash point results are monitored through daily verification with an anisole reference material and an annual verification using an Accu Standard ASTM-P-133-01 certified reference material. The instrument undergoes internal calibration every six months by internal calibration.

6.1.2.9 Nitrogen, ASTM D 4629-17

The Antek instruments are monitored daily by running a quality control sample with known nitrogen content. Control charts are maintained on each instrument.

6.1.2.10 Polycyclic and Total Aromatics, ASTM D 5186-19

The Selerity Technology instrument is monitored daily by running a quality control sample with known aromatic content. Control charts are maintained for the instrument.

6.1.2.11 Benzene, ASTM D 3606-22

Each instrument is calibrated as needed using a curve with a series of calibration standards containing benzene from 0% to 5% and toluene from 0.5% to 20%. Every tenth sample and at the end of the tray, a QA sample containing benzene and ETOH is run to ensure instrument stability and performance. Control charts are maintained for each instrument.

6.1.2.12 Oxygenate, ASTM D 5599-20b

Each chromatograph is calibrated with a standard set at regular intervals, and the calibration is verified daily before any sample run. The verification includes the measurement of a set of QA/QC standards with internal standards. Several external standards are used which include varied concentrations of TAME, ETOH, and MTBE. A blank and one of the instrument calibration standards containing approximately 0.5% of each component are also included at the beginning of each tray to determine if proper resolution is being achieved on each column. Each sample contains an internal standard to correct for any variation in injection volume. Control charts are maintained for each instrument.

A QA/QC sample is placed every 10 samples and at the end of each tray. A QA sample is run in duplicate every 10 samples. Regular instrument maintenance, multiple daily calibration checks, column performance checks, and review of the gas chromatograph traces for excessive noise, drift, or other operational problems assure that a system is in place that will generate quality data. Control charts are maintained and monitored daily for process stability for major oxygenate components for each instrument.

6.2 Calibrations and Quality Control Acceptance Criteria

The SwRI laboratory staff conducted the initial data verification. They accepted or rejected the data based on the QC samples and, if applicable, chromatography and laboratory replicates.

The SwRI Program Manager reviewed the data. The data were reviewed for apparent accuracy, completeness, and reasonableness. The SwRI Program Manager decided whether to validate, rerun, or invalidate the data based on their review.

6.2.1 DHA, ASTM D 6729-20

Since typical gasoline is a mixture of over 400 components, it would be impractical if not impossible to impose data quality indicators on each analyte of interest. Therefore, one component from each of the functional groups was tracked to assess the overall quality of the analytical performance.

Table 12. Data Quality Indicators—DHA

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	The difference between replicate results, in the normal and correct operation of the method, should not exceed the following values expressed as percentages of the average of the two values: 4.7% Benzene 3.2% MTBE 3.4% 2,2,4 Trimethyl pentane
Bias	The bias of this test method cannot be determined since an appropriate standard reference material is not available. It is impossible to account for every potential co-elution and quantify the magnitude of the interference.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Since a suitable reference material is not available, Accuracy will be maintained by a QC sample.	The 95% confidence interval limits for the QC sample should be as follows expressed as percentages of the average of the two values: 9.9% Benzene 8.9% MTBE 9.5% 2,2,4 Trimethyl pentane
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A

DQI	Definition/Discussion	Measurement Performance Criteria
Comparability	The resulting data set is defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique. In the case of petroleum, chemistry is generally not quantifiable. The data set should give a reasonable estimate of the component distribution in the fuel supply but it may not be directly comparable to other methods.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	Based on the cooperative study results, individual component concentrations and precision are determined in the range of 0.01% mass to approximately 30% mass.	See ASTM D 6729-15

6.2.2 RVP, D 5191-22

Table 13. Data Quality Indicators—RVP (ASTM D 5191-22)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 5191-22
Bias	There is no accepted reference material suitable for determining the bias for the procedures in this test method. Bias cannot be determined.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy will be maintained by a QC sample.	See ASTM D 5191-22
Representative	Fuel samples will be collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	Upper and lower vapor pressure limits are defined in Table 1 of ASTM D 5191-22.	See ASTM D 5191-22

6.2.3 Sulfur, ASTM D2622-21

Table 14. Data Quality Indicators—Sulfur (ASTM D 2622-21)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 2622-21
Bias	Sulfur bias is detailed in D 2622-21.	See ASTM D 2622-21
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D 2622-21
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	N/A	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	The test method covers the determination of total sulfur in gasoline and diesel.	See ASTM D 2622-21

6.2.4 Distillation, ASTM D 86-20b

Table 15. Data Quality Indicators—Distillation (ASTM D 86-20b)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 86-20b
Bias	Due to the use of total temperature probes, the distillation temperatures in this test method were somewhat lower than the true temperatures. The amount of bias depends on the product being distilled and the thermometer used. The bias due to the emergent stem has been determined for toluene and is shown in ASTM D 86-20b.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D 86-20b
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	The method is designed for the analysis of distillate fuels; it is not applicable to products containing appreciable quantities of residual material.	See ASTM D 86-20b

6.2.5 Cetane Number, ASTM D 613-18ae1

Table 16. Data Quality Indicators—Cetane Number (ASTM D 613-18ae1)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 613-18ae1
Bias	The procedure in this test method for the cetane number of diesel oil has no bias because the value of the cetane number can be defined only in terms of the test method.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D 613-18ae1
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	The cetane number scale ranges from zero to 100 but typical testing is in the range of 30 to 65 cetane number.	See ASTM D 613-18ae1

6.2.6 Aromaticity, ASTM D 1319-20a

Table 17. Data Quality Indicators—Aromaticity (ASTM D 1319-20a)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D1319-20a
Bias	The procedure in this test method for the cetane number of diesel oil has no bias because the value of the cetane number can be defined only in terms of the test method.	See ASTM D1319-20a
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D1319-20a
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A

DQI	Definition/Discussion	Measurement Performance Criteria
Completeness	All samples received by SwRI were analyzed according to the test method. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	This test method covers the determination of hydrocarbon types over the concentration ranges from 5 to 99 volume % aromatics, 0.3 to 55 volume % olefins and 1 to 95 volume % saturates in petroleum fraction that distills below 315°C.	See ASTM D1319-20a

6.2.7 Sulfur, ASTM D 5453-19a

Table 18. Data Quality Indicators—Sulfur (ASTM D 5453-19a)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability.	See ASTM D 5453-19a
Bias	The bias study is documented in ASTM Research Report RR-D02-1307 (1992). The report indicated that the bias is within the repeatability of the test method.	See ASTM D 5453-19a
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D 5453-19a
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	This method covers the determination of total sulfur in liquid hydrocarbons, boiling in the range of 25 to 400°C with viscosities of 0.2 and 20 cSt at room temperature.	See ASTM D 5453-19a

6.2.8 Flash Point, ASTM D 93-20

Table 19. Data Quality Indicators—Flashpoint (ASTM D 93-20)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability.	See ASTM D 93-20

DQI	Definition/Discussion	Measurement Performance Criteria
Bias	There is no accepted reference material suitable for determining the bias for the procedure in these test methods, bias has not been determined.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term).	See ASTM D 93-20
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	This test method covers the determination of flash points of petroleum products in the temperature range of 40 to 360°C by manual Pensky-Martens closed cup apparatus or an automated Pensky-Marten closed cup apparatus.	See ASTM D 93-20

6.2.9 Nitrogen, ASTM D 4629-17

Table 20. Data Quality Indicators—Nitrogen (ASTM D 4629-17)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability.	See ASTM D 4629-17
Bias	The bias cannot be determined since an appropriate standard reference material containing a known trace level of nitrogen in a liquid petroleum hydrocarbon is not available to form the basis of a bias study.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term).	See ASTM D 4629-17
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	This test method covers the determination of the trace total nitrogen naturally found in liquid hydrocarbons boiling in the range of 50 to 400°C with viscosities between 0.2 and 10 cSt at room temperature.	See ASTM D 4629-17

6.2.10 Polycyclic and Total Aromatics, ASTM D 5186-19

Table 21. Data Quality Indicators—Polycyclic and Total Aromatics

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability.	See ASTM D 5186-19
Bias	Reference materials for this test method are in development through ASTM. The bias cannot be determined at this time.	N/A
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term).	See ASTM 5186-19
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	The resulting data are defined only in terms of the method. Various analytical techniques that purport to report the same property have systematic biases that are functions of the measurement technique.	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	This test method covers the determination of the total amounts of monoaromatic and polynuclear aromatic hydrocarbon compounds in motor diesel by SFC. The range of aromatics concentration to which this test method is applicable is from 1 to 75 mass %. The range of polynuclear aromatic hydrocarbon concentrations to which this test method is applicable is from 0.5 to 50 mass %.	See ASTM 5186-19

6.2.11 Benzene, ASTM D 3606-22

Table 22. Data Quality Indicators—Benzene (ASTM D 3606-22)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 3606-22
Bias	Benzene bias is detailed in D 3606-22.	See ASTM D 3606-22
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy will be maintained by a QC sample.	See ASTM D 3606-22
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	N/A	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%

DQI	Definition/Discussion	Measurement Performance Criteria
Sensitivity	Benzene can be determined between the levels of 0.1 and 5 volume %.	See ASTM D 3606-22

6.2.12 Oxygenates, ASTM D 5599-20b

Table 23. Data Quality Indicators—Oxygenates (ASTM D 5599-20b)

DQI	Definition/Discussion	Measurement Performance Criteria
Precision	Precision in analytical petroleum chemistry is generally given in terms of repeatability. (Short term)	See ASTM D 5599-20b
Bias	Oxygenate bias is detailed in D 5599-20b.	See ASTM D 5599-20b
Accuracy	Accuracy in analytical petroleum chemistry is generally defined in terms of reproducibility (long-term). Accuracy was maintained by a QC sample.	See ASTM D 5599-20b
Representative	Fuel samples were collected by field contractors at locations defined by the study team.	N/A
Comparability	N/A	N/A
Completeness	All samples received by SwRI were analyzed according to the protocol. Should any sample be compromised, SwRI supplied a replacement sample.	100%
Sensitivity	The test method covers a gas chromatographic procedure for the quantitative determination of organic oxygenated compounds in gasoline having a boiling point limit of 220°C and oxygenates having a boiling point limit of 130°C. It is applicable when oxygenates are present in the 0.1 to 20% by mass range.	See ASTM D 5599-20b

6.3 SwRI Data Auditing

SwRI reviewed the sample collection receipts for all samples collected to ensure the proper grade was acquired and samples were obtained from designated retail outlets. SwRI also audited the steps of analysis for 30 of the samples taken (> 10%), as required by Category III projects. No data outliers/errors were identified during the audit.

6.4 TTI QA/QC

This section summarizes the QA/QC work TTI performed independently on the gasoline and diesel "NoDHA" files that were retrieved and analyzed by the ERG. TTI compared the 2023 survey files as obtained from ERG with the 2017 and 2020 files to identify outliers. For the 2023 values, only the results were collected in the month of June and do not include those collected during the second round of surveys in July 2023.

6.4.1 QA/QC on the Gasoline Component

Table 24 compares the 2023 RVP statistics of RU gasoline to the 2017 and 2020 values for each TxDOT district. The Brownwood district maximum value dropped from the PYA, whereas the Laredo district minimum and average values grew compared to the PYA. Importantly, the El Paso district average and maximum values exceed the seven psi limit of the El Paso Low RVP Program.

Table 24. Comparing RU Gasoline RVP (psi) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.90	9.25	9.64	9.90	9.50	9.74	9.90	9.69	9.80
Amarillo	9.70	9.39	9.39	9.77	9.57	9.51	9.80	9.69	9.71
Atlanta	7.50	7.23	7.68	7.53	7.63	7.71	7.60	8.38	7.72
Austin	7.60	7.65	7.52	7.62	8.12	7.68	7.70	9.09	8.20
Beaumont	7.00	7.07	7.61	7.60	7.38	7.67	8.10	7.92	7.79
Brownwood	7.40	9.21	7.32	8.80	9.48	7.53	9.80	9.67	**7.66**
Bryan	7.60	7.70	7.22	7.67	7.84	7.44	7.70	7.93	7.72
Childress	9.70	9.77	9.61	9.70	9.83	9.68	9.70	9.87	9.78
Corpus Christi	7.50	7.55	7.30	7.57	7.67	7.43	7.60	7.80	7.50
Dallas	7.20	7.06	7.19	7.25	7.19	7.30	7.30	7.31	7.37
El Paso	6.80	6.65	6.48	6.94	6.83	7.05	7.00	6.91	7.66
Fort Worth	7.20	7.21	7.16	7.25	7.38	7.22	7.40	7.49	7.27
Houston	6.90	6.92	7.11	7.06	7.30	7.21	7.10	7.93	7.30
Laredo	7.70	7.78	9.46	8.03	8.91	9.50	8.40	9.76	9.54
Lubbock	9.80	9.69	9.64	9.80	9.74	9.83	9.80	9.80	9.95
Lufkin	7.60	7.29	7.60	7.67	8.69	7.64	7.80	10.97	7.69
Odessa	9.70	9.85	9.82	9.80	9.90	9.90	9.90	9.97	10.03
Paris	7.50	7.29	7.55	7.50	7.51	7.63	7.50	7.65	7.69
Pharr	9.50	9.66	7.83	9.63	9.70	9.07	9.70	9.77	9.76
San Angelo	7.60	7.74	7.53	9.23	9.19	8.94	10.10	9.93	9.67
San Antonio	7.10	7.57	7.36	7.48	7.78	7.59	7.60	7.99	8.08
Tyler	7.30	7.35	7.54	7.50	7.45	7.67	7.70	7.58	7.92
Waco	7.70	7.61	7.67	7.70	7.72	8.14	7.70	7.79	8.96
Wichita Falls	7.90	7.66	7.07	9.13	9.04	8.80	9.80	9.74	9.71
Yoakum	7.20	7.44	7.17	7.60	7.63	7.21	7.90	7.89	7.27
Average	**7.94**	**7.98**	**7.90**	**8.23**	**8.36**	**8.20**	**8.42**	**8.74**	**8.47**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 25 compares the 2023 RVP statistics of MU gasoline to the 2017 and 2020 values for each TxDOT district. While the Lufkin district's maximum was lower than the 2020 value, it tied with the 2017 value. The El Paso district's maximum was 23% higher than the PYA. At 7.29 and 8.59 psi, respectively, the El Paso district average and maximum values exceed the 7 psi limit of the El Paso Low RVP Program [7], especially for the maximum.

Table 25. Comparing MU Gasoline RVP (psi) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.60	9.40	9.62	9.80	9.54	9.69	10.00	9.73	9.80
Amarillo	9.70	9.44	9.40	9.70	9.62	9.47	9.70	9.72	9.61
Atlanta	7.70	7.48	7.61	7.87	7.61	7.98	8.00	7.73	8.66
Austin	7.50	7.71	7.39	7.66	8.51	7.92	7.90	10.23	9.23
Beaumont	7.10	7.29	7.51	7.62	7.49	7.65	8.00	7.75	7.76
Brownwood	7.30	8.62	7.29	8.57	9.06	7.84	9.80	9.42	8.60
Bryan	7.50	7.58	7.33	7.53	8.23	7.51	7.60	8.69	7.80
Childress	9.60	9.69	9.60	9.67	9.75	9.78	9.70	9.85	9.99
Corpus Christi	7.50	7.58	7.37	7.53	7.67	7.59	7.60	7.77	7.95
Dallas	7.20	7.02	7.14	7.25	7.13	7.29	7.30	7.25	7.42
El Paso	6.80	6.74	6.51	6.94	6.83	7.29	7.00	6.96	8.59
Fort Worth	7.10	7.09	7.16	7.23	7.33	7.30	7.50	7.56	7.65
Houston	6.90	6.79	7.12	7.14	7.42	7.61	7.50	8.10	7.99
Laredo	8.10	9.02	8.75	8.13	9.32	9.31	8.20	9.86	9.78
Lubbock	9.60	9.75	9.60	9.70	10.03	10.05	9.80	10.35	10.43
Lufkin	7.50	7.23	7.64	7.60	8.87	7.68	7.70	11.64	**7.70**
Odessa	9.70	9.35	9.73	9.70	9.47	9.85	9.70	9.61	9.96
Paris	7.40	7.60	7.39	7.53	7.99	7.79	7.70	8.41	8.43
Pharr	9.10	9.45	8.26	9.37	9.75	9.10	9.60	10.12	9.55
San Angelo	7.70	7.78	7.76	8.60	8.99	9.11	9.40	9.60	9.93
San Antonio	7.30	7.49	7.44	7.50	7.74	7.65	7.60	7.94	7.89
Tyler	7.30	7.34	7.54	7.50	7.45	7.94	7.80	7.65	9.26
Waco	7.50	7.63	7.52	7.63	7.74	7.58	7.70	7.85	7.65
Wichita Falls	7.60	7.65	7.07	9.00	9.08	8.81	9.70	9.80	9.71
Yoakum	7.40	7.63	7.23	7.53	7.76	7.41	7.70	7.89	7.54
Average	**7.91**	**8.01**	**7.88**	**8.17**	**8.41**	**8.29**	**8.41**	**8.86**	**8.76**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 26 compares the 2023 RVP statistics of PU gasoline to the 2017 and 2020 values for each TxDOT district. While the Lufkin district's maximum was lower than the 2020 value, it is similar to its 2017 value. The El Paso and Tyler district's maximum were both 47% higher than their PYA.

Table 26. Comparing PU Gasoline RVP (psi) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.50	8.52	9.50	9.67	9.13	9.60	10.00	9.84	9.77
Amarillo	9.60	9.48	9.41	9.63	9.64	9.52	9.70	9.79	9.58
Atlanta	7.70	6.99	7.65	8.30	7.83	8.38	8.80	8.61	9.81
Austin	7.50	7.45	7.15	7.72	9.05	8.31	8.20	12.09	10.46
Beaumont	7.40	7.27	7.18	7.60	7.41	7.53	7.80	7.73	7.97
Brownwood	7.40	7.74	7.17	8.23	8.45	8.46	9.70	8.91	10.56
Bryan	7.20	7.21	7.16	7.40	8.95	7.71	7.70	10.19	8.42
Childress	9.50	9.33	9.72	9.63	9.59	9.94	9.80	9.81	10.36
Corpus Christi	7.40	7.67	7.39	7.50	7.71	7.92	7.70	7.75	8.72
Dallas	7.10	6.95	7.08	7.23	7.05	7.35	7.50	7.19	7.74
El Paso	6.80	6.80	6.63	6.88	6.87	7.68	7.00	7.07	10.32
Fort Worth	7.00	7.01	7.16	7.18	7.29	7.46	7.50	7.65	8.29
Houston	6.80	6.67	7.09	7.29	7.78	8.32	8.20	9.37	9.23
Laredo	7.90	8.54	7.27	8.07	9.50	8.92	8.20	10.30	10.12
Lubbock	9.20	9.76	9.54	9.60	10.39	10.25	9.90	11.13	10.84
Lufkin	7.40	7.18	7.38	7.67	9.15	7.73	8.00	12.98	**7.99**
Odessa	9.50	8.59	9.48	9.57	8.86	9.77	9.60	9.01	10.11
Paris	7.30	7.65	7.07	7.80	9.00	8.46	8.30	10.52	10.88
Pharr	8.50	9.09	9.09	8.97	9.77	9.30	9.50	10.75	9.44
San Angelo	7.50	7.85	8.41	7.97	8.88	9.41	8.40	9.48	10.26
San Antonio	7.10	7.54	7.53	7.48	7.84	7.86	7.70	8.16	8.14
Tyler	7.20	7.07	7.43	7.52	7.41	8.45	8.00	7.99	11.75
Waco	7.30	7.60	7.28	7.47	7.74	7.48	7.60	7.82	7.59
Wichita Falls	7.20	7.51	7.10	8.87	9.09	8.86	9.80	9.92	9.80
Yoakum	7.30	7.82	7.60	7.53	8.15	7.97	7.80	8.77	8.19
Average	**7.77**	**7.81**	**7.82**	**8.11**	**8.50**	**8.51**	**8.50**	**9.31**	**9.45**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 27 compares the 2023 sulfur statistics for RU gasoline to the 2017 and 2020 values for each TxDOT district. The difference between 2017 and 2020 values was considerable and the 2023 values fell in between the two previous surveys. For the minimum: the

Amarillo, Beaumont, Childress, Corpus Christi, and Yoakum districts were higher than their PYAs by at least 20%, whereas the El Paso, Lubbock, Paris, Tyler, and Waco districts were at least 20% lower than their PYAs. For the averages: the Bryan and Yoakum districts were at least 20% higher than their PYA whereas the Fort Worth, Lubbock, Paris, and Tyler districts were at least 20% lower. For the maximum: the Bryan, Corpus Christi, Lufkin, Pharr, and Yoakum districts were at least 20% higher than their PYA. The Amarillo, Fort Worth, Houston, and Lubbock districts have maximum values at least 20% lower than their PYA. Compared to 2020, the Corpus Christi district's RU gasoline sulfur minimum, average, and maximum increased by 99%, 111%, and 130%, respectively.

Table 27. Comparing RU Gasoline Sulfur (ppm) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	12.00	7.94	8.88	13.67	8.79	9.42	15.00	10.04	10.05
Amarillo	4.00	4.25	6.09	9.00	7.76	7.00	12.00	10.00	**8.46**
Atlanta	20.00	5.77	**7.15**	21.33	7.06	**7.99**	22.00	8.42	**8.95**
Austin	25.00	6.01	**9.22**	31.40	7.72	18.27	36.00	9.02	23.46
Beaumont	8.00	7.11	12.37	20.00	8.15	17.72	26.00	9.30	24.59
Brownwood	12.00	8.58	**7.92**	20.33	8.89	12.31	25.00	9.34	18.61
Bryan	12.00	7.43	8.61	16.67	9.15	15.62	19.00	11.88	21.79
Childress	5.00	3.84	8.02	11.33	5.85	8.68	19.00	7.70	**9.47**
Corpus Christi	16.00	6.06	21.94	18.33	6.71	26.39	20.00	7.17	31.22
Dallas	20.00	7.25	**8.24**	21.25	9.48	**10.25**	22.00	11.81	**13.30**
El Paso	17.00	4.30	**2.21**	19.20	4.83	**9.41**	22.00	6.07	13.71
Fort Worth	16.00	7.34	**8.24**	19.00	12.65	**10.12**	21.00	19.66	**12.60**
Houston	9.00	7.20	9.66	18.86	11.57	13.17	26.00	20.28	**17.83**
Laredo	19.00	4.49	18.99	24.00	9.48	20.31	29.00	12.39	21.39
Lubbock	7.00	5.36	**2.64**	15.33	6.87	**3.94**	27.00	8.68	**5.30**
Lufkin	9.00	6.81	7.55	13.00	8.34	12.83	16.00	10.42	22.26
Odessa	16.00	8.88	**8.59**	19.00	9.06	**10.19**	21.00	9.19	**11.60**
Paris	20.00	9.88	**7.22**	21.67	10.10	**9.36**	23.00	10.48	**10.98**
Pharr	18.00	7.55	12.84	20.00	8.78	20.20	23.00	10.05	25.31
San Angelo	22.00	7.70	**11.00**	25.00	8.45	15.46	27.00	9.09	20.82
San Antonio	21.00	5.43	**8.70**	28.20	7.56	20.59	33.00	9.44	24.98
Tyler	14.00	7.84	**4.99**	17.80	8.95	**6.46**	20.00	10.12	**9.67**
Waco	17.00	5.70	**8.64**	29.00	7.13	**11.96**	35.00	9.39	18.00
Wichita Falls	12.00	8.33	8.90	30.33	9.22	**15.47**	55.00	10.26	**25.06**
Yoakum	12.00	6.38	14.90	14.33	8.89	20.29	18.00	13.05	29.65

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Average	**14.52**	**6.70**	**9.34**	**19.92**	**8.46**	**13.34**	**24.48**	**10.53**	**17.56**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 28 compares the 2023 sulfur statistics for MU gasoline to the 2017 and 2020 values for each TxDOT district. Similar to RU gasoline, for this QAQC, TTI only considered 2023 values that are greater or lower than both previous years. For the minimum: the Amarillo, Childress, Corpus Christi, and Houston districts' values were considerably higher than their PYA whereas the Lubbock and Tyler district's values were considerably lower. For averages: the Corpus Christ, Pharr, and Yoakum districts were considerably larger, whereas the Tyler district was considerably lower. For the maximum: the Corpus Christi, Lufkin, Pharr, and Yoakum districts were considerably larger, whereas the Atlanta district was considerably smaller than its PYA. Among all districts, TTI observed the Corpus Christi district's MU gasoline sulfur increased the most by 123%, 113%, and 120% for the minimum, average, and maximum, respectively.

Table 28. Comparing MU Gasoline Sulfur (ppm) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	17.00	8.27	**9.38**	19.00	9.18	**10.71**	23.00	10.23	**13.10**
Amarillo	4.00	4.60	6.00	9.67	6.39	6.70	15.00	7.88	**7.47**
Atlanta	18.00	5.81	**7.13**	21.00	7.59	**7.62**	23.00	10.62	**8.09**
Austin	21.00	5.54	**10.18**	24.80	7.37	15.71	29.00	9.56	20.33
Beaumont	17.00	5.98	11.31	22.80	8.82	15.43	26.00	12.17	21.36
Brownwood	16.00	6.60	**7.70**	17.67	8.02	11.50	19.00	8.78	17.67
Bryan	15.00	7.24	9.43	17.67	8.40	12.93	21.00	9.52	14.78
Childress	5.00	3.52	6.01	11.33	5.80	7.65	18.00	8.18	**9.86**
Corpus Christi	14.00	5.48	21.68	16.00	6.05	23.48	17.00	6.44	25.77
Dallas	19.00	6.96	11.03	19.75	9.87	**11.48**	20.00	11.56	**12.04**
El Paso	19.00	4.11	**4.71**	20.60	4.86	**9.42**	22.00	5.40	13.48
Fort Worth	18.00	7.03	**8.76**	20.50	10.91	**10.56**	23.00	15.05	**11.59**
Houston	7.00	7.04	9.58	17.29	9.89	12.13	24.00	13.19	15.57
Laredo	25.00	4.14	16.34	30.33	9.70	17.87	34.00	12.77	19.14
Lubbock	6.00	4.46	**3.45**	13.67	5.51	**5.65**	23.00	7.19	**8.33**
Lufkin	15.00	6.34	**7.83**	17.33	9.43	12.21	19.00	13.63	20.40
Odessa	18.00	8.72	**10.61**	19.67	9.33	**11.54**	22.00	9.65	**12.53**
Paris	14.00	6.34	**6.60**	18.33	7.65	**8.20**	21.00	8.61	**9.21**
Pharr	15.00	7.97	13.76	17.00	8.56	19.00	19.00	9.49	21.85

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
San Angelo	19.00	5.74	12.12	25.00	7.36	14.33	34.00	8.43	**16.93**
San Antonio	20.00	5.35	**7.57**	30.80	8.78	18.12	34.00	10.65	22.87
Tyler	14.00	6.99	**4.93**	15.40	7.88	**6.25**	18.00	9.03	**9.69**
Waco	19.00	5.83	**7.08**	27.33	7.15	**9.93**	33.00	9.47	**15.52**
Wichita Falls	18.00	5.71	**9.40**	22.33	8.01	12.77	29.00	9.69	17.75
Yoakum	14.00	6.19	13.25	15.00	7.78	17.42	17.00	10.46	24.14
Average	**15.48**	**6.08**	**9.43**	**19.61**	**8.01**	**12.34**	**23.32**	**9.91**	**15.58**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 29 compares the 2023 sulfur statistics for PU gasoline to the 2017 and 2020 values for each TxDOT district. Similar to RU and MU gasoline, for this QAQC, TTI only considers 2023 values that are greater or lower than both previous years. For the minimum: the Amarillo, Corpus Christi, and Pharr districts have considerable increases over their PYAs, whereas the Lubbock district shows a considerable decrease. For averages: the Corpus Christi and Pharr districts saw considerable increases, whereas the Atlanta, Paris, and Tyler districts saw considerable decreases in their PYAs. For the maximum: the Corpus Christi and Pharr districts again saw considerable increases of over 20%, whereas the Lufkin, Paris, and Wichita Falls districts saw decreases in their PYAs. Among all districts, the Corpus Christi district’s PU gasoline sulfur increased the most by 85%, 98%, and 163% for the minimum, average, and maximum, respectively.

Table 29. Comparing PU Gasoline Sulfur (ppm) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	22.00	8.98	**10.64**	25.67	9.54	**12.66**	30.00	10.12	16.15
Amarillo	4.00	3.26	6.08	11.67	4.35	6.87	22.00	4.97	**8.21**
Atlanta	11.00	3.81	6.47	22.00	7.36	**6.80**	28.00	13.33	**7.42**
Austin	13.00	4.28	8.26	16.80	7.50	10.69	20.00	10.31	12.97
Beaumont	20.00	3.21	**6.69**	27.20	10.00	**12.24**	30.00	18.91	**14.91**
Brownwood	6.00	3.22	5.59	12.00	6.74	7.88	21.00	8.60	**10.81**
Bryan	16.00	6.52	**7.02**	20.67	8.43	**9.54**	27.00	9.98	**11.70**
Childress	5.00	3.28	4.83	11.33	5.74	**6.46**	17.00	8.91	**9.46**
Corpus Christi	11.00	3.40	13.34	13.00	4.51	17.37	14.00	5.22	25.29
Dallas	14.00	7.76	**8.40**	16.00	10.78	12.11	18.00	12.56	14.06
El Paso	22.00	4.85	**7.85**	23.40	5.68	**9.23**	25.00	7.05	**12.37**
Fort Worth	11.00	6.69	8.49	20.25	9.48	**11.05**	26.00	11.07	**12.94**
Houston	5.00	6.30	9.02	13.71	8.76	10.92	21.00	10.89	**12.28**

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Laredo	29.00	3.48	**5.46**	35.00	10.31	**12.05**	38.00	13.78	**15.90**
Lubbock	7.00	3.81	**2.91**	12.00	5.02	7.41	18.00	6.40	14.27
Lufkin	26.00	5.70	**9.16**	27.00	11.74	**11.05**	28.00	18.17	**13.34**
Odessa	19.00	8.96	12.83	20.67	9.57	13.63	23.00	10.53	14.29
Paris	5.00	4.41	4.21	9.33	7.02	**6.27**	15.00	12.16	**7.90**
Pharr	12.00	7.73	15.50	12.33	8.84	16.67	13.00	9.89	17.30
San Angelo	15.00	5.75	8.40	23.33	6.66	**11.56**	40.00	7.35	**15.36**
San Antonio	18.00	4.51	**7.21**	34.60	11.59	**13.97**	40.00	15.37	**19.27**
Tyler	5.00	2.92	**2.48**	10.80	5.09	**4.71**	27.00	9.16	**9.21**
Waco	20.00	3.79	**5.29**	20.33	6.30	**7.73**	21.00	10.57	**12.38**
Wichita Falls	12.00	4.04	7.82	18.33	8.30	**8.54**	24.00	10.95	**9.48**
Yoakum	14.00	5.43	12.27	17.67	6.55	12.75	21.00	7.26	13.66
Average	**13.68**	**5.04**	**7.85**	**19.00**	**7.83**	**10.41**	**24.28**	**10.54**	**13.24**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Compared to 2020, most districts saw an increase in sulfur content within their gasoline. In the 2020 Summer Fuel Survey report, ERG reported that 2020 saw the lowest gasoline sulfur values since 2001 [5]. Here, TTI observed that while the 2023 average gasoline sulfur values were higher than 2020, they were still lower than the 2017 values.

The Tier 3 Gasoline Sulfur program sets vehicle emissions standards and lowers the sulfur content of gasoline to meet an annual average standard of 10 ppm of sulfur by January 1, 2017 [8]. As seen in Table 27 through Table 29, at all three gasoline grades, most districts have average sulfur values higher than 10 ppm. It is important to note that these samples were all collected in the month of June, thus, do not represent an annual average number. In addition, on a per-gallon basis, sulfur content values for individual gasoline samples (all grades) ranged from 2.2 ppm to 31.2 ppm, which does not exceed the federal per-gallon sulfur content cap of 80 ppm.

Table 30 compares the 2023 RU gasoline ETOH statistics to the 2017 and 2020 values for each TxDOT district. The Houston district's maximum ETOH values were the only outlier in this set, where it increased by 52% over its PYA. While the Abilene and Odessa districts' minimums saw an increase from 2020, the 2023 values were in line with their 2017 values and the other districts, and the considerable increase was the effect of outliers in 2020.

Table 30. Comparing RU Gasoline ETOH (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.63	0.30	9.57	10.01	6.40	9.79	10.60	9.51	10.20
Amarillo	9.73	9.51	9.85	9.95	9.73	9.93	10.10	10.13	10.00
Atlanta	9.30	9.33	9.50	9.54	9.46	9.59	9.71	9.54	9.71
Austin	9.60	9.47	9.34	9.69	9.63	9.69	9.75	9.72	9.89
Beaumont	9.65	9.51	9.65	9.77	9.59	9.81	9.99	9.71	9.97
Brownwood	8.90	8.90	9.74	9.35	9.24	9.95	9.71	9.48	10.21
Bryan	9.65	9.12	9.54	9.72	9.41	9.86	9.81	9.59	10.04
Childress	9.70	9.74	9.59	9.94	9.94	10.03	10.20	10.16	10.29
Corpus Christi	9.27	9.22	9.79	9.33	9.41	9.81	9.36	9.54	9.83
Dallas	9.41	9.55	9.76	9.59	9.66	9.82	9.76	9.72	9.89
El Paso	9.39	9.37	9.60	9.59	9.51	9.88	9.71	9.57	10.14
Fort Worth	9.49	9.65	9.49	9.61	9.71	9.70	9.72	9.75	9.97
Houston	9.20	9.39	9.85	9.64	9.54	11.44	9.94	9.77	15.01
Laredo	9.51	9.59	9.97	9.62	9.64	9.99	9.77	9.72	10.04
Lubbock	9.66	9.77	10.16	9.96	9.96	10.35	10.18	10.10	10.49
Lufkin	9.66	9.58	9.72	9.76	9.76	9.84	9.84	9.91	9.99
Odessa	9.70	3.98	9.35	9.95	6.37	9.72	10.14	8.96	10.12
Paris	9.51	9.30	9.56	9.65	9.54	9.68	9.73	9.79	9.80
Pharr	9.26	9.19	9.71	9.53	9.56	9.79	9.83	9.81	9.86
San Angelo	8.77	8.06	9.73	9.16	8.82	9.84	9.57	9.53	9.98
San Antonio	9.44	9.50	9.21	9.66	9.68	9.58	9.88	9.81	9.78
Tyler	9.58	9.01	9.21	9.67	9.43	9.50	9.79	9.86	9.79
Waco	9.52	9.54	8.92	9.57	9.58	9.36	9.62	9.63	9.59
Wichita Falls	9.54	9.25	9.68	9.73	9.41	9.75	10.02	9.52	9.85
Yoakum	9.50	9.39	9.77	9.71	9.48	9.80	9.84	9.58	9.87
Average	**9.46**	**8.77**	**9.61**	**9.67**	**9.30**	**9.86**	**9.86**	**9.70**	**10.17**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 31 compares the 2023 MU gasoline ETOH statistics to the 2017 and 2020 values for each TxDOT district. The Houston district's maximum ETOH values were the only outlier in this set, where it increased by 35% over its PYA. Similar to RU gasoline, the Abilene and Odessa districts' increases were caused by 2020 outliers.

Table 31. Comparing MU Gasoline ETOH (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.77	3.00	9.50	10.01	7.34	9.78	10.36	9.61	10.18
Amarillo	9.74	9.65	9.91	10.06	9.84	9.93	10.39	10.20	9.96
Atlanta	9.56	9.34	9.54	9.64	9.41	9.67	9.72	9.46	9.86
Austin	9.58	9.57	9.50	9.66	9.70	9.83	9.72	9.80	10.08
Beaumont	9.55	9.42	9.07	9.71	9.59	9.72	9.88	9.77	10.05
Brownwood	8.86	8.91	9.75	9.35	9.30	9.99	9.61	9.60	10.30
Bryan	9.62	9.38	9.77	9.69	9.46	9.94	9.77	9.51	10.05
Childress	9.62	9.63	10.05	9.89	9.87	10.14	10.30	10.16	10.30
Corpus Christi	9.40	9.19	9.80	9.44	9.35	9.83	9.48	9.52	9.86
Dallas	9.50	9.50	9.77	9.64	9.67	9.85	9.79	9.73	9.94
El Paso	9.43	9.31	9.77	9.58	9.41	9.99	9.65	9.47	10.18
Fort Worth	9.60	9.54	9.53	9.77	9.64	9.67	10.02	9.70	9.88
Houston	9.34	9.28	9.83	9.67	9.55	10.95	9.90	9.81	13.31
Laredo	9.72	9.54	9.99	9.74	9.74	10.00	9.77	9.96	10.00
Lubbock	9.70	9.76	10.05	9.97	10.00	10.36	10.16	10.13	10.54
Lufkin	9.52	9.38	9.45	9.67	9.71	9.74	9.84	9.94	9.99
Odessa	9.76	6.50	9.91	9.90	7.66	10.04	10.03	9.19	10.20
Paris	9.37	9.29	9.61	9.59	9.57	9.74	9.77	9.81	9.99
Pharr	9.15	9.22	9.59	9.53	9.56	9.69	9.77	9.77	9.81
San Angelo	9.22	9.01	10.02	9.38	9.37	10.07	9.61	9.68	10.16
San Antonio	9.55	9.53	9.67	9.72	9.63	9.75	9.87	9.76	9.87
Tyler	9.42	9.07	9.40	9.54	9.38	9.61	9.65	9.83	9.81
Waco	9.57	9.54	9.40	9.63	9.60	9.61	9.66	9.69	9.91
Wichita Falls	9.69	9.39	9.70	9.83	9.55	9.81	10.05	9.77	9.92
Yoakum	9.49	9.46	9.72	9.73	9.50	9.89	9.85	9.54	10.03
Average	**9.51**	**9.02**	**9.69**	**9.69**	**9.42**	**9.90**	**9.86**	**9.74**	**10.17**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 32 compares the 2023 PU gasoline ETOH statistics to the 2017 and 2020 values for each TxDOT district. There were no outliers.

Table 32. Comparing PU Gasoline ETOH (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.84	9.20	8.82	9.96	9.50	9.58	10.05	9.73	10.29
Amarillo	9.76	9.64	9.85	10.06	9.86	9.96	10.31	10.18	10.17

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Atlanta	9.66	9.38	9.58	9.79	9.45	9.74	9.94	9.52	9.96
Austin	9.53	9.61	9.63	9.66	9.75	9.93	9.76	9.92	10.21
Beaumont	9.52	9.42	9.88	9.69	9.61	9.98	9.87	9.88	10.11
Brownwood	8.86	9.26	9.60	9.23	9.46	9.94	9.58	9.58	10.38
Bryan	9.67	9.50	9.67	9.78	9.67	9.91	10.00	9.89	10.07
Childress	9.67	9.42	10.08	9.88	9.79	10.18	10.28	10.20	10.29
Corpus Christi	9.52	9.11	9.80	9.59	9.35	9.95	9.64	9.50	10.02
Dallas	9.59	9.54	9.73	9.67	9.70	9.89	9.86	9.79	10.08
El Paso	9.38	9.16	9.66	9.63	9.43	10.06	9.98	9.67	10.24
Fort Worth	9.45	9.48	9.66	9.69	9.63	9.83	9.96	9.76	9.97
Houston	9.61	9.55	9.90	9.84	9.72	10.12	10.13	9.99	10.28
Laredo	9.70	9.42	9.84	9.77	9.69	10.09	9.83	9.83	10.33
Lubbock	9.70	9.77	10.05	9.90	10.00	10.37	10.03	10.21	10.58
Lufkin	9.40	9.34	9.02	9.59	9.82	9.55	9.90	10.23	9.97
Odessa	9.73	8.92	9.75	9.81	9.27	9.95	9.92	9.45	10.35
Paris	9.30	9.14	9.62	9.49	9.45	9.92	9.85	9.96	10.44
Pharr	8.85	9.25	9.19	9.51	9.60	9.51	9.94	9.87	9.94
San Angelo	9.36	9.63	9.91	9.57	9.78	10.19	9.78	9.89	10.49
San Antonio	9.70	9.40	9.68	9.87	9.57	9.77	10.06	9.74	9.88
Tyler	9.11	8.84	9.53	9.37	9.19	9.68	9.70	9.76	9.94
Waco	9.50	9.51	9.57	9.64	9.60	9.76	9.75	9.71	9.93
Wichita Falls	9.74	9.60	9.77	9.90	9.68	9.85	10.20	9.78	9.99
Yoakum	9.61	9.54	9.46	9.83	9.61	9.77	10.02	9.69	10.14
Average	**9.51**	**9.39**	**9.65**	**9.71**	**9.61**	**9.90**	**9.93**	**9.83**	**10.16**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

The ETBE and TAME values for all three survey years and gasoline grades were zero. For MTBE, all RU values are zero. For MU and PU gasoline, the Atlanta, Beaumont, Bryan, Lufkin, and Tyler districts were the only ones with non-zero values, among these, only the Atlanta district had non-zero values in 2023 (see Table 33).

Table 33. Comparing MU Gasoline MTBE (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Amarillo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Atlanta	0.0000	0.0000	0.0000	0.0033	0.0000	0.0024	0.0100	0.0000	0.0073
Austin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Beaumont	0.0000	0.0000	0.0000	0.0060	0.0000	**0.0000**	0.0100	0.0000	**0.0000**
Brownwood	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bryan	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Childress	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corpus Christi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dallas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
El Paso	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fort Worth	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Houston	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Laredo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lubbock	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lufkin	0.0000	0.0000	0.0000	0.0033	0.0000	**0.0000**	0.0100	0.0000	**0.0000**
Odessa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Paris	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pharr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
San Angelo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
San Antonio	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tyler	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Waco	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wichita Falls	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Yoakum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Average	**0.0000**	**0.0000**	**0.0000**	**0.0005**	**0.0000**	**0.0001**	**0.0012**	**0.0000**	**0.0003**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 34. Comparing PU Gasoline MTBE (% vol) Statistics

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Amarillo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Atlanta	0.0000	0.0000	0.0000	0.0100	0.0029	**0.0000**	0.0200	0.0086	**0.0000**
Austin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Beaumont	0.0000	0.0000	0.0000	0.0120	0.0021	**0.0000**	0.0200	0.0104	**0.0000**
Brownwood	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bryan	0.0000	0.0000	0.0000	0.0033	0.0000	**0.0000**	0.0100	0.0000	**0.0000**
Childress	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Corpus Christi	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Dallas	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
El Paso	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fort Worth	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Houston	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Laredo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lubbock	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Lufkin	0.0000	0.0000	0.0000	0.0133	0.0032	**0.0000**	0.0200	0.0097	**0.0000**
Odessa	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Paris	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pharr	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
San Angelo	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
San Antonio	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Tyler	0.0000	0.0000	0.0000	0.0000	0.0011	**0.0000**	0.0000	0.0054	**0.0000**
Waco	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Wichita Falls	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Yoakum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Average	**0.0000**	**0.0000**	**0.0000**	**0.0015**	**0.0004**	**0.0000**	**0.0028**	**0.0014**	**0.0000**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 35 compares the 2023 aromatics statistics in RU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: Almost half of the districts saw increases of over 20% from their PYAs; the Dallas, Fort Worth, Laredo, Lufkin, Paris, Pharr, Tyler, and Yoakum districts were the only districts that saw an increase of over 2%-vol from either of the previous years. Similarly, for the averages: the Dallas, Fort Worth, Houston, Pharr, and Waco districts saw increases in 2023 that were more than 20% higher than their respective PYAs. For the maximum: the Amarillo, Dallas, Houston, Odessa, Pharr, and Waco districts meet the criteria. Most significantly, the Dallas, Fort Worth, Houston, and Pharr districts saw increases by at least 29% in all three categories in 2023.

Table 35. Comparing RU Gasoline Aromatics (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	27.50	24.17	22.70	30.10	26.92	27.27	31.60	31.64	29.70
Amarillo	22.00	20.71	20.00	26.93	21.26	27.50	29.70	22.28	31.90
Atlanta	28.20	24.96	29.90	31.80	27.27	30.70	34.40	29.75	31.10
Austin	22.10	17.20	19.30	24.84	21.44	22.90	27.30	27.05	26.80
Beaumont	25.70	14.01	26.60	30.32	24.50	30.16	35.70	28.21	32.20

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Brownwood	25.20	19.99	24.70	28.17	23.81	25.53	31.70	25.97	27.00
Bryan	31.60	17.67	20.30	32.47	19.47	23.07	33.50	23.03	26.60
Childress	21.00	20.96	24.40	29.37	21.66	26.70	33.90	22.24	28.30
Corpus Christi	10.50	17.61	18.40	19.80	24.70	24.23	24.50	28.83	28.30
Dallas	16.50	14.18	22.20	20.58	15.46	24.13	22.40	17.96	26.60
El Paso	23.80	20.15	26.30	29.18	24.31	27.50	39.50	30.97	28.60
Fort Worth	14.40	13.21	25.40	20.75	15.03	27.90	29.00	16.57	30.20
Houston	20.90	12.53	21.50	22.06	16.43	25.96	23.30	21.71	28.10
Laredo	17.10	11.51	22.60	28.33	15.86	24.47	34.10	23.22	25.60
Lubbock	19.10	19.01	18.30	24.80	20.79	20.03	34.20	22.72	**21.00**
Lufkin	24.80	21.36	28.00	29.37	26.23	28.97	34.70	28.86	30.40
Odessa	25.00	21.26	19.80	26.70	23.75	25.13	29.00	25.25	34.40
Paris	22.40	18.51	30.40	29.90	21.64	31.20	34.60	27.61	31.80
Pharr	15.40	13.69	23.50	17.77	14.42	24.00	20.70	15.41	24.40
San Angelo	22.20	18.08	22.70	22.87	22.10	24.27	23.40	25.23	25.40
San Antonio	18.80	24.73	26.30	31.06	26.32	28.82	34.70	27.67	30.80
Tyler	24.50	24.80	30.00	31.24	27.52	31.68	37.10	30.06	34.50
Waco	25.20	18.19	24.50	28.07	22.33	30.87	30.30	25.46	41.50
Wichita Falls	27.60	19.45	25.90	29.73	22.14	27.20	32.20	24.59	29.10
Yoakum	20.00	7.20	25.60	28.77	13.84	27.63	34.60	20.51	29.80
Average	**22.06**	**18.21**	**23.97**	**27.00**	**21.57**	**26.71**	**31.04**	**24.91**	**29.36**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 36 compares the 2023 aromatics statistics in MU gasoline to the 2017 and 2020 values for each TxDOT district. The outliers were almost identical to the RU gasoline aromatics statistics. In addition, for the maximum, the Lubbock district saw a considerable decrease compared to its PYA, by 24%.

Table 36. Comparing MU Gasoline Aromatics (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	29.40	26.77	25.70	31.13	28.67	29.93	32.30	32.21	32.90
Amarillo	19.50	18.44	25.90	26.83	22.01	31.40	32.20	23.91	35.40
Atlanta	31.80	26.17	33.40	35.07	28.25	35.83	38.70	30.93	39.00
Austin	23.30	14.63	20.90	24.90	19.14	23.06	25.90	23.62	24.80
Beaumont	20.10	26.98	22.80	32.08	27.60	30.28	39.60	28.68	39.20
Brownwood	24.50	20.45	21.70	28.93	25.85	26.13	32.20	29.16	29.00
Bryan	25.40	16.57	25.70	33.37	18.04	26.53	39.10	20.72	28.00

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Childress	18.00	19.42	23.10	29.70	24.90	26.07	37.80	29.56	31.10
Corpus Christi	9.80	17.43	15.20	18.90	21.93	21.07	23.80	25.21	24.40
Dallas	16.10	14.33	22.70	19.40	15.59	23.83	22.00	17.98	24.60
El Paso	27.70	20.87	22.90	30.62	23.87	25.94	36.70	32.96	29.90
Fort Worth	14.90	12.05	25.60	20.63	15.62	26.88	27.50	17.71	28.10
Houston	18.20	12.74	24.10	20.10	16.17	26.89	22.60	21.67	29.50
Laredo	23.60	11.09	22.70	26.23	14.02	24.10	28.30	18.87	26.10
Lubbock	22.70	18.86	20.10	27.50	22.56	21.93	36.50	29.71	**25.30**
Lufkin	27.80	23.81	25.00	31.57	26.04	31.77	35.00	29.55	35.90
Odessa	28.80	24.56	23.90	30.83	26.07	27.80	32.30	27.13	34.60
Paris	24.80	17.90	27.90	27.97	20.27	29.40	31.10	23.32	31.70
Pharr	13.30	11.07	24.50	14.97	11.94	25.33	16.90	12.51	26.50
San Angelo	18.40	17.12	23.20	21.07	20.69	25.60	24.50	23.39	27.30
San Antonio	21.30	20.28	26.00	26.02	21.66	27.38	29.30	23.11	29.00
Tyler	26.00	23.11	27.20	31.24	26.33	31.00	34.50	28.49	35.90
Waco	25.20	17.49	27.20	26.20	20.26	28.27	27.60	21.84	29.20
Wichita Falls	21.60	18.68	24.40	26.97	22.09	27.43	31.80	26.41	30.40
Yoakum	18.60	13.33	25.20	23.70	16.02	26.10	26.40	19.40	27.40
Average	**22.03**	**18.57**	**24.28**	**26.64**	**21.42**	**27.20**	**30.58**	**24.72**	**30.21**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 37 compares the 2023 aromatics statistics in PU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, Atlanta, Bryan, Dallas, Fort Worth, Houston, Laredo, Pharr, San Antonio, Waco, Wichita Falls, and Yoakum districts saw substantial increases from their PYAs and were at least 2%-vol larger than the previous largest values. The Amarillo, Bryan, Houston, Pharr, San Antonio, and Wichita Falls districts' minimum values were at least 88% higher than their PYAs, with Pharr's increasing by 274%. Interestingly, the El Paso district's minimum value dropped by 34% in the 2023 survey compared to its PYA. For the average, the same characteristics as the minimum was shown, with the exception that the El Paso district's decrease was not substantial. For the maximum, most districts saw a considerable increase of over 20% from their PYAs, most significantly in the Pharr district, with an increase of 154%. Looking at the PU aromatics statistics, the Pharr district's 2023 minimum, average, and maximum values increased by 274%, 216%, and 154%, respectively.

Table 37. Comparing PU Gasoline Aromatics (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	33.00	29.25	31.30	34.17	30.89	35.93	36.00	33.13	39.30
Amarillo	15.40	16.92	30.70	27.60	24.07	35.80	37.60	28.44	40.00
Atlanta	33.00	28.10	43.90	42.27	30.36	46.60	50.20	32.84	50.50
Austin	20.00	9.80	19.10	24.50	15.27	23.90	27.80	17.82	26.70
Beaumont	14.40	19.49	18.60	37.22	26.25	31.28	52.50	31.36	51.60
Brownwood	20.60	20.12	23.20	26.10	27.61	25.57	35.70	31.86	27.50
Bryan	15.40	14.02	28.60	32.67	14.52	31.20	49.50	14.85	34.40
Childress	14.70	16.87	15.50	30.73	27.79	25.17	41.70	35.20	37.30
Corpus Christi	6.00	16.23	10.80	15.47	17.41	13.50	22.00	18.39	17.70
Dallas	12.40	14.75	22.40	13.75	15.89	24.93	16.00	17.88	29.20
El Paso	32.20	18.29	**16.80**	32.82	23.75	23.64	33.70	36.31	31.40
Fort Worth	15.90	9.73	21.20	17.40	16.52	24.30	18.40	19.32	27.50
Houston	11.10	12.05	23.80	14.99	15.52	27.57	26.00	21.33	32.00
Laredo	16.90	9.33	20.70	18.47	12.11	23.77	21.00	16.37	27.50
Lubbock	19.90	16.80	18.00	30.97	23.53	24.33	42.20	36.14	32.60
Lufkin	17.90	18.00	18.90	37.90	26.84	37.73	48.30	31.97	48.40
Odessa	34.00	28.86	29.40	35.77	29.56	32.83	38.20	30.41	37.70
Paris	15.60	16.37	19.00	21.17	18.85	23.67	26.30	21.59	31.20
Pharr	6.40	6.54	24.20	8.90	7.32	25.63	12.50	8.30	26.40
San Angelo	14.50	16.62	17.30	18.00	19.20	25.77	22.80	23.52	30.20
San Antonio	14.20	9.27	23.60	16.78	12.38	24.44	23.20	18.65	25.20
Tyler	24.40	19.89	**14.70**	32.02	24.20	30.60	51.30	27.54	54.80
Waco	18.80	14.10	27.70	23.80	16.10	29.13	30.10	18.22	31.90
Wichita Falls	12.50	11.55	29.80	24.40	21.04	32.17	31.00	29.41	36.80
Yoakum	12.60	12.31	21.70	13.23	14.62	22.73	13.80	16.84	24.30
Average	**18.07**	**16.21**	**22.84**	**25.24**	**20.46**	**28.09**	**32.31**	**24.71**	**34.08**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 38 compares the 2023 olefin statistics in RU gasoline to the 2017 and 2020 values for each TxDOT district. The Bryan, Childress, and Lufkin districts' values saw considerable increases by over 38% in 2023 compared to their PYAs, whereas the Dallas district's values decreased by at least 21%. Aside from these districts, the Amarillo, Beaumont, Brownwood, and Tyler districts saw substantial increases in their minimum, whereas the El Paso and Fort Worth districts saw decreases. For the average: the Brownwood and Pharr districts saw substantial increases whereas the Atlanta, Laredo, and Lubbock districts saw decreases. For the maximum, the Atlanta, Beaumont, Laredo, and Lubbock districts saw a decrease in their PYAs by at least 32%, whereas the Pharr and San Antonio districts saw some increase in their respective PYAs.

Table 38. Comparing RU Gasoline Olefin (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	8.60	11.22	10.20	10.57	12.12	11.80	12.10	13.58	13.00
Amarillo	3.30	5.40	6.80	3.90	9.12	6.97	4.70	11.99	7.30
Atlanta	2.80	6.26	4.30	7.27	8.29	**5.07**	10.00	11.63	**5.70**
Austin	12.80	8.37	11.60	17.32	9.31	13.38	19.70	10.28	14.70
Beaumont	2.50	3.05	4.50	5.54	6.84	5.52	9.20	11.88	**7.20**
Brownwood	9.70	9.84	12.70	11.20	10.77	13.47	12.80	11.60	14.10
Bryan	3.50	5.50	10.20	3.83	7.76	11.00	4.10	8.95	12.00
Childress	3.30	5.58	8.60	4.30	8.17	10.30	5.20	10.65	13.40
Corpus Christi	13.10	9.02	8.90	16.73	11.50	12.53	22.20	15.34	17.40
Dallas	9.50	9.00	**7.30**	10.80	10.09	**7.90**	11.80	10.88	**8.30**
El Paso	4.90	5.60	**3.40**	6.16	5.97	5.68	7.20	6.44	7.80
Fort Worth	10.00	7.70	**5.30**	10.85	9.08	9.43	12.20	10.49	12.10
Houston	10.80	8.55	8.20	12.11	9.44	10.56	14.20	10.47	12.40
Laredo	7.70	9.13	7.80	12.17	10.01	**8.43**	19.10	11.74	**9.40**
Lubbock	3.30	5.93	5.80	7.00	8.54	**6.13**	11.50	12.46	**6.80**
Lufkin	2.40	3.32	4.90	2.57	4.88	5.50	2.80	6.20	6.20
Odessa	10.90	10.06	10.30	12.33	10.83	11.07	13.30	11.78	12.40
Paris	9.80	7.95	9.10	10.30	9.94	10.03	11.20	12.76	11.40
Pharr	13.00	8.74	12.00	15.53	10.20	16.03	18.40	11.78	21.60
San Angelo	8.60	8.64	10.00	10.70	9.52	11.27	14.10	10.33	12.10
San Antonio	8.80	9.10	9.80	10.56	9.35	11.28	12.70	10.10	13.80
Tyler	2.40	4.57	5.90	6.46	9.43	9.30	9.60	12.65	10.70
Waco	7.10	10.07	7.20	14.27	10.81	11.43	18.90	11.45	13.80
Wichita Falls	8.90	9.59	10.10	10.93	10.29	11.23	13.30	10.89	12.40
Yoakum	3.50	9.97	8.10	6.80	10.05	10.47	13.20	10.22	12.00
Average	**7.25**	**7.69**	**8.12**	**9.61**	**9.29**	**9.83**	**12.14**	**11.06**	**11.52**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 39 compares the 2023 olefin statistics in MU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, Brownwood, Bryan, Childress, Lufkin, Pharr, Tyler, and Wichita Falls districts saw substantial increases, whereas the Abilene, Corpus Christi, Houston, and Lubbock districts saw substantial decreases. For the average: the Bryan, Childress, Lufkin, and Pharr districts saw substantial increases whereas Lubbock saw a substantial decrease. For the maximum, the trend is overall similar to the minimum and average, with the exception that the Laredo and San Antonio districts saw substantial increases in addition to the rest. Overall, the trends shown in the MU gasoline olefin statistics are similar to the RU gasoline's.

Table 39. Comparing MU Gasoline Olefin (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	13.00	10.96	**7.90**	13.47	12.10	11.13	14.30	13.54	12.80
Amarillo	3.70	4.31	6.40	4.57	7.49	6.83	5.80	10.25	7.20
Atlanta	3.90	6.80	5.20	6.50	7.94	6.53	8.70	8.73	7.50
Austin	11.40	7.00	9.60	12.90	7.75	11.56	15.20	8.62	13.50
Beaumont	4.30	3.85	3.70	5.88	6.10	6.48	7.80	7.93	9.20
Brownwood	7.50	7.73	9.80	10.50	10.56	10.83	15.60	12.57	12.30
Bryan	3.90	5.53	7.70	4.47	6.98	8.43	4.90	8.13	9.40
Childress	4.40	4.56	5.50	5.50	7.79	8.47	6.30	10.77	13.30
Corpus Christi	11.40	8.36	**6.40**	16.27	9.71	13.30	24.40	12.34	20.30
Dallas	9.60	6.71	**6.50**	9.88	7.82	7.28	10.20	8.54	7.80
El Paso	5.00	4.81	4.00	5.60	5.78	5.04	6.10	6.36	6.50
Fort Worth	8.60	6.87	6.90	9.88	7.49	8.95	10.50	8.19	10.50
Houston	9.20	7.54	**6.20**	10.40	7.98	8.97	12.00	9.11	10.70
Laredo	8.60	6.99	8.30	9.87	9.31	11.37	11.40	11.34	14.00
Lubbock	5.60	4.90	**3.50**	7.90	7.45	**5.27**	12.10	11.48	**7.20**
Lufkin	3.40	4.21	5.40	3.73	5.58	6.37	4.00	7.30	7.10
Odessa	11.70	11.25	**8.70**	13.40	11.48	10.67	14.80	11.64	13.80
Paris	6.40	6.88	7.60	7.63	7.23	8.07	9.10	7.68	8.70
Pharr	14.20	11.31	16.00	15.80	11.70	16.80	18.30	12.44	17.60
San Angelo	7.90	6.92	8.50	9.97	7.80	9.57	12.80	8.64	11.50
San Antonio	8.10	8.77	8.80	9.60	8.93	10.44	10.80	9.08	13.20
Tyler	3.20	5.60	7.30	5.30	8.04	8.00	7.30	9.93	8.70
Waco	7.40	8.84	7.90	12.40	9.19	9.63	16.20	9.39	11.90
Wichita Falls	6.80	6.75	8.60	8.60	8.53	9.87	11.40	10.98	10.70
Yoakum	3.50	7.81	5.80	6.27	8.63	7.90	11.20	9.10	9.40
Average	**7.31**	**7.01**	**7.29**	**9.05**	**8.37**	**9.11**	**11.25**	**9.76**	**10.99**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 40 compares the 2023 olefin statistics in PU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, Atlanta, Austin, Brownwood, Fort Worth, Paris, Pharr, Tyler, Waco, and Wichita Falls districts have considerably higher values compared to their PYAs by more than 20%. Most significantly, the Brownwood and Paris districts saw increases of 160% and 119%, respectively. On the other hand, the Abilene, Beaumont, Bryan, Childress, Corpus Christi, El Paso, Lufkin, Odessa, San Antonio, and Yoakum districts saw substantial decreases, with the Abilene, Beaumont, Bryan, El Paso, and San Antonio districts seeing their minimum values decreased by at least 50%. Interestingly, for the average: the Brownwood district's values decreased despite a large increase in its minimum, the Corpus Christi district saw a 72% increase despite seeing a 56% decrease in its minimum, and Laredo saw a 118% increase despite not showing any significant change in its minimum, and the San Antonio district saw a slight increase in its average despite seeing a 50% decrease in its minimum. For the maximum, the Brownwood district saw a substantial decrease despite a massive increase in the minimum and the Childress district saw an 87% increase despite its minimum decreasing by 56%. The Lubbock district was another outlier in the maximum that did not follow the trends in the minimum or average, with a substantial decrease from its PYA, despite being relatively consistent for both minimum and average. Overall, the RU gasoline olefin values do not show consistent trends among the minimum, average, and maximum values. Among the districts, the Laredo district stands out as it saw a 118% and 152% increase in its average and maximum values in 2023 compared to its PYAs.

Table 40. Comparing PU Gasoline Olefin (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	16.60	11.44	**6.60**	17.20	12.49	**11.13**	17.50	13.79	13.50
Amarillo	3.50	3.49	6.60	5.83	5.34	6.90	8.10	6.42	7.10
Atlanta	3.30	4.08	7.10	5.43	7.43	9.90	6.50	9.97	11.60
Austin	5.50	4.52	6.50	7.18	5.24	7.28	8.30	6.00	8.20
Beaumont	6.20	6.08	**3.10**	6.62	7.99	6.36	7.80	10.13	11.10
Brownwood	2.40	2.90	6.90	8.10	9.87	7.83	17.60	13.50	**8.50**
Bryan	6.20	4.39	**1.30**	6.37	5.12	**4.33**	6.60	5.67	7.10
Childress	3.60	3.45	**2.70**	7.07	6.63	6.43	9.40	8.80	12.40
Corpus Christi	7.90	5.36	**2.90**	13.13	6.03	16.47	23.10	7.17	28.30
Dallas	4.20	5.07	5.50	6.10	5.13	6.65	7.90	5.23	8.00
El Paso	3.80	4.29	**2.00**	5.32	5.76	5.22	8.80	6.91	8.60
Fort Worth	3.60	3.46	6.00	6.53	4.41	6.15	7.70	5.38	6.40
Houston	4.60	4.29	3.60	5.76	5.15	5.94	7.00	6.78	8.00
Laredo	9.40	5.77	8.70	9.67	8.98	20.37	10.10	11.51	27.20
Lubbock	4.20	3.60	4.60	9.03	6.09	6.27	13.30	10.51	**8.80**
Lufkin	5.20	5.71	**3.60**	6.37	6.95	7.03	7.70	8.98	9.40

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Odessa	12.00	11.20	**6.90**	15.87	12.11	**9.00**	18.20	13.53	**12.40**
Paris	2.30	2.36	5.10	3.13	3.28	5.27	4.70	4.88	5.50
Pharr	12.60	13.64	21.60	15.83	14.38	23.47	18.50	14.84	24.60
San Angelo	6.20	5.19	6.50	7.43	6.06	8.10	8.20	7.59	11.00
San Antonio	7.80	7.05	**3.70**	8.00	8.04	8.50	8.20	8.47	12.50
Tyler	2.10	2.43	3.80	3.22	4.94	6.16	6.10	8.57	9.00
Waco	5.70	5.04	7.20	6.13	5.97	8.20	6.50	6.78	9.00
Wichita Falls	4.30	4.31	6.40	7.20	6.95	8.90	12.80	11.98	13.30
Yoakum	5.00	3.99	**3.50**	5.77	5.33	5.17	6.50	6.14	6.40
Average	**5.93**	**5.32**	**5.70**	**7.93**	**7.03**	**8.68**	**10.28**	**8.78**	**11.52**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 41 compares the 2023 benzene statistics in RU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, El Paso, and Lubbock districts were considerably larger than their PYAs by 73%, 85%, and 120%, respectively. On the other hand, the Brownwood, Bryan, Odessa, Pharr, and San Angelo districts saw a decrease in their minimum values. For average: the Amarillo and Lubbock districts were considerably larger than their PYAs, at 117% and 97% respectively, whereas the Brownwood, Corpus Christi, Laredo, Odessa, Pharr, and Waco districts saw decreases by more than 20% from their PYAs, most at the Brownwood district with a 49% decrease. For the maximum: the Amarillo and Lubbock districts saw a considerable increase, by 125% and 76%, respectively, whereas the Atlanta, Brownwood, Corpus Christi, Laredo, and Pharr districts saw considerable decreases from their respective PYAs, with the Laredo district seeing the most significant decrease at 50%. Overall, the Amarillo and Lubbock districts stood out as they saw increases in their minimum, average, and maximum PYA values.

Table 41. Comparing RU Gasoline Benzene (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.54	0.86	0.62	0.59	0.87	0.65	0.64	0.88	0.69
Amarillo	0.47	0.51	0.85	0.68	0.62	1.41	0.83	0.70	1.72
Atlanta	1.00	0.55	**0.61**	1.16	0.69	**0.65**	1.25	0.95	**0.69**
Austin	0.29	0.57	**0.33**	0.37	0.65	0.53	0.53	0.77	0.69
Beaumont	0.76	0.49	0.79	1.12	0.63	0.83	1.55	0.67	**0.87**
Brownwood	0.55	0.78	**0.31**	0.82	0.88	**0.43**	1.23	0.96	**0.65**
Bryan	0.85	0.51	**0.44**	1.04	0.58	**0.55**	1.14	0.67	**0.63**

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Childress	0.50	0.51	0.47	0.75	0.61	0.70	0.90	0.70	0.92
Corpus Christi	0.51	0.24	0.35	0.61	0.57	**0.44**	0.68	0.84	**0.53**
Dallas	0.54	0.47	0.50	0.66	0.48	0.55	0.73	0.51	0.62
El Paso	0.61	0.31	0.86	1.13	0.49	1.12	1.57	0.71	1.53
Fort Worth	0.31	0.46	0.36	0.60	0.49	0.58	0.93	0.51	0.71
Houston	0.42	0.45	0.37	0.61	0.49	0.63	0.75	0.54	0.71
Laredo	0.17	0.22	0.27	0.38	0.35	**0.28**	0.62	0.57	**0.29**
Lubbock	0.55	0.51	1.17	0.69	0.58	1.25	0.90	0.68	1.39
Lufkin	0.81	0.62	0.64	0.89	0.71	0.70	0.99	0.84	0.79
Odessa	0.65	0.90	**0.47**	0.67	0.91	**0.62**	0.70	0.93	0.72
Paris	0.76	0.54	0.77	1.06	0.67	0.84	1.21	0.94	0.94
Pharr	0.60	0.60	**0.37**	0.65	0.70	**0.41**	0.71	0.91	**0.43**
San Angelo	0.43	0.76	**0.36**	0.64	0.82	0.60	0.77	0.93	0.73
San Antonio	0.19	0.22	0.27	0.34	0.31	0.30	0.60	0.54	**0.33**
Tyler	0.77	0.57	0.59	1.02	0.78	0.88	1.21	0.98	0.99
Waco	0.30	0.45	**0.30**	0.51	0.64	**0.43**	0.72	0.89	0.67
Wichita Falls	0.64	0.52	0.61	0.71	0.75	0.64	0.77	0.98	**0.69**
Yoakum	0.62	0.48	0.48	0.79	0.58	0.63	0.89	0.71	0.71
Average	**0.55**	**0.52**	**0.53**	**0.74**	**0.63**	**0.67**	**0.91**	**0.77**	**0.79**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 42 compares the 2023 benzene statistics in MU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, Childress, El Paso, Laredo, Lubbock, and San Antonio districts saw considerable increases compared to their PYAs, whereas the Abilene, Brownwood, Odessa, Pharr, and San Angelo districts saw considerable decreases. For the average: the Amarillo and Lubbock districts saw the most substantial increase, whereas the Abilene, Brownwood, Corpus Christi, Odessa, and Pharr districts saw decreases. Lastly, for the maximum: the Amarillo and San Angelo districts saw the most increased values, whereas the Abilene, Atlanta, Brownwood, Corpus Christi, Pharr, and San Antonio districts saw decreases. Most notably, the Amarillo district saw consistently high values in its minimum, average, and maximum values in the 2023 survey, by 68%, 142%, and 173%, respectively. On the other hand, the Brownwood district saw a decrease in 2023 by 60%, 51%, and 40% for its minimum, average, and maximum values, respectively.

Table 42. Comparing MU Gasoline Benzene (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.63	0.82	**0.56**	0.65	0.84	**0.58**	0.68	0.86	**0.60**
Amarillo	0.42	0.39	0.68	0.60	0.53	1.37	0.73	0.63	1.85
Atlanta	0.97	0.52	0.64	1.00	0.64	**0.65**	1.04	0.87	**0.65**
Austin	0.20	0.47	0.29	0.28	0.54	0.50	0.37	0.60	0.63
Beaumont	0.62	0.58	0.68	0.97	0.58	0.71	1.33	0.59	**0.77**
Brownwood	0.68	0.62	**0.26**	0.79	0.77	**0.38**	1.01	0.87	**0.56**
Bryan	0.69	0.47	0.49	0.87	0.51	**0.55**	1.03	0.58	**0.61**
Childress	0.36	0.40	0.47	0.65	0.55	0.64	0.84	0.68	0.75
Corpus Christi	0.40	0.24	0.30	0.51	0.48	**0.38**	0.57	0.66	**0.46**
Dallas	0.42	0.36	0.43	0.58	0.39	0.47	0.72	0.44	0.53
El Paso	0.54	0.29	0.70	1.13	0.45	0.94	1.43	0.58	1.31
Fort Worth	0.33	0.39	0.35	0.55	0.43	0.50	0.87	0.45	0.58
Houston	0.36	0.41	0.34	0.52	0.46	0.56	0.63	0.51	0.64
Laredo	0.16	0.18	0.25	0.27	0.25	0.30	0.47	0.32	0.33
Lubbock	0.52	0.42	0.83	0.61	0.59	0.87	0.78	0.89	0.94
Lufkin	0.68	0.55	0.65	0.81	0.61	0.66	0.94	0.73	0.69
Odessa	0.66	0.83	**0.43**	0.69	0.84	**0.56**	0.75	0.86	0.66
Paris	0.72	0.46	0.60	0.93	0.53	0.66	1.15	0.65	0.77
Pharr	0.50	0.48	**0.36**	0.55	0.58	**0.41**	0.60	0.73	**0.43**
San Angelo	0.36	0.52	**0.31**	0.45	0.59	0.62	0.61	0.69	1.00
San Antonio	0.12	0.20	0.24	0.30	0.26	0.29	0.67	0.43	**0.39**
Tyler	0.78	0.50	0.64	0.94	0.63	0.70	1.04	0.76	0.81
Waco	0.26	0.40	**0.24**	0.43	0.52	0.38	0.57	0.70	0.64
Wichita Falls	0.56	0.40	0.56	0.60	0.63	0.61	0.65	0.89	0.68
Yoakum	0.49	0.42	0.39	0.65	0.50	0.52	0.74	0.59	0.60
Average	**0.50**	**0.45**	**0.47**	**0.65**	**0.55**	**0.59**	**0.81**	**0.66**	**0.71**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 43 compares the 2023 benzene statistics in PU gasoline to the 2017 and 2020 values for each TxDOT district. For the minimum: the Amarillo, Atlanta, Bryan, Childress, Laredo, Pharr, San Antonio, and Wichita Falls districts saw considerably higher values in 2023, whereas the Abilene, Brownwood, Odessa, Paris, and Tyler districts' values were considerably lower. For the average: the Amarillo, Austin, Bryan, Houston, Laredo, San Angelo, and Waco districts' values were considerably higher, whereas the Abilene, Brownwood, Corpus Christi, Odessa, and Paris districts' values were considerably lower. Lastly, for the maximum: the Amarillo, Austin, Houston, Laredo, San Angelo, and Waco districts were considerably higher, whereas the Abilene, Brownwood, Dallas, Lubbock, Odessa, and Paris districts were lower. The Amarillo, Laredo, and San Angelo districts stood out as their 2023 values were higher than their PYAs, and the Amarillo and San Angelo districts were also larger than the other districts. These three district's average values grew by 204%, 117%, and 101%, respectively, whereas their maximum values grew by 239%, 101%, and 176%, respectively. On the other hand, the Abilene, Brownwood, and Odessa districts saw considerable decreases in their values in the 2023 survey compared to PYAs, most notable in the Brownwood district, which saw a 57%, 52%, and 49% decrease in its minimum, average, and maximum values, respectively.

Table 43. Comparing PU Gasoline Benzene (% vol) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.52	0.75	**0.45**	0.64	0.79	**0.52**	0.74	0.83	**0.56**
Amarillo	0.28	0.28	0.48	0.44	0.41	1.28	0.63	0.48	1.88
Atlanta	0.57	0.41	0.61	0.74	0.52	0.65	0.88	0.74	0.69
Austin	0.08	0.26	0.19	0.15	0.35	0.40	0.24	0.46	0.53
Beaumont	0.34	0.41	0.39	0.72	0.44	0.51	1.01	0.47	0.70
Brownwood	0.57	0.34	**0.19**	0.62	0.62	**0.30**	0.72	0.77	**0.38**
Bryan	0.36	0.37	0.56	0.54	0.38	0.59	0.84	0.40	0.64
Childress	0.25	0.28	0.37	0.51	0.48	0.54	0.67	0.65	0.78
Corpus Christi	0.25	0.21	0.19	0.32	0.31	**0.24**	0.36	0.38	0.31
Dallas	0.29	0.26	0.31	0.43	0.28	0.34	0.68	0.30	**0.36**
El Paso	0.45	0.27	0.43	1.13	0.41	0.66	1.40	0.58	0.94
Fort Worth	0.26	0.27	0.24	0.42	0.31	0.33	0.59	0.33	0.48
Houston	0.20	0.31	0.26	0.28	0.38	0.43	0.34	0.49	0.53
Laredo	0.09	0.14	0.21	0.14	0.17	0.34	0.23	0.19	0.42
Lubbock	0.38	0.29	0.38	0.52	0.57	0.46	0.69	1.07	**0.50**
Lufkin	0.35	0.37	0.34	0.65	0.42	0.57	0.82	0.46	0.70
Odessa	0.52	0.69	**0.44**	0.62	0.74	**0.48**	0.70	0.80	**0.57**
Paris	0.39	0.32	**0.26**	0.56	0.34	**0.30**	0.69	0.37	**0.35**
Pharr	0.29	0.31	0.38	0.35	0.35	0.41	0.39	0.36	0.43
San Angelo	0.13	0.29	0.19	0.29	0.39	0.68	0.49	0.52	1.39
San Antonio	0.06	0.09	0.17	0.27	0.13	0.27	0.80	0.21	0.53
Tyler	0.67	0.34	**0.21**	0.73	0.36	**0.39**	0.84	0.39	0.70
Waco	0.14	0.23	0.19	0.25	0.25	0.34	0.37	0.28	0.62
Wichita Falls	0.24	0.26	0.48	0.47	0.44	0.55	0.66	0.74	0.65
Yoakum	0.23	0.28	0.23	0.31	0.34	0.34	0.36	0.41	0.40

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Average	**0.32**	**0.32**	**0.33**	**0.48**	**0.41**	**0.48**	**0.64**	**0.51**	**0.64**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

6.4.2 Comparing Diesel Components by District

This section compares select diesel components in the 2023 survey to the previous 2017 and 2020 surveys. These values do not account for the second round survey in the Houston district.

Table 44 compares the 2023 specific gravity statistics to the 2017 and 2020 values. On average, the specific gravity values were consistent in all three surveys.

Table 44. Comparing Diesel Specific Gravity Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	0.84	0.85	0.84	0.85	0.85	0.85	0.85	0.85	0.85
Amarillo	0.83	0.83	0.83	0.84	0.84	0.84	0.84	0.84	0.85
Atlanta	0.84	0.84	0.84	0.84	0.84	0.84	0.85	0.84	0.84
Austin	0.83	0.82	0.82	0.83	0.83	0.84	0.84	0.84	0.85
Beaumont	0.84	0.84	0.84	0.85	0.84	0.84	0.86	0.84	0.85
Brownwood	0.84	0.84	0.82	0.85	0.85	0.84	0.85	0.85	0.85
Bryan	0.84	0.84	0.84	0.85	0.84	0.84	0.85	0.84	0.85
Childress	0.83	0.83	0.83	0.83	0.83	0.84	0.84	0.83	0.85
Corpus Christi	0.83	0.84	0.81	0.84	0.84	0.82	0.85	0.84	0.84
Dallas	0.84	0.84	0.84	0.85	0.84	0.85	0.86	0.84	0.85
El Paso	0.83	0.83	0.82	0.84	0.84	0.84	0.84	0.85	0.85
Fort Worth	0.83	0.82	0.84	0.84	0.83	0.84	0.85	0.84	0.85
Houston	0.84	0.84	0.79	0.85	0.85	0.83	0.86	0.86	0.85
Laredo	0.81	0.81	0.80	0.82	0.82	0.81	0.82	0.83	0.81
Lubbock	0.83	0.83	0.84	0.84	0.83	0.84	0.84	0.83	0.84
Lufkin	0.85	0.84	0.84	0.85	0.84	0.84	0.85	0.85	0.84
Odessa	0.84	0.84	0.84	0.85	0.85	0.84	0.85	0.85	0.84
Paris	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.85
Pharr	0.83	0.82	0.82	0.83	0.82	0.82	0.83	0.83	0.82
San Angelo	0.84	0.83	0.83	0.84	0.84	0.84	0.84	0.84	0.85
San Antonio	0.81	0.81	0.81	0.83	0.82	0.81	0.85	0.85	0.82
Tyler	0.84	0.84	0.84	0.84	0.84	0.84	0.85	0.84	0.84
Waco	0.83	0.82	0.82	0.83	0.83	0.83	0.83	0.85	0.85

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Wichita Falls	0.84	0.83	0.84	0.84	0.84	0.84	0.85	0.85	0.85
Yoakum	0.84	0.84	0.83	0.84	0.84	0.84	0.84	0.85	0.84
Average	**0.83**	**0.83**	**0.83**	**0.84**	**0.84**	**0.84**	**0.85**	**0.84**	**0.84**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 45 compares the 2023 total aromatics statistics to the 2017 and 2020 values. For the minimum: the Houston district's minimum total aromatics value was an outlier and was lower than all other districts (0.35%-mass versus the statewide average of 18.43%-mass) and was 98% lower than its PYA. Aside from that, the Fort Worth district saw a 25% increase in its minimum compared to PYAs, whereas the Brownwood, Corpus Christi, San Angelo, and Yoakum districts saw at least 20% decrease from their PYAs. For the average: the Corpus Christi, Houston, Laredo, and San Antonio districts saw considerable decreases compared to their PYAs. For the maximum, the Austin, Bryan, Childress, and Paris districts saw considerable increases, whereas the Corpus Christi, Laredo, and San Antonio districts saw considerable decreases.

Table 45. Comparing Diesel Total Aromatics (% mass) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	25.65	28.45	24.60	27.53	29.86	27.14	29.68	30.79	29.88
Amarillo	22.23	17.68	18.13	24.58	19.06	20.83	26.22	21.42	22.35
Atlanta	20.79	22.55	24.52	25.05	24.77	26.85	31.07	26.22	28.44
Austin	20.01	15.72	14.67	22.18	21.89	24.18	23.78	25.73	31.32
Beaumont	24.85	21.70	27.08	31.20	24.66	28.62	33.19	28.23	31.36
Brownwood	25.75	18.54	**15.12**	26.61	26.05	23.13	27.97	30.09	27.19
Bryan	26.40	25.38	24.54	26.97	26.09	27.95	27.85	26.90	33.49
Childress	21.00	18.39	20.95	22.86	19.74	24.87	26.24	21.31	30.25
Corpus Christi	21.07	20.61	**10.43**	23.62	22.34	**14.85**	25.15	24.12	**17.84**
Dallas	24.94	21.42	25.31	25.51	23.24	25.78	26.58	24.26	26.17
El Paso	21.41	19.96	18.95	23.44	22.95	20.65	24.50	25.61	21.71
Fort Worth	21.85	16.10	23.78	23.64	20.23	25.92	25.44	24.97	29.04
Houston	23.96	21.96	**0.35**	26.40	26.38	**16.15**	30.98	31.65	30.17
Laredo	12.36	9.60	9.82	13.74	13.97	**10.48**	15.48	20.60	**11.03**
Lubbock	20.78	19.46	21.75	23.68	20.73	23.48	25.67	22.67	24.38
Lufkin	28.94	25.31	26.63	31.81	26.81	28.34	34.39	28.62	29.22
Odessa	25.30	22.05	24.28	26.34	25.62	26.69	27.70	29.01	29.43
Paris	21.62	22.12	20.79	21.63	22.90	25.74	21.64	23.85	30.69

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Pharr	16.03	7.56	11.38	17.55	9.70	12.51	19.67	11.64	13.40
San Angelo	22.81	21.14	**17.55**	25.16	23.58	24.41	26.41	27.98	30.07
San Antonio	11.97	10.88	10.16	19.45	15.41	**12.18**	24.60	23.47	**15.56**
Tyler	21.13	16.95	20.57	25.62	23.31	22.82	34.99	28.56	27.71
Waco	22.11	15.95	15.84	22.81	19.36	19.79	23.65	25.57	27.36
Wichita Falls	21.88	14.21	18.55	23.75	22.94	24.92	25.87	29.78	30.05
Yoakum	21.81	23.08	**15.01**	25.02	24.05	21.37	27.06	25.65	25.24
Average	**21.87**	**19.07**	**18.43**	**24.25**	**22.23**	**22.39**	**26.63**	**25.55**	**26.13**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 46 compares the 2023 diesel sulfur statistics to the 2017 and 2020 values. For the minimum: the Bryan, Childress, El Paso, Wichita Falls, and Yoakum districts showed minimum values in 2023 that were over 20% higher than their PYAs, whereas the Atlanta, Corpus Christi, Houston, Laredo, and San Antonio districts saw at least 20% lower minimums. Among these, the Houston district's decrease was the most significant, at 84%, and was the lowest diesel sulfur value measured during the 2023 survey. For the average: the Bryan and Childress districts saw considerable increases from their PYAs, whereas the Atlanta, Brownwood, and Laredo districts saw considerable decreases. For the maximum, the Childress district's values grew by 49% from its PYAs, whereas the Atlanta, Brownwood, and Laredo districts saw decreases of 26%, 28%, and 57% from the PYAs, respectively. None of the diesel sulfur exceeded the ULSD limit of 15 ppm.

Table 46. Comparing Diesel Sulfur (ppm) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	9.02	7.72	7.87	10.09	8.06	8.70	11.45	8.50	10.13
Amarillo	5.76	3.30	4.32	6.29	4.01	5.11	6.86	5.45	5.73
Atlanta	5.61	8.42	**5.55**	7.54	9.82	**6.82**	8.61	12.57	**7.80**
Austin	6.66	4.80	6.34	7.30	5.80	6.90	8.11	6.91	7.32
Beaumont	5.75	1.92	5.33	6.32	4.77	6.00	7.23	6.74	6.77
Brownwood	5.10	5.29	5.17	7.94	7.71	**6.25**	10.08	9.07	**6.89**
Bryan	5.30	4.76	6.72	6.21	5.40	7.18	7.46	5.93	7.83
Childress	5.46	3.44	5.92	6.14	4.24	7.17	6.99	5.51	9.34
Corpus Christi	4.09	3.69	**1.64**	5.91	3.89	**3.28**	6.91	4.00	5.34
Dallas	5.05	4.76	5.68	6.09	5.66	6.16	7.19	6.84	6.81
El Paso	2.25	5.03	5.72	4.05	6.36	6.43	5.52	7.45	7.15
Fort Worth	6.05	4.58	4.88	6.42	5.73	6.57	6.98	6.80	7.55

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Houston	4.97	4.41	**0.75**	5.41	5.12	4.54	6.18	7.31	7.11
Laredo	4.02	1.85	**1.17**	4.81	2.47	**1.65**	5.64	3.57	**2.00**
Lubbock	5.25	5.09	5.41	5.95	5.90	7.06	6.94	6.82	7.94
Lufkin	6.04	6.14	5.68	6.11	6.90	6.44	6.26	8.25	6.93
Odessa	5.55	6.23	5.61	7.21	7.44	6.50	9.29	9.06	7.50
Paris	8.87	5.36	7.46	9.04	9.99	8.69	9.24	12.62	9.92
Pharr	3.52	0.38	1.76	3.82	1.48	2.31	4.19	2.41	2.70
San Angelo	6.19	5.22	5.90	6.75	5.67	6.33	7.40	6.24	6.84
San Antonio	3.27	1.44	**1.10**	5.45	3.28	**3.09**	7.47	6.50	6.28
Tyler	5.52	6.85	6.14	7.65	9.46	8.52	8.77	12.19	9.85
Waco	7.48	4.28	5.94	7.60	6.58	6.18	7.84	7.90	6.50
Wichita Falls	3.65	5.45	6.62	5.86	6.81	7.22	9.15	7.89	8.35
Yoakum	4.64	3.99	5.71	5.47	4.54	5.96	5.94	5.58	6.45
Average	**5.40**	**4.58**	**4.98**	**6.46**	**5.88**	**6.04**	**7.51**	**7.29**	**7.08**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 47 compares the 2023 cetane index statistics to the 2017 and 2020 values. The only outlier is the Houston district maximum cetane index, which increased 44% from its PYA.

Table 47. Comparing Cetane Index Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	48.70	47.70	48.01	49.30	48.20	49.47	49.90	48.70	50.85
Amarillo	48.00	49.80	50.10	49.53	50.47	50.95	51.30	51.20	52.34
Atlanta	47.10	46.80	48.25	50.87	48.60	49.44	53.40	51.20	51.02
Austin	50.40	49.80	45.67	53.14	51.74	51.39	54.80	56.70	58.38
Beaumont	46.10	45.00	46.24	48.44	48.12	48.92	50.80	50.10	50.55
Brownwood	49.20	47.90	48.50	49.57	49.80	51.87	50.10	53.20	57.83
Bryan	48.30	48.90	47.41	48.87	49.43	49.13	49.30	50.00	50.49
Childress	48.10	50.00	47.94	50.30	50.13	50.01	51.70	50.20	51.22
Corpus Christi	51.00	48.50	51.47	52.43	51.17	55.36	53.30	53.20	59.22
Dallas	47.30	48.50	48.08	49.40	49.73	48.49	50.30	51.40	48.73
El Paso	50.10	48.90	51.40	50.96	50.44	51.75	51.90	51.10	52.27
Fort Worth	50.30	48.60	48.43	50.68	52.05	49.69	51.10	56.40	50.72
Houston	48.20	48.80	46.95	50.04	49.89	57.87	51.20	51.30	73.60
Laredo	55.60	50.40	58.98	56.43	54.47	59.43	56.90	56.60	59.75
Lubbock	48.10	49.00	49.71	49.27	49.87	49.78	51.40	50.40	49.83

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Lufkin	45.10	44.90	47.48	46.97	48.83	48.00	49.20	51.70	48.40
Odessa	49.10	48.30	48.62	49.80	49.57	49.02	50.40	51.60	49.76
Paris	52.80	48.60	47.84	52.93	50.37	50.16	53.10	51.30	52.47
Pharr	53.20	55.00	55.91	55.10	56.87	56.97	56.60	58.60	58.01
San Angelo	48.50	48.70	48.10	49.67	50.17	49.80	51.50	52.70	52.12
San Antonio	50.10	50.40	57.53	53.98	54.72	58.80	57.70	57.00	60.11
Tyler	44.90	46.30	49.53	50.76	49.94	51.71	53.40	53.60	52.78
Waco	53.40	50.50	50.42	53.87	54.03	54.79	54.40	56.60	57.45
Wichita Falls	49.80	48.00	48.29	50.50	50.70	50.42	51.20	54.60	54.68
Yoakum	48.20	49.70	48.82	50.27	50.27	51.51	53.70	50.90	56.33
Average	**49.26**	**48.76**	**49.59**	**50.92**	**50.78**	**51.79**	**52.34**	**52.81**	**54.36**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 48 and Table 49 compare the 2023 diesel T50 and T90 number statistics to the 2017 and 2020 values. None of the 2023 values were considerably different from previous surveys. While the tables show considerable increases in the San Antonio district minimums, these were the result of extremely low outliers in the 2017 survey.

Table 48. Comparing Diesel T50 (F) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	513.40	519.00	509.80	517.37	520.77	525.40	522.70	522.80	547.00
Amarillo	489.60	481.60	490.40	498.80	496.97	509.53	511.00	513.40	533.20
Atlanta	506.90	475.10	496.40	515.47	489.50	505.77	523.10	511.60	514.30
Austin	504.40	491.20	501.00	516.04	503.06	511.94	525.20	509.50	523.80
Beaumont	486.00	464.00	492.60	517.28	491.10	510.20	545.00	508.40	532.00
Brownwood	512.10	518.70	505.90	520.13	520.43	520.97	530.60	523.10	535.10
Bryan	506.80	496.80	503.70	514.77	503.07	511.53	524.10	506.70	525.30
Childress	487.10	480.90	502.60	492.37	481.77	510.03	502.50	482.80	518.30
Corpus Christi	510.50	491.70	496.50	534.77	519.13	505.77	553.70	539.60	515.00
Dallas	502.80	486.60	504.70	518.38	503.60	510.93	533.00	522.30	521.80
El Paso	482.30	477.50	478.20	511.40	512.82	515.02	539.30	546.90	543.30
Fort Worth	488.30	481.50	507.50	501.83	495.70	519.13	523.40	503.20	542.60
Houston	519.40	520.00	498.20	534.73	533.36	532.06	544.60	558.50	574.10
Laredo	483.30	485.00	494.40	486.37	485.43	496.67	488.50	486.10	498.90
Lubbock	489.60	477.10	507.30	492.93	487.90	511.60	499.00	493.50	514.20
Lufkin	490.70	463.30	494.40	504.23	499.33	498.43	524.70	543.00	504.50
Odessa	505.10	499.10	504.50	520.77	515.67	506.13	548.50	531.30	508.10

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Paris	522.30	493.30	513.70	522.93	505.67	515.50	523.70	513.90	517.30
Pharr	511.00	505.80	508.70	514.37	509.03	510.53	521.00	510.70	513.10
San Angelo	501.10	492.10	503.20	505.07	496.27	504.43	508.60	503.70	505.20
San Antonio	162.10	487.30	493.90	434.36	500.00	502.96	536.60	524.70	518.10
Tyler	490.00	479.10	510.20	520.08	508.14	520.40	554.50	553.20	524.00
Waco	510.60	490.40	508.50	511.67	509.73	522.33	512.60	539.70	542.50
Wichita Falls	505.20	504.50	507.10	522.03	512.87	524.07	543.50	517.60	542.60
Yoakum	501.40	505.30	502.50	516.00	514.73	515.07	544.50	528.10	537.40
Average	**487.28**	**490.68**	**501.44**	**509.76**	**504.64**	**512.66**	**527.36**	**519.77**	**526.07**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

Table 49. Comparing Diesel T90 (F) Statistics.

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Abilene	627.10	630.30	625.00	630.53	630.60	629.97	634.70	631.00	637.90
Amarillo	600.70	579.40	608.00	608.83	602.40	615.27	621.60	618.10	625.10
Atlanta	621.70	613.20	620.30	625.53	618.93	623.60	628.40	626.70	628.30
Austin	602.20	617.40	620.00	611.00	619.70	625.32	614.50	622.80	629.60
Beaumont	619.10	603.30	623.10	626.58	618.78	628.06	634.40	630.30	635.10
Brownwood	625.80	630.30	620.30	630.07	630.97	627.27	632.30	631.70	634.50
Bryan	620.30	617.60	621.30	624.23	619.93	623.07	627.60	622.70	626.30
Childress	593.60	589.80	606.50	600.20	596.60	620.43	610.40	601.20	629.00
Corpus Christi	624.50	620.60	610.10	631.67	628.47	619.50	635.70	634.30	632.80
Dallas	616.10	611.90	618.30	625.53	623.00	622.23	632.60	633.70	628.60
El Paso	584.70	594.00	586.10	622.40	619.96	621.06	639.60	639.80	640.20
Fort Worth	594.80	611.40	619.50	611.73	615.73	624.23	630.20	623.80	636.60
Houston	632.30	630.70	589.80	633.41	632.54	612.14	634.70	635.90	621.90
Laredo	590.50	588.80	608.80	596.63	598.47	610.47	604.30	603.80	612.30
Lubbock	596.40	588.60	608.70	602.80	608.87	619.77	612.00	621.00	625.30
Lufkin	622.00	606.40	619.80	627.17	618.10	620.77	634.10	637.50	621.50
Odessa	619.00	621.30	619.20	627.27	627.40	621.27	637.30	633.30	623.60
Paris	627.20	615.00	620.00	628.40	623.40	624.75	630.50	627.80	629.50
Pharr	626.60	616.60	619.40	630.23	617.77	620.00	633.70	619.30	620.60
San Angelo	615.10	616.40	619.90	616.23	618.07	625.37	617.60	619.70	628.60
San Antonio	331.00	594.00	607.80	554.62	612.90	614.56	634.60	635.80	626.70
Tyler	621.40	615.70	622.20	628.08	625.24	630.30	638.30	638.90	633.20
Waco	603.80	615.70	616.70	604.30	623.03	625.03	605.20	634.40	634.60

Year-Statistics	2017 Min.	2020 Min.	2023 Min.	2017 Ave.	2020 Ave.	2023 Ave.	2017 Max.	2020 Max.	2023 Max.
Wichita Falls	631.30	620.50	619.00	633.40	627.13	631.40	634.50	634.70	641.80
Yoakum	615.10	621.10	617.10	619.77	627.20	623.83	628.00	632.00	634.90
Average	**602.49**	**610.80**	**614.68**	**618.02**	**619.41**	**622.39**	**627.47**	**627.61**	**629.54**

Red indicates the 2023 value is at least 20% larger than the average value of 2017 and 2020; **blue** indicates the value at least 20% smaller than the average value of 2017 and 2020.

6.4.3 TTI QAQC Highlights

The following are the observations the TTI made during its independent QA/QC of the gasoline values:

- RVP – The El Paso and Tyler districts' average RVP values in 2023 were considerably higher than in previous years. However, as explained in section 5.2, these were caused by a single very high outlier in the PU gasoline sample collected at both sites.
- Sulfur – The overall average sulfur values in 2023 were considerably higher than those measured in 2020 and were above 10 ppm for all three grades of gasoline. The Tier 3 Gasoline Sulfur program sets vehicle emissions standards and lowers the sulfur content of gasoline to meet an annual average standard of 10 ppm of sulfur [8]. However, as previously stated in Section 5.2, on a per-gallon basis, the sulfur content is capped at 80 ppm. Sulfur content values for individual gasoline samples (all grades) ranged from 2.2 ppm to 31.2 ppm. None of the individual samples exceed the federal per-gallon sulfur content cap of 80 ppm.
- ETOH – The Houston district's ETOH maximum values were considerably higher than in previous years and all other districts. These ETOH values (13.31%-vol for MU and 15.01%-vol for RU gasoline) are between 10.5% and 15% ETOH, which implies that the gasoline sampled was E15. Since April 28, 2023, the EPA issued a series of waivers allowing E15 gasoline to be sold nationwide during the summer of 2023 to address the fuel supply circumstances caused by the ongoing war in Ukraine [9]. The TTI believes this waiver to be the reason why E15 gasoline was showing up at some fuel stations in the Houston district. Interestingly, both the highest and second highest RU (15.01 and 14.95%-vol) and MU (13.31 and 13.07%-vol) ETOH values recorded at the Houston district were sampled from Flying J locations.
- MTBE – The Atlanta district is the only one in 2023 that had a non-zero value for MTBE. While TTI had noted this observation, it must be noted that this is a decrease from previous years where there were more districts with non-zero MTBE values. It

must also be noted that all districts with non-zero MTBE values since 2017 were at the state border, implying that the gasoline may be from outside the state of Texas.

- Benzene – The Amarillo district's average benzene value in 2023 was almost three times higher than in previous years. However, it must be noted that while the Amarillo district's values were significantly larger than previous surveys, they are within the vicinity of other districts, and thus, TTI does not believe this is an issue of concern.

TTI observed the following outliers during its independent QA/QC of the diesel values:

- Total aromatics – The Houston district's minimum total aromatics values were significantly lower than all other districts (0.35%-mass versus the statewide average of 18.43%-mass) and significantly lower compared to previous surveys. However, this value was recorded at the Loves Travel Stop 401 station, which was inoperable four weeks later.
- Sulfur – The Houston district's minimum sulfur values in 2023 were significantly lower than all other districts (0.75 ppm versus the statewide average of 4.96 ppm) and significantly lower compared to previous surveys. This outlier was sampled at a Flying J location in the City of Brookshire. Interestingly, in the second round of the survey, both Flying J locations in the Houston district have considerably low sulfur values as well (0.32 and 0.73 ppm). Independently, TTI identified and assigned fuel station brands to each of the fuel stations sampled. TTI observed that the average sulfur values at Flying J's were much lower than other brands in the 2023 survey (10.32 ppm versus the average of 22.88 ppm).
- Cetane Index – The Houston district's maximum cetane index was significantly larger compared to previous surveys. However, this value was recorded at the Loves Travel Stop 401 station, which was inoperable four weeks later.

7 FUTURE RECOMMENDATIONS

In this section, TTI lists several recommendations to improve future summer fuel surveys based on what TTI learned during the 2023 survey. These recommendations were made independent of ERG and SwRI.

7.1 Distribution of Fuel Stations to Survey

The total number of fuel stations is limited by the fact that a laboratory test is required for each sample taken. However, the TTI team believes that the current fuel sampling and site selection methodologies can be improved to put these limited resources to the best use.

The existing list of fuel stations to sample by the district was grandfathered in from many previous fuel surveys. Many of the ozone NAAQS designations have changed since (most notably, El Paso's attainment status was newly redesignated during the period when this study was being conducted [10]), and thus, TTI believes the current number of fuel stations to survey per district assigned no longer matches the narrative.

To address this, the TTI team recommends selection of fuel stations takes into account several key factors, including the ozone NAAQS attainment designation of areas within the district, whether the district is on the state border, the number of fuel stations and refineries within the district, and the district's population. The border district definition is important as these districts have a higher likelihood of obtaining gasoline and diesel from refineries outside the state. On a similar note, districts with refineries have a higher likelihood to use fuel produced within the district and a lower likelihood of using fuel from outside of Texas, thus, TTI believes that rather than committing the same amount of resources to these districts, the resources can be used more effectively elsewhere.

While the total number of fuel stations surveyed cannot be changed, the TTI team believes that by considering our recommendation, the resources can be distributed more effectively to districts where accurate information is required the most, for instance, those that are designated nonattainment according to NAAQS and those that have large populations. Future studies will maintain the same total number of fuel stations to survey, and there will be no changes in the way the fuel samples are collected.

The TTI team recommends the following steps to determine the number of fuel stations to be sampled at each TxDOT district:

1. Every TxDOT district is assigned three survey stations.
2. Two additional survey stations are added to each district that contains, in whole or in part, an ozone nonattainment area.
3. One additional survey station is added to districts with more than 750 gas stations; if the district has more than 1,500 gas stations, then two additional stations are added instead.
4. One additional survey station is added to the districts located at the borders of the state.
5. One survey station is removed for the districts with refineries.
6. One survey station should be removed for the districts with a population of less than 500,000.
7. If the number of counties within the district with a population above 100,000 is less than the number of survey stations assigned for the district, then the difference should be added so that the number of survey stations at least matches the number of counties within the district with over 100,000 in population.
8. Following steps 1 through 7, if the number of stations for the district is less than three, then the difference is added so that every district has at least three stations.

Table 50 shows TxDOT district information relevant to the steps listed above. The El Paso district's nonattainment status has been reverted by the D.C. Circuit Court on June 30, 2021. However, the Sunland Park Area, NM, still retains its nonattainment status. This is crucial as both El Paso and Sunland Park are part of a multistate nonattainment area (El Paso-Las Cruces) created by the EPA in 2021 [10]. Thus, TTI decided to treat the El Paso district as a "nonattainment" area for survey resource allocation.

Table 50. District Information for Distribution of Fuel Station.

TxDOT District (1)	Area Ozone Standard Designation (2)	Number of gas stations (3)	Border District (4)	No. of refineries (5)	Population (6)	No. of counties above 100,000 population (7)
Abilene	Attainment	145	-	*1*	*266,921*	1
Amarillo	Attainment	194	**1**	*2*	*388,323*	2
Atlanta	Attainment	141	**1**	-	*307,005*	
Austin	Attainment	**815**	-	-	2,413,274	3
Beaumont	Attainment	319	**1**	*5*	600,759	1
Brownwood	Attainment	78	-	-	*125,642*	
Bryan	Attainment	227	-	-	*483,084*	1
Childress	Attainment	23	**1**	-	*34,299*	
Corpus Christi	Attainment	265	-	*5*	586,539	1
Dallas	**Nonattainment**	**1,513**	-	-	5,082,634	6
El Paso	**Attainment[1]**	271	**1**	*1*	888,720	1
Fort Worth	**Nonattainment**	885	-	-	2,657,650	3
Houston	**Nonattainment**	**2,756**	-	*13*	6,953,874	5
Laredo	Attainment	139	**1**	-	*410,496*	1
Lubbock	Attainment	156	**1**	-	*486,931*	1
Lufkin	Attainment	119	**1**	-	*306,075*	
Odessa	Attainment	176	**1**	-	*417,184*	2
Paris	Attainment	196	**1**	-	*397,376*	1
Pharr	Attainment	334	**1**	-	1,404,035	2
San Angelo	Attainment	100	-	-	*163,226*	1
San Antonio	**Nonattainment**	**874**	-	*2*	2,654,290	3
Tyler	Attainment	322	-	*1*	704,800	2
Waco	Attainment	238	-	-	815,764	2
Wichita Falls	Attainment	120	**1**	-	*245,420*	1
Yoakum	Attainment	204	-	-	*339,211*	

Note – the numbers in the header represent the steps listed. The bold and italics represent variables that are relevant to steps: where bold represents addition whereas italics represent subtraction.

[1] On June 30, 2023, the D.C. Circuit Court issued a decision reversing the 2021 El Paso County Nonattainment Area Designation for the 2015 ozone NAAQS. As a result of the Court's decision, El Paso reverts to its prior attainment designation. Available at: https://www.epa.gov/ozone-designations/ozone-designations-regulatory-actions.

Table 51 lists all districts alongside the recommended steps and the final number of stations for the upcoming fuel studies. As seen in the table, most of the districts do not have changes. However, the numbers for the Austin, Beaumont, Houston, and Tyler districts have reduced, while the numbers for the Dallas, Fort Worth, and Pharr districts have increased based on the recommended steps. Based on the steps listed, the number of sampling stations assigned to the El Paso district should decrease, as it is no longer a nonattainment area. However, as previously mentioned, TTI decided to treat the area as "nonattainment" for the number of sampling station allocation purposes as it is part of the El Paso-Las Cruces nonattainment area.

Table 51. Selection Steps for Number of Sampling Stations from each District.

TxDOT District	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Final	2023 Study	Change
Abilene	3				-1	-1		2	3	3	-
Amarillo	3			1	-1	-1		1	3	3	-
Atlanta	3			1		-1			3	3	-
Austin	3		1						4	5	-1
Beaumont	3			1	-1				3	5	-2
Brownwood	3					-1		1	3	3	-
Bryan	3					-1		1	3	3	-
Childress	3			1		-1			3	3	-
Corpus Christi	3				-1			1	3	3	-
Dallas	3	2	2						7	4	+3
El Paso	3	2*		1	-1				5	5	-
Fort Worth	3	2	1						6	4	+2
Houston	3	2	2		-1				6	7	-1
Laredo	3			1		-1			3	3	-
Lubbock	3			1		-1			3	3	-
Lufkin	3			1		-1			3	3	-
Odessa	3			1		-1			3	3	-
Paris	3			1		-1			3	3	-
Pharr	3			1					4	3	+1
San Angelo	3					-1		1	3	3	-
San Antonio	3	2	1		-1				5	5	-
Tyler	3				-1			1	3	5	-2
Waco	3								3	3	-
Wichita Falls	3			1		-1			3	3	-
Yoakum	3					-1		1	3	3	-
Total									**91**	**91**	-

*El Paso is part of a multistate nonattainment area encompassing Doña Ana County, NM, and the then newly designated El Paso nonattainment area. While El Paso County's nonattainment status has been reverted on June 30, 2021, Doña Ana County, located within the Sunland Park Area, still retains its nonattainment status [10]. Thus, TTI decided to treat the El Paso district as a "nonattainment" area for survey resource allocation.

7.2 Spatial Variability of Sampling

TTI noticed that there was no consistency in the minimum distance between fuel stations surveyed among districts. For example, as shown in Figure 23, the three fuel stations surveyed in the Amarillo district were very close to each other, with the two stations furthest away from each other only being 2.2 miles apart. Going forward, TTI strongly recommends spacing out the fuel stations surveyed and ensuring that there is a minimum distance between the fuel stations surveyed, so the district average would be more representative of the entire district, rather than just a region within the district. For cases like the El Paso district, where most of the population is located within El Paso County, the sampling can be taken at different locations within the county, as long as the stations are not within the vicinity of each other.

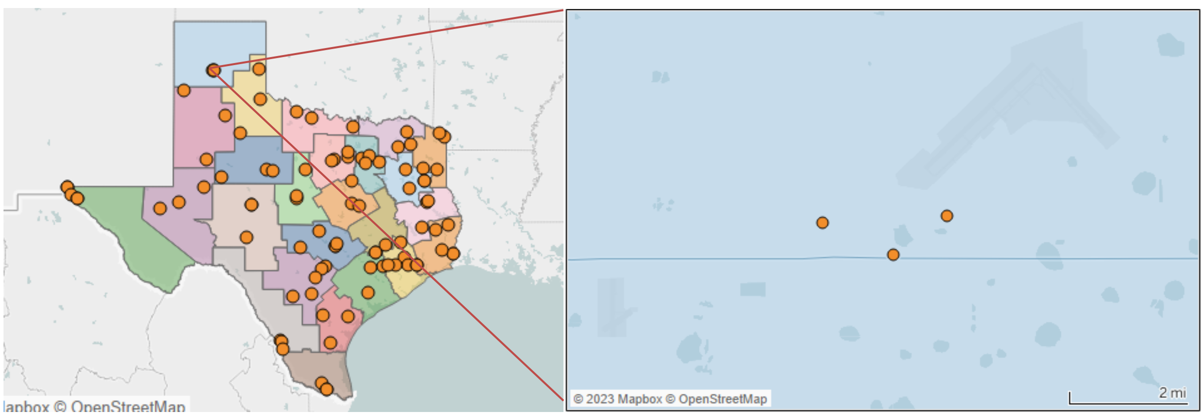

Figure 23. Closeup of the Amarillo District Fuel Stations used in this Survey.

In addition, the urban-rural characteristics of the location where the fuel stations were surveyed were not a factor in this and previous studies. TTI recommends including at least one urban location and one rural location for each district in future surveys. This allows for a better study and understanding of the fuel component characteristics of the samples collected.

For districts at the Texas border, TTI also recommends surveying at least one gas station located within the vicinity of the border. As previously mentioned, these districts have a higher likelihood of obtaining gasoline and diesel from refineries outside the state. Therefore, surveying a fuel station located closer to the border would increase the likelihood of capturing these samples.

To summarize, TTI recommends:

- Setting a minimum distance between fuel stations sampled so that the fuel samples are more representative of the entire district rather than just a region. TTI suggests when selecting a fuel station to sample, avoid fuel stations within the same zip code as another, and if possible, avoid those from adjacent zip codes. In addition, fuel stations with the same brand as a selected station within the district should be avoided as the likelihood of these fuel stations acquiring fuel from the same source is higher.
- Ensuring at least one urban and at least one rural location is sampled. As per the U.S. Census Bureau's urban-rural classification, at the census block, an urban area must encompass at least 2,000 housing units or have a population of at least 5,000. Otherwise, the census block is treated as rural [11]. By this definition, at least one sample must be taken at a rural census block within the district, and at least one sample must be taken at an urban census block within the district. The U.S. Census Bureau's 2020 or latest Census Urban Areas data can be used to identify these locations.
- If the district is located along the Texas Border, ensure that at least one sample is collected from a fuel station within the vicinity of the border. As there are no definitive statements on what constitutes "vicinity of the border", TTI suggests at least one sample taken from a fuel station within 10 miles of the state border.

7.3 The Second Round of Sampling

In this study, the results from the second round of sampling that SwRI conducted in the Houston district were used only to identify the temporal variation of fuel components at the same fuel station, as discussed in Chapter 5.1. Since both rounds of sampling were conducted during the summer months, TTI recommends, going forward, that the analysis results from the second round of sampling be incorporated into the fuel parameter development. This allows the results to be more representative of the summer season, instead of just the month of June, even if it was just for the Houston district.

If the second round results must remain only for comparative study purposes, TTI proposes an alternative approach of spacing out the survey rounds for more than four weeks. Doing so would allow for a better understanding of the seasonality of the fuel component characteristics.

Finally, TTI recommends collecting the second round of samples at different districts. This will allow a better understanding of the seasonality of the fuel component characteristics in different districts.

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APPENDIX A: PIPELINE NETWORK IN TEXAS

This appendix contains a list of pipeline networks in the Texas Gulf Coast and Texas Inland regions with their operator's name, origin, destination, distance, and capacity.

Pipelines in the Gulf Coast Region

Pipeline	Origin	Destination	Distance (miles)	Capacity (barrels/day)
Colonial Pipeline	Houston, TX	Greensboro, NC	5,500	2,500,000
Explorer Pipeline	Port Arthur, TX	Houston, TX	1,830	660,000
	Houston, TX	Wood River, IL	N/A	N/A
	Houston, TX	Ardmore, OK	N/A	N/A
Enterprise TEPPCO Pipeline	Texas City, TX	Selkirk, NY	4,700	330,000
Exxon Mobil Pipeline	Baytown, TX	San Antonio, TX	N/A	N/A
	Baytown, TX	Irving, TX	N/A	N/A
Magellan Midstream Pipeline	Houston, TX	Dallas/Fort Worth, TX	N/A	N/A
	Houston, TX	Odessa, TX	N/A	110,000
Centennial Pipeline	Beaumont, TX	Bourbon, IL	795	210,000
Sunoco Logistics Pipeline	Beaumont/Port Arthur, TX	Waskom, TX	N/A	N/A
	Beaumont/Port Arthur, TX	Houston, TX	N/A	N/A
	Beaumont/Port Arthur, TX	Hearne, TX	N/A	N/A
NuStar Central West Pipeline	Three Rivers, TX	Corpus Christi, TX	72	15,000
	Corpus Christi, TX	Brownsville, TX	194	45,000
Koch Pipeline	Corpus Christi, TX	Dallas/Fort Worth, TX	N/A	N/A
Citgo Pipeline	Corpus Christi, TX	San Antonio, TX	N/A	N/A

Source: EIA, 2016

Pipelines in the Texas Inland Region

Pipeline	Origin	Destination	Distance (miles)	Capacity (b/d)
Explorer Pipeline	Texas Gulf Coast	Wood River, IL	1,830	660,000
	Texas Gulf Coast	Ardmore, OK	N/A	N/A
	Greenville, TX	Grapevine, TX	N/A	N/A
Exxon Mobil Pipeline	Baytown, TX	San Antonio, TX	N/A	N/A
	Baytown, TX	Irving, TX	N/A	N/A
Magellan Midstream	OK and KS	Fort Worth, TX	N/A	N/A
	Houston, TX	Dallas/Fort Worth, TX	N/A	N/A
	Houston, TX	Odessa, TX	N/A	110,000
	Hearne, TX	Dallas, TX	N/A	N/A
	Odessa, TX	El Paso, TX	N/A	64,000
	El Paso, TX	Albuquerque, NM	257	28,200
Holly Energy Partners	Artesia, NM	El Paso, TX	156	19,000
	Artesia, NM	Orla, TX and El Paso, TX	214	70,000
	Midland, TX	Orla, TX	135	25,000
	Big Spring, TX	Abilene, TX	100	20,000
	Big Spring, TX	Wichita Falls, TX	227	23,000
	Wichita Falls, TX	Duncan, OK	47	21,000
Alon USA	Big Springs, TX	Midland, TX	N/A	N/A
Epic Midstream	El Paso, TX	Alamogordo, NM	N/A	N/A
Kinder Morgan SFPP East Line	El Paso, TX	Phoenix, AZ	230	200,000
PMI Frontera Juarez	El Paso, TX	Ciudad Juarez, Mexico	49	45,000
Phillips 66	Borger, TX	East St. Louis, IL	681	120,000
	McKee, TX	Denver, CO	405	38,000
NuStar Central West Refined Product Pipeline System	McKee, TX	Denver, CO	321	11,000
	McKee, TX	Colorado Springs, CO	357	32,500
	McKee, TX	Amarillo, TX	49	51,000
	Amarillo, TX	Albuquerque, NM	293	17,200
	McKee, TX	Abernathy, TX	102	16,800
	Abernathy, TX	Lubbock, TX	19	8,000
	McKee, TX	Southlake, TX	375	26,000
	McKee, TX	El Paso, TX	408	42,000
	Three Rivers, TX	San Antonio, TX	85	33,500
	Three Rivers, TX	Pettus, TX	112	27,500
	Three Rivers, TX	Corpus Christi, TX	72	15,000
	Three Rivers, TX	U.S.-Mexico border	N/A	N/A
	Corpus Christi, TX	Brownsville, TX	194	45,000

Pipeline	Origin	Destination	Distance (miles)	Capacity (b/d)
	U.S.-Mexico border	Edinburg, TX	33	24,000
Koch Pipeline	Corpus Christi, TX	Dallas/Fort Worth, TX	N/A	N/A
Citgo Pipeline	Corpus Christi, TX	San Antonio, TX	N/A	N/A
Sunoco Logistics	Beaumont/Port Arthur, TX	Hearne, TX	N/A	N/A
	Beaumont/Port Arthur, TX	Waskom, TX	N/A	N/A

Source: EIA, 2016

APPENDIX B: LIST OF FINAL SAMPLING LOCATIONS

This appendix contains the information, including the TxDOT district, facility name, and address, of each sampling site selected for this study. This appendix is available electronic only.

APPENDIX C: TESTING RESULTS FOR GASOLINE

This appendix provides test results for all 273 gasoline samples collected in round 1. (These do not include the round 2 sampling at the seven locations in the Houston district). This appendix is available electronic only.

APPENDIX D: TESTING RESULTS FOR DIESEL

This appendix provides sample identification information and test results for all the diesel samples collected in the initial sampling round. (These do not include round 2 samples. This appendix is available electronic only.

APPENDIX E1: UPDATED FUEL PARAMETERS FILES FOR MOVES3 AND TEXN2

This appendix contains the data required to update the fuel parameter inputs for MOVES3 and TexN2. It also contains the MySQL scripts that are needed to update and load the new fuel parameter data into TexN2. This appendix is available electronic only.

APPENDIX E2: GASOLINE AND DIESEL ANALYSIS

This appendix provides selected fuel parameters from the initial round of gasoline DHA and NoDHA datasets in a flat-file format, fuel-region-level averages by gasoline grade, fuel-region-level weighted averages across all grades, and county-level averages. It also provides diesel test results, fuel-region-level averages, and county-level averages for diesel. This appendix is available electronic only.

APPENDIX F1: ROUND 1 VERSUS ROUND 2 ANALYSIS DATA AND RESULTS

This appendix provides all the gasoline and diesel analysis data from round 1 and round 2 for the Houston district. It includes the round 1 and round 2 raw sampling results received from SwRI, data presented in Table 10 and Table 11, as well as Houston district-level averages for selected fuel parameters for round 1 and round 2 sampling of gasoline and diesel. This appendix is available electronic only.

APPENDIX F2: 2003 THROUGH 2023 GASOLINE AND DIESEL TREND ANALYSIS

This appendix contains two Excel spreadsheets with the trend analysis data for gasoline and diesel for the years 2003 through 2023. This appendix is available electronic only.